

Facility Energy Decision System Release 7.0 User's Guide



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Facility Energy Decision System (FEDS) User's Guide

1 Introduction to FEDS

The Facility Energy Decision System (FEDS) model has been developed at the Pacific Northwest National Laboratory (PNNL) for a number of agencies including the Department of Energy's (DOE) Federal Energy Management Program (FEMP), U.S. Army Construction Engineering Research Laboratory (USA-CERL), U.S. Army Installation Management Command (IMCOM), U.S. Army Forces Command (FORSCOM), DOE's Rebuild America Program, Defense Commissary Agency (DeCA), U.S. Naval Facilities Engineering Service Center (NFESC), Tennessee Army National Guard, U.S. Coast Guard (USCG), U.S. General Services Administration, and Public Works and Government Services Canada. FEDS is an energy analysis software system designed to provide a comprehensive approach to fuel-neutral, technology-independent, integrated (energy) resource planning and acquisition. The FEDS approach allows data input to range from minimal to extremely detailed. With minimal input, FEDS can be used as a top-down, first-pass energy systems analysis and energy resource acquisition decision software model for buildings and facilities. Providing FEDS with more detailed input allows the user to generate optimized building retrofits and provides detailed output for each recommendation, including energy, electric demand, cost, and emissions impacts.

FEDS is a flexible and user-friendly Windows-based software program for assessing the energy efficiency resource potential of facilities ranging from single buildings to multi-building campuses and large federal installations. Users may enter only high-level installation information (number, age, size, and types of buildings and energy systems) and the internal database of typical energy-system configurations and performance data then infers likely building parameters and the sophisticated energy simulation and optimization models estimate the net present value of potential energy retrofits. More detailed building models may also be developed, where the inferred information is augmented with user-supplied details on energy system information. The result is detailed and more accurate technology selection and economic information.

Please report any software bugs and refer any recommendations, comments, and/or questions of a technical nature to FEDS.Support@pnnl.gov. Also, visit the FEDS web site at www.pnnl.gov/FEDS for additional information and possible software updates.

1.1 General Description of FEDS

FEDS provides a comprehensive fuel-neutral, technology-independent, integrated (energy) resource planning approach from the top down. The basic intent of the model is to provide information needed to determine the minimum life-cycle cost (LCC) configuration of the installation's energy generation and consumption infrastructure. The model has no fuel or technology bias; it simply selects the technologies that will provide an equivalent or superior level of service (e.g., heating, cooling, illumination) at the minimum LCC.

When determining the minimum LCC configuration of building and end-use technologies, all interactive effects between energy systems are explicitly modeled. For example, when considering a lighting retrofit, the model evaluates the change in energy consumption in all building energy systems rather than just the change in the lighting energy. The value or cost of these interactive effects varies by building type (level of internal gain), building size (portion of heating, ventilation, and air conditioning loads attributable to internal gains versus envelope gains/losses), climate (whether a particular building is cooling- or heating-dominated), occupancy schedule, and a number of other factors. Thus, there is no simple solution, and detailed modeling, as is done in FEDS, is the best way to provide a credible estimate of the savings impact.

In determining the optimal retrofit for each technology, the interactions at the installation level are considered by determining the impact on the installation's electric energy and demand cost, as well as the interactive effects among end-uses. This is important because the peak electric demand in any individual building may not occur at the same time as the installation's peak demand. Since the buildings on large federal installations are often not individually metered, the installation is billed based on the combined demand of all buildings. Thus, proper valuation of the changes in an individual building's electric demand must be done in the context of the impact on the installation's demand profile--including time-of-day pricing and demand ratchets.

1.2 New in Release 7.0

FEDS 7.0 marks yet another significant step forward in the continued evolution of the FEDS building energy analysis software, adding enhancements that make it more powerful and flexible than ever, while just as easy to use. FEDS 7.0 now utilizes a full hourly simulation model and a number of related features to further enhance the accuracy and detail of its energy modeling capabilities. New HVAC and lighting technologies (including a variety of LED lighting options) have been added, the retrofit cost and performance model has been completely updated, and reports have been improved, among other enhancements. A more complete listing of what's new in FEDS 7.0 follows:

Conversion to a Full 8760 Hourly Simulation Engine

FEDS 7.0 has been transformed into a fully hourly simulation capable of modeling each of the 8,760 hours in a year. This improves the modeling accuracy and response to drivers such as weather and occupant variability throughout each month over the previous simplified hourly method. While runtimes will increase, this change allows FEDS to meet more stringent modeling criteria, and enables a number of possibilities for added detail and specification related to occupancy and building system modeling going forward. As part of this change, FEDS is now able to make appropriate adjustments for leap years and daylight saving periods, where applicable, and users can specify the start day of the simulation (the day of the week that January 1 falls on). The accuracy of the existing seasonal/variable occupancy and building operation specification has also been improved by changes enabling the hourly simulation.

New HVAC Technology Options

FEDS 7.0 adds a number of new HVAC options to enhance the modeling of a number of building technologies including the following:

- Variable Air Volume (VAV) Systems
- Economizers
- Demand Controlled Ventilation
- Terminal Reheat
- Subcool Dehumidification (aka, Central Reheat)

These advanced HVAC options are now available for specification in baseline building models from within the Ventilation inputs. Additionally, number of control options and setpoints are available for user input (or they can be inferred by FEDS based on your building type and climate zone, among other parameters).

Additionally, FEDS 7.0 expands the number of chiller type options to include screw and scroll compressor designs.

New Lighting Technology Options

Significant changes in the world of lighting continue with the phase-out of certain incandescent bulbs and increasing progress in the area and application of advanced lighting technologies such as LEDs. As such, FEDS 7.0 has added the following lighting to its vast inventory of available options:

- Over 130 LED lamps and fixtures suited to a range of applications
- Halogen lamps
- Induction lighting

- A number of additional linear and compact fluorescent choices

These added choices are selectable as existing lighting types and are also evaluated for cost-effective replacements.

Changes have also been made to the lighting inputs to make the specification and modeling of exterior lighting fixtures easier. A new "Fixture Location" input differentiates between Interior and Exterior fixtures and when Exterior is selected FEDS automatically sets the heat-to-space to 0% and infers appropriate utilization factors based on occupancy specifications.

Fully Updated Retrofit Cost and Performance Data with Enhanced Regional Resolution

The vast and growing database of energy efficiency measures that FEDS evaluates for cost effective retrofit upgrades has been thoroughly reviewed and updated. The performance and efficiency of available technologies have been assessed and current costs have been integrated. Additionally, regional labor rates, material cost factors, and sales tax rates have been updated, and expanded to provide significantly enhanced resolution. Whereas regional costs were previously modeled at the individual state level, FEDS 7.0 now models regional costs according to regions defined by the first three digits of the postal zip code. Zip code is a new input available in FEDS 7.0 and also helps set the state and weather station for U.S. locations. The impact on accounting for intra-state variations in construction costs is significant and further increases the accuracy of the results.

Additional changes to the FEDS cost model have also been made, including incorporating additional overhead and project cost layers into the base model. As usual, these are inferred and remain fully user-accessible and modifiable.

Report Writer Improvements

A number of enhancements have been made to the FEDS reporting functions. In addition to the existing report options, new Calibration Output and Retrofit Savings Overview reports are available. These are both spreadsheet formatted (.xls) reports; the Calibration Output is designed to make model calibration easier and the Retrofit Savings Overview report provides a building and site total look at the energy and dollar savings potential of an analysis, along with estimated investment, payback, and greenhouse gas reductions. An enhanced version of the standard TXS report is also available, which includes graphical output of building energy use by end use as well as energy use intensities.

A feature of the updated reporting system is that users may open report files directly from FEDS, and without first generating the reports (the report files are now created automatically at the end of each FEDS run).

Data Updates and Other Enhancements:

A significant number of additional enhancements and data updates are included, such as:

- The ability to go directly to "Maximum Detail" inputs without first satisfying the FEDS "Minimum Set".
- A new "pier" floor type.
- New window options including high performance aluminum frames, additional low-e films, and low-e storm windows available for retrofit.
- Ability to model additional technologies within a building (up to 40 lighting fixtures, 20 motors and miscellaneous equipment records).
- Improved design day capacity calculations.
- Updated equipment performance and other inference data improvements.
- Additional text description fields to aid in identifying use areas, lighting fixtures, and heating/cooling/hot water technologies. These descriptions are integrated within mapping features of the UI and are also listed on the retrofit reports (TXD and CSV).
- The latest DOE/EIA discount and energy escalation rates.

1.3 Getting Started

This section describes the minimum computer requirements, the installation of the software, opening a case, and developing and running a model.

1.3.1 Computer Requirements

The FEDS software requires the following minimum computer platform:

- A Windows-based personal computer (Windows 7, 8, XP, and Vista are compatible with FEDS).
- A fast processor is recommended as the FEDS program is computationally intensive. The time required to run the program depends upon the computer platform used. On a typical computer system of average speed, running the program (after data input) will take anywhere from a few minutes to several hours, depending upon the size of the input file (number of building sets) and its complexity (e.g., number of HVAC types and energy sources). *Tip: when running a large model, disable power saving features that put the hard drive and/or processor to sleep after a short time of keyboard inactivity.*
- CD-readable drive for installing the program.
- Mouse – although the program can be operated fully from the keyboard.

- Available hard disk space of approximately 2 GB – disk space is required for loading FEDS program files, and for storing FEDS input and output files. Additionally, during execution of the model, temporary files are created which are about 500 KB per building set.

1.3.2 FEDS Installation

1. Place CD into drive
2. Installation program will start automatically if Autorun feature is enabled. Otherwise, click **Start**, select **Run...**, type **D:\FEDS70_Setup.exe** (or substitute your CD drive letter for “D”.) Click **OK**.
3. Follow the prompts to complete installation.

1.3.3 Create New Case

To create a new case, select **Create New** under *Case Options*. The *New Case Selection* screen will appear and prompt you for a case name and path, as illustrated in Figure 1.1.

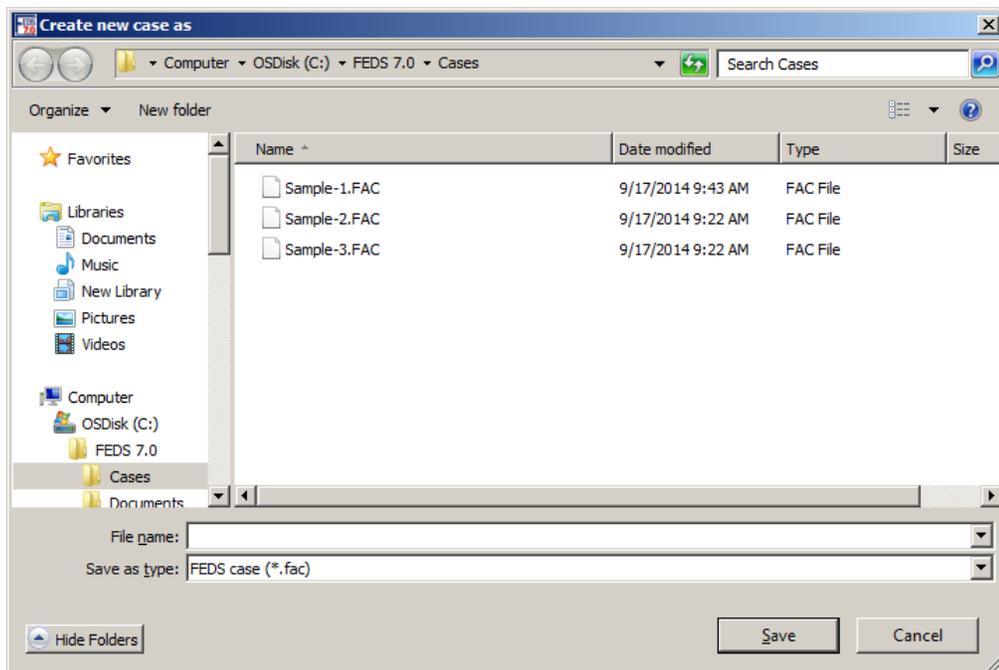


Figure 1.1 New Case Selection Screen

For each case, FEDS creates 16 input files (where casename represents the name you have given your model):

{casename}.fac	{casename}.flk
{casename}.bld	{casename}.llk
{casename}.blk	{casename}.lop

{casename}.ecn	{casename}.nep
{casename}.elk	{casename}.plk
{casename}.elp	{casename}.plt
{casename}.emi	{casename}.rcf
{casename}.eng	{casename}.rrs

These files are needed to create, view, edit, and run a case. A number of additional files are created during optimization and are needed for generating output reports. Adding the various report options, as many as 35 files are possible for each case. When transferring a FEDS case from one location on your computer to another, it is important to be sure to transfer ALL of the files having the same case name.

1.3.4 Open Existing Case

To open a previously created case, select **Open case** from the *File* menu. The *Existing Case Selection* screen will appear and prompt you for the location and name of the case (see Figure 1.2). Select a case name by clicking on one of the choices followed by the **<Open>** button. A double-click on the selected case will also open it.

Three cases are included with the FEDS software named “Sample-1”, “Sample-2”, and “Sample-3.” These appear in the case name list with a file extension of “.fac.” If not, check to ensure that the directory specified during the software installation is selected (default is C:\FEDS 7.0\Cases). For more information about the sample cases, see Description of Sample Cases in Section 1.4.

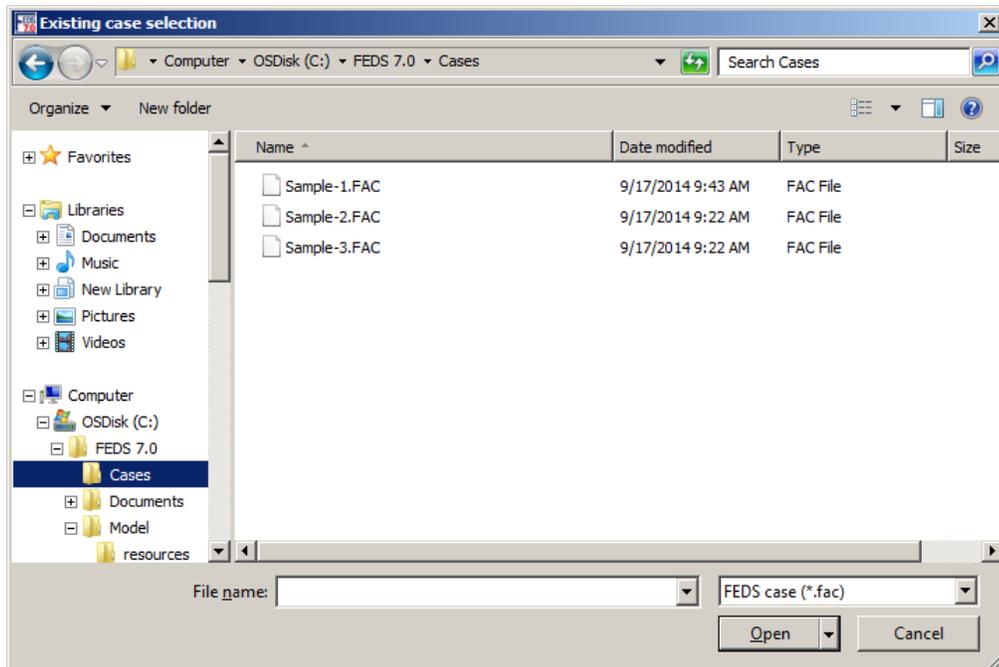


Figure 1.2 Existing Case Selection Screen

1.3.5 Converting Older FEDS Case Files

In order to run FEDS 7.0 using files created with an earlier version of FEDS, the files must be converted into the appropriate format. The following sections explain how to convert existing FEDS input files for use with the latest version.

NOTE: Expect to see changes in both inferred and output values due to improved performance and cost data.

Convert case files (“*.fac”) created with FEDS 6.0 or a previous version to FEDS 7.0 format as follows:

1. Follow procedure for Open Existing Case in Section 1.3.4.
2. Select an existing case file (“*.fac”) from any existing directory
3. If FEDS does not recognize this case to be in the current FEDS format, it will inform you that it is attempting to translate the case
4. If successful, a screen will appear prompting you for a name and destination directory for the translated case. The directory where the original case is stored will be the default destination. However, it is recommended that you place the case in a different location (e.g., your FEDS 7.0\Cases directory), by selecting the desired directory from the file structure list. If you choose not to save the translated case to a different directory, it is recommended that you give the case a new name rather than overwriting the original set of files. To do so, edit the name before pressing <Save>.

Note: The path and file names for existing cases that were created in versions of the FEDS software previous to FEDS 5.0 must comply with the short file name (8 character limit) format. If the folders in the path or the case file name exceed 8 characters in length or contain any spaces, the translate operation may fail. If this happens you will need to move the files to a compliant folder and/or rename them before they can be translated.

1.3.6 Running FEDS

Once you have started FEDS and have opened or created a case, an outline for running the model is as follows (refer to the individual sections for more information):

1. Enter or modify input data for buildings, central plant, and thermal loops (see Screens and Functions in Section 2).
2. Update inferences (see Program Options in Section 2.8).
3. Examine new inferences, make appropriate changes, update inferences again, and repeat process until satisfied with the model data set.
4. Select the Calibration run analysis type or exclude all building sets from optimization (see the discussion of this in Section 4.1).
5. Run FEDS (see Program Options in Section 2.8).

6. Open and examine the reports that are created including the calibration output report (*.Calib.xls) and the *.txs output, comparing consumption estimates to actual metered data to reconcile data and uncover any input errors or omissions (see Program Options in Section 2.8 and a description of the *.txs output in Section 6.1).
7. Fix any input errors and continue to calibrate the model until satisfied that it reasonably represents reality.
8. Set optimization parameters as described in Section 3.5.
9. Change analysis type to 'Optimization' (or remove building set exclusions) and run FEDS.
10. Open and review output reports to examine FEDS recommendations (see FEDS Output in Section 6).

For more detailed information, see FEDS Process in Section 3.

1.4 Description of Sample Cases

When you install FEDS onto your hard drive, the software will automatically create three sample input files for your use, "Sample-1.fac", "Sample-2.fac" and "Sample-3.fac".

These files can be used for several purposes, including the following:

- They may be recalled using the **Open case** option from the *File* menu to review on a screen-by-screen basis how data files are constructed.
- They may be run by FEDS to check whether your FEDS software is operating correctly. This can be especially useful if files that you have developed do not run, or if you get error messages that lead you to believe that your software may not be performing as designed. In rare cases, the program may not have installed properly, or it may not have the necessary user rights. In such cases, uninstalling and reinstalling FEDS may be advisable.
- They may be recalled using the **Open case** option from the *File* menu and edited to create your own case. This method provides a potential shortcut as compared to creating a new case from scratch. However, it is important to pay close attention to the inputs that require changes. Also, it is recommended to select the **Save case as...** option from the *File* menu to save the case to a new name to avoid overwriting the sample case data.

1.4.1 *Sample-1.fac Case File*

This case file contains the example of a single 40,000 ft² office building in San Francisco, California. The office was built in 1978. It is heated by electric resistance heaters and cooled by electric packaged single zone units. Service hot water is heated with electric resistance. The building has 30% incandescent lighting, 50% conventional fluorescent lighting, and 20% high-efficiency fluorescent lighting. On weekdays, the building is

occupied from 7 am to 6 pm; on Saturdays from 10 am to 4 pm; on Sundays the building is unoccupied.

1.4.2 *Sample-2.fac Case File*

The example in this case file is a complex consisting of two 50,000 ft² office buildings, six 50,000 ft² warehouses, ten 2,000 ft² single family (detached) residences, and three multifamily (five or more unit) buildings with an average floor area of 26,667 ft². All of these buildings are located in Seattle, Washington.

The two office buildings were constructed in 1977. One office is heated and cooled with an electric air-source heat pump; it has an electric water heater. The other office is heated with natural gas and cooled with packaged single zone units; it has natural gas water-heating. For both offices, the lighting is 20% incandescent and 80% conventional fluorescent. On weekdays, the buildings are occupied from 7 am to 6 pm; on Saturdays from 10 am to 4 pm; on Sundays the buildings are unoccupied.

The warehouses were all built in 1979. Three of the warehouses are heated with distillate oil; three are not heated at all. None of the warehouses has cooling. All six warehouses have distillate oil service water heaters. All of the warehouses have 100% high-pressure sodium lighting. The warehouses are occupied from 6 am to 8 pm on weekdays, 8 am to 6 pm on Saturdays, and 10 am to 4 pm on Sundays.

The single family residences were built in 1981. Five of the homes are heated and cooled by electric air-source heat pumps; the other five are heated by natural gas and not cooled at all. All of the homes have electric water heaters and 100% incandescent lighting. They are occupied from 5 pm to 7 am on the weekdays and continuously occupied during the weekends.

The multifamily buildings were constructed in 1984. One of the buildings (24,000 ft²) is all electric, with electric resistance heating and electric water heaters. The other two buildings (28,000 ft² each) are heated with natural gas and have gas water heaters. All three buildings cool with window air conditioners. Ten percent of the lighting is fluorescent and 90% is incandescent. The buildings are occupied from 5 pm to 7 am on the weekdays and continuously occupied during the weekends.

1.4.3 *Sample-3.fac Case File*

This sample case file contains three administration buildings and four warehouses located in Cincinnati, Ohio.

The first administration building set consists of a single L-shaped building and is modeled using the Advanced Geometry capability (see Section 2.9.2). The building's heating and hot water service are supplied by a central energy plant--Central Hot Water Plant. The thermal loop supplying central hot water to this building (Loop #1) has recently been upgraded and will not be considered for abandonment even if cost effective, and has thus been marked "No abandonment". Chilled water from the district chilled water plant provides all of the cooling.

The second administration building set has 2 nearly identical WWII-vintage buildings that have old leaky windows that are going to be replaced regardless of cost effectiveness (so the “Replacement required” box is checked for the windows—see Section 3.5). Heating for these buildings is all supplied by Central Hot Water Plant Loop #2 which is in very poor repair and is scheduled for abandonment; thus the loads supplied by this loop will be forced to retrofit to distributed building level technologies (e.g., building-level boilers). Chilled water from the district chilled water plant provides 80% of the cooling to each building and the other 20% is supplied by window air conditioners. The heating and cooling technology records are paired so that heat pumps (including ground-coupled systems) and gas packs may be evaluated as replacements. These buildings are utilized only every other weekend during the year except in the summer when they are operated daily (and are modeled using Seasonal/Variable Operation—see Section 2.9.2).

The first warehouse building set is a single fairly new insulated metal building with gas infrared heating, no cooling, and gas water heating. It has high output T5 fluorescent lighting inside, LED exit signs, and 250W high pressure sodium security lights on the exterior that operate at night.

The second warehouse building set represents 3 older buildings which receive their heat from either Central Hot Water Plant Loop #2 (scheduled for abandonment) or Loop #3. All have electric water heating and none have cooling.

2 Screens and Functions

This section provides a brief overview of the FEDS screens and user options. Information is available within FEDS for all inputs via Help on the *Help* menu and via the context-sensitive help key <F1>. For additional information on how to conduct a FEDS analysis, see FEDS Process in Section 3.

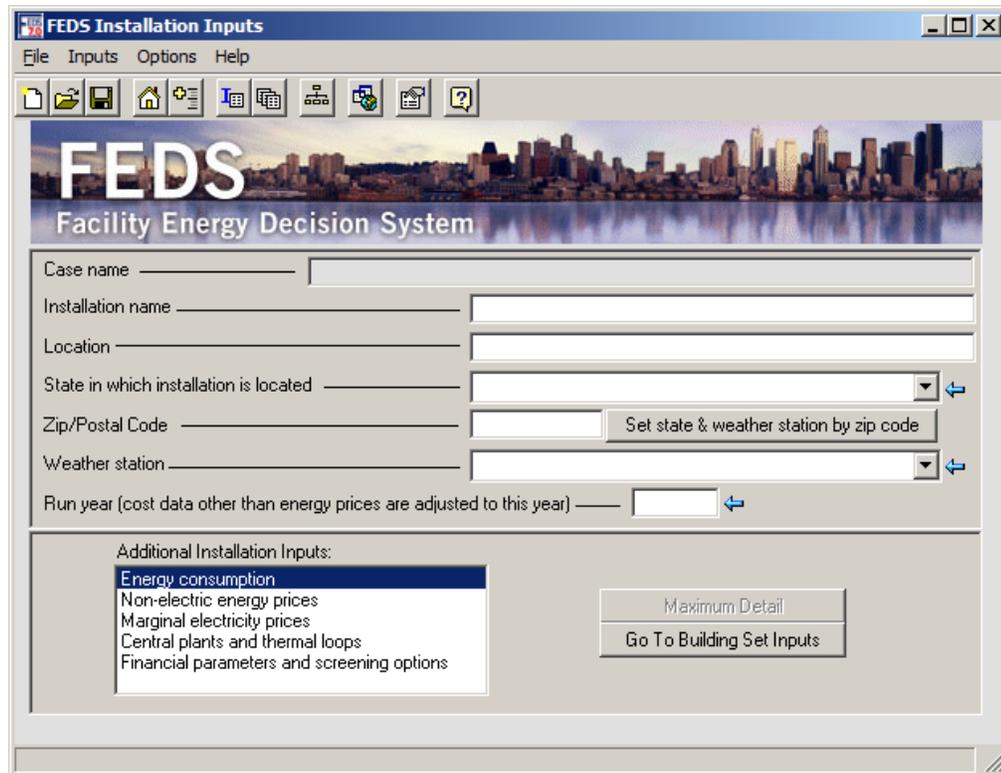


Figure 2.1 Main FEDS Input Screen

2.1 Screen Navigation and Operation

FEDS 7.0 is a menu-driven Windows application. Its features include the following:

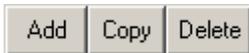
- **Tab and shift-tab:** Tab moves the cursor forward from one data field to the next. Shift-Tab moves the cursor backward from field to field.
- **Buttons:** Buttons control many operations, e.g., selecting individual lighting technology records. A single click of the left mouse button (or SPACEBAR) will activate any button.
- **Check boxes:** A left mouse (or SPACEBAR) click in a check box will select a function. Clicking the box again will turn off the function. Some check boxes are exclusive, that is, selecting one item will deselect a previously selected item.

- **Data fields:** On many screens, data fields are used to enter information. A label describing the function of the box is located next to the data field. When the cursor is in the desired data field, enter the requested information. A tab will move you to the next field.
- **Drop-down lists:** For several data screens, you will need to access a drop-down list to select from a list of choices. A left mouse click or pressing ALT+DOWNARROW will display the list. The slide bar and arrows will move you to the desired item. A single left mouse click will select the item.
- **List objects:** In the *FEDS Installation Inputs* and the *Building Set Inputs: General Information* screens there are list objects. These allow you to access different areas of the program to input site-specific information. A double left mouse click (or SPACEBAR) will bring up the selected submenu. NOTE: This is the only place where a double mouse click should be used.

2.2 Special Buttons



These three buttons are located on all submenus. **<Save>** will save the information you have entered and leave the cursor in that screen. **<Cancel>** will erase any information that has not been previously saved and take you to the previous screen. **<Save-Done>** saves the information you have entered and takes you to the previous screen.



For each building set and technology in a building set, and for each central plant and thermal loop, there is a separate group of screens (called a record). **<Add>** creates a new blank record. **<Copy>** creates a copy of an existing record. **<Delete>** removes an existing record and all associated data.



These buttons allow you to quickly move between building set, technology, central plant, or thermal loop records:



moves to the first record;



moves back one record;



moves forward one record;



moves to the last record in the set.



The "Go to" button displays a pick list of all records; a double left mouse click on the desired record or single left mouse click on the desired record followed by clicking on **<Continue>** moves you to that record. Selecting any of these options will automatically save the current screen data before moving on to the next.



This button selects the maximum detail display mode for the installation level and individual building set record screens. See Display Modes in Section 2.5.

2.3 Help

FEDS Help is available from the *Help* menu. Helpful information about each input is also available via the <F1> key. To access help for a particular input, activate the input cell or box by clicking on it with the mouse (or tabbing to it) and hit <F1>. A brief explanation of what input FEDS is requesting, along with information on how FEDS uses that data may be given. Whenever you are unclear about a certain input first check the help text - your questions will likely be answered.

2.4 Special Indicators and Locking

 Inputs that have a blue arrow pointing at them belong to the minimum set and have not yet been satisfied. For a new building set or technology record, all minimum set items must be provided in order to successfully determine the inferences and run the model. All minimum set items are not inferred by FEDS and, thus, do not have the locking feature associated with them. Once a valid input is provided for a minimum set item and saved successfully, the blue arrow will disappear, indicating that the requirement has been met. For further information about minimum set values, see Minimum Set Screening in Section 3.2.

 Inputs that have this open lock symbol next to them are inferable by FEDS meaning that FEDS will update the value when you select <Update Inferences>. Such values are subject to change each time inferences are updated depending upon which other values may have been changed by the user.

 This closed lock symbol next to an input indicates that its value is locked, and will not be changed by FEDS. All values entered by the user are automatically locked. To unlock a value, click on the lock icon to change it to an open lock. Once unlocked, this value will then be inferred the next time inferences are updated.

Recommended Inputs: Inputs without the blue minimum set arrow or lock icons are highly recommended but not required for FEDS to run. These include user-defined labels for the installation, building set, and miscellaneous equipment descriptions as well as most facility level information and economic parameters. Except as noted for particular inputs (e.g., energy consumption inputs), many of these values affect optimization and are essential for legitimate results. If, for example, the energy price input screens are not visited, all fuels will be valued at \$0.00/unit and no fuels will be inferred as available to the building sets. Similarly, if building occupancy hours are not specified, FEDS will assume that the building set is never occupied. Therefore, it is important to provide this information.

2.5 Display Modes

There are two modes available for displaying available model inputs:

Minimum set display: When a new case is created, or a new building set is added, only those input cells that are required for FEDS to run (i.e., the minimum set) will be

displayed. This significantly reduces the number of screens and inputs that appear, reducing the time and effort required to gather and input data and run the model. Using the minimum set input, FEDS requires the minimum possible information for making a reasonable first-cut estimate at the energy resource efficiency potential. For more details see Minimum Set Screening in Section 3.2.

Maximum detail display: Once all minimum set data have been entered at the installation level or for a particular building set and inferences have been updated successfully, the **<Maximum Detail>** button will be enabled. Clicking on this button will trigger the input data to be displayed in maximum detail. In addition to all minimum set inputs, nearly all parameter values which are inferable by FEDS are displayed. This gives you the ability to examine FEDS inferred values, lock those that are correct and change any values to more closely resemble the actual facility, thereby increasing the accuracy of the output (see Transitioning to Maximum Detail in Section 3.4 for more details).

NOTE: FEDS now allows you to jump right into maximum detail mode for a building set and no longer requires that you first satisfy the minimum set inputs.

Also, once any maximum detail value is locked, the building set containing the lock cannot return to minimum set display. If no values are locked, upon exiting the building set and returning, the display will be once again set to minimum set (with the **<Maximum Detail>** button enabled). Again, the maximum detail display is selected separately for each building set and the installation level. Therefore, it is possible to have a portion of your building sets at maximum detail (i.e., those in which you have made non-minimum set inputs) and some at minimum set. To keep track of the display mode for the building sets, click on the **<Go to...>** button. Building sets displayed at maximum detail will be indicated by [MAX] and those at minimum set by [min].

2.6 Installation Level Inputs

After launching FEDS 7.0, you will see the *FEDS Installation Inputs* screen. This screen displays the case filename and prompts you for general information about the installation, such as its name, location, zip code, and weather station. From this screen, you may select any of the installation level inputs or move to the building set inputs. You may also initiate case and program functions using the menu bar or icons.

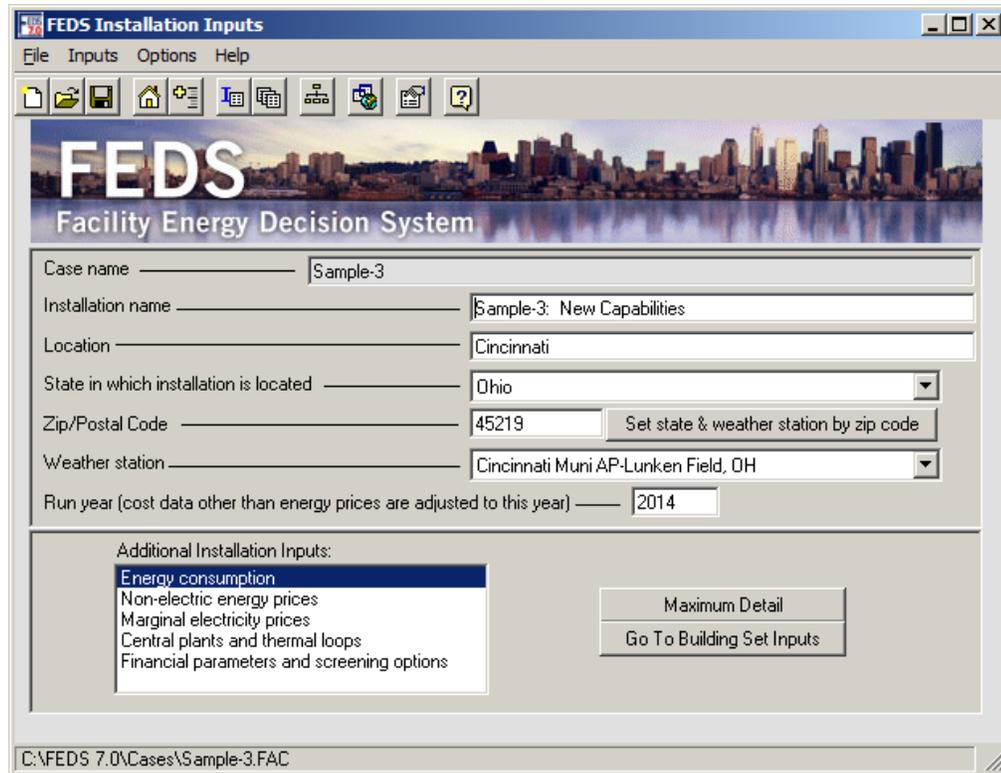


Figure 2.2 FEDS Installation Inputs Screen

2.6.1 Additional Installation Inputs

The following selections are the list objects on the *FEDS Installation Input* screen. To choose, double-click on the item name.

Energy consumption: Provides information on the energy consumption at the site for a typical year. These values are currently not used in FEDS calculations but are valuable as a measure of the input data accuracy when compared to consumption values generated in FEDS output.

Non-electric energy prices: Fuel price information for all non-electric fuels available at the installation, including oil (distillate and residual), natural gas, coal, purchased steam, purchased hot water, purchased chilled water, and other fuels. Building set fuel availability is defaulted based on these inputs. Note that if a price is entered for any energy type, then the program will assume (unless changed for a building set in "Fuel Type" inputs at maximum detail) that the energy source is available to all buildings being modeled and will optimize the life-cycle economics for all buildings using technologies that employ that energy source. Conversely, if a price is not entered for a particular fuel, then no technologies that use that fuel will be evaluated as possible retrofits. The value of any site-generated fuels (e.g., self-generated steam, hot water, chilled water) are determined by the model based on information provided in the central plants and thermal loops inputs.

Marginal electricity prices: These data include detailed electric rate structure information for flat and time-of-day rates and demand ratchets, as applicable.

Central plants and thermal loops: These input screens allow the creation of multiple central plant records, each with multiple thermal loops that distribute the central fuels to the buildings. The plant type, equipment and thermal loop parameters, and operating costs can be specified. All of this information will be used by the model to determine the value of the central fuels at each building and for use in retrofit optimization.

Financial parameter and screening options: This edit group provides the model information on financial parameters necessary for life-cycle cost analysis and system optimization. These parameters include discount rate, energy escalation rates, and screening on simple payback and savings-to-investment ratio. Specifications for alternative financing arrangements can also be accessed here.

Soil and water characteristics: This screen (which appears only in maximum detail display) stores the hydrogeologic information for the site. Such information is used in analyzing the cost and performance of various ground-coupled heat pump systems. The ground water temperature is also used in the service hot water calculations.

2.7 Case Options

Each of the following case options is accessible from the *File* menu:



New case: Allows you to create a new case. See Create New Case in Section 1.3.3.



Open case: Opens an existing binary (“*.fac”) case file to be viewed, edited, or run. Will also open and convert previous version FEDS cases. See Open Existing Case in Section 1.3.4 and Converting Older FEDS Case Files in Section 1.3.5.



Save case: Saves the current case input data.

Save case as: Enables you to save the current case to a new filename. You will be asked to specify a case name and path. If you just want to look at a case and not change any values, <Save case as...> is the best way to ensure that the original case will not be altered. It also provides a time-saving tool for creating a new case that has similarities to an existing case. Just save a current case as a new name and modify the parameters necessary to define the new installation and building data, rather than entering it all from scratch.

Import Building Sets: An import tool to allow building sets from other existing cases or a database to be merged into the current case. This feature allows the combining of data for integration of multi-user input sessions, from separate case files, and from data stored in a specially formatted database. There are two available methods for importing building sets:

Import building sets from a FEDS case: Select this option to import all of the building sets from a separate existing case file. All of the building sets from the selected case will be imported and appended at the end of any building sets in the current case. This

method will only import the building set data, and no facility data (energy prices, financial parameters, central plant and loop inputs) will be imported.

Import building sets from a database: Follow the on-screen instructions for importing building set data into FEDS from a database. A database template (FEDSBldImporter-Start.mdb) is provided in the FEDS \Documents directory and provides the proper formatting required for the import process to function properly. This database can be renamed and moved to a different location for convenience; however, maintaining the format is critical. A short PowerPoint tutorial is provided in this directory, with a more detailed description of how to import building set data from a database, along with a sample database (FEDSBldImporter-Sample.mdb) containing data for 18 buildings.

2.8 Program Options

The following program options may be accessed from the menu bar or command icons.



Update Installation Inferences: Updates the installation level inferable (non-minimum set) values. Infers all information on the central plants and thermal loops, plus soil and water characteristics and advanced options (e.g., alter cost data and emissions factors) screens.



Update All Inferences: Updates FEDS inferences for the installation and all building set data. Updating inferences also catches any input errors and makes sure that the minimum set of input is provided.



Advanced Options: Provides access to the Advanced Options screens, where various program options may be set, including excluding building sets and restricting retrofits from optimization, altering project cost data, reviewing emissions factors, specifying whether to generate the optimal or top three retrofits, and specifying which list of weather stations to enable.



Run FEDS: Initiates baseline energy consumption and optimization calculations. Depending on the size and complexity of the case, this may take anywhere from a few minutes to over an hour to complete. If successful, a “{casename}.opt” file will be created.



Report Options: Allows you to choose up to four formats of output report to produce. It also allows you to print text-based reports directly from within FEDS. For more information, see FEDS Output in Section 6.



Exit: Shuts down the FEDS application.

2.9 Building Set Inputs

A building set is a group of buildings of similar type that can be modeled together, ideally of similar size, age, fuel availability, occupancy hours, and construction. See Step 1: Breaking Building Types into Building Sets in Section 3.1 for more information.

Clicking the **<Go to Building Set Inputs>** button on the *FEDS Installation Inputs* screen sends you to the first *Building Set Inputs: General Information* screen. Each building set has its own *General Information* screen so while there will only be one *Installation Inputs* screen per case, the number of Building Set screens is essentially unlimited. They contain and access inputs describing the building set geometry, occupancy, construction, and energy use characteristics.

The screenshot shows the 'Building Set Inputs: General Information' dialog box. It features a title bar and a main content area with various input fields and controls. The fields include text boxes for identification, description, type classification, number of buildings, total floor area, average construction year, aspect ratio, and linked building set. There are also checkboxes for solar normalization options and radio buttons for the number of use-areas. Below the main fields are two list boxes for 'Additional Building Set Inputs' and 'End-Use Inputs', with 'Maximum Detail' and 'Update Inferences' buttons between them. At the bottom, there are 'Building Set Record Options' (Add, Delete, Copy, navigation arrows, Go to...) and 'Save', 'Cancel', 'Save-Done' buttons. A status bar at the bottom left displays 'Bldg: [min][5 in 5]'.

Figure 2.3 FEDS Building Set Inputs Screen

2.9.1 Minimum Set Inputs

The following inputs are required for each building set:

- **Building Type:** These include 16 civilian (commercial and residential), and 26 military types, which are listed in Table 2.1. You create building sets, which are logical groupings of buildings of one type that have similar characteristics. An unlimited number of building sets can be created of each building type.

- **Building Set Physical Data:** These data include the average vintage (construction year), size, and number of buildings in that particular building set.
- **Building Operating/Occupancy Hours:** These include occupancy starting and ending hours for weekdays, Saturdays, and Sundays (or weekdays, Fri/Sat, and Sundays if a 4-day week schedule is selected).
- **End-use Inputs:** These include the percentage of building set end-use service provided by each lighting technology, heating fuel type, cooling technology, and service hot water fuel type.

2.9.2 *Maximum Detail Inputs*

At maximum detail, FEDS gives you access to the data inferred at minimum set. In addition to more detailed information in the existing minimum set input screens, the following new screens are also available at maximum detail display:

- **Seasonal/Variable Operation:** Specifies the months and percentage of hours within each day type and month that the building set is occupied according to the general occupancy schedule, plus how the non-operating periods are modeled. Two options are available for specifying the non-operating periods; these are 'Non-operating (no occupancy)' which is the default setting and 'Low occupancy'. Under the Non-operating (no occupancy) definition, the building is modeled as if it is temporarily shut down with no occupants and only minimal energy use (e.g., only exit lighting and heating set at Unoccupied setting for freeze protection). Under the Low occupancy setting, the non-operating periods are modeled the same as the unoccupied periods of the regular operating schedule (e.g., with reduced occupants, thermostat setback if defined, and reduced lighting and equipment utilization).
- **Building Geometry:** The number of zones and floors and percentage of wall area that is glass. Additionally, an **Advanced Geometry** option allows users the ability to specify detailed building geometry parameters at the specific zone and/or orientation level. This enables more detailed and accurate modeling of unique and difficult to model buildings, such as those with non-uniform geometries (that may impact a zone's wall or roof area, or volume) or envelope characteristics (e.g., different window areas on each side of the building). Parameters that are available by zone for advanced specification include the following: exterior wall area, exterior window area, roof area, floor area (both total and ground floor), exterior perimeter length, and conditioned air volume.

FEDS Civilian Building Types	
Assembly	Public Order/Safety
Education	Warehouse & Storage
Food Sales	Other
Food Service	Single Family Detached
Health Care	Single Family Attached
Lodging	2 to 4 Unit Buildings
Mercantile and Service	5 or More Unit Buildings
Office	Mobile Homes
FEDS Military Building Types	
Administration	Morale, Welfare, and Recreation
Barracks	Military Other
Chapel	Production and/or Process
Clinic	Recreation
Clubs	Schools and/or Training
Commissaries	Security
Dining Halls	Shops
Electronics	Storage
Exchange Facilities	Warehouse
Guest Houses	Single Family Detached House
Hangar	Single Family Attached House
Hospital	Duplex
Labs	Multifamily 3 or More Units

Table 2.1. FEDS Building Types

- **Envelope Inputs:** Construction materials and thermal characteristics of roof, floor, walls, and windows. Detailed descriptions of FEDS floor, wall, roof, and window types are available in [Appendix F](#).
- **Ventilation System:** Control mode and specific system parameters, including design supply air, outdoor ventilation air, plus economizer, demand controlled ventilation, reheat, and dehumidification system specification and control options.
- **Service Hot Water:** Daily consumption, distributed and loop system types and associated parameters.
- **Miscellaneous Equipment:** Equipment capacity densities and utilization factors for all other miscellaneous loads (of any specified fuel type). Categories include refrigeration, food preparation, and other (which includes computer/office equipment, etc.)

- **Motors:** Electric motor parameters and operating characteristics.

See Transitioning to Maximum Detail for more information about specific data inputs.

2.9.3 **Dual-Use Building Sets**

Within each display mode, you are asked to specify the number of use areas in the building set. If no choice is made, one use area is assumed. Selecting "2" enables you to model building sets with two distinct uses (use areas). An example of a dual-use building set is a barracks renovated with administrative offices on the first floor. If this set were modeled as one use area, the entire building would be assumed to be barracks and all operating and energy consumption characteristics would be driven by the barracks building type. As a dual-use set, however, the use-area parameters are inferred and set distinctly for each area based on the area types and percentages. Following is a list of use-area-specific parameters:

- Use-area type: selected from existing list of use-area types; must specify the percentage of each building under this use type
- Occupancy: operating schedules, number of occupants during the different occupancy periods, and seasonal and variable operation
- Lighting technology configurations and fixture densities
- Distributed service hot water systems: Distributed systems are the only type that may be selected for Use-Area 2. *Loop systems are only specified in Use-Area 1 and are modeled to serve the entire building set.*
- Miscellaneous equipment types, fuel types, capacity densities and utilization factors
- Motor types, size, utilization and load factors.

When dual use is selected within the minimum set display mode, the following additional inputs will appear, joining the minimum data set:

- Use-Area 1 Service Hot Water system type: You must specify either loop or distributed system for Use-Area 1 only (all systems entered in Use-Area 2 must be distributed).

2.9.4 **Linked Building Sets**

A special feature that exists exclusively in maximum detail display is the ability to link pairs of building sets. This allows you to model buildings that are adjacent to one another, sharing either wall or floor/roof space (such as a warehouse with a small office built onto one side). The difference between linked sets and dual-use sets is that linked sets consist of two distinct building sets not only having unique uses and occupancy/operating schedules, but each also having their own separate HVAC systems.

Another option available for modeling unique building geometries is to use the Advanced Geometry specification, accessible from within the Geometry inputs screen.

How to link buildings sets:

1. Select "Link" from within the *Building Set Inputs: General Information* screen of one of the sets you wish to link.
2. This will bring up the *Linked Building Set Inputs* screen. Select the building set to link to and the orientation, and click **<Save-Done>**.
3. If the link was accepted, the name of the set linked to will appear in the "Linked Building Set" box.

You may link any combination of building sets, including combinations of single and dual use, as well as any size, type, vintage, aspect ratio, etc. The only requirements are:

- Each set must contain the same number of buildings.
- Solar normalization must be set to calculate solar gains by facing directions.
- When you select to link with a top/bottom orientation, the footprint area (total floor area / number of floors) of the top set must not be greater than that of the bottom set (FEDS does not model cantilevered buildings).

There are two ways to unlink a pair of building sets:

- Click on **<Unlink>** from the *Building Sets Inputs: General Information* screen of one of the sets you wish to unlink.
- Delete one of the linked building sets - this will sever the link to the remaining set.

2.9.5 Technology Records

A technology record consists of the complete set of information describing a single technology serving an end use in a particular building set. There are limits on the number of technology records for a particular end use, within each building set.

Table 2.2 contains the maximum number of technology records allowed for each end use per building set. Note that for end uses that are specified separately in dual-use building sets (i.e., lighting, service hot water, and miscellaneous equipment), there is no per use-area limit, only a total per building set limit. In such dual-use scenarios, the maximum number of records applies to the sum of technologies across both use areas. Note that the ventilation end use is somewhat different in that there can only be one common set of control, technology, and operational settings specified for the ventilation system for the buildings in the building set.

End Use	Maximum Per Building Set
Lighting	40
Heating	10
Cooling	10
Ventilation	N/A
Service Hot Water	10
Miscellaneous Equipment	20
Motors	20

Table 2.2. Maximum Technology Records by End Use

2.9.6 HVAC System Modeling

FEDS has three different algorithms for the calculation of heating, cooling, and ventilation loads. One algorithm models heating and cooling systems that use forced air for distribution. These are referred to as **linked systems** (the cooling or heating coil is directly linked with a fan). Linked systems include furnaces, fan coil units, air-handling units, rooftop packaged units, window air conditioners, and heat pumps. FEDS is able to model any combination of linked systems together in a building set. It is important to note however, that if heat pumps are selected, FEDS requires that the portion of the building set served by each type (air and water source) be equivalent for both heating and cooling.

A second algorithm models heating systems that do not use forced air for distribution (e.g., radiators). These systems are called **unlinked systems**, and there may or may not be a separate ventilation system in the building. Unlinked heating systems include electric baseboard heaters, radiators, infrared heaters and various other radiant heating technologies. FEDS is able to model unlinked heating systems with any cooling system type (except for air and water source heat pumps which necessitate linked heating).

A third algorithm models the special case of evaporative coolers (which are linked systems), which cool air by adding moisture to it. Evaporative coolers are assumed to only use ventilation energy, i.e., the cooling is essentially "free." They may be combined with both linked and unlinked heating.

The separate algorithms for linked and unlinked heating were developed because these systems operate so differently and as such cannot be modeled together within the same building set. Similarly, the process of evaporative cooling is so different than conventional cooling technologies that a separate algorithm was developed and evaporative cooling cannot be included in building sets with other cooling technologies.

[Appendix I](#) lists allowable HVAC combinations including unlinked heating types with acceptable cooling types, linked heating types with acceptable cooling types, and evaporative coolers.

FEDS also has the capability to model a number of different ventilation approaches and associated technologies. The ventilation control mode defines the periods during which

the supply air fans operate (continuous means that they run all the time over the specified period, cycle indicates that they operate only as needed to help meet conditioning demands). FEDS can also model constant volume or variable volume supply systems, economizers, demand controlled ventilation, terminal reheat, as well as two active dehumidification approaches (desiccant wheel and sub-cool/reheat, the latter which is also commonly referred to as central reheat). Users can specify design and operating parameters for these system configurations when in maximum detail.

2.9.7 Paired Heating and Cooling Technologies

In any given building set there can be an unlimited number of buildings and up to 10 heating and 10 cooling records. A heat/cool pair identifies to the model which heating and cooling technologies jointly serve a particular building or group of buildings in the building set. In order to consider heat pumps or any other integrated heating and cooling technology as replacements for existing heating and cooling technologies, the heat/cool pairing must be defined.

Heating and cooling technologies may be paired from the heating or cooling equipment record screens at maximum detail display mode. Corresponding heat pump records are automatically paired upon updating inferences. However, all non-heat pump technologies must be paired manually.

How to pair heating and cooling technologies:

1. Select "Pair" from the *Heating Equipment Inputs* or *Cooling Equipment Inputs* screens for one of the heating or cooling technologies that you wish to pair.
2. This will bring up the *Pair Heat/Cool Technologies* screen.
3. Select the technology to pair with the current equipment record, note whether the equipment is separate (distinct heating and cooling units) or integrated, and click **<Save-Done>**. Each technology must serve the same portion of the building set to be valid.
4. If the pair was accepted, the name of the paired technology will appear in the heat/cool pairing box.

You may pair any combination of heating and cooling technologies except for heat pumps, which must be paired to another heat pump of the same type (i.e., the same fuel, equipment type, loop types, etc.). Heat pumps are automatically paired when inferences are updated.

3 FEDS Process

Briefly summarized, the FEDS analysis process will usually consist of the following steps, although FEDS is designed to be flexible and allow for a variety of different types and method of application:

1. Determine building set breakdown.
2. Complete an initial minimum set screening.
3. Gather additional data about the buildings and central energy plants on the installation.
4. Enter maximum detail display for selected building sets and update and/or modify FEDS inferred data with more detailed building and technology system characteristics.
5. Set optimization parameters.
6. Run model on final maximum detail input data.

Each of these steps is described in the next sections.

3.1 Step 1: Breaking Building Types into Building Sets

It is not only impractical but also unnecessary to model each building at a site individually. Especially for large installations, with hundreds or thousands of buildings, it is unthinkable to model each individual building separately. FEDS is designed to model groups of buildings that can be categorized together into sets. When beginning a FEDS screening, it is important to try to group buildings into as few sets as possible, with just enough separation to adequately represent what is there.

The following example illustrates how and why building types are broken into building sets. An installation contains two groups of administration buildings: a group of approximately 1943-vintage buildings and a group of buildings constructed in the early 1980s. If you were to group these buildings into one set based on type, the average vintage of the administration buildings would be about 1963, a value that is not very representative of either group. To improve the results, the building type may be broken up into two sets, one for each vintage category. Making this one change will greatly improve the applicability of the inferred values to the two building sets.

It may also be appropriate to use other determinants as well, such as common construction characteristics, common HVAC system types or characteristics, to which central energy plants or thermal loops the buildings are attached, similar penetration rates of particular lighting technology configurations, or similar miscellaneous equipment densities.

[Appendix A](#) contains a brief description of the FEDS inference generation. After building type, the major determinants of inference selection are the building vintage, location,

and size. A first step for determining building sets could be to break each type into the vintage and size ranges used by FEDS, which are given below:

Size Categories (ft²)	Vintage Categories
0 – 4,999	Before 1946
5,000 – 9,999	1946 – 1960
10,000 – 24,999	1961 – 1973
25,000 – 49,999	1974 – 1979
50,000 – 99,999	1980 - 1986
100,000 or more	1987 - 1996
	1997+

Table 3.1. FEDS Size and Vintage Categories

With six size categories and seven vintage categories, there are potentially 42 building sets for each building type. Moreover, this does not even account for differences in occupancy hours or fuel availability among similar building sets. Obviously, a FEDS case file can grow very large, very quickly. A more reasonable approach may be to break up a particular building type into sets by grouping along common construction characteristics (e.g., wall type, presence or absence of insulation, percentage of wall area that is glazed, etc.), common lighting and/or equipment densities, and common fuel availability.

3.2 Step 2: Minimum Set Screening

The objective of the FEDS minimum set input approach is to provide a top-level screening as a preliminary indication of what actions should be initiated; further analysis is required before a project is designed and implemented. When entering only the minimum set inputs, FEDS depends upon numerous assumptions about the "typical" stock of U.S. buildings, with only minimal energy price and installation configuration information needed as input. Engineering parameters are not part of the minimum set.

FEDS uses the minimum set information that you provide to internally generate descriptions of prototype buildings for each building set that you create. The default values of the parameters used to describe the prototypes are inferred from the input data; for instance, the climate zone is used in conjunction with the building type, vintage, and size to infer parameters relating to the building construction characteristics. This information is also used to infer the most likely heating equipment types for each user-supplied heating fuel type. The resulting building prototype parameter values are statistically the most likely values for a given building type, climate zone, average vintage, size, and fuel/technology mix.

Specific FEDS capabilities with minimum set input include:

- accepting input data of a generic and/or aggregated nature – for example, the percentage of a building set that uses a particular heating fuel is entered, but the individual heating technologies are not specified.
- estimating current and post-retrofit energy consumption for all energy systems under consideration.
- determining the optimal retrofits to the current system (considering interactive effects) and estimating the post-retrofit energy consumption, initial installed cost of the retrofits, recurring costs of the retrofits, value of the change in energy consumption and operation and maintenance (O&M) requirements, and the net present value of the retrofit – the net present value is the difference between the life-cycle cost (LCC) of the existing technology and the LCC of the retrofit technology.

Running FEDS with only the minimum set input provides utility, institution, agency, energy, resource, or installation managers with a simple 3-4 hour method to:

- estimate resource efficiency potential at a single multi-building installation with limited metered energy-use data
- characterize and prioritize the most promising building and end-use retrofit project opportunities
- estimate capital investment requirements and potential energy and cost savings based upon Federal life-cycle cost economics.

The tool can also be used at the headquarters or agency level to characterize opportunities at all sites, thereby providing a way to prioritize among these sites.

Applicability. The application of the FEDS inferences to the development of the building prototypes via a most likely parameter-value approach allows FEDS to perform detailed modeling and analysis of an installation while requiring only very limited information from a user (the minimum set). The results from a minimum set FEDS analysis are intended to be used as a gross indication of the required investment to achieve the energy and cost savings potential at an installation. The results can indicate which building types and end uses have the greatest savings potential. However, the most likely parameter-value approach also means that when FEDS is used with only minimum set information, it is most appropriately applied to installations with large numbers of buildings.

3.3 Step 3: Gathering Additional Data

Results from the minimum set screening can be used to direct resources for additional data-gathering. The building types, end uses, and fuels with the largest potential savings (according to the screening) are the building types, end uses, and fuels that should be given the most time and money for additional data-gathering. This effort may

be as minimal as confirming the heating and cooling equipment types and the construction types with a quick walk-through or drive-by, or it may involve such detail as determining actual lighting densities by counting light fixtures.

For most large installations, there will be a limit to how much additional data it is reasonable to gather. As a FEDS user, you must make the trade-off between the cost of gathering additional data and the quality of the output. The minimum set screening results can be used to help prioritize the data-gathering effort, and the effort must also be coordinated with a re-examination of the building set breakdown to determine if any of the building set groupings should change. Sample FEDS data collection forms were installed during software installation to the FEDS \Documents directory.

Also during this step, more detailed information about any central plants and thermal loops located on site should be gathered including seasonal operation, temperatures, pipe lengths, leakage rates, etc.

3.4 Step 4: Transitioning to Maximum Detail

Transition to maximum detail. The objective of FEDS maximum detail is to allow a knowledgeable user to override the default building and energy-using/generating equipment parameters that were inferred at minimum set. The maximum detail display may be activated individually for the installation level or for any building set by clicking on the **<Maximum Detail>** button on the *FEDS Installation or Building Set Inputs General Information* screens. Whereas, a successful update of inferences at the minimum set level was a prerequisite for entering maximum detail mode in past versions of FEDS, this is no longer necessary and maximum detail may be turned on from the start if desired.

Modify inferred data. At this point, it is time to modify the FEDS inferred data to more closely model the particular buildings at the site. Additional detailed data collected for the buildings should be entered into the appropriate input fields. Do not worry about modifying all data--modify only those you have easy access to or believe to be most important (as determined in step 3). Unlike other models that require highly thorough and detailed inputs, this approach allows *but does not require* you to enter any site-specific information that is not readily available. For instance you may specify the wall system U-value if known, however, it is not necessary and FEDS will infer based on parameters including construction type, location, presence and thickness or R-value of insulation.

Following is a brief list of suggested areas to modify:

- **Solar normalization:** Select “Calculate solar gains by facing directions” if most buildings in the set are oriented similarly. Select “Ignore facing directions” for sets of buildings with different orientations.
- **Occupancy inputs:** You may specify occupied and unoccupied periods, as well as seasonal/variable occupancy for the ability to model buildings that are used only part of the year.

- **Fuel availability:** When considering fuel-switching retrofits at minimum set, it is assumed that the fuels available to the installation are available to each building on the installation. Maximum detail allows you to change this assumption to better reflect the actual fuel availability at different parts of an installation. If a fuel is currently not available at a building but you would like to determine whether it would be worthwhile to bring in a fuel, specifying that it is available will enable FEDS to examine the fuel-switching opportunity.
- **Building envelope characteristics:** You may change the minimum set inferences for the construction materials used for the walls, roof, floor, and windows. You may also specify different insulation R-values and thicknesses than those inferred at minimum set or simply specify the desired overall U-value for windows, walls, roof, and floor. [Appendix F](#) provides a detailed description of the FEDS wall and roof types.
- **Lighting systems:** You may change the inferences for the lighting technology configuration(s), the lighting fixture density, lighting utilization levels for occupied and unoccupied periods, and lighting heat to space. Maximum detail gives access to over 900 existing lighting technology configurations. A description of the FEDS lighting fixture codes and technology configurations is provided in [Appendix G](#). The complete listing of all available fixture codes contained within the FEDS model may be found in [Appendix H](#).
- **Heating and cooling equipment:** The inferences for equipment type, number of units, nominal capacity, and efficiency (or coefficient of performance) for heating and cooling equipment may be changed. Heat/Cool pairs can also be specified (see Dual-Use Building Sets).
- **Ventilation system:** Fan and fan-motor capacities and efficiencies, as well as the ventilation system control mode, amongst many other parameters, may be changed. Specific motor, economizer, demand controlled ventilation, and dehumidification system parameters may also be specified.
- **Service water heating system:** Assumptions regarding the hot water consumption levels, system type, equipment efficiency, and capacity may all be changed.
- **Miscellaneous equipment:** You may change the inferences for miscellaneous equipment densities, utilization levels, and heat to space.
- **Motors:** You may add records to model a wide range of 3-phase electric motors. The monthly duty cycle (combined utilization and load factor) can also be entered.

Update inferences. Any additional information that you provide at maximum detail is used to recalculate (where appropriate) any dependent inferred values. Inferences for a particular building set may be updated by selecting **<Update Inferences>** from the *Building Set Inputs: General Information* screen. You may update all installation and

building set inferences for the case by pressing the "Update All Inferences" icon on the *FEDS Installation Inputs* screen or selecting **Update All Inferences** from the *Options* menu.

Repeat. You may then examine these resulting inferences and, if desired, make further changes to them before running the FEDS model. If you feel that more changes are necessary, modify the inferred data, generate new inferences, and repeat the process until you are satisfied with the input data.

3.5 Step 5: Set Optimization Parameters

After you are satisfied with your inputs and believe that you have modeled the buildings accurately, you should review and set the optimization parameters to best suit your needs. Review the following optimization parameter options:

- Select funding source (appropriated / alternative financing). See Section 5.
- Set financial screening options as described in Section 2.6.1.
- Exclude building sets that you do not want to consider retrofits for as described in Section 4.1.
- Restrict retrofit technologies or end uses that you do not want to evaluate as described in Section 4.3.
- Alter cost data (labor rates, end use materials multipliers, tax rate, etc.) to match your locale. See Section 4.4.
- Review emissions factors for your locale as described in Section 4.5.
- Choose whether the spreadsheet output lists the optimal retrofit only or the top 3 retrofits. See Section 4.6.
- Set any "Replacement required" (i.e., force retrofit) flags for those techs that must be replaced. This gives the user the ability to specify that a particular piece of equipment or component **must** be replaced, and therefore require that FEDS select the best, most life-cycle cost effective replacement. Replace on failure economics-allows the user to specify that a piece of equipment must be replaced due to failure, renovation, or new construction. This is extremely useful in design and renovation. For example, if you know that all of the windows are going to be replaced, which type of window should be installed? Because the user is requiring the technology to be replaced there is no longer a requirement that the retrofit be life-cycle cost effective. Hence, some retrofits may have negative net present values.
- Review thermal loops and set force abandon/do not abandon settings as may be appropriate. If the user requires that a loop be abandoned then the model will select the most life-cycle cost effective retrofit technology to replace the existing technology. There is no requirement that the retrofit have a positive NPV; hence, some retrofits may have negative net present values. In fact, even if a

loop is not set for forced abandonment, retrofits with negative NPVs may appear on the TXD and CSV reports if the loop (and plant) savings gained from abandoning the loop (and possibly plant) are greater than the resulting costs (negative savings) associated with all of the connected technologies.

3.6 Step 6: Running the Model

Once you have checked and modified your data and the data inferred by FEDS, it is recommended that you set the Analysis Type to 'Calibration' (or exclude all building sets from optimization - see Section 4.1) and then run FEDS to determine baseline consumption estimations. This allows you to quickly get baseline information that you can check against real data and resolve any large discrepancies before doing a full run of the model. It also provides a valuable tool for analyzing various what-if scenarios, which can be modeled manually via changing parameters on the building or installation input screens and comparing resulting *.txs and calibration reports.

Once large discrepancies have been resolved, return Analysis Type to 'Optimization' (or remove the building set exclusions) and select "Run FEDS" from the *FEDS Installation Inputs* screen under the *Options* menu. You will be informed that all inferences will automatically be updated and asked if you are sure you want to proceed. Click on <Yes> to continue.

At this point, FEDS begins by loading the input information and calculating the baseline (existing) energy consumption. The energy price data that you supplied are used in conjunction with the estimates of full building set energy consumption (to account for the interactive effects) and your specified or selected real energy cost escalation rates to determine the energy costs of the existing and the potential retrofit technologies.

The retrofit modifications to existing equipment that FEDS analyzes include complete replacement with similar but more efficient equipment (e.g., replacing existing fluorescent fixtures with new high-efficiency fluorescent fixtures), changes to different equipment types that provide equivalent service more efficiently (e.g., replacing an electric forced-air furnace with a heat pump), and changes to more efficient equipment using different fuel (fuel-switching). A complete list of retrofit options appears in [Appendix B](#).

For technologies served by central plants, FEDS considers replacing the existing equipment with new single building technologies. Additionally, FEDS examines the cost effectiveness of abandoning loops and plants, comparing the savings associated with reduced transmission losses and maintenance requirements with the costs of installing and maintaining equipment at the building level.

The FEDS model then uses the Federally mandated life-cycle cost methodology, as specified in 10 CFR Part 436, to combine the retrofit capital cost, operation and maintenance cost changes, and changes in the energy costs to determine the cost-effectiveness of potential retrofits. For more information on FEDS optimization and retrofit modeling, see [Appendix A](#).

Once FEDS has successfully completed its optimization, relevant output reports will be generated automatically, and you are ready to open them from the *Report Options* screen as described in Section 6.

4 Advanced Options

This section provides an overview of the operation and effective use of the features known collectively as Advanced Options. Each of the advanced options screens may be accessed by selecting “Advanced Options” located under the *Options* menu on the *FEDS Installation Inputs* screen or by clicking the *Advanced Options* icon. There are currently four Advanced Options available.



Advanced Options icon

4.1 Simulation/Calibration Parameters

This option provides access to a number of inputs that define key parameters of the FEDS simulation process. This includes the Analysis Type as well as a number of options that help specify the simulation year.

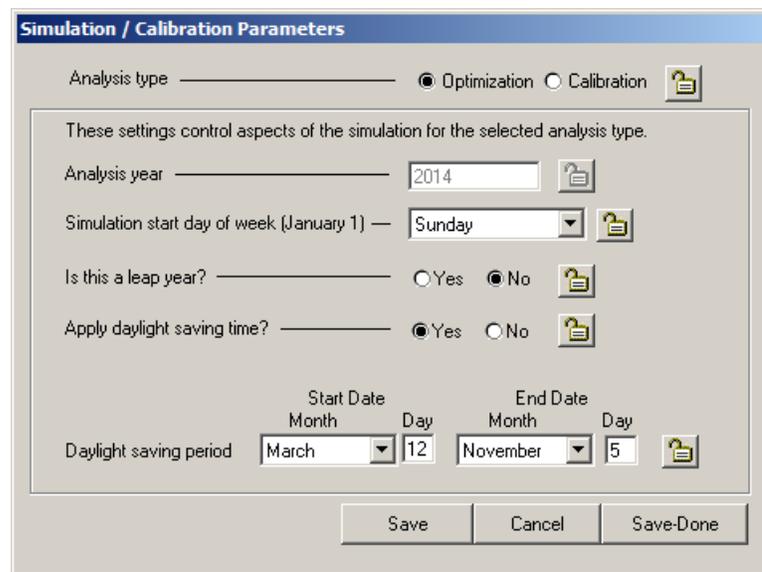
A screenshot of the 'Simulation / Calibration Parameters' dialog box. The title bar reads 'Simulation / Calibration Parameters'. Below the title bar, there are two radio buttons for 'Analysis type': 'Optimization' (selected) and 'Calibration'. To the right of these radio buttons is a small icon. Below this, a text box says 'These settings control aspects of the simulation for the selected analysis type.' The main area contains several input fields: 'Analysis year' with a text box containing '2014' and a small icon; 'Simulation start day of week (January 1)' with a dropdown menu set to 'Sunday' and a small icon; 'Is this a leap year?' with radio buttons for 'Yes' and 'No' (selected) and a small icon; 'Apply daylight saving time?' with radio buttons for 'Yes' (selected) and 'No' and a small icon; and 'Daylight saving period' with two sets of dropdown menus for 'Start Date' (Month: March, Day: 12) and 'End Date' (Month: November, Day: 5), each with a small icon. At the bottom, there are three buttons: 'Save', 'Cancel', and 'Save-Done'.

Figure 4.1 Simulation / Calibration Parameters Screen

Analysis type – ‘Optimization’ will run the FEDS retrofit optimization engine to evaluate and recommend energy efficiency projects. The ‘Calibration’ option on the other hand focuses on the FEDS baseline modeling to estimate current building and central plant energy consumption by fuel type in order to help calibrate the model (to check for input errors and compare resulting energy consumption from FEDS to actual metered consumption data). This further supports the calibration process by automatically turning off the optimization engine, so that the Calibration analysis is completed very quickly. Finally, at the end the Calibration run, FEDS will automatically generate not only the *.txs report but also a spreadsheet report containing many of the commonly

reviewed energy consumption metrics for the base building model, to facilitate comparison with available metered data.

Analysis year – for a ‘Calibration’ run, the Analysis Year may be specified by the user in order to help set up the calibration to match the characteristics and calendar of the year of the metered consumption data which is being calibrated to. For ‘Optimization’ runs, this is automatically set to the Run Year input on the main FEDS screen.

Simulation start day of week (January 1) – This day type input sets the day of the week the current simulation will begin on. In other words, it is the day that January 1 fell on for a particular analysis year. For ‘Calibration’ runs, this is inferred to the actual start day for the Analysis Year specified. For ‘Optimization’ runs, which attempt to run a non-specific year representative of the future, it is defaulted to Sunday (but can be changed).

Is this a leap year? – This Yes/No option allows you to specify whether the current simulation (for each Analysis Type) will model 365 days or 366 days for the year.

Apply daylight saving time? – Similarly, this option allows you dictate whether the simulation considers day saving time or not.

Daylight saving period – For simulations that include a daylight saving time adjustment, this set of inputs defines the range of dates for which daylight saving is applicable.

4.2 Exclude Building Sets from Optimization

This option allows the user to specify that a certain portion of building sets be excluded from optimization. FEDS still uses these sets to determine the installation electric demand profiles but will not consider any retrofits for them, saving valuable run time. There are three choices available for the exclusion of building sets, each chosen from the *Exclude Building Sets from Optimization* screen.

User Selects Building Sets to Exclude:

This method allows the user to choose specific sets to exclude from optimization. To access this option, mark the "Pick building sets" box in the top section of the screen. On the left portion of the screen there is a list of all building sets in the case. Simply select the sets to exclude from optimization by clicking on the set name with the mouse (or tabbing through the list and marking sets with the SPACEBAR). Those building sets picked for exclusion will then be shaded. Clicking on a highlighted set again will deselect it. Pressing the **<Select all>** button will mark all building sets for exclusion and **<Clear all>** deselects all sets.

Note: Excluding all building sets provides a helpful technique to run through the baseline calculations only, providing output that is helpful in verifying the input data, and to catch errors before spending the time to run the model with optimization.

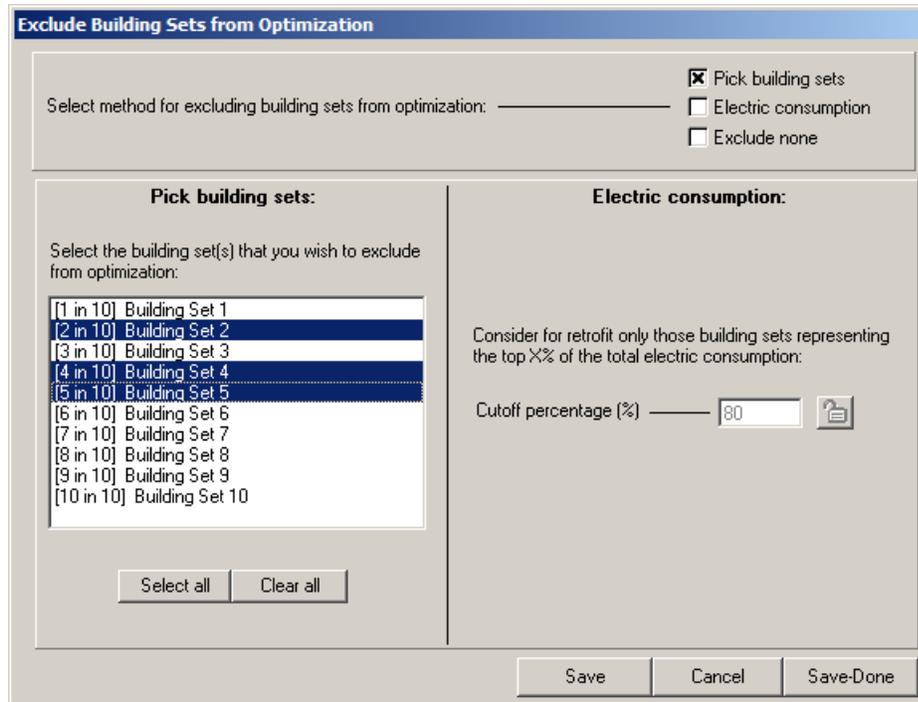


Figure 4.2 Exclude Building Sets from Optimization Screen

FEDS Selects Sets Based on Electric Consumption:

The second option for excluding building sets from optimization is a method that instructs FEDS to automatically eliminate a certain fraction of building sets. This determination is based on considering for retrofit only those building sets responsible for the top X% of the total baseline electric consumption, where X is a user-entered value. With this method, the number of sets excluded from optimization is variable, completely dependent on the entered percentage and the relative electric energy consumption among sets within the case. It enables the user to automatically target those building sets likely to offer the largest energy savings opportunities (i.e., those with the largest current electric consumption) without having to optimize all sets.

Optimize All Sets:

The final choice in this category is "Exclude none". Selecting this instructs FEDS to ignore all selections under the "Pick Building sets" method as well as the cutoff percentage of the "Electric consumption" method. This allows the user to optimize all building sets without losing the settings defined for either method of exclusion.

4.3 Restrict Retrofits from Optimization

This option enables the user to specify certain classes of retrofits that FEDS will not consider retrofitting to during optimization. For example, if you do not want FEDS to evaluate any window retrofits, select "Windows" from within the Envelope end-use category. Retrofits can be restricted at a variety of levels to meet a range of

requirements: entire end-uses (e.g., lighting retrofits), individual technologies (e.g., fluorescent fixtures), or specific configurations (e.g., fluorescent reflectors). They can be selected for individual building sets, groups of sets, or for all sets in a case.

The procedure for restricting retrofits is as follows:

1. Select a building set (or group of sets) from the list on the left by clicking on it with the mouse. The **<Select all>** and **<Clear all>** buttons can aid in this process. Symbols to the left of the building set list identify sets that have been excluded from optimization ("X>") and sets with existing retrofit restrictions defined ("-->"). In Figure 4.3, sets 2, 4, and 5 have been excluded while sets 1, 7, and 9 each have at least one retrofit restriction currently defined.
2. On the right half of the screen, select the end use category containing the retrofit(s) to eliminate from optimization. A new frame will appear containing a list of the restrictable retrofits for that end-use (see Figure 4.4).
3. Select the retrofit(s) to restrict for the chosen building set(s). Note that the options are hierarchical in that selecting high-level categories automatically restricts all underlying retrofits (i.e., choosing "Wall insulation" will mark "Interior masonry surface insulation" and clicking on "Envelope" will select all envelope retrofits). Again, the **<Select all>** and **<Clear all>** buttons can assist in making selections.
4. Pressing **<Save-Done>** at this point will save the specified restrictions and close the end-use window, bringing you back to the end-use buttons as shown in Figure 4.3. **<Cancel>** will take you back without saving any changes made since the last save.
5. At this point you may choose another end-use to specify more retrofit restrictions for the current building set(s), select a new building set or group of sets for which to specify restrictions, or exit the *Restrict Retrofits from Optimization* screen with **<Save-Done>** or **<Cancel>**.

Note: Copying a building set will copy any existing retrofit restrictions of the original set to the new building set.

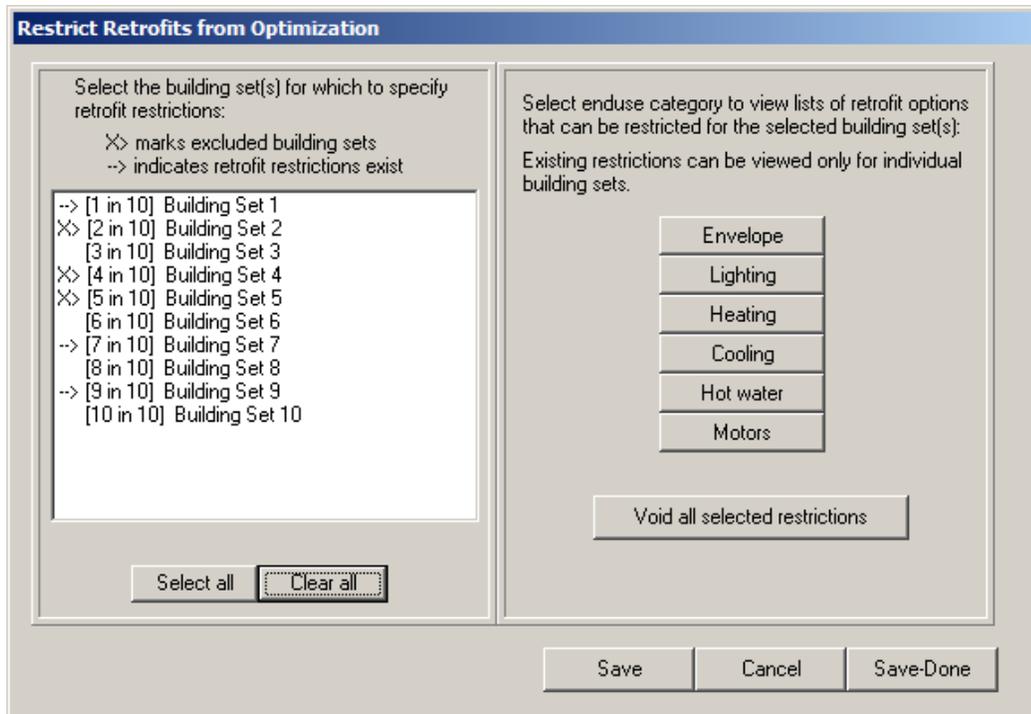
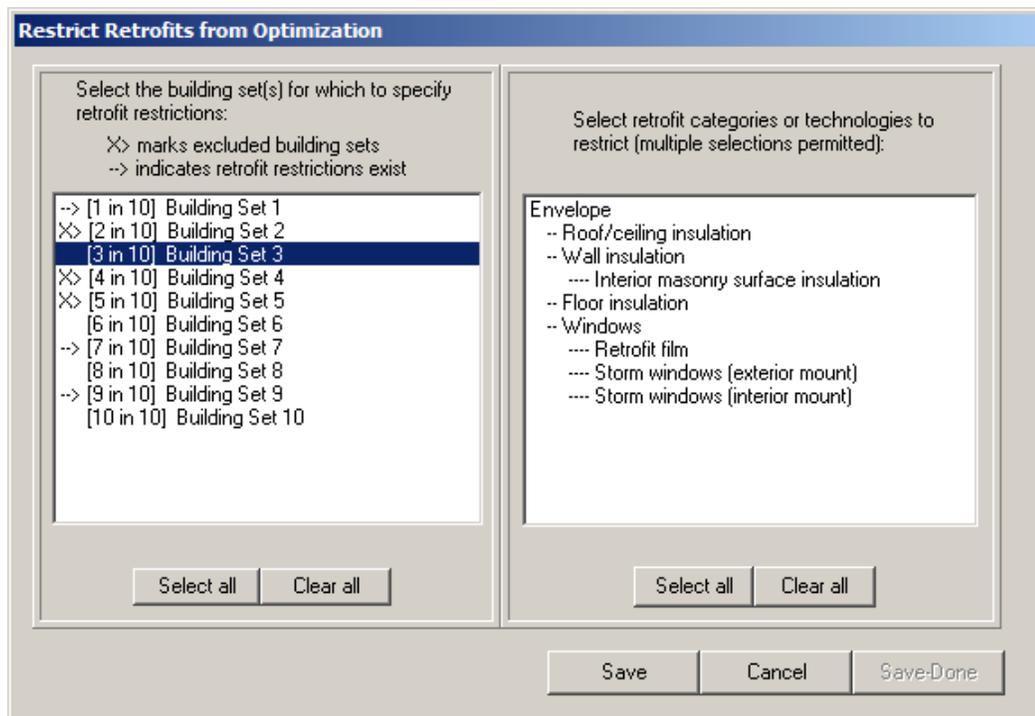


Figure 4.3 Restrict Retrofits from Optimization Screen



FEDS 4.4 Envelope Retrofit Restriction Options

Viewing and Clearing Retrofit Restrictions

The complete set of restricted retrofits can only be viewed for individual building sets. This is accomplished by selecting a single building set and following the procedure for defining restrictions. When an individual set is chosen, all existing retrofit selections will appear highlighted on the end-use lists and specific retrofits may be added or deleted with a click of the mouse.

Since each building set in a group of sets may have different retrofit restrictions defined, the complete set of restrictions cannot be viewed for any group. When retrofits are selected for a group of building sets, they are added to the current list of restrictions for each building set in that group. *In order to view the restricted retrofits or to delete specific restrictions for a building set, you must make sure that only one set is selected on the building set list.*

<Void all selected restrictions> will remove the entire set of retrofit restrictions for the highlighted building set(s). To clear all retrofit restrictions for a given case, select all building sets with the **<Select all>** button beneath the building set list and then hit the **<Void all selected restrictions>** button.

4.4 Alter Cost Data

This option allows the user access to FEDS' internal cost data used in calculating the cost of retrofit equipment. The FEDS default cost data considers important intra-state variations to construction labor rates and construction costs, based on the state and zip code inputs. Further altering these values allows users the ability to further adjust additional variation or local anomalies that may be important for project cost estimation and to more accurately model the cost of retrofit projects in specific locales.

This option provides the ability to alter retrofit cost data at two levels:

FEDS Regional Cost Data

The *Regional Cost Data* screen (Figure 4.5) displays the cost data for each case including labor rates, materials cost multipliers (fractions of national average costs), sales tax rate, contractor overhead & profit, design cost, and site SIOH rates for that location. The FEDS regional default data is displayed in the cells, and values may be changed by entering new data and saving. These changes apply globally to all cost data for all end-uses in a particular case.

The FEDS cost data for other regions may be viewed by selecting another zip code (or state if zip code is not provided) on the *FEDS Installation Inputs* screen, and updating the installation inferences. The "Other (global multiplier)" input on the *Regional Cost Data* screen is a value applied to the total cost of all retrofit projects considered during optimization. It should be used to account for any general costs associated with completing retrofit projects at your site that are not captured by any of the other cost values. As always, for more detailed information about specific inputs, refer to the on-line help for that input cell by pressing the **<F1>** key when the cell is active.

Fully burdened labor rates (\$/hr):		Regional materials cost multipliers (U.S. average = 1.0):	
Carpenter	53.61	Envelope insulation	1.009
Common laborer	47.79	Windows	1.011
Electrician	60.79	Electrical equipment	0.969
Equipment operator	61.52	HVAC equipment	0.999
Glazier	53.19	Service hot water equipment	0.999
Plumber	67.96	Sales tax rate (%)	6.5
Insulator	73.95	Contractor overhead & profit (%)	15.0
Sheet metal worker	65.64	Design cost (%)	10.0
Steamfitter	67.96	Site SIOH (%)	6.0
		Other (global multiplier)	1.0

End Use/Technology Multipliers

Save Cancel Save-Done

Figure 4.5 Regional Cost Data

End-Use/Technology Multipliers

A separate overall cost multiplier is available for each end-use (heating, cooling, lighting, etc.) and sub-end-use (boilers, package units, fluorescent fixtures, etc.) to allow for further adjustments to the cost of particular systems. These can be accessed with the button on the bottom of the *Regional Cost Data* screen. Using these multipliers, the user is able to adjust the total lumped cost (including all labor, materials, design, overhead, etc.) of specific types of systems or technologies. See Figure 4.6.

These multipliers are intended to be used only after adjusting the Regional Cost Data and running FEDS. At that point if the specified cost for a particular retrofit is different than the known cost, an adjustment may be made by entering a multiplier for that technology to replace the default 1.0. If the costs of all technologies within a given end-use technology (e.g., all lighting fixtures) are off by a certain factor, then an end-use multiplier may be applied. For example, if the cost output by FEDS = \$100 and the actual cost = \$95, 0.95 should be entered as a multiplier for that particular technology type for the next model run.

End Use / Technology Multipliers			
Envelope	1.0		
Roof/ceiling insulation	1.0		
Wall insulation	1.0		
Floor insulation	1.0		
Windows	1.0		
Lighting	1.0		
Incandescent	1.0		
Halogen	1.0		
Compact Fluorescent	1.0		
Fluorescent	1.0		
Mercury vapor	1.0		
Metal halide	1.0		
High pressure sodium	1.0		
Low pressure sodium	1.0		
LED	1.0		
Induction	1.0		
Exit	1.0		
Service hot water	1.0		
Distributed system tanks	1.0		
Distributed system heat pumps	1.0		
Loop system boilers	1.0		
Loop system heat pumps	1.0		
Other (wraps, flow reducers, etc.)	1.0		
Heating	1.0		
Boilers	1.0		
Furnaces	1.0		
Infrared	1.0		
Cooling	1.0		
Package units	1.0		
Conventional chillers	1.0		
Absorption chillers	1.0		
Gas engine-driven chillers	1.0		
Air source heat pumps	1.0		
Dual-fuel heat pumps	1.0		
Ground-coupled heat pump systems	1.0		
Water source heat pumps	1.0		
Horizontal ground loops	1.0		
Vertical ground loops	1.0		
Wells	1.0		
Pumps	1.0		
Motors	1.0		

Figure 4.6 End Use/Technology Multipliers

4.5 Emissions Factors

Along with energy consumption and costs, FEDS also tracks and reports the estimated emissions impacts of selected retrofits and upgrade packages. FEDS now provides the ability to view and modify the emissions factors for the 6 pollutant types (sulfur oxides, nitrogen oxides, carbon monoxide, carbon dioxide, particulate matter, and hydrocarbons) for each purchased fuel type available in FEDS. These factors are inferred based on the state or province in which the facility is located.¹ However, in order to provide greater flexibility in modeling site specific emissions and variations in electricity

¹ The state-level source emissions factors were derived from the sum of pre-combustion and combustion emissions factors associated with the electricity generation mix for each state presented by: Deru, M. and P. Torcellini. June 2007. *Source Energy and Emission Factors for Energy Use in Buildings*. NREL/TP-550-38617. Note that for the District of Columbia, where power generation is limited, the emissions factors for Maryland were substituted.

source fuel mix, the option to override these inferred factors is provided (see Figure 4.7). This is useful in instances where you know the specific emissions profile for the electricity used on-site, as well as perhaps for other fuels.

Sulfur Oxides (SO _x)		
Electricity	(lbs/kWh)	0.0119
Distillate oil	(lbs/gallon)	0.06935
Residual oil	(lbs/gallon)	0.07934
Natural gas	(lbs/therm)	0.122
Coal	(lbs/ton)	4.08199
Other fuels	(lbs/MBtu)	0.25

Figure 4.7 Regional Emissions Factors

4.6 Generate Top 3 Retrofits

This feature gives users the option of generating not only the optimal (minimum life-cycle cost) retrofit, but the second and third best as well.

The *Retrofit Specification* screen (Figure 4.8) may be accessed with the **<Generate Top 3 Retrofits>** button from the *Advanced Options* driver screen. "Generate Optimal Retrofits Only" is the default selection and will generate the one most life-cycle cost-effective retrofit for each technology and building system being evaluated. Choosing "Generate Top Three Retrofits" will instruct FEDS to determine the top three retrofit options for each existing piece of equipment or envelope component.

When the "Generate Top 3 Retrofits" option is enabled, the second and third best retrofits will be listed in the "{casename}.csv" output report. When the "{casename}.csv" report is generated, the top three retrofits will be listed (if available) on successive rows in the spreadsheet. The ranking of each retrofit technology will be identified on the "Rank" column to the right of the "Retrofit Technology" field. A maximum of three retrofits will be output for each existing technology or envelope component; this number can be less, however, as only those retrofit options that are cost-effective will be printed. For more information about the "{casename}.csv" output report, see Description of {Casename}.csv Output.

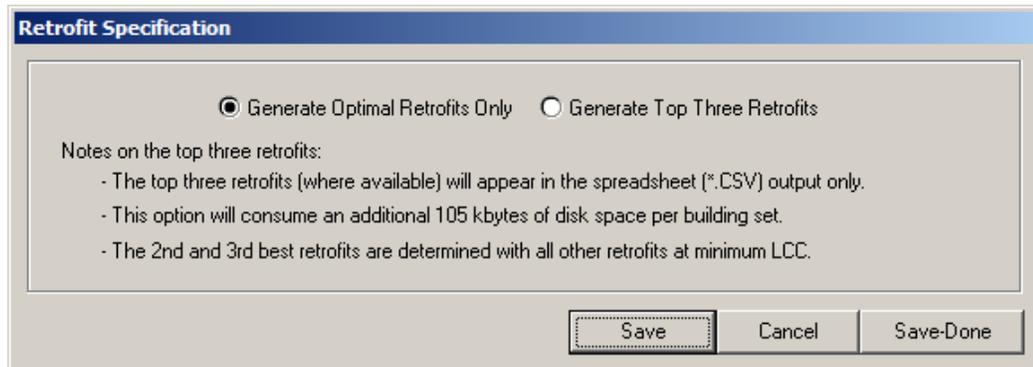


Figure 4.8 Retrofit Specification Screen

Note: The second and third best retrofits are determined with all other retrofits at the minimum LCC. If you decide to choose a second or third best retrofit for a project, it is recommended that you restrict the top retrofit technology (if possible) and re-run the case, as the selection of the other optimal retrofit technology selections may change.

5 Alternative Financing

The desired result of the alternative financing analysis is to provide the user with the appropriate data that leads them to the correct decisions regarding alternative financing and also allows for easy comparison to calculations done assuming government appropriations or site financing. Alternative financing includes utility or third party loans, leases, and energy savings performance contracts (ESPC).

When an alternative financing case is run, the comparison being made is between:

1. having the site continue to operate the baseline equipment and when it fails to replace it with the minimum life-cycle cost equipment, and
2. having an alternative financier replace the equipment immediately with the minimum life-cycle cost equipment and then continue to have minimum LCC equipment throughout the life of the contract.

In a site financing run the comparison is the same except the site makes the retrofits. Hence the output of an alternative financing run and a site financing/appropriated funding run can be directly compared to determine which is the more favorable situation.

5.1 Alternative Financing Inputs

The alternative financing inputs may be accessed by selecting "Financial Parameters and Screening Options" from the *FEDS Installation Inputs* screen. The following screen will appear:

Financial Parameters and Screening Options

Do you want to use the 3% real discount rate currently specified by the federal government? Yes No
 If no, enter your real discount rate (%): _____

Select the source of funding for the selected projects _____ Appropriated funding Alternative financing

Do you want to use the DOE/EIA real energy escalation rates _____ Yes No

Do you want FEDS to screen out projects that are life-cycle cost effective but do not meet a maximum simple payback or a minimum savings-to-investment ratio (SIR)? _____ Yes No

If yes, specify which values of maximum simple payback and minimum savings-to-investment ratio to use:

Use Energy Conservation Investment Program (ECIP) values _____ Yes No

OR

User defined: Maximum simple payback (years) _____
 Minimum savings-to-investment ratio _____

Figure 5.1 Financial Parameters and Screening Options Screen

At this point a decision is made between appropriated funding and alternative financing. Checking the "Alternative Financing" box will enable the "Alternative financing inputs" button and clicking on that button will take you to the following screen:

Alternative Financing

Select the type of alternative financing _____
 Utility or third-party loan
 Lease
 Energy savings performance contract (ESPC)

Life of the agreement (years) _____
 Third-party (financier) real interest or discount rate (%) _____
 Site contract development cost (\$) _____
 Annual contract administration cost (\$) _____
 Buy-out or balloon payment required at end of contract (% of installed cost) _____
 Should current O&M costs be included in savings calculations? _____ Yes No
 Party responsible for O&M requirements during contract _____ Site Alternative financier

Figure 5.2 Alternative Financing Screen

The alternative financing inputs are briefly explained below.

- **Type of alternative financing** – this is the source of funding with choices of low interest rate utility/third-party loans, lease, or energy savings performance contracting (ESPC)
- **Life of the agreement** – this is the loan period, lease period, or ESPC contract duration
- **Third-party interest or discount rate**
 - Leases: lessor pre-tax real discount rate
 - Utility/third party loans: loan interest rate
 - ESPC: ESCO's real required rate of return
- **Site contract development cost** – this is the amount by which the total cost of developing and entering into an alternative financing agreement exceeds the cost of securing budgeted funding to accomplish the same work (this generally consists of contract development, evaluation, negotiating, etc.)
- **Annual contract administration cost over the life of the agreement** – the first year cost which is assumed to escalate at the inflation rate over the contract life
- **Buy-out or balloon payment percentage**
 - Leases: fraction of installed cost required to take possession of the equipment at the end of the lease
 - Utility/third party loans: fraction of installed cost required at the end of the loan in the form of a balloon payment
 - ESPC: fraction of installed cost required at the normal end of the ESPC contract that goes its full duration
- **Should current O&M costs be included in savings calculations?** – this input is used to designate whether or not baseline O&M costs are to be considered in the savings calculations. (Generally the answer will be yes – without considering these savings many projects will not be cost effective.)
- **Party responsible for O&M requirements during contract** – designates who is responsible for the O&M costs during the period of the agreement. (This is generally the alternative financier – if the alternative financier is responsible they are better able to assure that savings occur and persist.)

5.2 Alternative Financing Output

Alternative financing output is identical to the output under appropriated funding except that the *.ecp output is not available for cases run with alternative financing because alternative financing and Energy Conservation Investment Program (ECIP) funding represent different and incompatible funding mechanisms.

6 FEDS Output

Upon completion of a successful FEDS run, a number of relevant reports will automatically be generated. Additional output reports may be generated at any time, or refreshed as needed. From the *Options* menu, select **Report Options**. The following report types are available (as shown in Figure 6.1):

- Summary Installation and Building Set Output (*.txs) – *always generated*
- Detailed Retrofit Output (*.txd)
- Detailed Retrofit Output – Spreadsheet (*.csv)
- ECIP Format Output (*.ecp)
- Calibration Output (*.Calib.xls)
- Retrofit Savings Overview (*.Retrofit.Savings.xls)
- Summary Installation and Building Set Output (*alternate version with formatted text and graphics*)

FEDS now allows direct access to the report files from the Report Options screen. To open a report, simply click on the folder icon next to the report you wish to view and FEDS will open it within the application you have established to open files of that type. When opening a report, if the report file type is not yet associated with a viewing application (e.g., a word processing program, spreadsheet program, or text viewer/editor), you will be prompted to select the application you wish to use to open and view the report. Also see Formatting Reports in Section 6.12 for tips on how to format the output reports for optimal viewing.

To create or refresh a report manually, check the “Create” box next to the report(s) you wish to generate and hit the “Create Reports” button. And then the report(s) may be opened.

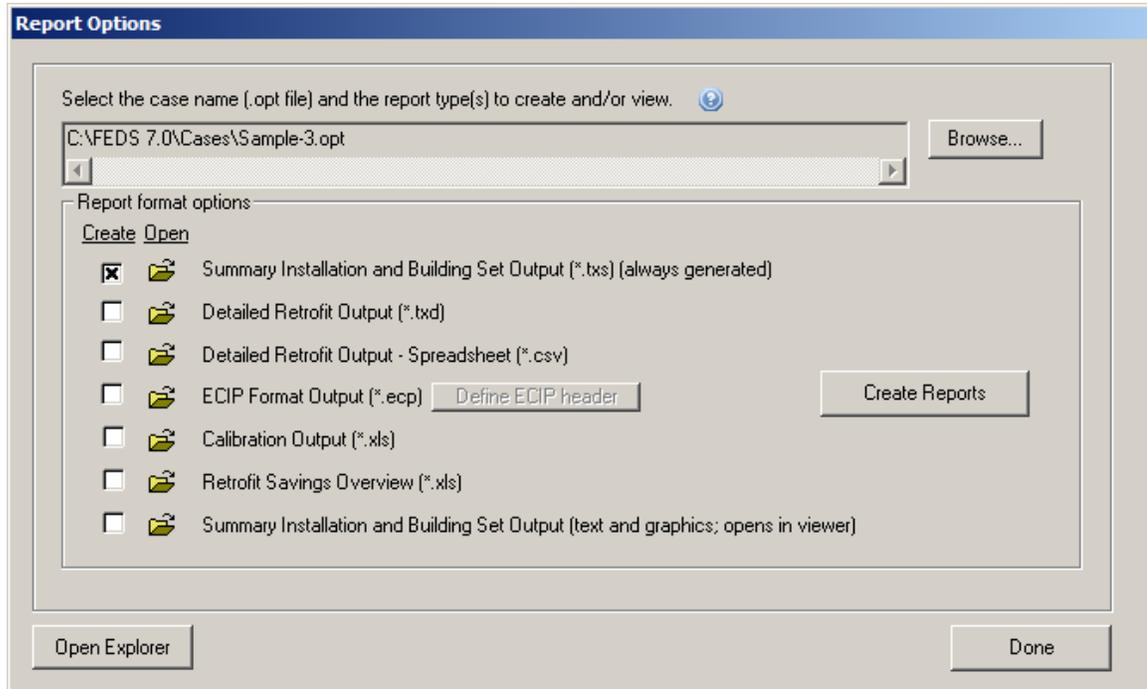


Figure 6.1 Report Options Screen

6.1 Description of {Casename}.txs Output

The “*.txs” report is a text based report that provides a summary report of the installation and building set energy, demand, dollar, and air pollution emissions impacts. It is automatically generated by FEDS at the end of each FEDS run plus any time any report format is created. The output file is structured as follows:

Page 1: An echo of the site energy-use characterization that you have provided in the input file.

Page 2: An echo of the electricity price and schedule information that you have provided in the input file.

Page 3+: An echo of the site building characteristics that you have provided in the input file. The echo includes the number of buildings, floor area, construction date, space heating technology, space cooling technology, and service water heating technology.

Page 4+: An echo of additional site building characteristics that you have provided in the input file, including indoor lighting technology and building operating hours.

Page 5+: An echo of the site economic data that you have provided in the input file, including financial analysis parameters (discount rate, energy cost escalation rates, etc.) and utility cost-sharing. Also, basic information regarding the status of the Advanced Options such as whether any cost data have been altered, and which building sets have been excluded from optimization or have retrofit restrictions defined. See Advanced Options.

Page 6: Reports the highest level of identified resource savings potential, as shown in Figure 6.2. A description of each line of output follows.

Summary of Retrofit Resource Potentials	
First year energy and demand dollar savings due to retrofits (\$)	xxx,xxx
Present value of life-cycle energy, demand, and O&M savings (\$)	xxx,xxx
Total estimated investment required for retrofits (\$)	xxx,xxx
Present value of capital investments (\$)	xxx,xxx
Total net present value (\$)	xxx,xxx
First year energy, demand, and O&M savings:	
Retrofits not due to plant/loop abandonment (\$)	xxx,xxx
Retrofits due to plant/loop abandonment (\$)	xxx,xxx
Net present value:	
Retrofits not due to plant/loop abandonment (\$)	xxx,xxx
Retrofits due to plant/loop abandonment (\$)	xxx,xxx
Estimated current installation energy use (MBtu)	xxx,xxx
Estimated post-retrofit installation energy use (MBtu)	xxx,xxx
Estimated installation annual energy savings (MBtu)	xxx,xxx

Figure 6.2 Example Output of {Casename}.txs File

First year energy and demand dollar savings due to retrofits. This is the sum of the energy savings for each fuel across the entire installation (all buildings, central plants, and thermal loops) plus the electric demand savings. The value of savings is the product of the energy savings and the user-entered price. Electric energy savings are based on hourly changes when time-of-day rates are used. Electric demand savings reflect changes in hourly demand and demand ratchets.

Present value of life-cycle energy, demand, and O&M savings. This is the sum of the present values of all energy, demand, and O&M savings over the investment lifetime across the entire installation. The investment lifetime for equipment is the shorter of 25 years or the remaining life of the existing equipment; for other improvements (e.g., envelope measures), the investment lifetime is 25 years. The "present value of life-cycle energy, demand, and O&M savings" is also the sum of the "net present value of retrofits" and the "present value of capital investments."

Total estimated investment required for retrofits. This is the sum of all the retrofit installed costs across the entire installation.

Present value of capital investments. This is the sum of all the present values of annualized installed costs. NOTE: The "present value of capital investments" can be greater than, less than, or equal to the "total estimated investment required for retrofits."

- It will be more than the investment cost if an improvement is being made to the existing equipment and if the life of the improvement is less than the life of the existing equipment. This is because there are interim capital charges due to continual replacement of the improvement over the remaining life of the existing equipment.

- It will be less than the investment cost if the existing equipment is being replaced and if the life of the new equipment is longer than the remaining life of the existing equipment. This is because only those equipment capital costs that are amortized during the remaining life of the existing equipment are included in the calculation of the present value of capital investments.

Net present value of retrofits. This is the present value of life-cycle energy, demand, and O&M savings less the present value of capital investments (also called the net savings) across the entire installation.

First year energy, demand, and O&M savings: (Note: This output is provided only when central energy plants are present.)

- **Retrofits not due to plant/loop abandonment.** This is the sum of the energy, demand, and O&M savings for each optimal retrofit that is not due to plant abandonment. Hence these retrofits would be selected based on their own cost effectiveness even if the plant or loop was not recommended for abandonment.
- **Retrofits due to plant/loop abandonment.** This is the sum of the energy, demand, and O&M savings for each optimal retrofit that has been selected as a direct result of its serving central plant or thermal loop being recommended for abandonment. Hence these retrofits would not be selected if the plant or loop was not being abandoned; on their own they are not cost effective, but the savings from abandoning the plant and/or loop are sufficient to drive the retrofit and result in a positive net savings. Or conversely, the thermal loop may have been marked for required abandonment, in which case the net savings may not be positive.

Net present value: (Note: This output is provided only when central energy plants are present.)

- **Retrofits not due to plant/loop abandonment.** This is the present value of life-cycle energy, demand, and O&M savings less the present value of capital investments (also called the net savings) for each optimal retrofit that is not due to plant abandonment. Hence these retrofits would be selected even if the plant was not recommended for abandonment.
- **Retrofits due to plant/loop abandonment.** This is the present value of life-cycle energy, demand, and O&M savings less the present value of capital investments (also called the net savings) for each optimal retrofit that is due to plant abandonment. Hence these retrofits would not be selected if the plant was not recommended for abandonment.

Estimated current installation energy use (MBtu). This is the estimated total annual site energy use in million Btu prior to retrofit for the entire installation that is modeled in FEDS. This does not include process energy not accounted for in buildings, electric distribution system losses, outdoor lighting that is not modeled, and other energy consumption that has not been explicitly modeled. This value will not equal the annual

energy consumption that you have entered but should be relatively close to indicate a well-calibrated model. The difference is due to excluded uses described above and the difference between the actual weather for the site during the time period for which consumption data were provided and the typical year weather data used by the model.

Estimated post-retrofit installation energy use (MBtu). This is the estimated total annual site energy use in MBtu for the entire installation that is modeled in FEDS, with the recommended package of energy efficiency measures in place.

Estimated installation annual energy savings (MBtu). This is the difference between the "estimated current installation energy use (MBtu)" and "estimated post-retrofit installation energy use (MBtu)."

Page 7: Annual installation energy use and cost by fuel type (before and after retrofit), the difference, and the percentage change.

Page 8: Annual installation electric peak demand and cost (before and after retrofit), the difference, and the percentage change. The time of the installation peak demand (month, day type, and hour) is also provided.

Page 9: Annual installation emissions by pollutant type (SO_x, NO_x, CO, CO₂, particulates (PM10), and hydrocarbons). Values are provided for existing, post-retrofit, the difference, and the percentage change.

Page 10: Annual energy use by fuel type and end use for all buildings (heating, cooling, ventilation, lights, motors and miscellaneous loads, and hot water). Values are provided for existing, post-retrofit, the difference, and the percentage change.

Page 11+: Central plant and thermal loop annual energy and cost. For each central plant, information is printed on existing and post-retrofit source energy consumption, plant output, annual O&M cost, and marginal and average value of output. Also, a section is printed for each loop connected to the plant, listing the connected loads by building set or downstream plant, total delivered energy, loop loss, energy input, loop efficiency, annual O&M cost, and marginal and average value of delivered fuel. If the plant and/or loops are abandoned during optimization, a first year and present value of abandonment are also reported. This page (one per central plant) is only created for cases that have central plants and thermal loops defined.

Page 12+: Annual energy use and cost by building set similar to that provided on page 7 for the installation. Electric costs on this page are based on the installation average cost and, thus, will not necessarily match the value on page 14 of the output. There will be one page per building set.

Page 13+: Annual electric peak demand by building set (before and after retrofit), the difference, and the percentage change. The time of the building set peak electric demand (month, day type, and hour). The contribution to the installation peak demand (coincident demand) and cost (before and after retrofit), the difference, and the percentage change. There will be one page per building set.

Page 14+: Annual emissions by building set and pollutant type, similar to that provided on page 9 for the installation. There will be one page per building set.

Page 15+: Annual building set energy use, by fuel type and end use, similar to that provided on page 10 for the installation. There will be one page per building set.

Page 16+: Energy intensity by building set and fuel type, expressed in user units per 1,000 ft² of floor area. Both existing and post-retrofit values are printed.

Page 17+: Energy intensity by building set and fuel type, expressed in MBtu per 1,000 ft² of floor area. Both existing and post-retrofit values are printed.

6.2 Description of {Casename}.txd Output

This text report format contains detailed information on each retrofit selected for each building set in the case:

Page 1+: Summary building set information, including building set description, number of buildings in set, total floor area in set. Existing, post-retrofit, and the change in the building set energy and demand costs are also provided. Lastly, summary life-cycle cost savings and installed capital costs for building set retrofits are included.

Page 2+: Detailed information on each optimal retrofit selected. Figure 6.3 shows an example. The output is broken down into 8 sections with a blank line separating each:

Section 1: A description of the existing and retrofit technology and where the technology is located on the installation. This includes a description of the building set, building type, and use area; the technology end use; the type of existing and retrofit technology; and the portion of the building set served by this technology.

Section 2: Retrofit Technology -- Technical information about the existing and retrofit technologies, including information on capacity, number of units, performance, vintage and remaining life.

Section 3: Technology Energy Use/Demand (this technology) -- The direct energy usage and demand information for the existing and retrofit technologies in this building set (no interactive effects included) and the change due to the retrofit.

Section 4: Building Set Energy Use/Demand (All technologies at minimum LCC except technology being retrofit) -- Building set energy consumption by end use, total building set energy use, and peak electric demand. The "Existing" column shows the energy use and demand assuming all technologies in the building set are at the minimum life-cycle cost, as determined in the FEDS run, except the technology being retrofit (the existing technology). The "Retrofit" column shows the energy use and demand with all technologies at the minimum life-cycle cost - this column is the same for all retrofits within a building set as it represents the optimized building set consumption, as determined in this FEDS run. The "Difference" column shows the energy change, by end use, including interactive

effects, as a result of this retrofit and the overall building set peak demand change.

Section 5: Air Pollution Emissions (All technologies at minimum LCC except technology being retrofit) -- Existing, retrofit, and difference in the air pollution emissions for six pollutant types. These values are derived from the changes in fuel consumption associated with the retrofit's Building Set Energy Use/Demand impact described above.

Section 6: Building Set Energy/Demand Cost--First Year (All technologies at minimum LCC except technology being retrofit) -- The value of the energy and demand for:

- This technology -- The energy and demand costs, and savings, directly associated with the existing and retrofit technology energy usage and demand
- Balance of Building Set -- The energy and demand costs, and savings, associated with the entire building set excluding those directly tied to the technology being retrofit. Thus, the energy and demand savings displayed here represent the value of the interactive effects.

Section 7: Life-Cycle Costs Savings -- The present and annualized values of the installed cost, annual maintenance costs, non-annual maintenance costs, energy/demand costs, and total LCC savings (NPV). Also provided are the simple payback (years), AIRR (percent/year), and SIR (savings-to-investment ratio). There are several reasons that some retrofits can have negative net present values (NPVs) as explained in Section 3.5 and Section A.6. If a negative NPV retrofit occurs there will be a note on that page to indicate the reason (e.g., marked for required replacement, loop abandoned, or plant abandoned).

Section 8: Installed Capital Cost -- The estimated installed cost of the retrofit.

Technology Retrofit Information for Building Set #3: (B) Office (C)
Sample-2 Building Set 3: Office (D)
End Use: Lights (E)
Use Area: Office (F)
Equipment Description: Main Office Lights (G)
Existing Technology: FL1: FL 2X4 4F40T12 STD2 (H)
Percent of Building Set Served by this Technology: 80.00%
Retrofit Technology: FL280: FL 2X4 3F32ST8 ELC3 REF (FIX REPL) (J)

	Existing		Retrofit		Difference
Retrofit Technology					
Watts/fixture	192.0 (P)		81.0 (Q)		-111.0
Operating hours/Year	2,952 (R)		2,952 (S)		0
Fixtures in this Bldg. Set	776 (N)		776 (O)		0
Vintage	1977 (M)		New		
Remaining Life (years)	25		25		
Technology Energy Use/Demand (This technology)					
Energy (user units)	439,873 (T) (kWh) (U)		185,572 (V) (kWh) (W)		-254,302
Energy (MBtu)	1,501		633		-868 (X)
Electric Peak Demand (kW)	94		40		-54 (Y)
Coincident Peak Demand (kW)	94		40		-54
Building Set Energy Use/Demand (All technologies at minimum LCC except those being retrofit)					
Heating (MBtu)	726		876		150
Cooling (MBtu)	446		341		-105
Ventilation (MBtu)	680		675		-5
Lighting (MBtu)	1,795		927		-868
Misc. Equip. (MBtu)	1,794		1,794		0
Motors (MBtu)	0		0		0
Service Water Heating (MBtu)	67		67		0
Total (MBtu)	5,508		4,680		-829 (Z)
Peak Electric Demand (kW)	380		310		-70 (AA)
Air Pollution Emissions (All technologies at minimum LCC except those being retrofit)					
Sulfur Oxides (lb)	3,190.3		2,864.4		-325.9 (AF)
Nitrogen Oxides (lb)	958.6		803.9		-154.8 (AG)
Carbon Monoxide (lb)	325.7		289.0		-36.8 (AH)
Carbon Dioxide (tons)	315.0		269.9		-45.1 (AI)
Particulate Matter (lb)	41.4		35.8		-5.6 (AJ)
Hydrocarbons (lb)	2,111.5		1,872.4		-239.1 (AK)
Building Set Energy/Demand Cost--First Year (All technologies at minimum LCC except those being retrofit)					
This technology					
Energy	\$ 39,589		\$ 16,701		\$ -22,887 (AB)
Annual Electric Demand	\$ 5,050		\$ 2,167		\$ -2,883 (AC)
Balance of Building Set (All technologies other than those being retrofit--includes systems and retrofit interactions)					
Energy	\$ 93,993		\$ 92,764		\$ -1,229 (AD)
Annual Electric Demand	\$ 13,357		\$ 12,660		\$ -697 (AE)
Life-Cycle Costs Savings					
	Present Values		Annualized Values		
Installed Cost	\$ -197,627 (AL)		\$ -11,349 (AM)		
Annual Maintenance	\$ 0 (AN)		\$ 0 (AO)		
Non-Annual Maintenance	\$ 150,579 (AP)		\$ 8,647 (AQ)		
Energy/Demand	\$ 451,428 (AR)		\$ 25,925 (AS)		
Total LCC Savings (NPV)	\$ 404,379 (AT)		\$ 23,223 (AU)		
Simple Payback (years)	5.4 (AV)				
AIRR (percent/year)	7.7 (AW)				
SIR	3.0 (AX)				
Installed Capital Cost:	\$ 197,627 (AY)				

Figure 6.3 Example Output of {Casename}.txd Report (The characters in parentheses represent the spreadsheet column indicator where the data will reside once opened in a spreadsheet program.)

6.3 Description of {Casename}.csv Output

The “Detailed Retrofit Output - Spreadsheet (*.csv)” option from the *Report Options* screen represents a comma-separated variable format report that can be opened by most any spreadsheet program. This file will be named “{casename}.csv.” Selected quantities from the “{casename}.txd” output report are included in this file as indicated by the mapping shown in parentheses in Figure 6.3. The colored characters (e.g., “ (J) “) correspond to the column in which that information will appear in the spreadsheet. Each page of the “*.txd” output is represented as a single row of data on the “*.csv” report. This information is included for each existing technology considered in each end use, regardless whether a retrofit was selected or not. In cases where a retrofit project was not chosen (either because it was not cost-effective or due to retrofit restrictions) the “Retrofit Technology” will be listed simply as "none."

In addition to the data from the “{casename}.txd” reports shown in Figure 6.3, the “{casename}.csv” output will display the following additional columns of information:

- Installation Name (Column A) – The installation name entered on the *FEDS Installation Inputs* screen will appear in the first column.
- Required Replacement (Column I) – Indicates whether the user selected the technology for required replacement (or forced retrofit); note that this can result in retrofits with negative NPVs as explained in Section 3.5.
- Rank (Column K) – This field lists the ranking of the current retrofit technology. If the “Generate Top 3 Retrofits” option has been enabled, up to three retrofits may be listed for each existing technology, and ranked according to lowest life-cycle cost. If this option was disabled during the FEDS run, all retrofits listed will be the optimal retrofits. For more information see Generate Top 3 Retrofits in Section 4.6.
- End-use Retrofit Restrictions (Column L) – This field displays information pertaining to the Exclude Building Sets and Restrict Retrofits from Optimization portions of the Advanced Options. It displays whether the current building set has been excluded from optimization or whether any end-use retrofit restrictions exist for that building set. If neither applies "none" will be printed.
- Fuel Savings (MBtu/Yr) and Value of First Year Fuel Savings (\$) (Columns AZ - BQ) – These 18 columns present the annual energy savings and first year dollar savings for each fuel type. This provides another layer of detail for the overall energy and dollar savings, to identify the savings for each fuel used in the building.

Notes:

- *Some fields of data on the *.csv output list results in units of measure that vary according to the type of retrofit project. For example, the #Units fields present the number of pieces of equipment or lighting fixtures for most types of projects, but for most envelope projects it represents the area in square feet of roof, wall, window, or*

floor area impacted. For slab floor insulation projects, the #Units identifies the perimeter floor length in feet. The Performance fields generally list the equipment efficiency, insulation R-value, window U-value, or lighting wattage. The Rated Size fields also report data in varying units, as identified in the header (“Rated Size: (kBtu/hr); Light(hrs/yr); Motor(hp); Envel(thickness); Glass(SC)”).

- Values of “NA” appearing in the *.csv output represent values that are not applicable for the current retrofit technology. Examples of this are the fuel/units for the existing and retrofit technology energy consumption associated with an envelope measure (e.g., wall insulation).

6.4 Description of {Casename}.ecp Output

Selecting the “ECIP report” option will generate a life cycle cost analysis summary in the format and calculation method prescribed for the Energy Conservation Investment Program (ECIP). This file contains three pages of information for each retrofit project identified by FEDS. Figure 6.4 shows examples of output for the three pages of an ECIP report.

Page 1: Header information listing the building set, end use, and existing and retrofit technologies.

Page 2: The Energy Project Summary Sheet, containing general project description, location, and savings information.

```

Technology Retrofit Information for Building Set #3: Office
Sample-2 Building Set 3: Office
End Use: Lights
Use Area: Office
Existing Technology: FL1: FL 2X4 4F40T12 STD2
Percent of Building Set Served by this Technology: 80.00%
Retrofit Technology: FL280: FL 2X4 3F32ST8 ELC3 REF (FIX REPL)

                                Energy Project Summary Sheet

Installation:                      Sample-2: Four Building Sets
Location:                          Seattle, WA
Project Title:                     Lighting Systems
                                    Sample-2 Building Set 3:
Office
Project Description:              FL280: FL 2X4 3F32ST8 ELC3 REF
(FIX REPL)
Project Number:
Total Investment:                 $    229,248
MBtu/Yr Saved:                   $      829
Discounted MBtu Savings:         $   270,135
Discounted Demand Savings:       $    42,738
Discounted Total Energy Savings: $   312,873
Discounted Total Non-Energy Savings: $  113,726
First Year Dollar Savings:       $    36,989
Simple Payback in Years:         6.20
Discounted Total Net Savings:    $   426,599
Savings To Investment Ratio (SIR): 1.86
Point Of Contact:                 I.M. Somebody
Phone Number:                    (123) 456-7890

```

ECIP Page 1 and Page 2 Output

Figure 6.4 Example Output of {Casename}.ecp Report

Page 3: The Energy Life Cycle Cost Analysis Summary listing the specific energy and cost savings associated with the particular project.

Energy Life Cycle Cost Analysis Summary					
Location:	Seattle	Region:	4	Project No:	
Category:	6	Economic Life:	15	Project Title:	Lighting
Systems					
FY:	2008	Date:	27-Aug-2008		
Prepared By:	I.M. Somebody				
State:	WA				
1. Investment Costs					
A. Construction Cost		\$	197,627		
B. SIOH (6.00%)		\$	11,858		
C. Design Cost (10.00%)		\$	19,763		
D. Energy Credit Calc (1A+1B+1C)				\$	229,248
E. Salvage Value of Existing Equipment				\$	0
F. Public Utility Company Rebate				\$	0
G. Total Investment (1D-(1E+1F))				\$	229,248
2. Energy Savings(+) or Cost(-)					
Analysis Date Savings, Unit Costs & Discounted Savings					
Fuel	Cost \$/MBtu(1)	Savings MBtu/Yr (2)	Annual \$ Savings (3)	Discount Factor (4)	Discounted Savings (5)
A. Electricity	\$ 26.37	949	\$ 25,017	11.16	\$ 279,288
B. Distillate Oil	\$ 21.27	0	\$ 0	8.78	\$ 0
C. Residual Oil	\$ 0.00	0	\$ 0	11.63	\$ 0
D. Natural Gas	\$ 7.50	-120	\$ -901	10.15	\$ -9,153
E. Coal	\$ 0.00	0	\$ 0	11.66	\$ 0
F. Steam	\$ 0.00	0	\$ 0	0.00	\$ 0
G. Hot Water	\$ 0.00	0	\$ 0	0.00	\$ 0
H. Chilled Water	\$ 0.00	0	\$ 0	0.00	\$ 0
I. Other Fuels	\$ 0.00	0	\$ 0	0.00	\$ 0
J. Demand Savings			\$ 3,580	11.94	\$ 42,738
K. Subtotal		829	\$ 27,696		\$ 312,873
	Cost \$/Mgal(1)	Savings Mgal/Yr (2)	Annual \$ Savings (3)	Discount Factor (4)	Discounted Savings (5)
L. Water			\$ 0	11.94	\$ 0
M. Total			\$ 27,696		\$ 312,873
3. Non-Energy Savings(+) or Cost(-)					
A. Annual Recurring(+/-)					
(1) Discount Factor				11.94	\$ 0
(2) Discounted Savings/Cost (3Ax3A1)					\$ 0
B. Non-Recurring Savings(+) or Cost(-)					
Item	Savings \$ Cost(1)	Year of Occurrence(2)	Discount Factor(3)		Discounted Savings (+) or Cost(-) (4)
d. Total	\$ 139,398				\$ 113,726
C. Total Non-Energy Discounted Savings/Cost (3A2+3Bd4)					
					\$ 113,726
4. First Year \$ Savings (2P3+3A+(3Bd1/Yrs Econ Life))					
					\$ 36,989
5. Simple Payback (1G/4)					
					6.20
6. Total Net Discounted Savings (2P5+3C)					
					\$ 426,599
7. SIR (If < 1.25 Project Does Not Qualify)					
SIR = (6/1G)					1.86

6.4.1 Differences Between ECIP Output and Other FEDS Output

There are at least two reasons why the ECIP results can differ from the results in the FEDS "*.txd" and "*.csv" output. You should be aware of these reasons if you try to reconcile the ECIP results with the "*.txd" and "*.csv" results. The differences arise because the ECIP specification directs that some computations be performed in a manner that is different from that used in computing the "*.txd" and "*.csv" output.

- The analysis period used by the LCC model in FEDS is usually different from that dictated by the guidelines for ECIP reporting. This affects the discounted savings computed for the five ECIP fuels and for the non-recurring maintenance savings.
- In the ECIP output, the average for nonrecurring maintenance cost is used in computing total first-year savings, which is then used to compute the simple payback. The FEDS "*.txd" results for the simple payback are based upon an annualized value for the nonrecurring maintenance costs.

Note: prior to FEDS 7.0, the site SIOH and Design costs were factored into the ECIP cost analysis only. Now, these costs are fully reflected in all FEDS analyses and report types, to include overhead and design costs related to the project beyond those paid to the contractor.

6.5 Description of the Calibration Output Report

The purpose of the Calibration Output report is to assist in calibrating FEDS building and site energy models to available metered consumption data for a particular year. The report contains many of the same results as the Summary Installation and Building Set Output (*.txs) report, but formatted as a spreadsheet file (*.Calib.xls) for easier comparison to a table of metered consumption data by building set. Results are presented across three worksheets (four when the case contains central energy plants and thermal distribution loops) within the spreadsheet file, as follows:

- FEDS Summary:
 - Overview of the run including Case Name and date and time of the analysis
 - Total Installation Energy Use By Fuel Type – listing total combined annual energy consumption, EUI, and Cost over all fuel types
 - A counter to report the number of building sets, central plants, and thermal loops present in the case
- FEDS Building Summary:
 - FEDS Summary of building set characteristics including identification, description, number of buildings, floor area, vintage
 - Energy Use By Building and Fuel Type – lists energy use and EUI for each fuel type as well as overall

- Energy Use By Building, End Use and Fuel Type – lists total consumption by end use, for each fuel type
- Energy Intensity By Building and Fuel Type – lists in MBtu/ksf, the EUIs for each fuel type
- Energy Intensity By Building and End Use – lists in MBtu/ksf, the EUIs for each end use as well as overall
- FEDS CEP Summary: *(only present for cases containing central energy plants and/or thermal loops)*
 - Central Energy Plant Energy Use – lists the equipment level energy consumption for each central plant, auxiliary equipment electricity, total energy consumption, and annual plant output in either MBtu (for steam or hot water plants) or ton-hr (for chilled water plants)
 - Central Energy Plant Loop Losses – lists for each modeled thermal distribution loop, the total delivered energy, thermal loss, leakage loss, total loss, total energy input, loop efficiency, annual O&M cost, and both marginal and average values of delivered energy
- Full Summary: this table presents all of the data contained on the preceding tables but in a single worksheet, which may be preferred for certain calibration processes

The Calibration Output report will be automatically generated at the end of each Calibration analysis (in which the Analysis type is set to “Calibration” from within the *Simulation/Calibration Parameters* screen which is accessed from the Advanced Options).

6.6 Description of the Retrofit Savings Overview Report

The Retrofit Savings Overview report provides a high level summary of a site’s energy and cost savings potential identified by FEDS during an Optimization analysis. The report is output in a spreadsheet table including the following results for each building, as well as the total over all buildings:

- Current Estimated Energy Use (MBtu)
- Energy Savings (MBtu)
- Energy Savings (%)
- Energy / Demand Savings (\$)
- Estimated Investment (\$)
- Simple Payback (yrs)
- SIR
- Carbon Reduction (tons CO₂)

An example of the Retrofit Savings Overview report is shown below in Figure 6.5, based on the Sample-3 case. It is important to note however, that the data presented on the Retrofit Savings Overview table reflect energy and dollar savings compiled at the individual building level only, and do not include any savings that may have been identified within the central plants or thermal loops. The *.txs report would need to be consulted to review the savings attributable to recommendations specific to the central plants and/or thermal loops.

Sample-3: New Capabilities - Retrofit Savings Overview								
Building Set	Current Estimated Energy Use (MBtu)	Energy Savings (MBtu)	Energy Savings (%)	Energy / Demand Savings (\$)	Estimated Investment (\$)	Simple Payback (Years)	SIR	Carbon Reduction (tons CO2)
L-Shaped Admin	5,927.48	143.00	2.41	5,373.03	37,990.70	7.82	2.42	34.41
Var Occ Admin								
New Windows	4,736.69	1,097.39	23.17	17,727.15	603,999.56	25.62	0.91	301.90
Warehouse with IR Heating	7,450.18	2,065.40	27.72	21,569.83	347,347.75	18.01	1.10	138.06
Warehouses on CEPs	15,592.56	3,618.27	23.21	87,768.67	597,864.75	5.15	3.63	1,193.43
Site Total	33,706.91	6,924.06	20.54	132,438.68	1,587,202.77	9.69	2.15	1,667.81

Figure 6.5 Example Output of {Casename}.Retrofit.Savings.xls Report

6.7 Formatting and Printing Reports

Once the FEDS run has completed and the reports have been generated (see FEDS Output), the report files can be opened from the *Report Options* screen. The report files themselves are created and stored within the FEDS\Cases subdirectory with all of the other files that make up a FEDS case.

To open a report simply click on the open folder icon next to the report you wish to view and FEDS will open the report in the application you have assigned to view the report type. For example, if you have FEDS to open the text-based report files (e.g., *.txs, *.txd, *.ecp) in a word processing application, that application will launch to view, edit, and print the report.

Text-Based Reports

Once opened in a word processing program, the following formatting tips will ensure that the *.txs, *.txd, and *.ecp reports display properly:

1. change the font to a fixed-pitch font such as **Courier New**
2. change the font size to **8pt**
3. set the left and right **margins to 0.5 inch** each

Once these steps have been taken, the files should be ready for easy viewing or printing.

Spreadsheet Reports

The spreadsheet-based reports (e.g., *.csv, *.Calib.xls, *.Retrofit.Savings.xls) may only be opened and examined inside of a spreadsheet application. To view or print the spreadsheet report:

1. select to open the desired report from the FEDS *Report Options* window (the report will open in your spreadsheet application)
2. format the report as desired (adjust column widths to accommodate column headings, sort/filter data, add sums or subtotals, hide fields, etc.)

A post processor that allows you to combine and organize the spreadsheet (*.csv) output reports from multiple cases has been installed to your FEDS\Documents directory (default location is C:\FEDS 7.0\Documents). A short PowerPoint tutorial is also provided in this directory with a description of how to use the post processor.

Appendix A – FEDS Technical Approach

FEDS contains complex energy and economic modeling capabilities, which are utilized by a sophisticated optimization algorithm in the determination of the most cost-effective life-cycle energy resource/utilization configuration for facilities ranging from a single building to a multi-building campus or large Federal installation. The FEDS approach allows estimation of the installation-wide energy and peak demand, which is used in conjunction with complex electric rate schedules to determine installation electric costs.

A.1 Design Goals

FEDS was designed with two primary purposes in mind:

- Estimating current energy consumption for all energy systems under consideration – currently, FEDS models only building systems; it is intended that future FEDS releases will capture all energy-consuming systems.
- Determining the minimum life-cycle-cost retrofits to systems within a facility and on an installation (considering all interactive effects) – this includes estimating the pre- and post-retrofit consumption, first cost of the retrofits, recurring O&M costs for the retrofits, the value of the change in annual energy consumption and annual O&M requirements, and the net present value of the retrofits.

A.1.1 *Minimum Set Specific Design Goals*

The FEDS minimum set provides a user-friendly tool for analyzing energy use and the potential for energy-efficiency retrofit projects at large installations. A major feature of its design is that only a minimal amount of energy-system information is required to perform a first-level screening of an entire installation. FEDS uses user-supplied information to infer the appropriate values needed to determine the amount of installation energy consumption and the potential cost-effectiveness of energy retrofits.

A.1.2 *Maximum Detail Specific Design Goals*

Maximum detail display is intended to allow a user to identify specific projects that are cost-effective and appropriate to the installation. This is done by allowing a user to override FEDS inferences, specify seasonal occupancy and fuel availability for each building set, and describe linked building sets. This approach allows **but does not require** a user to enter any site-specific information that is readily available.

A.2 Inference Generation

FEDS uses user-supplied information to internally generate descriptions of prototypes for each building type selected. The default values of the parameters used to describe the prototypes are inferred from the input data; for instance, the climate zone is used in conjunction with the building type, vintage, and size to infer parameters relating to the building construction characteristics. This information is also used to infer the most likely heating equipment types for user-supplied heating fuel type. The resulting

building parameter values are statistically the most likely values for a given building type, climate zone, vintage, size, and fuel/technology mix. The FEDS building model (described in the next section) uses these parameters to estimate the energy consumption of each building prototype.

The most likely parameter-value approach to the development of the building prototype allows FEDS to perform detailed modeling of an installation while requiring only very limited information from a user. The results from the FEDS analysis are intended to be used as a gross indication of the required investment, and the energy- and cost-savings potential at an installation. The results can indicate which building types and end uses have the greatest savings potential. However, the most likely parameter-value approach also means that FEDS is most appropriately applied to installations with large numbers of buildings. This approach makes the application of the FEDS minimum set to single buildings less accurate than when it is used to model multi-building installations. Of course, accuracy is improved if actual parameter values are entered in the maximum detail display mode to override the inferred values.

Sources for the inferences about the building characteristics are mostly from the following:

- NBECS and RECS building characteristics data
- ELCAP commercial and residential end-use load and building characteristics data
- ASHRAE standard design and construction practices.

A.3 Central Energy Plant Modeling

The FEDS central plants and thermal loops model estimates energy consumption for any central energy plants located on site as well as any purchased steam, hot water, and chilled water that is piped in. At the building level, central fuels may be defined to provide any combination of heating, cooling, service hot water, desiccant regeneration, and miscellaneous equipment service. For heating, cooling, and service hot water records, once a central fuel type is selected the serving loop will also need to be identified to specify the plant and thermal loop that serves the building technology. Desiccant and miscellaneous equipment will apportion energy to loops and plants according to the energy delivered by loop for heat, cool, and service hot water for that building set.

Energy losses are added to the energy consumed at the building level for each loop, and summed for each central plant. From this FEDS can determine:

- The total load from all connected buildings and other central plant equipment, both at baseline and throughout the retrofit optimization process
- The value of steam, hot water, or chilled water delivered to each building, considering central plant equipment types and efficiencies, source fuel costs, auxiliary power requirements, O&M costs, loop losses, and other parameters
- The cost effectiveness of various decentralization options including:

- Which individual technologies served centrally should be replaced with distributed technologies,
- Which thermal loops of a central energy plant should be abandoned with all attached technologies becoming decentralized, and
- Which central energy plants should be abandoned with all attached loops becoming abandoned and all attached technologies becoming decentralized

Some things to bear in mind regarding central plant and thermal loop modeling are:

- The "loop season" controls only the heat loss in the loop and not the delivery of energy. For example, if the loop operates only for November through March there will be 5 months of loop loss; however, if a building connected to the loop needs heat in October or hot water in the summer it will be supplied and the delivered energy considered.
- Leakage loss values are expressed in terms of the amount of heat energy being transferred out of the thermal loop. Therefore, they are positive numbers for energy loss from steam and hot water lines and typically negative for heat gain through loss from chilled water lines as heat energy is transferred to the loop. However, during cold times of the year chilled water lines can also lose heat to the surroundings.
- There is only ONE fuel price escalation rate associated with Steam (and one for hot water and one for chilled water) per building set; it is based on the predominate fuel source across all plants and purchased fuels of the same kind that are serving that building set.

A.4 Building Energy Modeling

The FEDS building model estimates energy consumption for the following end uses:

- Lighting
- Electric motors
- Miscellaneous equipment
- Service hot water
- Heating
- Cooling
- Ventilation.

Lighting, motor, and miscellaneous equipment consumptions are calculated according to the user-supplied occupancy schedule, based on capacity and load/utilization factors. Heating, cooling, and service hot water consumption estimates are calculated using estimated loads and system efficiencies. Ventilation energy consumption is also modeled using a number of possible operating scenarios.

A.5 Retrofit Modeling

After modeling the current energy consumption using the existing equipment, the replacement or modification of the equipment is considered. These modifications include complete replacement with similar, but more efficient equipment (e.g., replacing existing fluorescent fixtures with new high-efficiency fluorescent fixtures); changes to different types of equipment which provide equivalent service more efficiently (e.g., replacing a forced air electric furnace with a heat pump); and changes to more efficient equipment using a different fuel (fuel-switching). Additionally, equipment served by central fuels will be considered for replacement with more cost effective equipment and fuels. Thermal loops and entire central plants are also evaluated for abandonment if each of the technologies served can be replaced and each loop may be abandoned. In such cases, the value of the loop losses and plant and loop fixed operations and maintenance costs will be included in the overall economic evaluation to determine the cost effectiveness of shutting down an entire loop and perhaps a plant.

When considering any equipment changes, the total effect on the building's energy consumption is considered. For example, the model determines the full impact of a lighting system retrofit by determining not only the change in lighting electrical consumption but also the change in the heating, cooling, and ventilation system consumption due to the change in the internal gains.

The impact of any difference in electric consumption is assessed by determining the change in the installation electric energy consumption and demand profiles. These profiles are used in conjunction with the detailed electric rate structures and demand ratchets to calculate the cost or benefit of the change.

A.6 Optimization

Optimization of the building and central plant energy systems is accomplished by an iterative process, as illustrated in Figures A.1 and A.2. The first end use is evaluated (e.g., lights) and the minimum life-cycle cost configuration for that end use is determined. When the second end use is evaluated, the model assumes that the first end use has already been changed. Once all end uses have been evaluated, the model reconsiders the first end use to see if the minimum life-cycle cost configuration for that end use has changed due to changes in other end uses; this is driven by interactive effects. This process continues until the model has converged to the minimum life-cycle cost configuration for each end use in the entire building set. The model then considers the next building set.

Next, FEDS evaluates the central plants and thermal loops to determine whether it is cost effective to abandon any loops and plants. Any heating, cooling, or service hot water technology that remains connected at this point to a central fuel is optimized and forced to select its most cost effective non-central fuelled replacement technology (even if it has a negative life-cycle cost savings). Then, each loop is evaluated to compare the savings associated with shutting down the loop (due to eliminating

maintenance and loop loss costs) with the extra life-cycle cost of the new building technologies. If the net savings (known as the loop abandonment value) are positive, then the loop will be abandoned. Otherwise, the abandonment values for all of the loops on a plant are combined, and added to the savings associated with shutting down the plant to determine if it is cost effective to abandon the plant and all of its loops. If this plant abandonment value is positive, the plant and each of its loops are abandoned, and the building technology replacements are kept.² Otherwise, they are set back to previous state.

The process then repeats to optimize all building sets again. Building technologies that are served by loops now marked for abandonment will be forced to retrofit to their most life-cycle cost effective replacement.

² In this case, the central fuel technologies that were replaced with in-building technologies may report a negative NPV on the TXD and CSV technology output along with a note that the retrofit was due to plant or loop abandonment. The savings associated with abandoning the loop and possibly plant will not be shown on these reports but on the TXS report where the overall savings will be shown to be positive.

FEDS ENGINE : Baseline

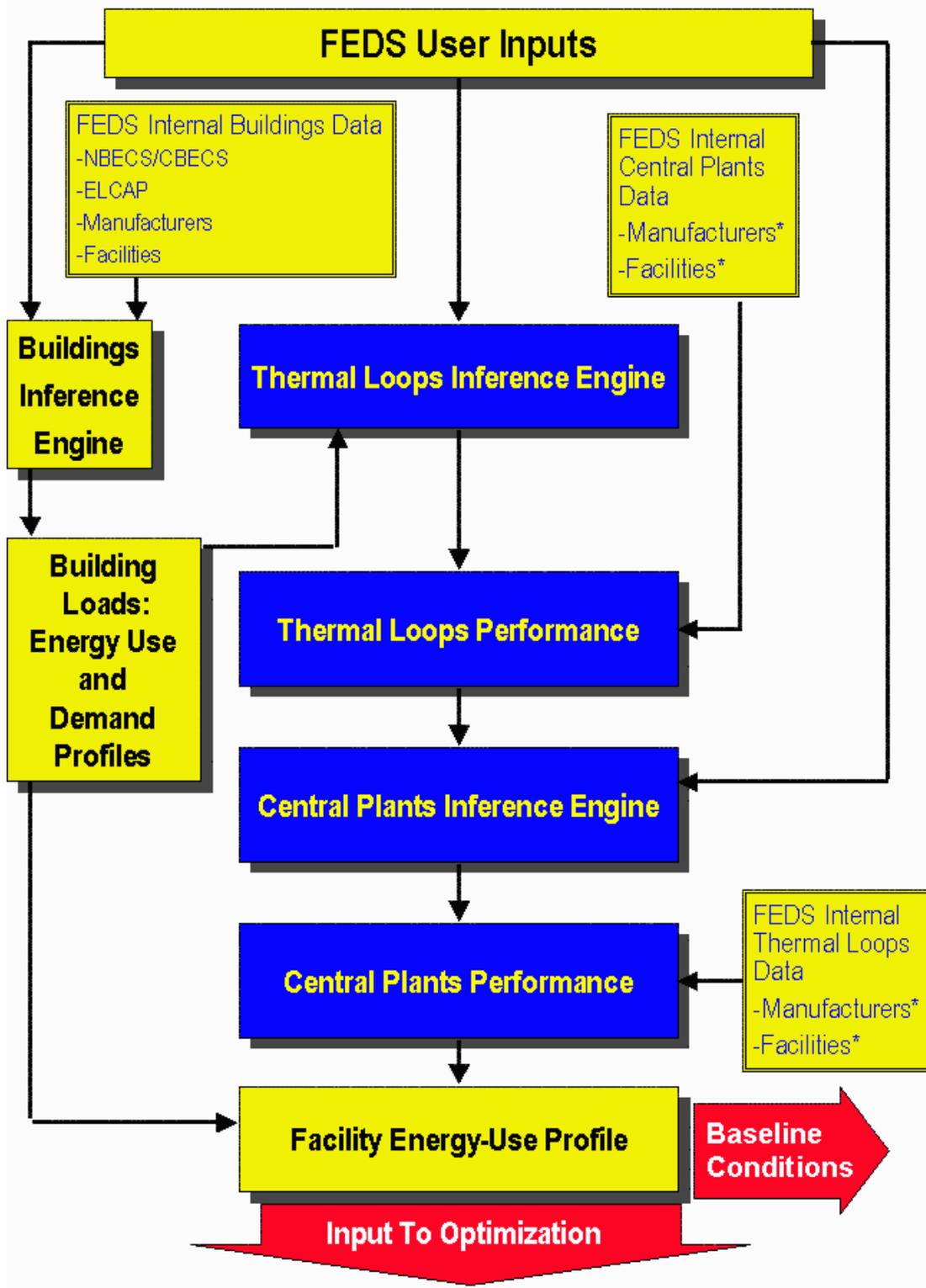


Figure A.1 FEDS Baseline Process

FEDS ENGINE: Optimization

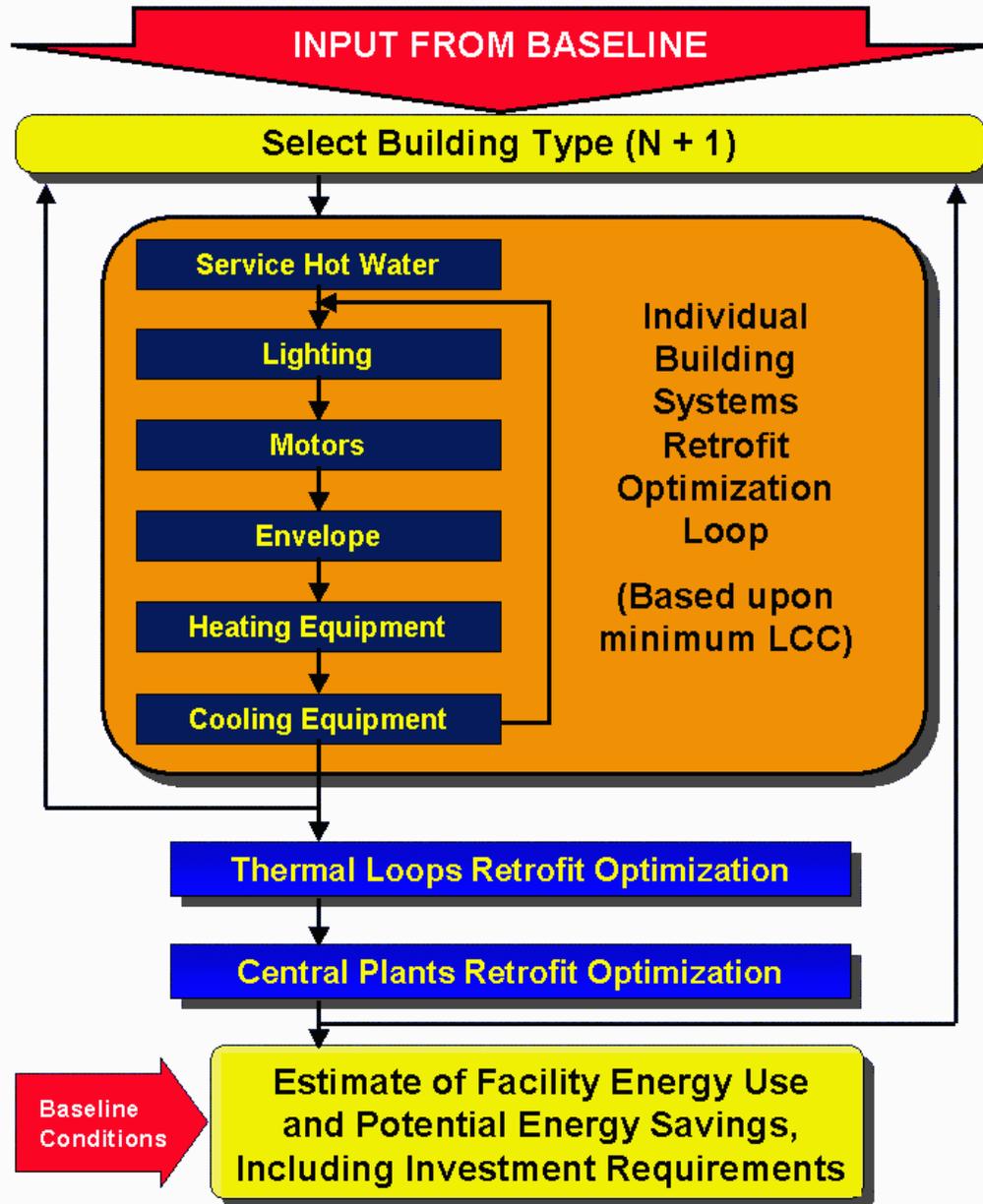


Figure A.2 FEDS Retrofit Optimization Process

Appendix B – FEDS Retrofit Options

The retrofit options for the FEDS software are listed below. This list is continually expanded and refined as new functionality is added to the software. Notes on specific end uses are presented below under each category.

B.1 Heating Retrofit Alternatives

The available heating retrofit alternatives are listed below. Both equipment replacements and add-on technologies are considered for building-level heating systems. Retrofit options are dependent on a number of factors including existing equipment type, whether the existing technology has a paired cooling technology defined, the fuel types available to the building, and the required heating capacity. For central district heating systems, the only retrofit options involve conversion to a building-level centralized system (typically involving a boiler or infrared heating system as applicable).

Replacement Heating Retrofit Technology Options Include:

- Conventional forced air furnaces using fuels including electricity, distillate oil, natural gas, and lpg
- Condensing natural gas or lpg furnaces
- Conventional boilers using fuels including electricity, distillate or residual oil, natural gas, and lpg
- Condensing natural gas or lpg boilers
- Infrared heating systems using fuels including electricity, natural gas, and lpg
- Electric air source heat pumps*
- Dual-fuel air source heat pumps (with integrated or separate types of backup heat)*
- Electric ground-coupled heat pump systems (in open-loop, and horizontal or vertical close-loop configurations)*
- Replace water source heat pump units of an existing ground-coupled heat pump system
- Packaged DX A/C unit with integral natural gas or lpg heat (e.g., a gas pack)*

*These heating retrofit options are considered only when the existing heating technology is identified as a pair with a specific cooling technology.

Add-On Retrofit Heating Technology Options Include:

- Boiler feedwater economizers
- Boiler automatic electric dampers
- Adding a forced air furnace to an existing air source heat pump plus controls for dual-fuel operation
- Adding an electric air source heat pump plus controls to an existing furnace for dual-fuel operation
- Adjusting the crossover temperature of an existing dual-fuel heat pump

B.2 Cooling Retrofit Alternatives

The available cooling retrofit alternatives are listed below. Replacement technologies are considered for both building-level and district cooling systems. Retrofit options are dependent on a number of factors including existing equipment type, whether the existing technology has a paired heating technology defined, the fuel types available to the building, and the required cooling capacity. For central district heating systems, the only retrofit options involve conversion to a building-level centralized system (typically involving a chiller or similar equipment).

Replacement Cooling Retrofit Technology Options Include:

- Packaged DX AC units
 - Window/through wall (<1.5 tons cooling)
 - Residential split system (1.5 - 5.4 tons cooling)
 - Commercial single zone rooftop (1.5 - 20 tons cooling)
 - Commercial multi-zone rooftop (20 - 150 tons cooling)
- Conventional electric chillers (reciprocating, scroll, screw, or centrifugal compressors; in air- and water-cooled configurations)
- Gas engine driven chillers (reciprocating, scroll, screw, or centrifugal compressors; in air- and water-cooled configurations)
- Absorption chillers (single or double effect, direct or indirect fired; in air- and water-cooled configurations)
- Electric air source heat pumps*
- Dual-fuel air source heat pumps (with integrated or separate types of backup heat)*
- Electric ground-coupled heat pump systems (in open-loop, and horizontal or vertical close-loop configurations)*
- Replace water source heat pump units of an existing ground-coupled heat pump system

- Packaged DX A/C unit with integral natural gas or lpg heat (e.g., a gas pack)*

*These cooling retrofit options are considered only when the existing cooling technology is identified as a pair with a specific heating technology.

B.3 Envelope Retrofit Alternatives

The following retrofits are available for building envelope (roof, walls, floor, and windows) depending on building construction type, existing insulation and window characteristics, and space available for additional insulation.

Roof/Ceiling Insulation:

- Attic ceiling insulation
- Suspended ceiling insulation
- Insulate built-up roof surface and re-roof
- Insulate interior surface of metal roof with fiberglass, bubble pack, or foam

Wall Insulation:

- Blow-in insulation to fill available space
- Interior masonry surface insulation
- Interior metal wall surface insulation (fiberglass, bubble pack, or foam)

Floor Insulation:

- Insulate above crawlspace
- Insulate pier floor
- Insulate perimeter of slab on grade

Window Retrofits:

- Add retrofit film
- Add regular or low-e storm windows (to window exterior or interior)
- Install new windows with a combination of the following characteristics:
 - Number of panes: two or three
 - Frame types: vinyl, aluminum, aluminum with thermal break, or high performance aluminum
 - Films/tint: tinted glass, reflective, low-e, super low-e high gain low-e, low-gain-low-e, heat mirror (with 1, 2, or 3 films)
 - Gas fill: none, argon, krypton, or xenon

B.4 Service Hot Water Retrofit Alternatives

The following retrofits are available distributed and loop hot water systems.

Replacement Hot Water Retrofit Technology Options Include:

- Residential and commercial storage tank water heaters using fuels including electricity, distillate oil, natural gas, and lpg
- Electric heat pump water heaters
- Conventional boilers using fuels including distillate oil, residual oil, natural gas, and lpg
- Condensing natural gas or lpg boilers

Add-On Hot Water Retrofit Options Include Combinations of the Following:

- Insulate existing storage tank
- Insulate pipe near water heater
- Low-flow (high efficiency) shower heads
- Faucet aerators
- Decrease service hot water temperature (only possible for certain building types and only recommended in conjunction with flow reducers)

B.5 Lighting Retrofit Alternatives

The Pacific Northwest National Laboratory has developed a large database of over 900 lighting technology configurations that are included in FEDS. These lighting technologies are available to be modeled as existing lighting technologies and considered as retrofit technologies. FEDS considers cross-technology substitution only where it is appropriate (e.g., HPS for fluorescent in warehouses). Additionally, FEDS only considers retrofit alternatives that provide at least 90% of the light output of the existing lighting technology configuration. All possible existing and retrofit lighting technology configurations are listed in [Appendix G](#) and [Appendix H](#).

B.6 Ventilation Retrofit Alternatives

Currently, ventilation system retrofits are not available.

B.7 Miscellaneous Equipment Alternatives

Currently, miscellaneous equipment (plug-load) retrofits are not available.

B.8 Motor Retrofits

FEDS provides the capability to analyze the cost-effectiveness of replacing old, inefficient three-phase asynchronous electric motors with new energy-efficient motors. The list of possible motor retrofits (nearly 1000) were derived from the database of

motors meeting current standards contained within the *MotorMaster+* software program developed under the U.S. Department of Energy's Motor Challenge Program. The motors were sorted according to key characteristics (size, speed, voltage, enclosure, etc.) and grouped based on efficiency and cost. For a more detailed (and manufacturer-specific) motor analysis it is suggested that a FEDS run be augmented with *MotorMaster+*.

Appendix C – Sample Output

Actual text- and spreadsheet-based report files for the sample cases have been installed to your FEDS\Documents\Sample Case Output directory (default location is C:\FEDS 7.0\Documents\Sample Case Output). These files are:

- sample-1_txs.pdf
- sample-1_txd.pdf
- sample-1_csv.xls
- sample-1.Calib.xls
- sample-1.Retrofit.Savings.xls
- sample-2_txs.pdf
- sample-2_txd.pdf
- sample-2_csv.xls
- sample-2.Calib.xls
- sample-2.Retrofit.Savings.xls
- sample-3_txs.pdf
- sample-3_txd.pdf
- sample-3_csv.xls
- sample-3.Calib.xls
- sample-3.Retrofit.Savings.xls

The spreadsheet output files can be opened with Excel and the text-based output files are in pdf format and may be viewed by opening them with the Adobe Acrobat Reader. If you need to download Adobe Acrobat Reader, visit <http://get.adobe.com/reader/>.

Appendix D – Weather Station File Names and Locations

There are 1,116 weather files available for use within FEDS (1,036 for the U.S. and locations in the Caribbean and Pacific Islands, and 80 in Canada). FEDS uses data in the EnergyPlus Weather (EPW) format. The station file names and locations are listed below, along with a map of available weather locations for the United States from NREL. The weather data for building energy simulation are intended to represent a typical meteorological year rather than a specific year's weather, and can include data sourced from the following energy weather data types:

- Canadian Weather for Energy Calculations (CWEC): based on weather data from 1953-1995.
- FEDS Special Weather Data (FSW): weather specifically developed for FEDS analysis at sites for which there was no existing weather file from any other source at the time of development; based on available weather data from the site or nearby location.
- Typical Meteorological Year Weather (TMY): based on weather data from 1948-1980.
- Typical Meteorological Year Weather – Version 2 (TMY2): based on weather data from 1961-1990. For more information see http://rredc.nrel.gov/solar/old_data/nsrdb/1961-1990/tmy2/
- Typical Meteorological Year Weather – Version 3 (TMY3): based on weather data for 1991-2005. For more information see http://rredc.nrel.gov/solar/old_data/nsrdb/1991-2005/tmy3/
- Weather Year for Energy Calculations (WYEC): based on weather data from 1952-1975.
- Weather Year for Energy Calculations – Version 2 (WYEC-2): based on weather data from 1952-1975.

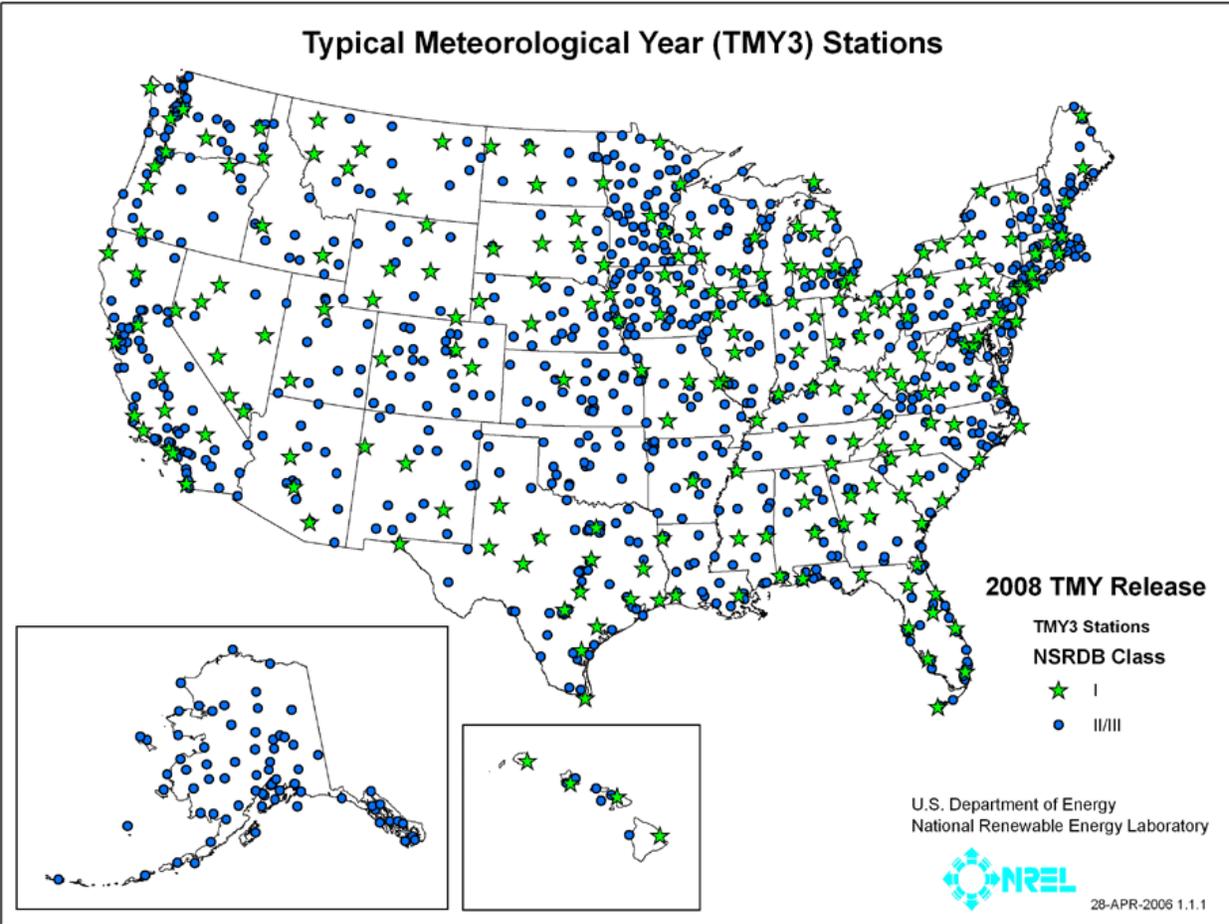


Figure D.1 Locations of Typical Meteorological Year weather stations across the United States (from http://rredc.nrel.gov/solar/old_data/nsrdb/1991-2005/tmy3/usTMYmaps3medium.gif)

State	Location	Location	Location
Alabama	Anniston Metro AP	Gadsen Muni AWOS	Montgomery-Dannelly Field
	Auburn-Opelika AP	Huntsville Intl AP-Jones Field	Muscle Shoals Rgnl AP
	Birmingham Muni AP	Maxwell AFB	Troy Air Field
	Dothan Muni AP	Mobile-Downtown AP	Tuscaloosa Muni AP
	Fort Rucker-Cairns Field	Mobile-Rgnl AP	
Alaska	Adak NAS	Gulkana	Point Hope AWOS
	Ambler	Gustavus	Port Heiden
	Anaktuvuk Pass	Hayes River	Saint Marys AWOS
	Anchorage Intl AP	Healy River AP	Sand Point
	Anchorage-Elmendorf AFB	Homer AP	Savoonga
	Anchorage-Lake Hood Seaplane Base	Hoonah	Selawik
	Anchorage-Merrill Field	Hooper Bay	Seward

	Aniak AP	Huslia	Shemya AFB
	Annette Island AP	Hydaburg Seaplane Base	Shishmaref AWOS
	Anvik	Iliamna AP	Sitka-Japonski Island AP
	Barrow-W Post-W Rogers AP	Juneau Intl AP	Skagway AP
	Bethel AP	Kake Seaplane Base	Sleetmute
	Bettles Field	Kenai Muni AP	Soldotna
	Big Delta-Allen AAF	Ketchikan Intl AP	St Paul Island AP
	Big River Lake	King Salmon AP	Summit
	Birchwood	Kodiak AP	Talkeetna State AP
	Chulitna	Kotzebue-Ralph Wein Mem AP	Tanana-Ralph Calhoun AP
	Cold Bay AP	McGrath AP	Togiak Village AWOS
	Cordova	Mekoryuk	Unalakleet Field
	Deadhorse	Middleton Island	Unalaska-Dutch Harbor Field
	Dillingham AWOS	Minchumina	Valdez
	Eielson AFB	Nenana Muni AP	Valdez-Pioneer Field
	Emmonak	Nome Muni AP	Whittier
	Fairbanks Intl AP	Northway AP	Wrangell
	Fort Yukon	Palmer Muni AP	Yakutat State AP
	Gambell	Petersburg	
Arizona	Casa Grande AWOS	Luke AFB	Scottsdale Muni AP
	Davis-Monthan AFB	Page Muni AWOS	Show Low Muni AP
	Douglas-Bisbee Douglas Intl AP	Phoenix-Deer Valley AP	Tucson Intl AP
	Flagstaff-Pulliam AP	Phoenix-Sky Harbor Intl AP	Winslow Muni AP
	Grand Canyon National Park AP	Prescott-Love Field	Yuma Intl AP
	Kingman AWOS	Safford AWOS	Yuma MCAS
Arkansas	Batesville AWOS	Harrison AP	Rogers AWOS
	Bentonville AWOS	Hot Springs Mem AP	Siloam Spring AWOS
	El Dorado-Goodwin Field	Jonesboro Muni AP	Springdale Muni AP
	Fayetteville-Drake Field	Little Rock AFB	Stuttgart AWOS
	Flippin AWOS	Little Rock-Adams Field	Texarkana-Webb Field
	Fort Smith Rgnl AP	Pine Bluff AP	Walnut Ridge AWOS
California	Alturas	Lemoore NAS	Sacramento McClellan Airfield
	Arcata AP	Livermore Muni AP	Sacramento Exec AP
	Bakersfield-Meadows Field	Lompoc AWOS	Sacramento Metro AP
	Barstow Daggett AP	Long Beach-Daugherty Field	Salinas Muni AP
	Beale AFB	Los Angeles Intl AP	San Diego-Lindbergh Field
	Bishop AP	March AFB	San Diego-Miramar NAS
	Blue Canyon AP	Merced-Macready Field	San Diego-Montgomery Field

	Blythe-Riverside County AP	Modesto Muni AP	San Diego-North Island NAS
	Burbank-Glendale-Pasadena Bob Hope AP	Montague-Siskiyou County AP	San Francisco Intl AP
	Camarillo AWOS	Monterey NAF	San Jose Intl AP
	Camp Pendleton MCAS	Mount Shasta	San Luis Obispo AP
	Carlsbad	Mountain View-Moffett Field NAS	Sandberg
	China Lake NAF	Napa County AP	Santa Ana-John Wayne AP
	Chino AP	Needles AP	Santa Barbara Muni AP
	Chula Vista-Brown Field Muni AP	Oakland Intl AP	Santa Maria Public AP
	Concord-Buchanan Field	Oxnard AP	Santa Monica Muni AP
	Crescent City-Jack McNamara Field	Palm Springs Intl AP	Santa Rosa AWOS
	Edwards AFB	Palm Springs-Thermal AP	South Lake Tahoe-Lake Tahoe AP
	El Toro MCAS	Palmdale AP	Stockton Metro AP
	Fairfield-Travis AFB	Paso Robles Muni AP	Truckee Tahoe AP
	Fresno Air Terminal	Point Mugu NAS	Twentynine Palms
	Fullerton Muni AP	Porterville AWOS	Ukiah Muni AP
	Hawthorne-Jack Northrop Field	Red Bluff Muni AP	Van Nuys AP
	Hayward Air Terminal	Redding Muni AP	Visalia Muni AWOS
	Imperial County AP	Riverside Muni AP	Yuba County AP
	Lancaster-Gen Wm Fox Field		
Colorado	Akron-Washington County AP	Denver-Stapleton	La Junta Muni AP
	Alamosa Muni AP	Durango-La Plata County AP	Lamar Muni AP
	Aspen-Pitkin County-Sardy Field	Eagle County Rgnl AP	Leadville-Lake County AP
	Aurora-Buckley Field ANGB	Fort Collins AWOS	Limon Muni AP
	Boulder-Broomfield-Jefferson County AP	Golden-NREL	Montrose County AP
	Colorado Springs-Peterson Field	Grand Junction-Walker Field	Pueblo Mem AP
	Cortez-Montezuma County AP	Greeley-Weld County AWOS	Rifle-Garfield County Rgnl AP
	Craig Moffat AP	Gunnison County AWOS	Trinidad-Las Animas County AP
	Denver Intl AP	Hayden-Yampa AWOS	
Connecticut	Bridgeport-Sikorsky Mem AP	Hartford-Bradley Intl AP	New Haven-Tweed AP
	Danbury Muni AP	Hartford-Brainard Field	Oxford AWOS
Delaware	Dover AFB	Wilmington-New Castle County AP	

Florida	Apalachicola	Lakeland Linder Rgnl AP	Panama City-Bay County AP
	Crestview-Bob Sikes AP	MacDill AFB	Pensacola Rgnl AP
	Daytona Beach Intl AP	Marathon AP	Pensacola-Forest Sherman NAS
	Fort Lauderdale Executive AP	Mayport NS	Sarasota-Bradenton Intl AP
	Fort Lauderdale Intl AP	Melbourne Rgnl AP	Southwest Florida Intl AP
	Fort Myers-Page Field	Miami Intl AP	St Petersburg-Albert Whitted Station
	Fort Pierce-St Lucie County AP	Miami-Kendall-Tamiami Executive AP	St Petersburg-Clearwater Intl AP
	Fort Walton Beach-Hurlburt Field	Miami-Opa Locka AP	Tallahassee Rgnl AP
	Gainesville Rgnl AP	Naples Muni AP	Tampa Intl AP
	Homestead AFB	NASA Shuttle Landing Facility	Tyndall AFB
	Jacksonville Intl AP	Ocala Muni AWOS	Valparaiso-Elgin AFB
	Jacksonville NAS	Orlando Executive AP	Vero Beach Muni AP
	Jacksonville-Craig Field	Orlando Intl AP	West Palm Beach Intl AP
	Key West Intl AP	Orlando-Sanford AP	Whiting Field NAS
	Key West NAS		
Georgia	Albany-Dougherty County AP	Columbus Metro AP	Rome-Richard B Russell AP
	Alma-Bacon County AP	Dekalb Peachtree AP	Savannah Intl AP
	Athens-Ben Epps AP	Fort Benning-Lawson Field	Savannah-Hunter AAF
	Atlanta-Hartsfield-Jackson Intl AP	Fulton County AP	Valdosta Rgnl AP
	Augusta-Bush-Field	Macon-Middle Georgia Rgnl AP	Valdosta-Moody AFB
	Brunswick-Golden Isles AP	Marietta-Dobbins AFB	Warner Robins AFB
	Brunswick-Malcolm McKinnon AP		
Hawaii	Barbers Point NAS	Kailua-Kaneohe Bay MCAS	Lanai AP
	Hilo Intl AP	Kapalua-West Maui AP	Lihue AP
	Honolulu Intl AP	Keahole-Kona Intl AP	Molokai AWOS
	Kahului AP		
Idaho	Boise Air Terminal	Idaho Falls-Fanning Field	Pocatello Muni AP
	Burley Muni AP	Lewiston-Nez Perce County AP	Salmon-Lemhi AWOS
	Caldwell AWOS	Malad City AP	Soda Springs-Tigert AP
	Coeur d'Alene AWOS	Mountain Home AFB	Twin Falls-Magic Valley Rgnl AP-Joslin Field
	Hailey-Sun Valley AP		
Illinois	Aurora Muni AP	Decatur AP	Quincy Muni AP
	Belleville-Scott AFB	Du Page AP	Rockford-Greater Rockford AP

	Bloomington Normal-Central Illinois Rgnl AP	Marion-Williamson County Rgnl AP	Springfield-Capital AP
	Cahokia AP	Moline-Quad City Intl AP	Sterling-Rock Falls-Whiteside County AP
	Carbondale-Southern Illinois AP	Mount Vernon AWOS	University of Illinois-Willard AP
	Chicago-Midway AP	Peoria-Greater Peoria AP	Waukegan Rgnl AP
	Chicago-O'Hare Intl AP		
Indiana	Delaware County-Johnson Field	Huntingburg Muni AP	Monroe County AP
	Evansville Rgnl AP	Indianapolis Intl AP	South Bend-Michiana Rgnl AP
	Fort Wayne Intl AP	Lafayette-Purdue University AP	Terre Haute-Hulman Rgnl AP
	Grissom AFB		
Iowa	Algona Muni AP	Denison Muni AP	Newton Muni AP
	Atlantic Muni AP	Des Moines Intl AP	Oelwein Muni AP
	Boone Muni AP	Dubuque Rgnl AP	Orange City Muni AP
	Burlington Muni AP	Estherville Muni AP	Ottumwa Industrial AP
	Carroll Muni AP	Fairfield Muni AP	Red Oak Muni AP
	Cedar Rapids Muni AP	Fort Dodge AWOS	Sheldon Muni AP
	Chariton Muni AP	Fort Madison Muni AP	Shenandoah Muni AP
	Charles City Muni AP	Keokuk Muni AP	Sioux City-Sioux Gateway AP
	Clarinda Muni AP	Knoxville Muni AP	Spencer Muni AP
	Clinton Muni AWOS	Le Mars Muni AP	Storm Lake Muni AP
	Council Bluffs Muni AP	Mason City Muni AP	Washington Muni AP
	Creston Muni AP	Monticello Muni AP	Waterloo Muni AP
	Decorah Muni AP	Muscatine Muni AP	Webster City Muni AP
Kansas	Chanute-Martin Johnson AP	Hays Muni AWOS	Russell Muni AP
	Concordia-Blosser Muni AP	Hill City Muni AP	Salina Muni AP
	Dodge City Rgnl AP	Hutchinson Muni AP	Topeka-Forbes AFB
	Emporia Muni AP	Liberal Muni AP	Topeka-Phillip Billard Muni AP
	Fort Riley-Marshall AAF	Manhattan Rgnl AP	Wichita-Col Jabara Field
	Garden City Muni AP	Newton AWOS	Wichita-McConnell AFB
	Goodland-Renner Field	Olathe-Johnson County Executive AP	Wichita-Mid Continent AP
	Great Bend AWOS	Olathe-Johnson County Industrial AP	
Kentucky	Bowling Green-Warren County AP	Henderson City County AP	Louisville-Bowman Field
	Cincinnati-Northern Kentucky AP	Jackson-Julian Carroll AP	Louisville-Standiford Field
	Fort Campbell AAF	Lexington-Bluegrass AP	Paducah-Barkley Rgnl AP

	Fort Knox-Godman AAF	London-Corbin-Magee Field	Somerset-Pulaski County AWOS
Louisiana	Alexandria-England AFB	Lafayette Rgnl AP	New Orleans-Alvin Callender Field
	Alexandria-Esler Rgnl AP	Lake Charles AP	New Orleans-Lakefront AP
	Barksdale AFB	Lake Charles Rgnl AP	Patterson Mem AP
	Baton Rouge-Ryan AP	Monroe Rgnl AP	Shreveport Downtown
	Fort Polk	New Iberia	Shreveport Rgnl AP
	Houma-Terrebonne AP	New Orleans Intl AP	
Maine	Auburn-Lewiston Muni AP	Caribou Muni AP	Presque Isle Muni AP
	Augusta AP	Edmundston-Northern Aroostook Rgnl AP	Rockland-Knox AWOS
	Bangor Intl AP	Houlton Intl AP	Sanford Muni AWOS
	Bar Harbor AWOS	Millinocket Muni AP	Waterville AWOS
	Brunswick NAS	Portland Intl Jetport	Wiscasset AP
Maryland	Andrews AFB	Hagerstown-Washington County Rgnl AP	Salisbury-Wicomico County Rgnl AP
	Baltimore-Washington Intl AP	Patuxent River NAS	
Massachusetts	Barnstable-Boardman Poland AP	Martha's Vineyard AP	Otis ANGB
	Beverly Muni AP	Nantucket Mem AP	Plymouth Muni AP
	Boston-Logan Intl AP	New Bedford Rgnl AP	Provincetown AWOS
	Chicopee Falls-Westover AFB	North Adams AP	Westfield-Barnes Muni AP
	Lawrence Muni AP	Norwood Mem AP	Worcester Rgnl AP
Michigan	Alpena County Rgnl AP	Grand Rapids-Kent County Intl AP	Menominee AWOS
	Ann Arbor Muni AP	Hancock-Houghton County AP	Mount Clemens-Selfridge ANGB
	Battle Creek-Kellogg AP	Houghton-Lake Roscommon County AP	Muskegon County AP
	Benton Harbor-Ross Field-Twin Cities AP	Howell-Livingston County AP	Oakland County Intl AP
	Cadillac-Wexford County AP	Iron Mountain-Ford Field	Oscoda-Wurtsmith AFB
	Chippewa County Intl AP	Ironwood AWOS	Pellston-Emmet County AP
	Detroit Metro AP	Jackson-Reynolds Field	Saginaw-Tri City Intl AP
	Detroit-City AP	Kalamazoo-Battle Creek Intl AP	Sault Ste Marie-Sanderson Field
	Detroit-Willow Run AP	Lansing-Capital City AP	St Clair County Intl AP
	Escanaba AWOS	Manistee AWOS	Traverse City-Cherry Capital AP
	Flint-Bishop Intl AP		

Minnesota	Aitkin AWOS	Faribault Muni AWOS	Orr Rgnl AP
	Albert Lea AWOS	Fergus Falls AWOS	Owatonna AWOS
	Alexandria Muni AP	Fosston AWOS	Park Rapids Muni AP
	Austin Muni AP	Glenwood AWOS	Pipestone AWOS
	Baudette Intl AP	Grand Rapids AWOS	Red Wing Muni AP
	Bemidji Muni AP	Hallock	Redwood Falls Muni AP
	Benson Muni AP	Hibbing-Chisholm Hibbing AP	Rochester Intl AP
	Brainerd-Crow Wing County AP	Hutchinson AWOS	Roseau Muni AWOS
	Cambridge Muni AP	International Falls Intl AP	Silver Bay Muni AP
	Cloquet AWOS	Litchfield Muni AP	South St Paul Muni AP
	Crane Lake AWOS	Little Falls AWOS	St Cloud Muni AP
	Crookston Muni Field	Mankato AWOS	St Paul-Downtown AP
	Detroit Lakes AWOS	Marshall Muni-Ryan Field AWOS	Thief River AWOS
	Duluth Intl AP	Minneapolis-Crystal AP	Two Harbors Muni AP
	Edin Prairie-Flying Cloud AP	Minneapolis-St Paul Intl AP	Wheaton AWOS
	Ely Muni AP	Mora Muni AWOS	Willmar Muni AP
	Eveleth Muni AWOS	Morris Muni AWOS	Winona Muni AWOS
	Fairmont Muni AWOS	New Ulm Muni AWOS	Worthington AWOS
Mississippi	Biloxi-Keesler AFB	Gulfport-Biloxi Intl AP	Meridian NAS
	Columbus AFB	Hattiesburg-Laurel AP	Meridian-Key Field
	Golden Triangle Rgnl AWOS	Jackson Intl AP	Natchez-Hardy Anders Field
	Greenville Muni AP	McComb-Pike Co AP	Tupelo Muni-C D Lemons AP
	Greenwood-Leflore AP		
Missouri	Cape Girardeau Muni AP	Kaiser-Lee Fine Mem AWOS	Springfield Rgnl AP
	Columbia Rgnl AP	Kansas City Downtown AP	St Joseph-Rosecrans Mem AP
	Farmington Rgnl AP	Kansas City Intl AP	St Louis-Lambert Intl AP
	Fort Leonard Wood-Forney AAF	Kirkville Muni AP	St Louis-Spirit of St Louis AP
	Jefferson City Mem AP	Poplar Bluff AWOS	Whiteman AFB
	Joplin Muni AP	Rolla National AP	
Montana	Billings-Logan Intl AP	Glendive AWOS	Lewistown Muni AP
	Bozeman-Gallatin Field	Great Falls -Malmstrom AFB	Livingston-Mission Field
	Butte-Bert Mooney AP	Great Falls Intl AP	Miles City Muni AP
	Cut Bank Muni AP	Havre City-County AP	Missoula Intl AP
	Dillon	Helena Rgnl AP	Sidney-Richland Muni AP
	Glasgow Intl AP	Kalispell-Glacier Park Intl AP	Wolf Point Intl AP
Nebraska	Ainsworth Muni AP	Grand Island-Central Nebraska Rgnl AP	Omaha WSFO

	Alliance Muni AP	Hastings Muni AP	Omaha-Eppley Airfield
	Beatrice Muni AP	Holdrege-Brewster Field	O'Neill-Baker Field
	Bellevue-Offutt AFB	Imperial Muni AP	Ord-Sharp Field
	Broken Bow Muni AP	Kearney Muni AWOS	Scottsbluff-W B Heilig Field
	Chadron Muni AP	Lincoln Muni AP	Sidney Muni AP
	Columbus Muni AP	McCook Muni AP	Tekamah AWOS
	Falls City-Brenner Field	Norfolk-Karl Stefan Mem AP	Valentine-Miller Field
	Fremont Muni AP	North Platte Rgnl AP	
Nevada	Elko Muni AP	Lovelock-Derby Field	Tonopah AP
	Ely-Yelland Field	Mercury-Desert Rock AP	Winnemucca Muni AP
	Fallon NAS	Nellis AFB	Yucca Flat Test Site
	Las Vegas-McCarran Intl AP	Reno-Tahoe Intl AP	
New Hampshire	Berlin Muni AP	Laconia Muni AWOS	Mount Washington
	Concord Muni AP	Lebanon Muni AP	Pease Intl Tradeport
	Keene-Dillant Hopkins AP	Manchester Muni AP	
New Jersey	Atlantic City Intl AP	Cape May County AP	Newark Intl AP
	Belmar-Monmouth County AP	McGuire AFB	Teterboro AP
	Caldwell-Essex County AP	Millville Muni AP	Trenton-Mercer County AP
New Mexico	Albuquerque Intl AP	Farmington-Four Corners Rgnl AP	Roswell Industrial Air Park
	Carlsbad Cavern City Air Terminal	Gallup-Sen Clarke Field	Ruidoso-Sierra Blanca Rgnl AP
	Clayton Muni AP	Holloman AFB	Santa Fe County Muni AP
	Clovis Muni AWOS	Las Cruces Intl AP	Taos Muni AP
	Clovis-Cannon AFB	Las Vegas-Muni AP	Truth or Consequences Muni AP
	Deming Muni AP	Los Alamos	Tucumcari AP
New York	Albany County AP	Massena AP	Republic AP
	Binghamton-Edwin A Link Field	Monticello AWOS	Rochester-Greater Rochester Intl AP
	Buffalo-Greater Buffalo Intl AP	New York-Central Park	Saranac Lake-Adirondack Rgnl AP
	Elmira Rgnl AP	New York-J F Kennedy Intl AP	Syracuse-Hancock Intl AP
	Fort Drum-Wheeler Sack AAF	New York-LaGuardia AP	Utica-Oneida County AP
	Glens Falls-Bennett Mem AP	Newburgh-Stewart Intl AP	Watertown AP
	Islip-Long Island MacArthur AP	Niagara Falls Intl AP	Westhampton-Suffolk County AP
	Jamestown AWOS	Poughkeepsie-Dutchess County AP	White Plains-Westchester County AP

North Carolina	Asheville Rgnl AP	Goldsboro-Seymour Johnson AFB	New River MCAS
	Cape Hatteras	Greensboro-Piedmont Triad Intl AP	Pitt Greenville AP
	Charlotte-Douglas Intl AP	Hickory Rgnl AP	Raleigh-Durham Intl AP
	Cherry Point MCAS	Jacksonville AWOS	Rocky Mount-Wilson AP
	Elizabeth City CGAS	Kinston Stallings AFB	Southern Pines-Moore County AP
	Fayetteville Muni AP	Manteo-Dare County Rgnl AP	Wilmington Intl AP
	Fayetteville-Pope AFB	New Bern-Craven County Rgnl AP	Winston Salem-Smith Reynolds AP
	Fort Bragg-Simmons AAF		
North Dakota	Bismarck Muni AP	Grand Forks AFB	Minot AFB
	Devils Lake AWOS	Grand Forks Intl AP	Minot Intl AP
	Dickinson Muni AP	Jamestown Muni AP	Williston-Sloulin Field Intl AP
	Fargo-Hector Intl AP		
Ohio	Akron Canton Rgnl AP	Dayton Intl AP	Ohio State University AP
	Cincinnati Muni AP-Lunken Field	Dayton-Wright Patterson AFB	Toledo Express AP
	Cleveland-Burke Lakefront AP	Findlay AP	Youngstown Rgnl AP
	Cleveland-Hopkins Intl AP	Mansfield-Lahm Muni AP	Zanesville Muni AP
	Columbus-Port Columbus Intl AP		
Oklahoma	Altus AFB	Hobart Muni AP	Oklahoma City-Will Rogers World AP
	Bartlesville-Phillips Field	Lawton Muni AP	Ponca City Muni AP
	Clinton Sherman AP	McAlester Rgnl AP	Stillwater Rgnl AP
	Fort Sill-Henry Post AAF	Oklahoma City-Tinker AFB	Tulsa Intl AP
	Gage AP	Oklahoma City-Wiley Post Field	Vance AFB
Oregon	Astoria Rgnl AP	La Grande Muni AP	Portland-Hillsboro AP
	Aurora State AP	Lakeview AWOS	Portland-Troutdale AP
	Baker Muni AP	Medford-Rogue Valley Intl AP	Redmond-Roberts Field
	Burns Muni AP	North Bend Muni AP	Roseburg Rgnl AP
	Corvallis Muni AP	Pendleton-Eastern Oregon Rgnl AP	Salem-McNary Field
	Eugene-Mahlon Sweet AP	Portland Intl AP	Sexton Summit
	Klamath Falls Intl AP		
Pennsylvania	Allentown-Lehigh Valley Intl AP	Harrisburg Intl AP	Pittsburgh-Allegheny County AP
	Altoona-Blair County AP	Harrisburg-Capital City AP	Reading Mem AP-Spaatz Field

	Bradford Rgnl AP	Johnstown-Cambria County AP	State College-Penn State University
	Butler County AWOS	Lancaster AP	Washington AWOS
	DuBois-Jefferson County AP	Philadelphia Intl AP	Wilkes-Barre-Scranton Intl AP
	Erie Intl AP	Philadelphia-NE Philadelphia AP	Williamsport Rgnl AP
	Franklin-Chess Lemberon AP	Pittsburgh Intl AP	Willow Grove NAS
Rhode Island	Block Island State AP	Pawtucket AWOS	Providence-T F Green State AP
South Carolina	Anderson County AP	Florence Rgnl AP	Myrtle Beach AFB
	Beaufort MCAS	Greenville-Downtown AP	North Myrtle Beach-Grand Strand Field
	Charleston Intl AP	Greer Greenville-Spartanburg AP	Shaw AFB
	Columbia Metro AP		
South Dakota	Aberdeen Rgnl AP	Mitchell AWOS	Sioux Falls-Foss Field
	Brookings AWOS	Mobridge Muni AP	Watertown Muni AP
	Ellsworth AFB	Pierre Muni AP	Yankton-Chan Gurney Muni AP
	Huron Rgnl AP	Rapid City Rgnl AP	
Tennessee	Bristol-TriCities Rgnl AP	Dyersburg Muni AP	Memphis Intl AP
	Chattanooga-Lovell Field AP	Jackson-McKellar Sipes Rgnl AP	Nashville Intl AP
	Crossville Mem AP	Knoxville-McGhee Tyson AP	
Texas	Abilene Rgnl AP	El Paso Intl AP	Lufkin-Angelina Co AP
	Abilene-Dyess AFB	Fort Hood	Marfa AP
	Alice Intl AP	Fort Worth NAS	McAllen-Miller Intl AP
	Amarillo Intl AP	Fort Worth-Alliance AP	McGregor AWOS
	Austin-Camp Mabry	Fort Worth-Meacham AP	Midland Intl AP
	Austin-Mueller Muni AP	Fort Worth Stephenville-Clark Field	Mineral Wells Muni AP
	Brownsville-South Padre Island AP	Galveston	Nacogdoches AWOS
	Childress Muni AP	Georgetown AWOS	Palacios Muni AP
	College Station-Easterwood Field	Greenville Muni AP	Port Arthur-Jefferson Co AP
	Corpus Christi Intl AP	Harlingen-Valley Intl AP	Randolph AFB
	Corpus Christi NAS	Hondo Muni AP	Rockport-Aransas Co AP
	Cotulla AP	Houston-Bush Intercontinental AP	San Angelo-Mathis AP
	Cox Field	Houston-D W Hooks AP	San Antonio Intl AP
	Dalhart Muni AP	Houston-Ellington AFB	San Antonio-Kelly AFB
	Dallas-Addison AP	Houston-William P Hobby AP	San Antonio-Stinson AP

	Dallas-Fort Worth Intl AP	Killeen Muni AWOS	Sherman-Perrin
	Dallas-Love Field	Killeen-Fort Hood Rgnl AP	Tyler-Pounds Field
	Dallas-Redbird AP	Kingsville	Victoria Rgnl AP
	Del Rio	Laredo Intl AP	Waco Rgnl AP
	Del Rio-Laughlin AFB	Longview-Gregg County AP	Wichita Falls Muni AP
	Draughton-Miller Central Texas AP	Lubbock Intl AP	Wink-Winkler County AP
Utah	Blanding Muni AP	Moab-Canyonlands Field	Saint George AWOS
	Bryce Canyon AP	Ogden-Hill AFB	Salt Lake City Intl AP
	Cedar City Muni AP	Ogden-Hinkley AP	Vernal AP
	Delta Muni AP	Provo Muni AWOS	Wendover USAF Auxiliary Field
	Hanksville AP		
Vermont	Burlington Intl AP	Rutland State AP	Springfield-Hartnes State AP
	Montpelier AP		
Virginia	Abingdon-Virgina Highlands AP	Langley AFB	Oceana NAS
	Arlington-Ronald Reagan Washington Natl AP	Leesburg Muni AP-Godfrey Field	Petersburg Muni AP
	Blacksburg-Virginia Tech AP	Lynchburg Rgnl AP-Preston Glen Field	Pulaski-New River Valley AP
	Charlottesville-Albemarle County AP	Manassas Muni AWOS	Quantico MCAS
	Danville Rgnl AP	Marion-Wytheville-Mountain Empire AP	Richmond Intl AP
	Davison AAF	Martinsville-Blue Ridge AP	Roanoke Rgnl AP-Woodrum Field
	Farmville Muni AP	Melfa-Accomack County AP	Staunton-Shenandoah Valley Rgnl AP
	Franklin Muni AP	Newport News	Sterling-Washington Dulles Intl AP
	Fredericksburg-Shannon AP	Norfolk Intl AP	Winchester Rgnl AP
	Hillsville-Twin County AP	Norfolk NAS	Wise-Lonesome Pine AP
	Hot Springs-Ingalls Field		
Washington	Bellingham Intl AP	Pasco-Tri Cities AP	Stampede Pass
	Bremerton National AP	Port Angeles-William R Fairchild Intl AP	Tacoma Narrows AP
	Ephrata Muni AP	Pullman-Moscow Rgnl AP	Tacoma-McChord AFB
	Fairchild AFB	Quillayute State AP	The Dalles Muni AP
	Fort Lewis-Gray AAF	Renton Muni AP	Toledo-Winlock-Ed Carlson Mem AP
	Hanford	Seattle-Boeing Field	Walla Walla City-County AP

	Hoquiam AP	Seattle-Tacoma Intl AP	Wenatchee-Pangborn Mem AP
	Kelso AP	Snohomish County AP	Whidbey Island NAS
	Moses Lake-Grant County AP	Spokane Intl AP	Yakima Air Terminal-McAllister Field
	Olympia AP	Spokane-Felts Field	
West Virginia	Beckley-Raleigh County Mem AP	Elkins-Randolph County AP	Morgantown Muni-Hart Field
	Bluefield-Mercer County AP	Huntington-Tri State Walker Long Field	Parkersburg-Wood County-Gill Robb Wilson AP
	Charleston-Yeager AP	Lewisburg-Greenbrier Valley AP	Wheeling-Ohio County AP
	Clarksburg-Harrison Marion Rgnl AP	Martinsburg-Eastern WV Rgnl AP	
Wisconsin	Appleton-Outagamie County AP	Madison-Dane County Rgnl AP	Rhineland-Oneida County AP
	Eau Claire County AP	Manitowac Muni AWOS	Rice Lake Muni AP
	Ephraim AWOS	Marshfield Muni AP	Sturgeon Bay-Door County AP
	Green Bay-Austin Straubel Intl AP	Milwaukee-Mitchell Intl AP	Watertown Muni AP
	Janesville-Rock County AP	Minocqua-Woodruff-Lee Field	Wausau Muni AP
	La Crosse Muni AP	Mosinee-Central Wisconsin AP	Wittman Rgnl AP
	Lone Rock AP	Phillips-Price County AP	
Wyoming	Casper-Natrona County Intl AP	Greater Green River Intergalactic Spaceport	Rawlins Muni AP
	Cheyenne Muni AP	Jackson Hole AP	Riverton Rgnl AP
	Cody Muni AWOS	Lander-Hunt Field	Sheridan County AP
	Evanston-Uinta County AP-Burns Field	Laramie-General Brees Field	Worland Muni AP
	Gillette-Gillette County AP		
Pacific Islands	American Samoa	Tamuning-Won Pat Intl AP-GUAM	Wake Island
	Andersen AFB-GUAM	Kwajalein Atoll	
Puerto Rico	Aguadilla-Borinquen AP	Mercedita AP	San Juan Intl AP
	Mayaguez-Eugenio Maria de Hostos AP	Roosevelt Roads NAS	San Juan-Luis Munoz Marin Intl AP
Virgin Islands	Charlotte Amalie-Harry S Truman AP		
Alberta	Calgary	Fort McMurray	Lethbridge
	Edmonton	Grand Prairie	Medicine Hat
British Columbia	Abbotsford	Port Hardy	Smithers
	Comox	Prince George	Summerland

	Cranbrook	Prince Rupert	Vancouver
	Fort St John	Sandspit	Victoria
	Kamloops		
Manitoba	Brandon	The Pas	Winnipeg
	Churchill		
New Brunswick	Fredericton	Miramichi	Saint John
Newfoundland & Labrador	Battle Harbour	Goose	Stephenville
	Gander	St Johns	
Northwest Territories	Inuvik	Yellowknife	
Nova Scotia	Greenwood	Shearwater	Truro
	Sable Island	Sydney	
Nunavut	Resolute		
Ontario	Kingston	Ottawa	Timmins
	London	Sault Ste Marie	Toronto
	Mount Forest	Simcoe	Trenton
	Muskoka	Thunder Bay	Windsor
	North Bay		
Prince Edward Island	Charlottetown		
Quebec	Bagotville	Mont Joli	Roberval
	Baie Comeau	Montreal Intl AP	Schefferville
	Grindstone Island	Montreal Jean Brebeuf	Sept-Iles
	Kuujuarapik	Montreal Mirabel	Sherbrooke
	Kuujuaq	Nitchequon	St Hubert
	La Grande Riviere	Quebec	Ste Agathe des Monts
	Lake Eon	Riviere du Loup	Val d Or
Saskatchewan	Estevan	Regina	Swift Current
	North Battleford	Saskatoon	
Yukon	Whitehorse		

Appendix E – Building and Use-Area Types

Building type describes the original intent and construction characteristic of the buildings in a building set. Use-area type describes the current function and operating characteristics of the buildings within a building set. There are 2 different building classes within FEDS: civilian and military. These classes describe the general characteristic of the buildings; a "military" building or use-area type may be the most appropriate choice for a "civilian" building or use-area and vice versa.

E.1 Civilian Building and Use-Area Types

The civilian building and use-area types are the same as evaluated by DOE in the NBECS and RECS surveys.

Assembly

Examples: entertainment, recreational, religious, social/public/civic buildings
Characteristics: building for public gatherings

Education

Examples: preschool, elementary, junior high, senior high, college or university classrooms, vocational school
Characteristics: buildings that house technical classroom instruction

Food Sales

Examples: convenience store, market, bakery, supermarket, grocery store
Characteristics: retail or wholesale food selling

Food Service

Examples: cafeteria, carryout-service, full-service restaurant
Characteristics: preparation and sale of food and beverage for consumption

Health Care

Examples: hospital, mental health facility, rehabilitation facility, veterinary facility, clinics
Characteristics: diagnostic and treatment facilities for both inpatient and outpatient care

Lodging

Examples: hotel, motel, inn, boarding house, dormitory/sorority/fraternity, nursing home
Characteristics: multiple accommodations for short- or long-term residents

Mercantile and Service

Examples: retail sales, department stores, drugstores, post office
Characteristics: sales and displays of goods or services (excluding food)

Office

Examples: bank, financial office building, professional office building
Characteristics: general, professional, and administrative office spaces

Public Order/Safety

Examples: courthouse, fire station, jail/prison, penitentiary, police station, reformatory, sheriff's office

Characteristics: building used in the preservation of law and order or safety

Warehouse and Storage

Examples: warehouse, storage facility

Characteristics: building used to store good, manufactured products, merchandise, or raw material

Other

Examples:

Characteristics: not elsewhere classified

Single Family Detached

Examples: typical single family home

Characteristics: structure that provides living space for one household or family that is not attached to another living unit

Single Family Attached

Examples: town house, row house

Characteristics: structure that provides living space for one household or family that is attached to another living unit

2 to 4 Unit Multifamily

Examples: duplex, triplex, or four-plex

Characteristics: structure that has living quarters for two, three, or four families or households

5 or More Unit Multifamily

Examples: apartment building

Characteristics: structure that has living quarters for five or more families or households

Mobile Homes

Examples: trailer

Characteristics: structure that provides living space for one household or family that is not attached to another living unit and is built on a movable chassis

E.2 Military Building and Use-Area Types

The military building and use-area types were developed in conjunction with USA-CERL and are not intended to represent an official list of military buildings or categories. Rather, the list is intended to represent the range and type of buildings typically found on a military installation.

Administration

Examples: headquarter buildings, R&D offices

Similar Civilian Type: Office

Characteristics: sedentary activities, high lighting levels, approx. 2 occupants/100 square feet, highly regular schedule, heating and cooling present.

Barracks

Examples: UEPH, UOPH

Similar Civilian Type: Lodging, dormitories

Characteristics: long term occupancy, centralized bathing and laundry facilities, typically 1-2 occupants per room, residential type schedule.

Chapel

Examples: post chapel, unit chapel, chapel center facilities

Similar Civilian Type: church, Assembly

Characteristics: high occupancy density, low frequency occupancy, high ceilings

Clinic

Examples: dental and medical clinics

Similar Civilian Type: clinic, Health Care

Characteristics: no overnight stays, high density of specialty equipment, high lighting levels

Clubs

Examples: restaurant, officer and enlisted clubs, rod and gun clubs, golf club house

Similar Civilian Type: Food Service

Characteristics: table service, low number of meals served, typically no breakfast service, high density of food preparation and refrigeration equipment

Commissaries

Examples: grocery stores

Similar Civilian Type: Food Sales

Characteristics: high ceilings, high lighting density, high refrigeration density

Dining Halls

Examples: enlisted personnel dining, fast food restaurants, cafeterias, food malls

Similar Civilian Type: Food Service

Characteristics: self-service dining, long operating hours, large number of meals served, high food preparation and refrigeration equipment densities, high occupant density

Electronics

Examples: communication buildings, ADP, simulators, r&d electronics labs

Similar Civilian Type: None

Characteristics: very high density of electronic specialty equipment (computers, lab devices), cooling provided, potential special ventilation requirements

Exchange Facilities

Examples: banks, dry good retail, post offices, shopettes (convenience stores)

Similar Civilian Type: Mercantile and Service

Characteristics: high ceilings, regular schedules, high lighting density, typically metered and bills paid separately

Single Family Detached House

Examples:

Similar Civilian Type: Single Family Detached House

Characteristics: residential schedule, cooled regionally

Single Family Attached House

Examples:

Similar Civilian Type: Single Family Attached House

Characteristics: residential schedule, cooled regionally

Duplex

Examples:

Similar Civilian Type: 2 to 4 Unit Buildings (with modification)

Characteristics: residential schedule, cooled regionally

Multi-Family 3 or More Unit

Examples:

Similar Civilian Type: 5 or More Unit Buildings (with modification)

Characteristics: residential schedule, cooled regionally

Mobile Homes

Examples:

Similar Civilian Type: Mobile Homes

Characteristics: residential schedule, cooled regionally

Guest Houses

Examples: hotels, civilian dormitories, BEQ, BOQ

Similar Civilian Type: Lodging

Characteristics: short duration occupancy, lightly occupied over weekends, bathing facilities in each room, no laundry facilities, residential type schedule

Hangar

Examples: maintenance hangar, storage hangar

Similar Civilian Type: hangar (Other)

Characteristics: very large, semi-conditioned space, potential special ventilation requirements, high density of specialty equipment (e.g., power tools)

Hospital

Examples: hospital/clinic, medical center

Similar Civilian Type: hospital, Health Care

Characteristics: overnight stays, staffed 24-hours, high density of specialty equipment, always heated and cooled, more energy intensive than civilian hospitals (e.g., 20 ACH in operating suites)

Labs

Examples: medical/veterinary labs, r&d labs, chemical labs

Similar Civilian Type: None

Characteristics: high density of specialty equipment, special ventilation requirements, high lighting density

Laundry

Examples: institutional/commercial laundries and dry cleaning plants

Similar Civilian Type: None

Characteristics: process dominated consumption, special ventilation requirements

Morale, Welfare, and Recreation

Examples: libraries, bus terminals, scout building, theaters

Similar Civilian Type: Assembly

Characteristics: irregular or low frequency occupancy schedule, high occupancy density

Military Other

Examples: fuel dispensing buildings, detached restrooms, huts, kennels, plant (heating, cooling, electrical) buildings, pump houses, outdoor pool buildings

Similar Civilian Type: None

Characteristics: typically unheated, low equipment density--typically lighting only, low occupancy density

Production and/or Process

Examples: industrial buildings, foundries

Similar Civilian Type: None

Characteristics: process dominated consumption

Recreation

Examples: gyms, skating rinks, bowling alleys, indoor pools

Similar Civilian Type: None

Characteristics: high occupant activity level, high ventilation requirements, high ceilings

Schools and/or Training

Examples: dependant schools, dependant day care, training classrooms; no simulators (see ELECTRONICS)

Similar Civilian Type: Education

Characteristics: regularly scheduled occupancy, high occupant density, high lighting density, possible seasonal occupancy

Security

Examples: fire stations, confinement, guard stations, police stations

Similar Civilian Type: Public Order/Safety

Characteristics: typically 24-hour occupancy, office-like equipment and lighting densities, sedentary occupants

Shops

Examples: motor pools, aircraft, electric, heavy equipment, weapons, maintenance shops

Similar Civilian Type: None

Characteristics: semi-conditioned or unheated, high density of specialty equipment, potential special ventilation requirements

Storage

Examples: hazardous materials storage, ammunition storage

Similar Civilian Type: None

Characteristics: unheated and usually unoccupied

Warehouse

Examples: general purpose warehouse, shipping and receiving building

Similar Civilian Type: Warehouse

Characteristics: occupied, heated, high occupant activity level

Appendix F – FEDS Envelope Types

F.1 FEDS Floor Types

- **Slab on grade** – a concrete slab typically set on grade. Buildings with basements should typically also select a slab on grade floor type.
- **Crawlspace** – floor set above a crawlspace area that is typically partially ventilated such that the air within the crawlspace is generally between the building interior and outside ambient temperature conditions.
- **Pier** – similar to a high crawlspace, but with full airflow beneath the floor such that the underside of the bottom floor is exposed to outside ambient conditions. This type of construction is common along coastal areas to lift and protect occupied spaces from storm surges. This type can also be useful to model buildings that sit atop ventilated parking garages or have similar characteristics.

F.2 FEDS Wall Types

- **Wood siding over wood frame** – also includes vinyl or metal siding on a wood frame.
- **Masonry façade on wood frame** – standard wood frame with brick, stone, stucco, or other masonry exterior.
- **Masonry façade on masonry frame** – represents a solid masonry wall where both the outside surface and the structural wall is masonry. Also includes wood, plastic, or metal siding on masonry frame or concrete wall construction panel whether prefabricated or poured in place.
- **Masonry façade on steel frame** – steel frame with brick, stone, stucco, or other masonry exterior.
- **Pre-engineered metal** – outside walls which are factory fabricated aluminum or galvanized steel panel which are fastened to the building frame.

F.3 FEDS Roof Types

- **Built-up** – several layers of roofing felt with asphalt between and covered by a mineral-surfaced layer of a heavy asphalt coat embedded with gravel. Roof deck can be wood, concrete, or metal.
- **Pre-engineered metal** – light gauge metal roofing sheets (often corrugated).
- **Shingles or shakes** – pitched roof covered with a series of overlapping rows of roofing material, including wood, plastic, fiber glass, baked clay, tile, slate, asbestos, asphalt, and aluminum. A key distinguishing feature of this roof type is that there is typically an attic space in which insulation can be added.

F.4 FEDS Window Types

- **Commercial style** – “commercial style” refers to larger, single vision or fixed lite, punched windows that are typically non-operable and more common in newer commercial buildings. FEDS models their thermal and cost parameters based on a 48”x72” opening.
- **Residential style** – smaller, operable dual vision vertical windows (e.g., single or double hung). Thermal parameters and cost estimates are based on a typical 36” x 48” opening.

Note: despite the style names, select the most applicable window type regardless of whether you are modeling commercial or residential buildings.

Appendix G – Lighting Fixture Name Abbreviations

G.1 Exit Signs

Abbreviation		Description
EX1	EXIT – INC (2X20)	Two 20-watt incandescent lamps
EX2	EXIT – INC (2X15)	Two 15-watt incandescent lamps
EX3	EXIT – FL 1-PL9	One 9-watt compact fluorescent lamp
EX4	EXIT – FL 2-PL9	Two 9-watt compact fluorescent lamps
EX5	EXIT – FL RET 1-PL9	One 9-watt compact fluorescent lamp retrofit kit
EX6	EXIT – LED	Light emitting diode
EX7	EXIT – SELF LUMINOUS	Tritium gas self-luminous
EX8	EXIT – INC (2X25)	Two 25-watt incandescent lamps
EX9	EXIT – FLEX TUBE 8	Flexible tube, 8-watt fixture
EX10	EXIT – LED RETRO KIT	Light emitting diode retrofit kit
EX11	EXIT – PANEL	Light emitting capacitor (LEC)
EX12	EXIT – PANEL RETRO KIT	Light emitting capacitor (LEC) retrofit kit

G.2 Fluorescent

Fluorescent fixtures are based on a standard notation comprising codes that describe the different fixture parts. Fluorescent fixtures are further subdivided into fluorescent and compact fluorescent (CFL) fixtures. Compact fluorescent fixtures are discussed in the next subsection. The naming convention for fluorescent fixtures can be divided into five parts: dimension of the fixture, number of lamps, lamp type, ballast type, and reflector. As each part is described, an example will be given to illustrate how that part fits into the whole description based on a standard 4-40-watt lamp fixture.

Table 1 lists the possible fixture dimensions (**2X4 4F40T12 STD2 REF**). The fixture dimension is the size of the "box" that contains the lamps, ballasts, and reflectors, in feet.

The second part of the naming convention refers to the number of lamps contained within the fixture (**2X4 4F40T12 STD2 REF**). The number of lamps can vary from one to four lamps per fixture.

Dimensions	Common Fixture Types
1X4	One or two four-foot fluorescent lamps
2X4	One to four foot four fluorescent lamps, most commonly three or four lamps, or eight biax lamps
2X2	One or two U-shaped fluorescent lamps or two or four straight lamps
2X3	Six biax lamps
1X8	One or two eight-foot fluorescent lamps

Table 1. Fixture Dimensions

The third part of the naming convention refers to the type of lamp in the fixture (2X4 4F40T12 STD2 REF). The "T" number (T12, T8, or T5) describes the diameter of the lamp tube, in eighths of an inch; e.g., a T12 lamp has a diameter of 12/8 or 1.5 inches. Table 2 lists the possible lamp types and their descriptions.

Lamp Type	Description
F40T12	40-watt T12 lamp, 48-in. length
F40T12U	40-watt T12 U-shaped lamp, 22-in. length
F40T12ES	Energy saving 40-watt T12 lamp (approx. 34 watts), 48-in. length
F40T12UES	Energy saving 40-watt T12 U-shaped lamp (approx. 34 watts), 22-in. length
F40T12HO	High-output 40-watt T12 lamp (approx. 60 watts), 48-in. length
F32T8	32-watt T8 lamp, 48-in. length
F32T8U	32-watt T8 U-shaped lamp, 22-in. length
F25ST8	25-watt Super T8, 48-in. length
F28ST8	28-watt Super T8, 48-in. length
F30ST8	30-watt Super T8, 48-in. length
F32ST8	32-watt Super T8, 48-in. length
F28T5	28-watt T5 lamp, 46-in. length
F14T5	14-watt T5 lamp, 22-in. length
F54T5HO	High-output 54-watt T5 lamp, 46-in. length
F96T12	75-watt T12 lamp, 96-in. length
F96T12ES	Energy saving 75-watt T12 lamp (approx. 60 watts), 96-in. length
F96T12HO	High-output 75-watt T12 lamp (approx. 110 watts), 96-in. length
F96T8	T8 lamp, 96-in. length
F40BX	40-watt Biax lamp 22½-in. length

Table 2. Lamp Types

The fourth part of the naming convention refers to the type of ballast within the fixture (2X4 4F40T12 **STD2** REF). Table 3 lists the possible ballast types and their descriptions.

Ballast Type	Description
STD1	Standard magnetic ballast designed for one lamp
STD2	Standard magnetic ballast designed for two lamps; for four-lamp fixtures, two STD2s are used
STD1,2	Combination of one lamp and two lamp standard magnetic ballasts, for use with three-lamp fixtures
EEF1	Energy-efficient magnetic ballast designed for one lamp
EEF2	Energy-efficient magnetic ballast designed for two lamps; for four-lamp fixtures, two EEF2s are used
EEF1,2	Combination of one- and two-lamp energy-efficient magnetic ballasts, for use with three-lamp fixtures
ELC1	Electronic ballast designed for one lamp
ELC2	Electronic ballast designed for two lamps; for four-lamp fixtures, two ELC2s or one ELC4 can be used
ELC1,2	Combination of one- and two-lamp electronic ballasts, for use with three-lamp fixtures
ELC3	Electronic ballast designed for three lamps
ELC4	Electronic ballast designed for four lamps

Table 3. Ballast Type

The final part of the naming convention indicates whether a reflector is added to the fixture (2X4 4F40T12 STD2 **REF**). If the fixture is followed with "REF", a reflector is part of the fixture. If the fixture is not followed with the reflector indicator, then the fixture does not contain a reflector.

G.3 Compact Fluorescent

Abbreviation		Description
CF1	CFL 7 INTEGRAL UNIT ELC	7-watt compact fluorescent lamp w/integral electronic ballast
CF2	CFL 9 INTEGRAL UNIT ELC	9-watt compact fluorescent lamp w/integral electronic ballast
CF3	CFL 11 INTEGRAL UNIT ELC	11-watt compact fluorescent lamp w/integral electronic ballast
CF4	CFL 15 INTEGRAL UNIT ELC	15-watt compact fluorescent lamp w/integral electronic ballast
CF5	CFL 18 INTEGRAL UNIT ELC	18-watt compact fluorescent lamp w/integral electronic ballast
CF6	CFL 20 INTEGRAL UNIT ELC	20-watt compact fluorescent lamp w/integral electronic ballast
CF7	CFL 23 INTEGRAL UNIT ELC	23-watt compact fluorescent lamp w/integral electronic ballast
CF8	CFL 25 INTEGRAL UNIT ELC	25-watt compact fluorescent lamp w/integral electronic ballast

Abbreviation		Description
CF9	CFL 26 INTEGRAL UNIT ELC	26-watt compact fluorescent lamp w/integral electronic ballast
CF10	CFL 27 INTEGRAL UNIT ELC	27-watt compact fluorescent lamp w/integral electronic ballast
CF11	CFL 30 INTEGRAL UNIT ELC	30-watt compact fluorescent lamp w/integral electronic ballast
CF12	CFL 15 GLOBE UNIT	15-watt compact fluorescent globe lamp
CF13	CFL 18 GLOBE UNIT	18-watt compact fluorescent globe lamp
CF14	CFL 5 + BLST UNIT	5-watt compact fluorescent lamp and adapter assembly (obsolete)
CF15	CFL 7 + BLST UNIT	7-watt compact fluorescent lamp and adapter assembly (obsolete)
CF16	CFL 9 + BLST UNIT	9-watt compact fluorescent lamp and adapter assembly (obsolete)
CF17	CFL 2-9 + BLST UNIT	Two 9-watt compact fluorescent lamps and adapter assemblies (obsolete)
CF18	CFL 11 + BLST UNIT	11-watt compact fluorescent lamp and adapter assembly (obsolete)
CF19	CFL 13 + BLST UNIT	13-watt compact fluorescent lamp and adapter assembly (obsolete)
CF20	CFL 2-13 + BLST UNIT	Two 13-watt compact fluorescent lamps and adapter assemblies (obsolete)
CF21	CFL 15 + BLST UNIT	15-watt compact fluorescent lamp and adapter assembly (obsolete)
CF22	CFL 20 + BLST UNIT	20-watt compact fluorescent lamp and adapter assembly (obsolete)
CF23	CFL 7 CEIL FIXT	7-watt compact fluorescent hardwired ceiling fixture
CF24	CFL 11 CEIL FIXT	11-watt compact fluorescent hardwired ceiling fixture
CF25	CFL 15 CEIL FIXT	15-watt compact fluorescent hardwired ceiling fixture
CF26	CFL 2-11 CEIL FIXT	Hardwired ceiling fixture w/two 11-watt compact fluorescent lamps
CF27	CFL 2-15 CEIL FIXT	Hardwired ceiling fixture w/two 15-watt compact fluorescent lamps
CF28	CFL 7 WALL FIXT	7-watt compact fluorescent hardwired wall fixture
CF29	CFL 11 WALL FIXT	11-watt compact fluorescent hardwired wall fixture
CF30	CFL 15 WALL FIXT	15-watt compact fluorescent hardwired wall fixture
CF31	CFL 2-11 WALL FIXT	Hardwired wall fixture w/two 11-watt compact fluorescent lamps
CF32	CFL 2-15 WALL FIXT	Hardwired wall fixture w/two 15-watt compact fluorescent lamps
CF33	CFL 7 CAN	7-watt compact fluorescent hardwired recessed can fixture

Abbreviation		Description
CF34	CFL 11 CAN	11-watt compact fluorescent hardwired recessed can fixture
CF35	CFL 15 CAN	15-watt compact fluorescent hardwired recessed can fixture
CF36	CFL 13 INTEGRAL UNIT ELC	13-watt compact fluorescent lamp w/integral electronic ballast
CF37	CFL 32 INTEGRAL UNIT ELC	32-watt compact fluorescent lamp w/integral electronic ballast
CF38	CFL 42 INTEGRAL UNIT ELC	42-watt compact fluorescent lamp w/integral electronic ballast
CF39	CFL 55 INTEGRAL UNIT ELC	55-watt compact fluorescent lamp w/integral electronic ballast
CF40	CFL 85 INTEGRAL UNIT ELC	85-watt compact fluorescent lamp w/integral electronic ballast
CF41	CFL 105 INTEGRAL UNIT ELC	105-watt compact fluorescent lamp w/integral electronic ballast
CF42	CFL 4 GLOBE UNIT	4-watt compact fluorescent globe lamp
CF43	CFL 9 GLOBE UNIT	9-watt compact fluorescent globe lamp
CF44	CFL 14 INTEGRAL FLOOD ELC	14-watt compact fluorescent flood lamp w/integral electronic ballast
CF45	CFL 16 INTEGRAL FLOOD ELC	16-watt compact fluorescent flood lamp w/integral electronic ballast
CF46	CFL 23 INTEGRAL FLOOD ELC	23-watt compact fluorescent flood lamp w/integral electronic ballast
CF47	CFL 27 INTEGRAL FLOOD ELC	27-watt compact fluorescent flood lamp w/integral electronic ballast
CF48	CFL 18 + BLST UNIT (Obsolete)	18-watt compact fluorescent lamp and adapter assembly (obsolete)
CF49	CFL 26 + BLST UNIT (Obsolete)	26-watt compact fluorescent lamp and adapter assembly (obsolete)
CF50	CFL 20 INTEGRAL FLOOD ELC	20-watt compact fluorescent lamp w/integral electronic ballast
CF51	CFL 30 INTEGRAL FLOOD ELC	30-watt compact fluorescent lamp w/integral electronic ballast
CF52	CFL 2-9 CAN	Can light w/two 9-watt compact fluorescent lamps
CF53	CFL 2-11 CAN	Can light w/two 11-watt compact fluorescent lamps
CF54	CFL 2-13 CAN	Can light w/two 13-watt compact fluorescent lamps
CF55	CFL 2-15 CAN	Can light w/two 15-watt compact fluorescent lamps
CF56	CFL 120 INTEGRAL UNIT ELC	120-watt compact fluorescent lamp w/integral electronic ballast
CF57	CFL 150 INTEGRAL UNIT ELC	150-watt compact fluorescent lamp w/integral electronic ballast
CF58	CFL 180 INTEGRAL UNIT ELC	180-watt compact fluorescent lamp w/integral electronic ballast
CF59	CFL 200 INTEGRAL UNIT ELC	200-watt compact fluorescent lamp w/integral electronic ballast
CF60	CFL 2-18 CEIL FIXT	Hardwired ceiling fixture w/two 18-watt compact fluorescent lamps

Abbreviation		Description
CF61	CFL 2-26 CEIL FIXT	Hardwired ceiling fixture w/two 26-watt compact fluorescent lamps
CF62	CFL 2-18 CAN	Can light w/two 18-watt compact fluorescent lamps
CF63	CFL 2-26 CAN	Can light w/two 26-watt compact fluorescent lamps

G.4 High-Pressure Sodium

Abbreviation		Description
HS1	HPS 35 POLE	35-watt high-pressure sodium pole fixture
HS2	HPS 50 POLE	50-watt high-pressure sodium pole fixture
HS3	HPS 70 POLE	70-watt high-pressure sodium pole fixture
HS4	HPS 100 POLE	100-watt high-pressure sodium pole fixture
HS5	HPS 150 POLE	150-watt high-pressure sodium pole fixture
HS6	HPS 200 POLE	200-watt high-pressure sodium pole fixture
HS7	HPS 250 POLE	250-watt high-pressure sodium pole fixture
HS8	HPS 310 POLE	310-watt high-pressure sodium pole fixture
HS9	HPS 400 POLE	400-watt high-pressure sodium pole fixture
HS10	HPS 1000 POLE	1000-watt high-pressure sodium pole fixture
HS11	HPS 35 PEND	35-watt high-pressure sodium pendant fixture
HS12	HPS 50 PEND	50-watt high-pressure sodium pendant fixture
HS13	HPS 70 PEND	70-watt high-pressure sodium pendant fixture
HS14	HPS 100 PEND	100-watt high-pressure sodium pendant fixture
HS15	HPS 150 PEND	150-watt high-pressure sodium pendant fixture
HS16	HPS 200 PEND	200-watt high-pressure sodium pendant fixture
HS17	HPS 250 PEND	250-watt high-pressure sodium pendant fixture
HS18	HPS 310 PEND	310-watt high-pressure sodium pendant fixture
HS19	HPS 400 PEND	400-watt high-pressure sodium pendant fixture
HS20	HPS 1000 PEND	1000-watt high-pressure sodium pendant fixture
HS21	HPS 35 WALL	35-watt high-pressure sodium wall fixture
HS22	HPS 50 WALL	50-watt high-pressure sodium wall fixture
HS23	HPS 70 WALL	70-watt high-pressure sodium wall fixture
HS24	HPS 100 WALL	100-watt high-pressure sodium wall fixture

Abbreviation		Description
HS25	HPS 150 WALL	150-watt high-pressure sodium wall fixture
HS26	HPS 200 WALL	200-watt high-pressure sodium wall fixture
HS27	HPS 250 WALL	250-watt high-pressure sodium wall fixture
HS28	HPS 310 WALL	310-watt high-pressure sodium wall fixture
HS29	HPS 400 WALL	400-watt high-pressure sodium wall fixture
HS30	HPS 35 FLD	35-watt high-pressure sodium floodlight
HS31	HPS 70 FLD	70-watt high-pressure sodium floodlight
HS32	HPS 50 CAN	50-watt high-pressure sodium can fixture
HS33	HPS 70 CAN	70-watt high-pressure sodium can fixture
HS34	HPS 100 CAN	100-watt high-pressure sodium can fixture
HS35	HPS 150 REP FOR MV PEND	150-watt high-pressure sodium lamp for merc. vapor pendant fixture
HS36	HPS 215 REP FOR MV PEND	215-watt high-pressure sodium lamp for merc. vapor pendant fixture
HS37	HPS 220 REP FOR MV PEND	220-watt high-pressure sodium lamp for merc. vapor pendant fixture
HS38	HPS 360 REP FOR MV PEND	360-watt high-pressure sodium lamp for merc. vapor pendant fixture
HS39	HPS 880 REP FOR MV PEND	880-watt high-pressure sodium lamp for merc. vapor pendant fixture
HS40	HPS 940 REP FOR MV PEND	940-watt high-pressure sodium lamp for merc. vapor pendant fixture
HS41	HPS 150 REP FOR MV WALL	150-watt high-pressure sodium lamp for merc. vapor wall fixture
HS42	HPS 215 REP FOR MV WALL	215-watt high-pressure sodium lamp for merc. vapor wall fixture
HS43	HPS 220 REP FOR MV WALL	220-watt high-pressure sodium lamp for merc. vapor wall fixture
HS44	HPS 360 REP FOR MV WALL	360-watt high-pressure sodium lamp for merc. vapor wall fixture
HS45	HPS 880 REP FOR MV WALL	880-watt high-pressure sodium lamp for merc. vapor wall fixture
HS46	HPS 940 REP FOR MV WALL	940-watt high-pressure sodium lamp for merc. vapor wall fixture
HS47	HPS 150 REP FOR MV POLE	150-watt high-pressure sodium lamp for merc. vapor pole fixture
HS48	HPS 215 REP FOR MV POLE	215-watt high-pressure sodium lamp for merc. vapor pole fixture
HS49	HPS 220 REP FOR MV POLE	220-watt high-pressure sodium lamp for merc. vapor pole fixture

Abbreviation		Description
HS50	HPS 360 REP FOR MV POLE	360-watt high-pressure sodium lamp for merc. vapor pole fixture
HS51	HPS 880 REP FOR MV POLE	880-watt high-pressure sodium lamp for merc. vapor pole fixture
HS52	HPS 940 REP FOR MV POLE	940-watt high-pressure sodium lamp for merc. vapor pole fixture
HS53	HPS 70 IS PEND	70-watt high-pressure sodium instant start pendant fixture
HS54	HPS 100 IS PEND	100-watt high-pressure sodium instant start pendant fixture
HS55	HPS 150 IS PEND	150-watt high-pressure sodium instant start pendant fixture
HS56	HPS 250 IS PEND	250-watt high-pressure sodium instant start pendant fixture
HS57	HPS 400 IS PEND	400-watt high-pressure sodium instant start pendant fixture
HS58	HPS 70 IS WALL	70-watt high-pressure sodium instant start wall fixture
HS59	HPS 100 IS WALL	100-watt high-pressure sodium instant start wall fixture
HS60	HPS 150 IS WALL	150-watt high-pressure sodium instant start wall fixture
HS61	HPS 250 IS WALL	250-watt high-pressure sodium instant start wall fixture
HS62	HPS 400 IS WALL	400-watt high-pressure sodium instant start wall fixture
HS63	HPS 70 IS POLE	70-watt high-pressure sodium instant start pole fixture
HS64	HPS 100 IS POLE	100-watt high-pressure sodium instant start pole fixture
HS65	HPS 150 IS POLE	150-watt high-pressure sodium instant start pole fixture
HS66	HPS 250 IS POLE	250-watt high-pressure sodium instant start pole fixture
HS67	HPS 400 IS POLE	400-watt high-pressure sodium instant start pole fixture
HS68	HPS 35 WL PEND	35-watt high-pressure sodium "white light" pendant fixture
HS69	HPS 50 WL PEND	50-watt high-pressure sodium "white light" pendant fixture
HS70	HPS 100 WL PEND	100-watt high-pressure sodium "white light" pendant fixture

Abbreviation		Description
HS71	HPS 35 WL WALL	35-watt high-pressure sodium "white light" wall fixture
HS72	HPS 50 WL WALL	50-watt high-pressure sodium "white light" wall fixture
HS73	HPS 100 WL WALL	100-watt high-pressure sodium "white light" wall fixture
HS74	HPS 35 WL POLE	35-watt high-pressure sodium "white light" pole fixture
HS75	HPS 50 WL POLE	50-watt high-pressure sodium "white light" pole fixture
HS76	HPS 100 WL POLE	100-watt high-pressure sodium "white light" pole fixture
HS77	HPS 150 REP FOR MH PEND	150-watt high-pressure sodium lamp for metal halide pendant fixture
HS78	HPS 215 REP FOR MH PEND	215-watt high-pressure sodium lamp for metal halide pendant fixture
HS79	HPS 220 REP FOR MH PEND	220-watt high-pressure sodium lamp for metal halide pendant fixture
HS80	HPS 360 REP FOR MH PEND	360-watt high-pressure sodium lamp for metal halide pendant fixture
HS81	HPS 880 REP FOR MH PEND	880-watt high-pressure sodium lamp for metal halide pendant fixture
HS82	HPS 940 REP FOR MH PEND	940-watt high-pressure sodium lamp for metal halide pendant fixture
HS83	HPS 150 REP FOR MH WALL	150-watt high-pressure sodium lamp for metal halide wall fixture
HS84	HPS 215 REP FOR MH WALL	215-watt high-pressure sodium lamp for metal halide wall fixture
HS85	HPS 220 REP FOR MH WALL	220-watt high-pressure sodium lamp for metal halide wall fixture
HS86	HPS 360 REP FOR MH WALL	360-watt high-pressure sodium lamp for metal halide wall fixture
HS87	HPS 880 REP FOR MH WALL	880-watt high-pressure sodium lamp for metal halide wall fixture
HS88	HPS 940 REP FOR MH WALL	940-watt high-pressure sodium lamp for metal halide wall fixture
HS89	HPS 150 REP FOR MH POLE	150-watt high-pressure sodium lamp for metal halide pole fixture
HS90	HPS 215 REP FOR MH POLE	215-watt high-pressure sodium lamp for metal halide pole fixture
HS91	HPS 220 REP FOR MH POLE	220-watt high-pressure sodium lamp for metal halide pole fixture

Abbreviation		Description
HS92	HPS 360 REP FOR MH POLE	360-watt high-pressure sodium lamp for metal halide pole fixture
HS93	HPS 880 REP FOR MH POLE	880-watt high-pressure sodium lamp for metal halide pole fixture
HS94	HPS 940 REP FOR MH POLE	940-watt high-pressure sodium lamp for metal halide pole fixture
HS95	HPS 70 POLE ELC	70-watt high-pressure sodium pole fixture w/electronic ballast
HS96	HPS 70 PEND ELC	70-watt high-pressure sodium pendant fixture w/electronic ballast
HS97	HPS 70 WALL ELC	70-watt high-pressure sodium wall fixture w/electronic ballast
HS98	HPS 70 FLD ELC	70-watt high-pressure sodium floodlight w/electronic ballast
HS99	HPS 70 CAN ELC	70-watt high-pressure sodium can fixture w/electronic ballast
HS100	HPS 100 POLE ELC	100-watt high-pressure sodium pole fixture w/electronic ballast
HS101	HPS 100 PEND ELC	100-watt high-pressure sodium pendant fixture w/electronic ballast
HS102	HPS 100 WALL ELC	100-watt high-pressure sodium wall fixture w/electronic ballast
HS103	HPS 100 CAN ELC	100-watt high-pressure sodium can fixture w/electronic ballast

G.5 Incandescent

Abbreviation		Description
IN1	INC 40 CEIL	40-watt incandescent ceiling fixture
IN2	INC 2-40 CEIL	Incandescent ceiling fixture w/two 40-watt lamps
IN3	INC 3-40 CEIL	Incandescent ceiling fixture w/three 40-watt lamps
IN4	INC 4-40 CEIL	Incandescent ceiling fixture w/four 40-watt lamps
IN5	INC 60 CEIL	60-watt incandescent ceiling fixture
IN6	INC 2-60 CEIL	Incandescent ceiling fixture w/two 60-watt lamps
IN7	INC 3-60 CEIL	Incandescent ceiling fixture w/three 60-watt lamps
IN8	INC 75 CEIL	75-watt incandescent ceiling fixture
IN9	INC 2-75 CEIL	Incandescent ceiling fixture w/two 75-watt lamps
IN10	INC 3-75 CEIL	Incandescent ceiling fixture w/three 75-watt lamps

IN11	INC 100 CEIL	100-watt incandescent ceiling fixture
IN12	INC 2-100 CEIL	Incandescent ceiling fixture w/two 100-watt lamps
IN13	INC 25 TABLE LAMP	25-watt incandescent table lamp
IN14	INC 40 TABLE LAMP	40-watt incandescent table lamp
IN15	INC 60 TABLE LAMP	60-watt incandescent table lamp
IN16	INC 75 TABLE LAMP	75-watt incandescent table lamp
IN17	INC 100 TABLE LAMP	100-watt incandescent table lamp
IN18	INC 25 WALL	25-watt incandescent wall fixture
IN19	INC 40 WALL	40-watt incandescent wall fixture
IN20	INC 2-40 WALL	Incandescent wall fixture w/two 40-watt lamps
IN21	INC 3-40 WALL	Incandescent wall fixture w/three 40-watt lamps
IN22	INC 4-40 WALL	Incandescent wall fixture w/four 40-watt lamps
IN23	INC 60 WALL	60-watt incandescent wall fixture
IN24	INC 2-60 WALL	Incandescent wall fixture w/two 60-watt lamps
IN25	INC 75 WALL	75-watt incandescent wall fixture
IN26	INC 2-75 WALL	Incandescent wall fixture w/two 75-watt lamps
IN27	INC 100 WALL	100-watt incandescent wall fixture
IN28	INC 150 PEND	150-watt incandescent pendant fixture
IN29	INC 200 PEND	200-watt incandescent pendant fixture
IN30	INC 300 PEND	300-watt incandescent pendant fixture
IN31	INC 40 CAN	40-watt incandescent can fixture
IN32	INC 60 CAN	60-watt incandescent can fixture
IN33	INC 75 CAN	75-watt incandescent can fixture
IN34	INC 100 CAN	100-watt incandescent can fixture
IN35	INC 40 FLD	40-watt incandescent floodlight
IN36	INC 60 FLD	60-watt incandescent floodlight
IN37	INC 75 FLD	75-watt incandescent floodlight
IN38	INC 100 FLD	100-watt incandescent floodlight
IN39	INC 150 FLD	150-watt incandescent floodlight
IN40	INC 200 FLD	200-watt incandescent floodlight
IN41	INC 250 FLD	250-watt incandescent floodlight
IN42	INC 500 FLD	500-watt incandescent floodlight

G.6 Halogen

Abbreviation		Description
HI1	HAL 20 PAR	20-watt halogen parabolic aluminized reflector (PAR) lamp
HI2	HAL 35 PAR	35-watt halogen PAR lamp
HI3	HAL 40 PAR	40-watt halogen PAR lamp
HI4	HAL 45 PAR	45-watt halogen PAR lamp
HI5	HAL 50 PAR	50-watt halogen PAR lamp
HI6	HAL 60 PAR	60-watt halogen PAR lamp
HI7	HAL 65 PAR	65-watt halogen PAR lamp
HI8	HAL 70 PAR	70-watt halogen PAR lamp
HI9	HAL 75 PAR	75-watt halogen PAR lamp
HI10	HAL 85 PAR	85-watt halogen PAR lamp
HI11	HAL 90 PAR	90-watt halogen PAR lamp
HI12	HAL 100 PAR	100-watt halogen PAR lamp
HI13	HAL 120 PAR	120-watt halogen PAR lamp
HI14	HAL 250 PAR	250-watt halogen PAR lamp
HI15	HAILIR 40 PAR	40-watt halogen infrared PAR lamp
HI16	HAILIR 45 PAR	45-watt halogen infrared PAR lamp
HI17	HAILIR 48 PAR	48-watt halogen infrared PAR lamp
HI18	HAILIR 55 PAR	55-watt halogen infrared PAR lamp
HI19	HAILIR 60 PAR	60-watt halogen infrared PAR lamp
HI20	HAILIR 67 PAR	67-watt halogen infrared PAR lamp
HI21	HAILIR 70 PAR	70-watt halogen infrared PAR lamp
HI22	HAILIR 83 PAR	83-watt halogen infrared PAR lamp
HI23	HAILIR 100 PAR	100-watt halogen infrared PAR lamp
HI24	HAL 20 MR16 (12V) SPOT	20-watt halogen 2" multifaceted reflector (MR) spot lamp
HI25	HAL 35 MR16 (12V) SPOT	35-watt halogen 2" multifaceted reflector (MR) spot lamp
HI26	HAL 50 MR16 (12V) SPOT	50-watt halogen 2" multifaceted reflector (MR) spot lamp
HI27	HAL 75 MR16 (12V) SPOT	75-watt halogen 2" multifaceted reflector (MR) spot lamp
HI28	HAL 100 MR16 (12V) SPOT	100-watt halogen 2" multifaceted reflector (MR) spot lamp
HI29	HAL 20 MR16 (12V) FLOOD	20-watt halogen 2" multifaceted reflector (MR) flood lamp

HI30	HAL 35 MR16 (12V) FLOOD	35-watt halogen 2" multifaceted reflector (MR) flood lamp
HI31	HAL 50 MR16 (12V) FLOOD	50-watt halogen 2" multifaceted reflector (MR) flood lamp
HI32	HAL 75 MR16 (12V) FLOOD	75-watt halogen 2" multifaceted reflector (MR) flood lamp
HI33	HAL 100 MR16 (12V) FLOOD	100-watt halogen 2" multifaceted reflector (MR) flood lamp
HI34	HAL 20 MR11 (12V) SPOT	20-watt halogen 1.375" multifaceted reflector (MR) spot lamp
HI35	HAL 35 MR11 (12V) SPOT	35-watt halogen 1.375" multifaceted reflector (MR) spot lamp
HI36	HAL 20 MR11 (12V) FLOOD	20-watt halogen 1.375" multifaceted reflector (MR) flood lamp
HI37	HAL 35 MR11 (12V) FLOOD	35-watt halogen 1.375" multifaceted reflector (MR) flood lamp

G.7 Induction

Abbreviation		Description
IL1	INDUCTION 150Wx1 High Bay	High bay induction fixture w/one 150-watt lamp
IL2	INDUCTION 150Wx2 High Bay	High bay induction fixture w/two 150-watt lamps
IL3	INDUCTION 150Wx3 High Bay	High bay induction fixture w/three 150-watt lamps
IL4	INDUCTION 85W Low Bay	Low bay induction fixture w/one 85-watt lamp
IL5	INDUCTION 100W Low Bay	Low bay induction fixture w/one 100-watt lamp

G.8 Light Emitting Diode (LED)

Abbreviation		Description
LD1	LED 3W A-Line (200 Lumens)	3-watt A-Line screw-in LED lamp
LD2	LED 5W A-Line (350 Lumens)	5 -watt A-Line screw-in LED lamp
LD3	LED 7W A-Line (500 Lumens)	7-watt A-Line screw-in LED lamp
LD4	LED 11W A-Line (850 Lumens)	11-watt A-Line screw-in LED lamp
LD5	LED 15W A-Line (1200 Lumens)	15-watt A-Line screw-in LED lamp

Abbreviation		Description
LD6	LED 20W A-Line (1700 Lumens)	20-watt A-Line screw-in LED lamp
LD7	LED 30W A-Line (2850 Lumens)	30-watt A-Line screw-in LED lamp
LD8	LED 40W A-Line (4000 Lumens)	40-watt A-Line screw-in LED lamp
LD9	LED 52W A-Line (5800 Lumens)	52-watt A-Line screw-in LED lamp
LD30	LED 4W MR16 SPOT (240 Lumens)	4-watt pin-based MR16 spot LED lamp
LD31	LED 7W MR16 SPOT (490 Lumens)	7-watt pin-based MR16 spot LED lamp
LD35	LED 4W MR16 FLOOD (240 Lumens)	4-watt pin-based MR16 flood LED lamp
LD36	LED 7W MR16 FLOOD (490 Lumens)	7-watt pin-based MR16 flood LED lamp
LD40	LED 4W MR11 SPOT (240 Lumens)	4-watt pin-based MR11 spot LED lamp
LD41	LED 7W MR11 SPOT (490 Lumens)	7-watt pin-based MR11 spot LED lamp
LD45	LED 4W MR11 FLOOD (240 Lumens)	4-watt pin-based MR11 flood LED lamp
LD46	LED 7W MR11 FLOOD (490 Lumens)	7-watt pin-based MR11 flood LED lamp
LD70	LED 4W Reflector Lamp (240 Lumens)	4-watt screw-in LED reflector lamp
LD71	LED 5W Reflector Lamp (350 Lumens)	5-watt screw-in LED reflector lamp
LD72	LED 7W Reflector Lamp (450 Lumens)	7-watt screw-in LED reflector lamp
LD73	LED 8W Reflector Lamp (500 Lumens)	8-watt screw-in LED reflector lamp
LD74	LED 9W Reflector Lamp (575 Lumens)	9-watt screw-in LED reflector lamp
LD75	LED 10W Reflector Lamp (630 Lumens)	10-watt screw-in LED reflector lamp
LD76	LED 11W Reflector Lamp (750 Lumens)	11-watt screw-in LED reflector lamp
LD77	LED 13W Reflector Lamp (850 Lumens)	13-watt screw-in LED reflector lamp
LD78	LED 14W Reflector Lamp (900 Lumens)	14-watt screw-in LED reflector lamp
LD79	LED 14W Reflector Lamp (950 Lumens)	14-watt screw-in LED reflector lamp
LD80	LED 15W Reflector Lamp (1000 Lumens)	15-watt screw-in LED reflector lamp
LD81	LED 16W Reflector Lamp (1050 Lumens)	16-watt screw-in LED reflector lamp
LD82	LED 18W Reflector Lamp (1200 Lumens)	18-watt screw-in LED reflector lamp
LD83	LED 25W Reflector Lamp (1750 Lumens)	25-watt screw-in LED reflector lamp

Abbreviation		Description
LD84	LED 39W Reflector Lamp (2850 Lumens)	39-watt screw-in LED reflector lamp
LD85	LED 53W Reflector Lamp (4000 Lumens)	53-watt screw-in LED reflector lamp
LD86	LED 62W Reflector Lamp (4850 Lumens)	62-watt screw-in LED reflector lamp
LD87	LED 116W Reflector Lamp (10500 Lumens)	116-watt screw-in LED reflector lamp
LD110	LED 8W Can Fixture Repl (500 Lumens)	8-watt hardwired LED can fixture
LD111	LED 15W Can Fixture Repl (1000 Lumens)	15-watt hardwired LED can fixture
LD112	LED 23W Can Fixture Repl (1500 Lumens)	23-watt hardwired LED can fixture
LD113	LED 31W Can Fixture Repl (2000 Lumens)	31-watt hardwired LED can fixture
LD114	LED 39W Can Fixture Repl (2500 Lumens)	39-watt hardwired LED can fixture
LD150	LED 19Wx1 4' 25W ST8 Lamp Repl (2110 Lumens/Lamp)	One 4-foot 19-watt LED replacement lamp for a 25-watt super T8 lamp
LD151	LED 19Wx2 4' 25W ST8 Lamp Repl (2110 Lumens/Lamp)	Two 4-foot 19-watt LED replacement lamps for 25-watt super T8 lamps
LD152	LED 19Wx3 4' 25W ST8 Lamp Repl (2110 Lumens/Lamp)	Three 4-foot 19-watt LED replacement lamps for 25-watt super T8 lamps
LD153	LED 19Wx4 4' 25W ST8 Lamp Repl (2110 Lumens/Lamp)	Four 4-foot 19-watt LED replacement lamps for 25-watt super T8 lamps
LD160	LED 19Wx1 4' 25W ST8 REF Lamp Repl (2110 Lumens/Lamp)	One 4-foot 19-watt LED replacement lamp for a 25-watt super T8 lamp in a fixture with a reflector
LD161	LED 19Wx2 4' 25W ST8 REF Lamp Repl (2110 Lumens/Lamp)	Two 4-foot 19-watt LED replacement lamps for 25W super T8 lamps in a fixture with a reflector
LD162	LED 19Wx3 4' 25W ST8 REF Lamp Repl (2110 Lumens/Lamp)	Three 4-foot 19-watt LED replacement lamps for 25W super T8 lamps in a fixture with a reflector
LD163	LED 19Wx4 4' 25W ST8 REF Lamp Repl (2110 Lumens/Lamp)	Four 4-foot 19-watt LED replacement lamps for 25W super T8 lamps in a fixture with a reflector
LD170	LED 21Wx1 4' 28W ST8 Lamp Repl (2330 Lumens/Lamp)	One 4-foot 21-watt LED replacement lamp for a 28-watt super T8 lamp
LD171	LED 21Wx2 4' 28W ST8 Lamp Repl (2330 Lumens/Lamp)	Two 4-foot 21-watt LED replacement lamps for 28-watt super T8 lamps
LD172	LED 21Wx3 4' 28W ST8 Lamp Repl (2330 Lumens/Lamp)	Three 4-foot 21-watt LED replacement lamps for 28-watt super T8 lamps

Abbreviation		Description
LD173	LED 21Wx4 4' 28W ST8 Lamp Repl (2330 Lumens/Lamp)	Four 4-foot 21-watt LED replacement lamps for 28-watt super T8 lamps
LD180	LED 21Wx1 4' 28W ST8 REF Lamp Repl (2330 Lumens/Lamp)	One 4-foot 21-watt LED replacement lamp for a 28-watt super T8 lamp in a fixture with a reflector
LD181	LED 21Wx2 4' 28W ST8 REF Lamp Repl (2330 Lumens/Lamp)	Two 4-foot 21-watt LED replacement lamps for 28-watt super T8 lamps in a fixture with a reflector
LD182	LED 21Wx3 4' 28W ST8 REF Lamp Repl (2330 Lumens/Lamp)	Three 4-foot 21-watt LED replacement lamps for 28-watt super T8 lamps in a fixture with a reflector
LD183	LED 21Wx4 4' 28W ST8 REF Lamp Repl (2330 Lumens/Lamp)	Four 4-foot 21-watt LED replacement lamps for 28-watt super T8 lamps in a fixture with a reflector
LD190	LED 23Wx1 4' 30W ST8/32W T8 Lamp Repl (2550 Lumens/Lamp)	One 4-foot 23-watt LED replacement lamp for a 30-watt super T8 lamp or 32-watt T8 lamp
LD191	LED 23Wx2 4' 30W ST8/32W T8 Lamp Repl (2550 Lumens/Lamp)	Two 4-foot 23-watt LED replacement lamps for 30-watt super T8 lamps or 32-watt T8 lamps
LD192	LED 23Wx3 4' 30W ST8/32W T8 Lamp Repl (2550 Lumens/Lamp)	Three 4-foot 23-watt LED replacement lamps for 30-watt super T8 lamps or 32-watt T8 lamps
LD193	LED 23Wx4 4' 30W ST8/32W T8 Lamp Repl (2550 Lumens/Lamp)	Four 4-foot 23-watt LED replacement lamps for 30-watt super T8 lamps or 32-watt T8 lamps
LD200	LED 23Wx1 4' 30W ST8/32W T8 REF Lamp Repl (2550 Lumens/Lamp)	One 4-foot 23-watt LED replacement lamp for a 30-watt super T8 lamp or 32-watt T8 lamp in a fixture with a reflector
LD201	LED 23Wx2 4' 30W ST8/32W T8 REF Lamp Repl (2550 Lumens/Lamp)	Two 4-foot 23-watt LED replacement lamps for 30-watt super T8 lamps or 32-watt T8 lamps in a fixture with a reflector
LD202	LED 23Wx3 4' 30W ST8/32W T8 REF Lamp Repl (2550 Lumens/Lamp)	Three 4-foot 23-watt LED replacement lamps for 30-watt super T8 lamps or 32-watt T8 lamps in a fixture with a reflector
LD203	LED 23Wx4 4' 30W ST8/32W T8 REF Lamp Repl (2550 Lumens/Lamp)	Four 4-foot 23-watt LED replacement lamps for 30-watt super T8 lamps or 32-watt T8 lamps in a fixture with a reflector
LD210	LED 25Wx1 4' 32W ST8 Lamp Repl (2730 Lumens/Lamp)	One 4-foot 25-watt LED replacement lamp for a 32-watt super T8 lamp

Abbreviation		Description
LD211	LED 25Wx2 4' 32W ST8 Lamp Repl (2730 Lumens/Lamp)	Two 4-foot 25-watt LED replacement lamps for 32-watt super T8 lamps
LD212	LED 25Wx3 4' 32W ST8 Lamp Repl (2730 Lumens/Lamp)	Three 4-foot 25-watt LED replacement lamps for 32-watt super T8 lamps
LD213	LED 25Wx4 4' 32W ST8 Lamp Repl (2730 Lumens/Lamp)	Four 4-foot 25-watt LED replacement lamps for 32-watt super T8 lamps
LD220	LED 25Wx1 4' 32W ST8 REF Lamp Repl (2730 Lumens/Lamp)	One 4-foot 25-watt LED replacement lamp for a 32-watt super T8 lamp in a fixture with a reflector
LD221	LED 25Wx2 4' 32W ST8 REF Lamp Repl (2730 Lumens/Lamp)	Two 4-foot 25-watt LED replacement lamps for 32-watt super T8 lamps in a fixture with a reflector
LD222	LED 25Wx3 4' 32W ST8 REF Lamp Repl (2730 Lumens/Lamp)	Three 4-foot 25-watt LED replacement lamps for 32-watt super T8 lamps in a fixture with a reflector
LD223	LED 25Wx4 4' 32W ST8 REF Lamp Repl (2730 Lumens/Lamp)	Four 4-foot 25-watt LED replacement lamps for 32-watt super T8 lamps in a fixture with a reflector
LD230	LED 10Wx2 2' 15W T8 Lamp Repl (1040 Lumens/Lamp)	Two 2-foot 10-watt LED replacement lamps for 15-watt T8 lamps
LD231	LED 10Wx3 2' 15W T8 Lamp Repl (1040 Lumens/Lamp)	Three 2-foot 10-watt LED replacement lamps for 15-watt T8 lamps
LD232	LED 10Wx4 2' 15W T8 Lamp Repl (1040 Lumens/Lamp)	Four 2-foot 10-watt LED replacement lamps for 15-watt T8 lamps
LD240	LED 10Wx2 2' 15W T8 REF Lamp Repl (1040 Lumens/Lamp)	Two 2-foot 10-watt LED replacement lamps for 15-watt T8 lamps in a fixture with a reflector
LD241	LED 10Wx3 2' 15W T8 REF Lamp Repl (1040 Lumens/Lamp)	Three 2-foot 10-watt LED replacement lamps for 15-watt T8 lamps in a fixture with a reflector
LD242	LED 10Wx4 2' 15W T8 REF Lamp Repl (1040 Lumens/Lamp)	Four 2-foot 10-watt LED replacement lamps for 15-watt T8 lamps in a fixture with a reflector
LD250	LED 12Wx2 2' 17W ST8 Lamp Repl (1150 Lumens/Lamp)	Two 2-foot 12-watt LED replacement lamps for 17-watt T8 lamps
LD251	LED 12Wx3 2' 17W ST8 Lamp Repl (1150 Lumens/Lamp)	Three 2-foot 10-watt LED replacement lamps for 17-watt T8 lamps
LD252	LED 12Wx4 2' 17W ST8 Lamp Repl (1150 Lumens/Lamp)	Four 2-foot 10-watt LED replacement lamps for 17-watt T8 lamps
LD260	LED 12Wx2 2' 17W ST8 REF Lamp Repl (1150 Lumens/Lamp)	Two 2-foot 10-watt LED replacement lamps for 17-watt T8 lamps in a fixture with a reflector

Abbreviation		Description
LD261	LED 12Wx3 2' 17W ST8 REF Lamp Repl (1150 Lumens/Lamp)	Three 2-foot 10-watt LED replacement lamps for 17-watt T8 lamps in a fixture with a reflector
LD262	LED 12Wx4 2' 17W ST8 REF Lamp Repl (1150 Lumens/Lamp)	Four 2-foot 10-watt LED replacement lamps for 17-watt T8 lamps in a fixture with a reflector
LD280	LED 34W 2x4 Fixture (3300 Lumens)	34-watt 2x4 LED fixture—fluorescent troffer replacement
LD281	LED 41W 2x4 Fixture (4000 Lumens)	41-watt 2x4 LED fixture—fluorescent troffer replacement
LD282	LED 51W 2x4 Fixture (5000 Lumens)	51-watt 2x4 LED fixture—fluorescent troffer replacement
LD283	LED 61W 2x4 Fixture (6000 Lumens)	61-watt 2x4 LED fixture—fluorescent troffer replacement
LD284	LED 71W 2x4 Fixture (7000 Lumens)	71-watt 2x4 LED fixture—fluorescent troffer replacement
LD300	LED 44W 2x4 Retrofit Panel (4678 Lumens)	44-watt 2x4 LED retrofit panel—fluorescent troffer replacement
LD301	LED 59W 2x4 Retrofit Panel (6227 Lumens)	59-watt 2x4 LED retrofit panel—fluorescent troffer replacement
LD320	LED 20W 1x4 Fixture (2000 Lumens)	20-watt 1x4 LED fixture—fluorescent troffer replacement
LD321	LED 34W 1x4 Fixture (3300 Lumens)	34-watt 1x4 LED fixture—fluorescent troffer replacement
LD322	LED 41W 1x4 Fixture (4000 Lumens)	41-watt 1x4 LED fixture—fluorescent troffer replacement
LD340	LED 34W 1x4 Retrofit Panel (2980 Lumens)	34-watt 1x4 LED retrofit panel—fluorescent troffer replacement
LD341	LED 41W 1x4 Retrofit Panel (3369 Lumens)	41-watt 1x4 LED retrofit panel—fluorescent troffer replacement
LD342	LED 52W 1x4 Retrofit Panel (4083 Lumens)	52-watt 1x4 LED retrofit panel—fluorescent troffer replacement
LD360	LED 20W 2x2 Fixture (2000 Lumens)	20-watt 2x2 LED fixture—fluorescent troffer replacement
LD361	LED 26W 2x2 Fixture (2500 Lumens)	26-watt 2x2 LED fixture—fluorescent troffer replacement
LD362	LED 31W 2x2 Fixture (3000 Lumens)	31-watt 2x2 LED fixture—fluorescent troffer replacement
LD363	LED 36W 2x2 Fixture (3500 Lumens)	36-watt 2x2 LED fixture—fluorescent troffer replacement
LD364	LED 41W 2x2 Fixture (4000 Lumens)	41-watt 2x2 LED fixture—fluorescent troffer replacement

Abbreviation		Description
LD380	LED 34W 2x2 Retrofit Panel (3430 Lumens)	34-watt 2x2 LED retrofit panel—fluorescent troffer replacement
LD381	LED 41W 2x2 Retrofit Panel (3904 Lumens)	41-watt 2x2 LED retrofit panel—fluorescent troffer replacement
LD382	LED 52W 2x2 Retrofit Panel (4679 Lumens)	52-watt 2x2 LED retrofit panel—fluorescent troffer replacement
LD430	LED 30W Low Bay Fixture (3500 Lumens)	30-watt LED low bay fixture
LD431	LED 34W Low Bay Fixture (4000 Lumens)	34-watt LED low bay fixture
LD432	LED 43W Low Bay Fixture (5000 Lumens)	43-watt LED low bay fixture
LD433	LED 51W Low Bay Fixture (6000 Lumens)	51-watt LED low bay fixture
LD460	LED 91W High Bay Fixture (10000 Lumens)	91-watt LED high bay fixture
LD461	LED 136W High Bay Fixture (15000 Lumens)	136-watt LED high bay fixture
LD462	LED 182W High Bay Fixture (20000 Lumens)	182-watt LED high bay fixture
LD463	LED 227W High Bay Fixture (25000 Lumens)	227-watt LED high bay fixture
LD464	LED 273W High Bay Fixture (30000 Lumens)	273-watt LED high bay fixture
LD465	LED 364W High Bay Fixture (40000 Lumens)	364-watt LED high bay fixture
LD466	LED 455W High Bay Fixture (50000 Lumens)	455-watt LED high bay fixture
LD467	LED 546W High Bay Fixture (60000 Lumens)	546-watt LED high bay fixture
LD500	LED 9W Wall Pack (1000 Lumens)	9-watt LED wall pack fixture
LD501	LED 19W Wall Pack (2000 Lumens)	19-watt LED wall pack fixture
LD502	LED 37W Wall Pack (4000 Lumens)	37-watt LED wall pack fixture
LD503	LED 56W Wall Pack (6000 Lumens)	56-watt LED wall pack fixture
LD504	LED 75W Wall Pack (8000 Lumens)	75-watt LED wall pack fixture
LD505	LED 111W Wall Pack (10000 Lumens)	111-watt LED wall pack fixture
LD506	LED 167W Wall Pack (15000 Lumens)	167-watt LED wall pack fixture
LD550	LED 20W Pole Lamp (2000 Lumens)	20-watt LED pole lamp fixture
LD551	LED 30W Pole Lamp (3000 Lumens)	30-watt LED pole lamp fixture
LD552	LED 40W Pole Lamp (4000 Lumens)	40-watt LED pole lamp fixture

Abbreviation		Description
LD553	LED 50W Pole Lamp (5000 Lumens)	50-watt LED pole lamp fixture
LD554	LED 60W Pole Lamp (6000 Lumens)	60-watt LED pole lamp fixture
LD555	LED 80W Pole Lamp (8000 Lumens)	80-watt LED pole lamp fixture
LD556	LED 120W Pole Lamp (12000 Lumens)	120-watt LED pole lamp fixture
LD557	LED 160W Pole Lamp (16000 Lumens)	160-watt LED pole lamp fixture
LD558	LED 240W Pole Lamp (24000 Lumens)	240-watt LED pole lamp fixture
LD559	LED 360W Pole Lamp (36000 Lumens)	360-watt LED pole lamp fixture

G.9 Low-Pressure Sodium

Abbreviation		Description
LS1	LPS 18 PEND	18-watt low-pressure sodium pendant fixture
LS2	LPS 35 PEND	35-watt low-pressure sodium pendant fixture
LS3	LPS 55 PEND	55-watt low-pressure sodium pendant fixture
LS4	LPS 90 PEND	90-watt low-pressure sodium pendant fixture
LS5	LPS 135 PEND	135-watt low-pressure sodium pendant fixture
LS6	LPS 180 PEND	180-watt low-pressure sodium pendant fixture
LS7	LPS 18 POLE	18-watt low-pressure sodium pole fixture
LS8	LPS 35 POLE	35-watt low-pressure sodium pole fixture
LS9	LPS 55 POLE	55-watt low-pressure sodium pole fixture
LS10	LPS 90 POLE	90-watt low-pressure sodium pole fixture
LS11	LPS 135 POLE	135-watt low-pressure sodium pole fixture
LS12	LPS 180 POLE	180-watt low-pressure sodium pole fixture
LS13	LPS 18 WALL	18-watt low-pressure sodium wall fixture
LS14	LPS 35 WALL	35-watt low-pressure sodium wall fixture
LS15	LPS 55 WALL	55-watt low-pressure sodium wall fixture
LS16	LPS 90 WALL	90-watt low-pressure sodium wall fixture
LS17	LPS 135 WALL	135-watt low-pressure sodium wall fixture
LS18	LPS 180 WALL	180-watt low-pressure sodium wall fixture

G.10 Metal Halide

Abbreviation		Description
MH1	MH 50 PEND	50-watt metal halide pendant fixture
MH2	MH 70 PEND	70-watt metal halide pendant fixture
MH3	MH 100 PEND	100-watt metal halide pendant fixture
MH4	MH 175 PEND	175-watt metal halide pendant fixture
MH5	MH 250 PEND	250-watt metal halide pendant fixture
MH6	MH 400 PEND	400-watt metal halide pendant fixture
MH7	MH 1000 PEND	1000-watt metal halide pendant fixture
MH8	MH 1500 PEND	1500-watt metal halide pendant fixture
MH9	MH 50 WALL	50-watt metal halide wall fixture
MH 10	MH 70 WALL	70-watt metal halide wall fixture
MH11	MH 100 WALL	100-watt metal halide wall fixture
MH12	MH 175 WALL	175-watt metal halide wall fixture
MH13	MH 250 WALL	250-watt metal halide wall fixture
MH14	MH 400 WALL	400-watt metal halide wall fixture
MH15	MH 1000 WALL	1000-watt metal halide wall fixture
MH16	MH 1500 WALL	1500-watt metal halide wall fixture
MH17	MH 50 POLE	50-watt metal halide pole fixture
MH18	MH 70 POLE	70-watt metal halide pole fixture
MH19	MH 100 POLE	100-watt metal halide pole fixture
MH20	MH 175 POLE	175-watt metal halide pole fixture
MH21	MH 250 POLE	250-watt metal halide pole fixture
MH22	MH 400 POLE	400-watt metal halide pole fixture
MH23	MH 1000 POLE	1000-watt metal halide pole fixture
MH24	MH 1500 POLE	1500-watt metal halide pole fixture
MH25	MH 50 CAN	50-watt metal halide can fixture
MH26	MH 70 CAN	70-watt metal halide can fixture
MH27	MH 750 WALL	750-watt metal halide wall fixture
MH28	MH 32 WALL	32-watt metal halide wall fixture
MH29	MH 32 PEND	32-watt metal halide pendant fixture
MH30	MH 750 POLE	750-watt metal halide pole fixture
MH31	MH 750 PEND	750-watt metal halide pendant fixture
MH32	MH 32 POLE	32-watt metal halide pole fixture
MH33	MH 70 HE PEND	70-watt metal halide high-efficiency pendant fixture

MH34	MH 150 HE PEND	150-watt metal halide high-efficiency pendant fixture
MH35	MH 175 HE PEND	175-watt metal halide high-efficiency pendant fixture
MH36	MH 250 HE PEND	250-watt metal halide high-efficiency pendant fixture
MH37	MH 400 HE PEND	400-watt metal halide high-efficiency pendant fixture
MH38	MH 1000 HE PEND	1000-watt metal halide high-efficiency pendant fixture
MH39	MH 70 HE WALL	70-watt metal halide high-efficiency wall fixture
MH40	MH 150 HE WALL	150-watt metal halide high-efficiency wall fixture
MH41	MH 175 HE WALL	175-watt metal halide high-efficiency wall fixture
MH42	MH 250 HE WALL	250-watt metal halide high-efficiency wall fixture
MH43	MH 400 HE WALL	400-watt metal halide high-efficiency wall fixture
MH44	MH 1000 HE WALL	1000-watt metal halide high-efficiency wall fixture
MH45	MH 70 HE POLE	70-watt metal halide high-efficiency pole fixture
MH46	MH 150 HE POLE	150-watt metal halide high-efficiency pole fixture
MH47	MH 175 HE POLE	175-watt metal halide high-efficiency pole fixture
MH48	MH 250 HE POLE	250-watt metal halide high-efficiency pole fixture
MH49	MH 400 HE POLE	400-watt metal halide high-efficiency pole fixture
MH50	MH 1000 HE POLE	1000-watt metal halide high-efficiency pole fixture
MH51	MH 32 POLE ELC	32-watt metal halide pole fixture w/electronic ballast
MH52	MH 50 PEND ELC	50-watt metal halide pendant fixture w/electronic ballast
MH53	MH 32 WALL ELC	32-watt metal halide wall fixture w/electronic ballast
MH54	MH 50 POLE ELC	50-watt metal halide pole fixture w/electronic ballast
MH55	MH 50 PEND ELC	50-watt metal halide pendant fixture w/electronic ballast
MH56	MH 50 WALL ELC	50-watt metal halide wall fixture w/electronic ballast
MH57	MH 50 CAN ELC	50-watt metal halide can fixture w/electronic ballast
MH58	MH 70 POLE ELC	70-watt metal halide pole fixture w/electronic ballast
MH59	MH 70 PEND ELC	70-watt metal halide pendant fixture w/electronic ballast

MH60	MH 70 WALL ELC	70-watt metal halide wall fixture w/electronic ballast
MH61	MH 70 CAN ELC	70-watt metal halide can fixture w/electronic ballast
MH62	MH 100 POLE ELC	100-watt metal halide pole fixture w/electronic ballast
MH 63	MH 100 PEND ELC	100-watt metal halide pendant fixture w/electronic ballast
MH64	MH 100 WALL ELC	100-watt metal halide wall fixture w/electronic ballast
MH65	MH 150 HE POLE ELC	150-watt metal halide high-efficiency pole fixture w/electronic ballast
MH66	MH 150 HE PEND ELC	150-watt metal halide high-efficiency pendant fixture w/electronic ballast
MH67	MH 150 HE WALL ELC	150-watt metal halide high-efficiency wall fixture w/electronic ballast

G.11 Mercury Vapor

Abbreviation		Description
MV1	MERC 50 PEND	50-watt mercury vapor pendant fixture
MV2	MERC 75 PEND	75-watt mercury vapor pendant fixture
MV3	MERC 100 PEND	100-watt mercury vapor pendant fixture
MV4	MERC 175 PEND	175-watt mercury vapor pendant fixture
MV5	MERC 250 PEND	250-watt mercury vapor pendant fixture
MV6	MERC 400 PEND	400-watt mercury vapor pendant fixture
MV7	MERC 700 PEND	700-watt mercury vapor pendant fixture
MV8	MERC 1000 PEND	1000-watt mercury vapor pendant fixture
MV9	MERC 50 POLE	50-watt mercury vapor pole fixture
MV10	MERC 75 POLE	75-watt mercury vapor pole fixture
MV11	MERC 100 POLE	100-watt mercury vapor pole fixture
MV12	MERC 175 POLE	175-watt mercury vapor pole fixture
MV13	MERC 250 POLE	250-watt mercury vapor pole fixture
MV14	MERC 400 POLE	400-watt mercury vapor pole fixture
MV15	MERC 700 POLE	700-watt mercury vapor pole fixture
MV16	MERC 1000 POLE	1000-watt mercury vapor pole fixture
MV17	MERC 50 WALL	50-watt mercury vapor wall fixture
MV18	MERC 75 WALL	75-watt mercury vapor wall fixture
MV19	MERC 100 WALL	100-watt mercury vapor wall fixture
MV20	MERC 175 WALL	175-watt mercury vapor wall fixture

MV21	MERC 250 WALL	250-watt mercury vapor wall fixture
MV22	MERC 400 WALL	400-watt mercury vapor wall fixture
MV23	MERC 700 WALL	700-watt mercury vapor wall fixture
MV24	MERC 1000 WALL	1000-watt mercury vapor wall fixture

Appendix H – Fixture Codes

Fixture Code	Fixture Name
CF1	CFL 7 INTEGRAL UNIT ELC
CF2	CFL 9 INTEGRAL UNIT ELC
CF3	CFL 11 INTEGRAL UNIT ELC
CF4	CFL 15 INTEGRAL UNIT ELC
CF5	CFL 18 INTEGRAL UNIT ELC
CF6	CFL 20 INTEGRAL UNIT ELC
CF7	CFL 23 INTEGRAL UNIT ELC
CF8	CFL 25 INTEGRAL UNIT ELC
CF9	CFL 26 INTEGRAL UNIT ELC
CF10	CFL 27 INTEGRAL UNIT ELC
CF11	CFL 30 INTEGRAL UNIT ELC
CF12	CFL 15 GLOBE UNIT
CF13	CFL 18 GLOBE UNIT
CF14	CFL 5 + BLST UNIT (Obsolete)
CF15	CFL 7 + BLST UNIT (Obsolete)
CF16	CFL 9 + BLST UNIT (Obsolete)
CF17	CFL 2-9 + BLST UNIT (Obsolete)
CF18	CFL 11 + BLST UNIT (Obsolete)
CF19	CFL 13 + BLST UNIT (Obsolete)
CF20	CFL 2-13 + BLST UNIT (Obsolete)
CF21	CFL 15 + BLST UNIT (Obsolete)
CF22	CFL 20 + BLST UNIT (Obsolete)
CF23	CFL 7 CEIL FIXT
CF24	CFL 11 CEIL FIXT
CF25	CFL 15 CEIL FIXT
CF26	CFL 2-11 CEIL FIXT
CF27	CFL 2-15 CEIL FIXT
CF28	CFL 7 WALL FIXT
CF29	CFL 11 WALL FIXT
CF30	CFL 15 WALL FIXT
CF31	CFL 2-11 WALL FIXT
CF32	CFL 2-15 WALL FIXT
CF33	CFL 7 CAN
CF34	CFL 11 CAN
CF35	CFL 15 CAN
CF36	CFL 13 INTEGRAL UNIT ELC
CF37	CFL 32 INTEGRAL UNIT ELC
CF38	CFL 42 INTEGRAL UNIT ELC
CF39	CFL 55 INTEGRAL UNIT ELC
CF40	CFL 85 INTEGRAL UNIT ELC
CF41	CFL 105 INTEGRAL UNIT ELC
CF42	CFL 4 GLOBE UNIT
CF43	CFL 9 GLOBE UNIT
CF44	CFL 14 INTEGRAL FLOOD ELC

Fixture Code	Fixture Name
CF45	CFL 16 INTEGRAL FLOOD ELC
CF46	CFL 23 INTEGRAL FLOOD ELC
CF47	CFL 27 INTEGRAL FLOOD ELC
CF48	CFL 18 + BLST UNIT (Obsolete)
CF49	CFL 26 + BLST UNIT (Obsolete)
CF50	CFL 20 INTEGRAL FLOOD ELC
CF51	CFL 30 INTEGRAL FLOOD ELC
CF52	CFL 2-9 CAN
CF53	CFL 2-11 CAN
CF54	CFL 2-13 CAN
CF55	CFL 2-15 CAN
CF56	CFL 120 INTEGRAL UNIT ELC
CF57	CFL 150 INTEGRAL UNIT ELC
CF58	CFL 180 INTEGRAL UNIT ELC
CF59	CFL 200 INTEGRAL UNIT ELC
CF60	CFL 2-18 CEIL FIXT
CF61	CFL 2-26 CEIL FIXT
CF62	CFL 2-18 CAN
CF63	CFL 2-26 CAN
EX1	EXIT - INC (2x20)
EX2	EXIT - INC (2x15)
EX3	EXIT - FL 1-PL9
EX4	EXIT - FL 2-PL9
EX5	EXIT - FL RET 1-PL9
EX6	EXIT - LED
EX7	EXIT - SELF LUMINOUS
EX8	EXIT - INC (2x25)
EX9	EXIT - FLEX TUBE 8
EX10	EXIT - LED RETRO KIT
EX11	EXIT - ELECTROLUMINESCENT PANEL
EX12	EXIT - ELECTROLUMINESCENT PANEL RETRO KIT
FL1	FL 2X4 4F40T12 STD2
FL2	FL 2X4 3F40T12 STD1,2
FL3	FL 2X4 2F40T12 STD2
FL4	FL 1X4 2F40T12 STD2
FL5	FL 1X4 1F40T12 STD1
FL6	FL 2X2 2F40T12U STD2
FL7	FL 2X4 4F40T12 STD2 REF
FL8	FL 2X4 3F40T12 STD1,2 REF
FL9	FL 2X4 2F40T12 STD2 REF
FL10	FL 1X4 2F40T12 STD2 REF
FL11	FL 1X4 1F40T12 STD1 REF
FL12	FL 2X2 2F40T12U STD2 REF

Fixture Code	Fixture Name
FL13	FL 2X4 4F40T12 EEF2
FL14	FL 2X4 3F40T12 EEF1,2
FL15	FL 2X4 2F40T12 EEF2
FL16	FL 1X4 2F40T12 EEF2
FL17	FL 1X4 1F40T12 EEF1
FL18	FL 2X2 2F40T12U EEF2
FL19	FL 2X4 4F40T12 EEF2 REF
FL20	FL 2X4 3F40T12 EEF1,2 REF
FL21	FL 2X4 2F40T12 EEF2 REF
FL22	FL 1X4 2F40T12 EEF2 REF
FL23	FL 1X4 1F40T12 EEF1 REF
FL24	FL 2X2 2F40T12U EEF2 REF
FL25	FL 2X4 4F40T12 ELC2
FL26	FL 2X4 3F40T12 ELC1,2
FL27	FL 2X4 2F40T12 ELC2
FL28	FL 1X4 2F40T12 ELC2
FL29	FL 1X4 1F40T12 ELC1
FL30	FL 2X2 2F40T12U ELC2
FL31	FL 2X4 4F40T12 ELC2 REF
FL32	FL 2X4 3F40T12 ELC1,2 REF
FL33	FL 2X4 2F40T12 ELC2 REF
FL34	FL 1X4 2F40T12 ELC2 REF
FL35	FL 1X4 1F40T12 ELC1 REF
FL36	FL 2X2 2F40T12U ELC2 REF
FL37	FL 2X4 4F32T8 EEF2
FL38	FL 2X4 3F32T8 EEF1,2
FL39	FL 2X4 2F32T8 EEF2
FL40	FL 1X4 2F32T8 EEF2
FL41	FL 1X4 1F32T8 EEF1
FL42	FL 2X2 2F32T8U EEF2
FL43	FL 2X4 4F32T8 EEF2 REF
FL44	FL 2X4 3F32T8 EEF1,2 REF
FL45	FL 2X4 2F32T8 EEF2 REF
FL46	FL 1X4 2F32T8 EEF2 REF
FL47	FL 1X4 1F32T8 EEF1 REF
FL48	FL 2X2 2F32T8U EEF2 REF
FL49	FL 2X4 4F32T8 ELC2
FL50	FL 2X4 3F32T8 ELC1,2
FL51	FL 2X4 2F32T8 ELC2
FL52	FL 1X4 2F32T8 ELC2
FL53	FL 1X4 1F32T8 ELC1
FL54	FL 2X2 2F32T8U ELC2
FL55	FL 2X4 4F32T8 ELC2 REF
FL56	FL 2X4 3F32T8 ELC1,2 REF
FL57	FL 2X4 2F32T8 ELC2 REF
FL58	FL 1X4 2F32T8 ELC2 REF

Fixture Code	Fixture Name
FL59	FL 1X4 1F32T8 ELC1 REF
FL60	FL 2X2 2F32T8U ELC2 REF
FL61	FL 1X8 4F96T12 STD2
FL62	FL 1X8 2F96T12 STD2
FL63	FL 1X8 1F96T12 STD1
FL64	FL 1X8 4F96T12 STD2 REF
FL65	FL 1X8 2F96T12 STD2 REF
FL66	FL 1X8 1F96T12 STD1 REF
FL67	FL 1X8 4F96T12 EEF2
FL68	FL 1X8 2F96T12 EEF2
FL69	FL 1X8 1F96T12 EEF1
FL70	FL 1X8 4F96T12 EEF2 REF
FL71	FL 1X8 2F96T12 EEF2 REF
FL72	FL 1X8 1F96T12 EEF1 REF
FL73	FL 1X8 4F96T12 ELC2
FL74	FL 1X8 2F96T12 ELC2
FL75	FL 1X8 1F96T12 ELC1
FL76	FL 1X8 4F96T12 ELC2 REF
FL77	FL 1X8 2F96T12 ELC2 REF
FL78	FL 1X8 1F96T12 ELC1 REF
FL79	FL 2X4 4F40T12ES STD2
FL80	FL 2X4 3F40T12ES STD1,2
FL81	FL 2X4 2F40T12ES STD2
FL82	FL 1X4 2F40T12ES STD2
FL83	FL 1X4 1F40T12ES STD1
FL84	FL 2X2 2F40T12UES STD2
FL85	FL 2X4 4F40T12ES STD2 REF
FL86	FL 2X4 3F40T12ES STD1,2 REF
FL87	FL 2X4 2F40T12ES STD2 REF
FL88	FL 1X4 2F40T12ES STD2 REF
FL89	FL 1X4 1F40T12ES STD1 REF
FL90	FL 2X2 2F40T12UES STD2 REF
FL91	FL 2X4 4F40T12ES EEF2
FL92	FL 2X4 3F40T12ES EEF1,2
FL93	FL 2X4 2F40T12ES EEF2
FL94	FL 1X4 2F40T12ES EEF2
FL95	FL 1X4 1F40T12ES EEF1
FL96	FL 2X2 2F40T12UES EEF2
FL97	FL 2X4 4F40T12ES EEF2 REF
FL98	FL 2X4 3F40T12ES EEF1,2 REF
FL99	FL 2X4 2F40T12ES EEF2 REF
FL100	FL 1X4 2F40T12ES EEF2 REF
FL101	FL 1X4 1F40T12ES EEF1 REF
FL102	FL 2X2 2F40T12UES EEF2 REF
FL103	FL 2X4 4F40T12ES ELC2
FL104	FL 2X4 3F40T12ES ELC1,2

Fixture Code	Fixture Name
FL105	FL 2X4 2F40T12ES ELC2
FL106	FL 1X4 2F40T12ES ELC2
FL107	FL 1X4 1F40T12ES ELC1
FL108	FL 2X2 2F40T12UES ELC2
FL109	FL 2X4 4F40T12ES ELC2 REF
FL110	FL 2X4 3F40T12ES ELC1,2 REF
FL111	FL 2X4 2F40T12ES ELC2 REF
FL112	FL 1X4 2F40T12ES ELC2 REF
FL113	FL 1X4 1F40T12ES ELC1 REF
FL114	FL 2X2 2F40T12UES ELC2 REF
FL115	FL 1X8 4F96T12ES STD2
FL116	FL 1X8 2F96T12ES STD2
FL117	FL 1X8 1F96T12ES STD1
FL118	FL 1X8 4F96T12ES STD2 REF
FL119	FL 1X8 2F96T12ES STD2 REF
FL120	FL 1X8 1F96T12ES STD1 REF
FL121	FL 1X8 4F96T12ES EEF2
FL122	FL 1X8 2F96T12ES EEF2
FL123	FL 1X8 1F96T12ES EEF1
FL124	FL 1X8 4F96T12ES EEF2 REF
FL125	FL 1X8 2F96T12ES EEF2 REF
FL126	FL 1X8 1F96T12ES EEF1 REF
FL127	FL 1X8 4F96T12ES ELC2
FL128	FL 1X8 2F96T12ES ELC2
FL129	FL 1X8 1F96T12ES ELC1
FL130	FL 1X8 4F96T12ES ELC2 REF
FL131	FL 1X8 2F96T12ES ELC2 REF
FL132	FL 1X8 1F96T12ES ELC1 REF
FL133	FL 2X4 4F40T12HO STD2 REF
FL134	FL 2X4 3F40T12HO STD1,2 REF
FL135	FL 2X4 2F40T12HO STD2 REF
FL136	FL 1X4 2F40T12HO STD2 REF
FL137	FL 1X4 1F40T12HO STD1 REF
FL138	FL 2X4 4F40T12HO EEF2
FL139	FL 2X4 3F40T12HO EEF1,2
FL140	FL 2X4 2F40T12HO EEF2
FL141	FL 1X4 2F40T12HO EEF2
FL142	FL 1X4 1F40T12HO EEF1
FL143	FL 2X4 4F40T12HO EEF2 REF
FL144	FL 2X4 3F40T12HO EEF1,2 REF
FL145	FL 2X4 2F40T12HO EEF2 REF
FL146	FL 1X4 2F40T12HO EEF2 REF
FL147	FL 1X4 1F40T12HO EEF1 REF
FL148	FL 2X4 4F40T12HO ELC2
FL149	FL 2X4 3F40T12HO ELC1,2
FL150	FL 2X4 2F40T12HO ELC2

Fixture Code	Fixture Name
FL151	FL 1X4 2F40T12HO ELC2
FL152	FL 1X4 1F40T12HO ELC1
FL153	FL 2X4 4F40T12HO ELC2 REF
FL154	FL 2X4 3F40T12HO ELC1,2 REF
FL155	FL 2X4 2F40T12HO ELC2 REF
FL156	FL 1X4 2F40T12HO ELC2 REF
FL157	FL 1X4 1F40T12HO ELC1 REF
FL158	FL 1X8 4F96T12HO STD2 REF
FL159	FL 1X8 2F96T12HO STD2 REF
FL160	FL 1X8 1F96T12HO STD1 REF
FL161	FL 1X8 4F96T12HO EEF2
FL162	FL 1X8 2F96T12HO EEF2
FL163	FL 1X8 1F96T12HO EEF1
FL164	FL 1X8 4F96T12HO EEF2 REF
FL165	FL 1X8 2F96T12HO EEF2 REF
FL166	FL 1X8 1F96T12HO EEF1 REF
FL167	FL 1X8 4F96T12HO ELC2
FL168	FL 1X8 2F96T12HO ELC2
FL169	FL 1X8 1F96T12HO ELC1
FL170	FL 1X8 4F96T12HO ELC2 REF
FL171	FL 1X8 2F96T12HO ELC2 REF
FL172	FL 1X8 1F96T12HO ELC1 REF
FL198	FL 1X8 4F96T8 EEF2
FL199	FL 1X8 2F96T8 EEF2
FL200	FL 1X8 1F96T8 EEF1
FL201	FL 1X8 4F96T8 EEF2 REF
FL202	FL 1X8 2F96T8 EEF2 REF
FL203	FL 1X8 1F96T8 EEF1 REF
FL204	FL 2X4 3F40T12HO STD1,2
FL205	FL 2X4 2F40T12HO STD2
FL206	FL 1X4 2F40T12HO STD2
FL207	FL 1X4 1F40T12HO STD1
FL208	FL 1X8 2F96T12HO STD2
FL209	FL 1X8 1F96T12HO STD1
FL210	FL 1X8 3F96T12 STD1,2 REF
FL211	FL 1X8 3F96T12 EEF1,2 REF
FL212	FL 1X8 3F96T12 ELC1,2 REF
FL213	FL 1X8 3F96T8 EEF1,2 REF
FL214	FL 1X8 3F96T12HO STD1,2
FL215	FL 1X8 3F96T12HO STD1,2 REF
FL216	FL 1X8 3F96T12HO EEF1,2
FL217	FL 1X8 3F96T12HO ELC1,2
FL218	FL 1X8 3F96T12HO EEF1,2 REF
FL219	FL 1X8 3F96T12HO ELC1,2 REF
FL220	FL 1X8 3F96T12ES STD1,2
FL221	FL 1X8 3F96T12ES STD1,2 REF

Fixture Code	Fixture Name
FL222	FL 1X8 3F96T12ES EEF1,2
FL223	FL 1X8 3F96T12ES EEF1,2 REF
FL224	FL 1X8 3F96T12ES ELC1,2
FL225	FL 1X8 3F96T12ES ELC1,2 REF
FL226	FL 1X8 3F96T12 STD1,2
FL227	FL 1X8 3F96T12 EEF1,2
FL228	FL 1X8 3F96T12 ELC1,2
FL229	FL 1X8 3F96T8 EEF1,2
FL230	FL 2X4 3F40T12ES ELC3
FL231	FL 2X4 3F40T12ES ELC3 REF
FL232	FL 2X4 3F40T12 ELC3
FL233	FL 2X4 3F40T12 ELC3 REF
FL234	FL 2X4 3F40T12HO ELC3
FL235	FL 2X4 3F40T12HO ELC3 REF
FL236	FL 2X4 3F32T8 ELC3
FL237	FL 2X4 3F32T8 ELC3 REF
FL238	FL 2X4 4F40T12ES ELC4
FL239	FL 2X4 4F40T12ES ELC4 REF
FL240	FL 2X4 4F40T12 ELC4
FL241	FL 2X4 4F40T12 ELC4 REF
FL242	FL 2X4 4F40T12HO ELC4
FL243	FL 2X4 4F40T12HO ELC4 REF
FL244	FL 2X4 4F32T8 ELC4
FL245	FL 2X4 4F32T8 ELC4 REF
FL246	FL 1X8 4F96T12HO STD2
FL247	FL 2X4 4F40T12HO STD2
FL248	FL 1X8 4F96T8 ELC2
FL249	FL 1X8 2F96T8 ELC2
FL250	FL 1X8 1F96T8 ELC1
FL251	FL 1X8 3F96T8 ELC1,2
FL252	FL 1X8 4F96T8 ELC2 REF
FL253	FL 1X8 2F96T8 ELC2 REF
FL254	FL 1X8 1F96T8 ELC1 REF
FL255	FL 1X8 3F96T8 ELC1,2 REF
FL256	FL 2X2 2F14T5 ELC2
FL257	FL 2X2 4F14T5 ELC4
FL258	FL 1X4 1F28T5 ELC1
FL259	FL 1X4 2F28T5 ELC2
FL260	FL 2X4 2F28T5 ELC2
FL261	FL 2X4 3F28T5 ELC3
FL262	FL 2X4 4F28T5 ELC4
FL263	FL 2X2 2F14T5 ELC2 REF
FL264	FL 2X2 4F14T5 ELC4 REF
FL265	FL 1X4 1F28T5 ELC1 REF
FL266	FL 1X4 2F28T5 ELC2 REF
FL267	FL 2X4 2F28T5 ELC2 REF

Fixture Code	Fixture Name
FL268	FL 2X4 3F28T5 ELC3 REF
FL269	FL 2X4 4F28T5 ELC4 REF
FL270	FL 1X4 1F54T5HO ELC1 REF
FL271	FL 2X4 2F54T5HO ELC2 REF
FL272	FL 2X4 3F54T5HO ELC1,2 REF
FL273	FL 2X4 4F54T5HO ELC2 REF
FL274	FL 1X4 1F32ST8 ELC1
FL275	FL 2X4 2F32ST8 ELC2
FL276	FL 2X4 3F32ST8 ELC3
FL277	FL 2X4 4F32ST8 ELC2
FL278	FL 1X4 1F32ST8 ELC1 REF
FL279	FL 2X4 2F32ST8 ELC2 REF
FL280	FL 2X4 3F32ST8 ELC3 REF
FL281	FL 2X4 4F32ST8 ELC2 REF
FL282	FL 1X4 1F30ST8 ELC1
FL283	FL 2X4 2F30ST8 ELC2
FL284	FL 2X4 3F30ST8 ELC3
FL285	FL 2X4 4F30ST8 ELC2
FL286	FL 1X4 1F30ST8 ELC1 REF
FL287	FL 2X4 2F30ST8 ELC2 REF
FL288	FL 2X4 3F30ST8 ELC3 REF
FL289	FL 2X4 4F30ST8 ELC2 REF
FL290	FL 1X4 1F28ST8 ELC1
FL291	FL 2X4 2F28ST8 ELC2
FL292	FL 2X4 3F28ST8 ELC3
FL293	FL 2X4 4F28ST8 ELC2
FL294	FL 1X4 1F28ST8 ELC1 REF
FL295	FL 2X4 2F28ST8 ELC2 REF
FL296	FL 2X4 3F28ST8 ELC3 REF
FL297	FL 2X4 4F28ST8 ELC2 REF
FL298	FL 1X4 1F25ST8 ELC1
FL299	FL 2X4 2F25ST8 ELC2
FL300	FL 2X4 3F25ST8 ELC3
FL301	FL 2X4 4F25ST8 ELC2
FL302	FL 1X4 1F25ST8 ELC1 REF
FL303	FL 2X4 2F25ST8 ELC2 REF
FL304	FL 2X4 3F25ST8 ELC3 REF
FL305	FL 2X4 4F25ST8 ELC2 REF
FL306	FL 2X2 4F40BX EEF2 REF
FL307	FL 2X2 4F40BX ELC2 REF
FL308	FL 2X3 6F40BX EEF2 REF
FL309	FL 2X3 6F40BX ELC2 REF
FL310	FL 2X4 8F40BX EEF2 REF
FL311	FL 2X4 8F40BX ELC2 REF
FL312	FL 2X2 1F25BX ELC1 REF
FL313	FL 2X2 2F25BX ELC2 REF

Fixture Code	Fixture Name
FL314	FL 2X2 3F25BX ELC3 REF
FL315	FL 2X2 1F40BX ELC1 REF
FL316	FL 2X2 2F40BX ELC2 REF
FL317	FL 2X2 3F40BX ELC3 REF
FL318	FL 2X2 1F50BX ELC1 REF
FL319	FL 2X2 2F50BX ELC2 REF
FL320	FL 2X2 3F50BX ELC3 REF
FL321	FL 2X2 1F55BX ELC1 REF
FL322	FL 2X2 2F55BX ELC2 REF
FL323	FL 2X2 3F55BX ELC3 REF
FL324	FL 2X2 2F17T8 ELC2
FL325	FL 2X2 3F17T8 ELC3
FL326	FL 2X2 4F17T8 ELC4
FL327	FL 2X2 2F17T8 ELC2 REF
FL328	FL 2X2 3F17T8 ELC3 REF
FL329	FL 2X2 4F17T8 ELC4 REF
FL330	FL 2X2 2F15ST8 ELC2
FL331	FL 2X2 3F15ST8 ELC3
FL332	FL 2X2 4F15ST8 ELC4
FL333	FL 2X2 2F15ST8 ELC2 REF
FL334	FL 2X2 3F15ST8 ELC3 REF
FL335	FL 2X2 4F15ST8 ELC4 REF
FL336	FL 2X2 3F14T5 ELC3
FL337	FL 2X2 3F14T5 ELC3 REF
FL338	FL 2X2 2F32ST8U ELC2
FL339	FL 2X2 2F29ST8U ELC2
FL340	FL 2X2 2F26ST8U ELC2
FL341	FL 2X2 2F32ST8U ELC2 REF
FL342	FL 2X2 2F29ST8U ELC2 REF
FL343	FL 2X2 2F26ST8U ELC2 REF
FL344	FL 2x4 6F32T8 ELC3
FL345	FL 2x4 8F32T8 ELC4
FL346	FL 2x4 6F32T8 ELC3 REF
FL347	FL 2x4 8F32T8 ELC4 REF
FL348	FL 2x4 4F32ST8 ELC4
FL349	FL 2x4 6F32ST8 ELC3
FL350	FL 2x4 8F32ST8 ELC4
FL351	FL 2x4 4F32ST8 ELC4 REF
FL352	FL 2x4 6F32ST8 ELC3 REF
FL353	FL 2x4 8F32ST8 ELC4 REF
FL354	FL 2x4 4F30ST8 ELC4
FL355	FL 2x4 6F30ST8 ELC3
FL356	FL 2x4 8F30ST8 ELC4
FL357	FL 2x4 4F30ST8 ELC4 REF
FL358	FL 2x4 6F30ST8 ELC3 REF
FL359	FL 2x4 8F30ST8 ELC4 REF

Fixture Code	Fixture Name
FL360	FL 2x4 4F28ST8 ELC4
FL361	FL 2x4 6F28ST8 ELC3
FL362	FL 2x4 8F28ST8 ELC4
FL363	FL 2x4 4F28ST8 ELC4 REF
FL364	FL 2x4 6F28ST8 ELC3 REF
FL365	FL 2x4 8F28ST8 ELC4 REF
FL366	FL 2x4 4F25ST8 ELC4
FL367	FL 2x4 6F25ST8 ELC3
FL368	FL 2x4 8F25ST8 ELC4
FL369	FL 2x4 4F25ST8 ELC4 REF
FL370	FL 2x4 6F25ST8 ELC3 REF
FL371	FL 2x4 8F25ST8 ELC4 REF
FL372	FL 2x4 6F28T5 ELC3
FL373	FL 2x4 8F28T5 ELC4
FL374	FL 2x4 6F28T5 ELC3 REF
FL375	FL 2x4 8F28T5 ELC4 REF
FL376	FL 2X4 3F54T5HO ELC3 REF
FL377	FL 2X4 4F54T5HO ELC4 REF
FL378	FL 2x4 6F54T5HO ELC3 REF
FL379	FL 2x4 8F54T5HO ELC4 REF
FL380	FL 1X4 1F49T5HO ELC1 REF
FL381	FL 2X4 2F49T5HO ELC2 REF
FL382	FL 2X4 3F49T5HO ELC1,2 REF
FL383	FL 2X4 4F49T5HO ELC2 REF
FL384	FL 2X4 3F49T5HO ELC3 REF
FL385	FL 2X4 4F49T5HO ELC4 REF
FL386	FL 2x4 6F49T5HO ELC3 REF
FL387	FL 2x4 8F49T5HO ELC4 REF
FL388	FL 1X4 1F47T5HO ELC1 REF
FL389	FL 2X4 2F47T5HO ELC2 REF
FL390	FL 2X4 3F47T5HO ELC1,2 REF
FL391	FL 2X4 4F47T5HO ELC2 REF
FL392	FL 2X4 3F47T5HO ELC3 REF
FL393	FL 2X4 4F47T5HO ELC4 REF
FL394	FL 2x4 6F47T5HO ELC3 REF
FL395	FL 2x4 8F47T5HO ELC4 REF
FL396	FL 1X4 1F25T5 ELC1
FL397	FL 1X4 2F25T5 ELC2
FL398	FL 2X4 2F25T5 ELC2
FL399	FL 2X4 3F25T5 ELC3
FL400	FL 2X4 4F25T5 ELC4
FL401	FL 1X4 1F25T5 ELC1 REF
FL402	FL 1X4 2F25T5 ELC2 REF
FL403	FL 2X4 2F25T5 ELC2 REF
FL404	FL 2X4 2F25T5 ELC3 REF
FL405	FL 2X4 4F25T5 ELC4 REF

Fixture Code	Fixture Name
FL406	FL 2x4 6F25T5 ELC3
FL407	FL 2x4 8F25T5 ELC4
FL408	FL 2x4 6F25T5 ELC3 REF
FL409	FL 2x4 8F25T5 ELC4 REF
FL410	FL 1x8 2F32T8 ELC2
FL411	FL 1x8 4F32T8 ELC4
FL412	FL 1x8 6F32T8 ELC3
FL413	FL 1x8 8F32T8 ELC4
FL414	FL 1x8 2F32T8 ELC2 REF
FL415	FL 1x8 4F32T8 ELC4 REF
FL416	FL 1x8 6F32T8 ELC3 REF
FL417	FL 1x8 8F32T8 ELC4 REF
FL418	FL 1X4 2F32ST8 ELC2
FL419	FL 1X4 2F32ST8 ELC2 REF
FL420	FL 1X4 2F30ST8 ELC2
FL421	FL 1X4 2F30ST8 ELC2 REF
FL422	FL 1X4 2F28ST8 ELC2
FL423	FL 1X4 2F28ST8 ELC2 REF
FL424	FL 1X4 2F25ST8 ELC2
FL425	FL 1X4 2F25ST8 ELC2 REF
HI1	HAL 20 PAR
HI2	HAL 35 PAR
HI3	HAL 40 PAR
HI4	HAL 45 PAR
HI5	HAL 50 PAR
HI6	HAL 60 PAR
HI7	HAL 65 PAR
HI8	HAL 70 PAR
HI9	HAL 75 PAR
HI10	HAL 85 PAR
HI11	HAL 90 PAR
HI12	HAL 100 PAR
HI13	HAL 120 PAR
HI14	HAL 250 PAR
HI15	HALIR 40 PAR
HI16	HALIR 45 PAR
HI17	HALIR 48 PAR
HI18	HALIR 55 PAR
HI19	HALIR 60 PAR
HI20	HALIR 67 PAR
HI21	HALIR 70 PAR
HI22	HALIR 83 PAR
HI23	HALIR 100 PAR
HI24	HAL 20 MR16 (12V) SPOT
HI25	HAL 35 MR16 (12V) SPOT
HI26	HAL 50 MR16 (12V) SPOT

Fixture Code	Fixture Name
HI27	HAL 75 MR16 (12V) SPOT
HI28	HAL 100 MR16 (12V) SPOT
HI29	HAL 20 MR16 (12V) FLOOD
HI30	HAL 35 MR16 (12V) FLOOD
HI31	HAL 50 MR16 (12V) FLOOD
HI32	HAL 75 MR16 (12V) FLOOD
HI33	HAL 100 MR16 (12V) FLOOD
HI34	HAL 20 MR11 (12V) SPOT
HI35	HAL 35 MR11 (12V) SPOT
HI36	HAL 20 MR11 (12V) FLOOD
HI37	HAL 35 MR11 (12V) FLOOD
HS1	HPS 35 POLE
HS2	HPS 50 POLE
HS3	HPS 70 POLE
HS4	HPS 100 POLE
HS5	HPS 150 POLE
HS6	HPS 200 POLE
HS7	HPS 250 POLE
HS8	HPS 310 POLE
HS9	HPS 400 POLE
HS10	HPS 1000 POLE
HS11	HPS 35 PEND
HS12	HPS 50 PEND
HS13	HPS 70 PEND
HS14	HPS 100 PEND
HS15	HPS 150 PEND
HS16	HPS 200 PEND
HS17	HPS 250 PEND
HS18	HPS 310 PEND
HS19	HPS 400 PEND
HS20	HPS 1000 PEND
HS21	HPS 35 WALL
HS22	HPS 50 WALL
HS23	HPS 70 WALL
HS24	HPS 100 WALL
HS25	HPS 150 WALL
HS26	HPS 200 WALL
HS27	HPS 250 WALL
HS28	HPS 310 WALL
HS29	HPS 400 WALL
HS30	HPS 35 FLD
HS31	HPS 70 FLD
HS32	HPS 50 CAN
HS33	HPS 70 CAN
HS34	HPS 100 CAN
HS35	HPS 150 REP FOR MV PEND

Fixture Code	Fixture Name
HS36	HPS 215 REP FOR MV PEND
HS37	HPS 220 REP FOR MV PEND
HS38	HPS 360 REP FOR MV PEND
HS39	HPS 880 REP FOR MV PEND
HS40	HPS 940 REP FOR MV PEND
HS41	HPS 150 REP FOR MV WALL
HS42	HPS 215 REP FOR MV WALL
HS43	HPS 220 REP FOR MV WALL
HS44	HPS 360 REP FOR MV WALL
HS45	HPS 880 REP FOR MV WALL
HS46	HPS 940 REP FOR MV WALL
HS47	HPS 150 REP FOR MV POLE
HS48	HPS 215 REP FOR MV POLE
HS49	HPS 220 REP FOR MV POLE
HS50	HPS 360 REP FOR MV POLE
HS51	HPS 880 REP FOR MV POLE
HS52	HPS 940 REP FOR MV POLE
HS53	HPS 70 IS PEND
HS54	HPS 100 IS PEND
HS55	HPS 150 IS PEND
HS56	HPS 250 IS PEND
HS57	HPS 400 IS PEND
HS58	HPS 70 IS WALL
HS59	HPS 100 IS WALL
HS60	HPS 150 IS WALL
HS61	HPS 250 IS WALL
HS62	HPS 400 IS WALL
HS63	HPS 70 IS POLE
HS64	HPS 100 IS POLE
HS65	HPS 150 IS POLE
HS66	HPS 250 IS POLE
HS67	HPS 400 IS POLE
HS68	HPS 35 WL PEND
HS69	HPS 50 WL PEND
HS70	HPS 100 WL PEND
HS71	HPS 35 WL WALL
HS72	HPS 50 WL WALL
HS73	HPS 100 WL WALL
HS74	HPS 35 WL POLE
HS75	HPS 50 WL POLE
HS76	HPS 100 WL POLE
HS77	HPS 150 REP FOR MH PEND
HS78	HPS 215 REP FOR MH PEND
HS79	HPS 220 REP FOR MH PEND
HS80	HPS 360 REP FOR MH PEND
HS81	HPS 880 REP FOR MH PEND

Fixture Code	Fixture Name
HS82	HPS 940 REP FOR MH PEND
HS83	HPS 150 REP FOR MH WALL
HS84	HPS 215 REP FOR MH WALL
HS85	HPS 220 REP FOR MH WALL
HS86	HPS 360 REP FOR MH WALL
HS87	HPS 880 REP FOR MH WALL
HS88	HPS 940 REP FOR MH WALL
HS89	HPS 150 REP FOR MH POLE
HS90	HPS 215 REP FOR MH POLE
HS91	HPS 220 REP FOR MH POLE
HS92	HPS 360 REP FOR MH POLE
HS93	HPS 880 REP FOR MH POLE
HS94	HPS 940 REP FOR MH POLE
HS95	HPS 70 POLE ELC
HS96	HPS 70 PEND ELC
HS97	HPS 70 WALL ELC
HS98	HPS 70 FLD ELC
HS99	HPS 70 CAN ELC
HS100	HPS 100 POLE ELC
HS101	HPS 100 PEND ELC
HS102	HPS 100 WALL ELC
HS103	HPS 100 CAN ELC
IL1	INDUCTION 150Wx1 High Bay
IL2	INDUCTION 150Wx2 High Bay
IL3	INDUCTION 150Wx3 High Bay
IL4	INDUCTION 85W Low Bay
IL5	INDUCTION 100W Low Bay
IN1	INC 40 CEIL
IN2	INC 2-40 CEIL
IN3	INC 3-40 CEIL
IN4	INC 4-40 CEIL
IN5	INC 60 CEIL
IN6	INC 2-60 CEIL
IN7	INC 3-60 CEIL
IN8	INC 75 CEIL
IN9	INC 2-75 CEIL
IN10	INC 3-75 CEIL
IN11	INC 100 CEIL
IN12	INC 2-100 CEIL
IN13	INC 25 TABLE LAMP
IN14	INC 40 TABLE LAMP
IN15	INC 60 TABLE LAMP
IN16	INC 75 TABLE LAMP
IN17	INC 100 TABLE LAMP
IN18	INC 25 WALL
IN19	INC 40 WALL

Fixture Code	Fixture Name
IN20	INC 2-40 WALL
IN21	INC 3-40 WALL
IN22	INC 4-40 WALL
IN23	INC 60 WALL
IN24	INC 2-60 WALL
IN25	INC 75 WALL
IN26	INC 2-75 WALL
IN27	INC 100 WALL
IN28	INC 150 PEND
IN29	INC 200 PEND
IN30	INC 300 PEND
IN31	INC 40 CAN
IN32	INC 60 CAN
IN33	INC 75 CAN
IN34	INC 100 CAN
IN35	INC 40 FLD
IN36	INC 60 FLD
IN37	INC 75 FLD
IN38	INC 100 FLD
IN39	INC 150 FLD
IN40	INC 200 FLD
IN41	INC 250 FLD
IN42	INC 500 FLD
LD1	LED 3W A-Line (200 Lumens)
LD2	LED 5W A-Line (350 Lumens)
LD3	LED 7W A-Line (500 Lumens)
LD4	LED 11W A-Line (850 Lumens)
LD5	LED 15W A-Line (1200 Lumens)
LD6	LED 20W A-Line (1700 Lumens)
LD7	LED 30W A-Line (2850 Lumens)
LD8	LED 40W A-Line (4000 Lumens)
LD9	LED 52W A-Line (5800 Lumens)
LD30	LED 4W MR16 SPOT (240 Lumens)
LD31	LED 7W MR16 SPOT (490 Lumens)
LD35	LED 4W MR16 FLOOD (240 Lumens)
LD36	LED 7W MR16 FLOOD (490 Lumens)
LD40	LED 4W MR11 SPOT (240 Lumens)
LD41	LED 7W MR11 SPOT (490 Lumens)
LD45	LED 4W MR11 FLOOD (240 Lumens)
LD46	LED 7W MR11 FLOOD (490 Lumens)
LD70	LED 4W Reflector Lamp (240 Lumens)

Fixture Code	Fixture Name
LD71	LED 5W Reflector Lamp (350 Lumens)
LD72	LED 7W Reflector Lamp (450 Lumens)
LD73	LED 8W Reflector Lamp (500 Lumens)
LD74	LED 9W Reflector Lamp (575 Lumens)
LD75	LED 10W Reflector Lamp (630 Lumens)
LD76	LED 11W Reflector Lamp (750 Lumens)
LD77	LED 13W Reflector Lamp (850 Lumens)
LD78	LED 14W Reflector Lamp (900 Lumens)
LD79	LED 14W Reflector Lamp (950 Lumens)
LD80	LED 15W Reflector Lamp (1000 Lumens)
LD81	LED 16W Reflector Lamp (1050 Lumens)
LD82	LED 18W Reflector Lamp (1200 Lumens)
LD83	LED 25W Reflector Lamp (1750 Lumens)
LD84	LED 39W Reflector Lamp (2850 Lumens)
LD85	LED 53W Reflector Lamp (4000 Lumens)
LD86	LED 62W Reflector Lamp (4850 Lumens)
LD87	LED 116W Reflector Lamp (10500 Lumens)
LD110	LED 8W Can Fixture Repl (500 Lumens)
LD111	LED 15W Can Fixture Repl (1000 Lumens)
LD112	LED 23W Can Fixture Repl (1500 Lumens)
LD113	LED 31W Can Fixture Repl (2000 Lumens)
LD114	LED 39W Can Fixture Repl (2500 Lumens)
LD150	LED 19Wx1 4' 25W ST8 Lamp Repl (2110 Lumens/Lamp)
LD151	LED 19Wx2 4' 25W ST8 Lamp Repl (2110 Lumens/Lamp)

Fixture Code	Fixture Name
LD152	LED 19Wx3 4' 25W ST8 Lamp Repl (2110 Lumens/Lamp)
LD153	LED 19Wx4 4' 25W ST8 Lamp Repl (2110 Lumens/Lamp)
LD160	LED 19Wx1 4' 25W ST8 REF Lamp Repl (2110 Lumens/Lamp)
LD161	LED 19Wx2 4' 25W ST8 REF Lamp Repl (2110 Lumens/Lamp)
LD162	LED 19Wx3 4' 25W ST8 REF Lamp Repl (2110 Lumens/Lamp)
LD163	LED 19Wx4 4' 25W ST8 REF Lamp Repl (2110 Lumens/Lamp)
LD170	LED 21Wx1 4' 28W ST8 Lamp Repl (2330 Lumens/Lamp)
LD171	LED 21Wx2 4' 28W ST8 Lamp Repl (2330 Lumens/Lamp)
LD172	LED 21Wx3 4' 28W ST8 Lamp Repl (2330 Lumens/Lamp)
LD173	LED 21Wx4 4' 28W ST8 Lamp Repl (2330 Lumens/Lamp)
LD180	LED 21Wx1 4' 28W ST8 REF Lamp Repl (2330 Lumens/Lamp)
LD181	LED 21Wx2 4' 28W ST8 REF Lamp Repl (2330 Lumens/Lamp)
LD182	LED 21Wx3 4' 28W ST8 REF Lamp Repl (2330 Lumens/Lamp)
LD183	LED 21Wx4 4' 28W ST8 REF Lamp Repl (2330 Lumens/Lamp)
LD190	LED 23Wx1 4' 30W ST8/32W T8 Lamp Repl (2550 Lumens/Lamp)
LD191	LED 23Wx2 4' 30W ST8/32W T8 Lamp Repl (2550 Lumens/Lamp)
LD192	LED 23Wx3 4' 30W ST8/32W T8 Lamp Repl (2550 Lumens/Lamp)
LD193	LED 23Wx4 4' 30W ST8/32W T8 Lamp Repl (2550 Lumens/Lamp)
LD200	LED 23Wx1 4' 30W ST8/32W T8 REF Lamp Repl (2550 Lumens/Lamp)
LD201	LED 23Wx2 4' 30W ST8/32W T8 REF Lamp Repl (2550 Lumens/Lamp)
LD202	LED 23Wx3 4' 30W ST8/32W T8 REF Lamp Repl (2550 Lumens/Lamp)
LD203	LED 23Wx4 4' 30W ST8/32W T8 REF Lamp Repl (2550 Lumens/Lamp)

Fixture Code	Fixture Name
LD210	LED 25Wx1 4' 32W ST8 Lamp Repl (2730 Lumens/Lamp)
LD211	LED 25Wx2 4' 32W ST8 Lamp Repl (2730 Lumens/Lamp)
LD212	LED 25Wx3 4' 32W ST8 Lamp Repl (2730 Lumens/Lamp)
LD213	LED 25Wx4 4' 32W ST8 Lamp Repl (2730 Lumens/Lamp)
LD220	LED 25Wx1 4' 32W ST8 REF Lamp Repl (2730 Lumens/Lamp)
LD221	LED 25Wx2 4' 32W ST8 REF Lamp Repl (2730 Lumens/Lamp)
LD222	LED 25Wx3 4' 32W ST8 REF Lamp Repl (2730 Lumens/Lamp)
LD223	LED 25Wx4 4' 32W ST8 REF Lamp Repl (2730 Lumens/Lamp)
LD230	LED 10Wx2 2' 15W T8 Lamp Repl (1040 Lumens/Lamp)
LD231	LED 10Wx3 2' 15W T8 Lamp Repl (1040 Lumens/Lamp)
LD232	LED 10Wx4 2' 15W T8 Lamp Repl (1040 Lumens/Lamp)
LD240	LED 10Wx2 2' 15W T8 REF Lamp Repl (1040 Lumens/Lamp)
LD241	LED 10Wx3 2' 15W T8 REF Lamp Repl (1040 Lumens/Lamp)
LD242	LED 10Wx4 2' 15W T8 REF Lamp Repl (1040 Lumens/Lamp)
LD250	LED 12Wx2 2' 17W ST8 Lamp Repl (1150 Lumens/Lamp)
LD251	LED 12Wx3 2' 17W ST8 Lamp Repl (1150 Lumens/Lamp)
LD252	LED 12Wx4 2' 17W ST8 Lamp Repl (1150 Lumens/Lamp)
LD260	LED 12Wx2 2' 17W ST8 REF Lamp Repl (1150 Lumens/Lamp)
LD261	LED 12Wx3 2' 17W ST8 REF Lamp Repl (1150 Lumens/Lamp)
LD262	LED 12Wx4 2' 17W ST8 REF Lamp Repl (1150 Lumens/Lamp)
LD280	LED 34W 2x4 Fixture (3300 Lumens)
LD281	LED 41W 2x4 Fixture (4000 Lumens)
LD282	LED 51W 2x4 Fixture (5000 Lumens)
LD283	LED 61W 2x4 Fixture (6000 Lumens)

Fixture Code	Fixture Name
LD284	LED 71W 2x4 Fixture (7000 Lumens)
LD300	LED 44W 2x4 Retrofit Panel (4678 Lumens)
LD301	LED 59W 2x4 Retrofit Panel (6227 Lumens)
LD320	LED 20W 1x4 Fixture (2000 Lumens)
LD321	LED 34W 1x4 Fixture (3300 Lumens)
LD322	LED 41W 1x4 Fixture (4000 Lumens)
LD340	LED 34W 1x4 Retrofit Panel (2980 Lumens)
LD341	LED 41W 1x4 Retrofit Panel (3369 Lumens)
LD342	LED 52W 1x4 Retrofit Panel (4083 Lumens)
LD360	LED 20W 2x2 Fixture (2000 Lumens)
LD361	LED 26W 2x2 Fixture (2500 Lumens)
LD362	LED 31W 2x2 Fixture (3000 Lumens)
LD363	LED 36W 2x2 Fixture (3500 Lumens)
LD364	LED 41W 2x2 Fixture (4000 Lumens)
LD380	LED 34W 2x2 Retrofit Panel (3430 Lumens)
LD381	LED 41W 2x2 Retrofit Panel (3904 Lumens)
LD382	LED 52W 2x2 Retrofit Panel (4679 Lumens)
LD430	LED 30W Low Bay Fixture (3500 Lumens)
LD431	LED 34W Low Bay Fixture (4000 Lumens)
LD432	LED 43W Low Bay Fixture (5000 Lumens)
LD433	LED 51W Low Bay Fixture (6000 Lumens)
LD460	LED 91W High Bay Fixture (10000 Lumens)
LD461	LED 136W High Bay Fixture (15000 Lumens)
LD462	LED 182W High Bay Fixture (20000 Lumens)

Fixture Code	Fixture Name
LD463	LED 227W High Bay Fixture (25000 Lumens)
LD464	LED 273W High Bay Fixture (30000 Lumens)
LD465	LED 364W High Bay Fixture (40000 Lumens)
LD466	LED 455W High Bay Fixture (50000 Lumens)
LD467	LED 546W High Bay Fixture (60000 Lumens)
LD500	LED 9W Wall Pack (1000 Lumens)
LD501	LED 19W Wall Pack (2000 Lumens)
LD502	LED 37W Wall Pack (4000 Lumens)
LD503	LED 56W Wall Pack (6000 Lumens)
LD504	LED 75W Wall Pack (8000 Lumens)
LD505	LED 111W Wall Pack (10000 Lumens)
LD506	LED 167W Wall Pack (15000 Lumens)
LD550	LED 20W Pole Lamp (2000 Lumens)
LD551	LED 30W Pole Lamp (3000 Lumens)
LD552	LED 40W Pole Lamp (4000 Lumens)
LD553	LED 50W Pole Lamp (5000 Lumens)
LD554	LED 60W Pole Lamp (6000 Lumens)
LD555	LED 80W Pole Lamp (8000 Lumens)
LD556	LED 120W Pole Lamp (12000 Lumens)
LD557	LED 160W Pole Lamp (16000 Lumens)
LD558	LED 240W Pole Lamp (24000 Lumens)
LD559	LED 360W Pole Lamp (36000 Lumens)
LS1	LPS 18 PEND
LS2	LPS 35 PEND
LS3	LPS 55 PEND
LS4	LPS 90 PEND
LS5	LPS 135 PEND

Fixture Code	Fixture Name
LS6	LPS 180 PEND
LS7	LPS 18 POLE
LS8	LPS 35 POLE
LS9	LPS 55 POLE
LS10	LPS 90 POLE
LS11	LPS 135 POLE
LS12	LPS 180 POLE
LS13	LPS 18 WALL
LS14	LPS 35 WALL
LS15	LPS 55 WALL
LS16	LPS 90 WALL
LS17	LPS 135 WALL
LS18	LPS 180 WALL
MH1	MH 50 PEND
MH2	MH 70 PEND
MH3	MH 100 PEND
MH4	MH 175 PEND
MH5	MH 250 PEND
MH6	MH 400 PEND
MH7	MH 1000 PEND
MH8	MH 1500 PEND
MH9	MH 50 WALL
MH10	MH 70 WALL
MH11	MH 100 WALL
MH12	MH 175 WALL
MH13	MH 250 WALL
MH14	MH 400 WALL
MH15	MH 1000 WALL
MH16	MH 1500 WALL
MH17	MH 50 POLE
MH18	MH 70 POLE
MH19	MH 100 POLE
MH20	MH 175 POLE
MH21	MH 250 POLE
MH22	MH 400 POLE
MH23	MH 1000 POLE
MH24	MH 1500 POLE
MH25	MH 50 CAN
MH26	MH 70 CAN
MH27	MH 750 WALL
MH28	MH 32 WALL
MH29	MH 32 PEND
MH30	MH 750 POLE
MH31	MH 750 PEND
MH32	MH 32 POLE
MH33	MH 70 HE PEND

Fixture Code	Fixture Name
MH34	MH 150 HE PEND
MH35	MH 175 HE PEND
MH36	MH 250 HE PEND
MH37	MH 400 HE PEND
MH38	MH 1000 HE PEND
MH39	MH 70 HE WALL
MH40	MH 150 HE WALL
MH41	MH 175 HE WALL
MH42	MH 250 HE WALL
MH43	MH 400 HE WALL
MH44	MH 1000 HE WALL
MH45	MH 70 HE POLE
MH46	MH 150 HE POLE
MH47	MH 175 HE POLE
MH48	MH 250 HE POLE
MH49	MH 400 HE POLE
MH50	MH 1000 HE POLE
MH51	MH 32 POLE ELC
MH52	MH 32 PEND ELC
MH53	MH 32 WALL ELC
MH54	MH 50 POLE ELC
MH55	MH 50 PEND ELC
MH56	MH 50 WALL ELC
MH57	MH 50 CAN ELC
MH58	MH 70 POLE ELC
MH59	MH 70 PEND ELC
MH60	MH 70 WALL ELC
MH61	MH 70 CAN ELC
MH62	MH 100 POLE ELC
MH63	MH 100 PEND ELC
MH64	MH 100 WALL ELC
MH65	MH 150 HE POLE ELC
MH66	MH 150 HE PEND ELC
MH67	MH 150 HE WALL ELC
MV1	MERC 50 PEND
MV2	MERC 75 PEND
MV3	MERC 100 PEND
MV4	MERC 175 PEND
MV5	MERC 250 PEND
MV6	MERC 400 PEND
MV7	MERC 700 PEND
MV8	MERC 1000 PEND
MV9	MERC 50 POLE
MV10	MERC 75 POLE
MV11	MERC 100 POLE
MV12	MERC 175 POLE

Fixture Code	Fixture Name
MV13	MERC 250 POLE
MV14	MERC 400 POLE
MV15	MERC 700 POLE
MV16	MERC 1000 POLE
MV17	MERC 50 WALL
MV18	MERC 75 WALL

Fixture Code	Fixture Name
MV19	MERC 100 WALL
MV20	MERC 175 WALL
MV21	MERC 250 WALL
MV22	MERC 400 WALL
MV23	MERC 700 WALL
MV24	MERC 1000 WALL

Appendix I – FEDS Allowable HVAC Combinations

Unlinked heating types

Any combination of

- electric resistance baseboard
- radiator using central steam or hot water
- radiator using single-building boiler
- infrared heating
- radiant heat using district steam/hot water or single-building boiler
- window/through-wall air conditioning units
- fan coil units using single-building electric or gas engine-driven chiller
- fan coil units using single-building absorption chiller
- fan coil units using central chilled water
- rooftop packaged unit
- air handling unit using single-building electric or gas engine-driven chiller
- air handling unit using single-building absorption chiller
- air handling unit using central chilled water
- no heating
- no cooling

Linked heating types with any cooling types

Any combination of

- fan coil units using central steam, hot water or electricity
- fan coil units using single-building boiler
- forced air furnace
- air source heat pump (heating)
- ground-coupled heat pump (heating)
- air handling unit using central steam or hot water
- air handling unit using single-building boiler
- window/through-wall air conditioning units
- fan coil units using single-building electric or gas engine-driven chiller
- fan coil units using single-building absorption chiller
- fan coil units using central chilled water
- air source heat pump (cooling)
- ground-coupled heat pump (cooling)
- rooftop packaged unit
- air-handling unit using single-building electric or gas engine-driven chiller
- air-handling unit using single-building absorption chiller
- air-handling unit using central chilled water

- no heating
- no cooling

Evaporative Coolers

Evaporative coolers are compatible with any linked or unlinked heating types. However, evaporative coolers may not be combined with any other cooling equipment types, though they may be combined with no cooling.

Appendix J – Tips and Troubleshooting

J.1 Data Input Tips

Unreasonable but Valid Input: The model will accept unreasonable but valid inputs. For example, you could enter “1000” for the number of floors. This is clearly an unreasonable input. Unreasonable inputs will often generate very large or very small values for other variables that can result in overflow errors. Range checking for unreasonable values is performed to help identify such values. ***Pay attention to warning messages and verify inputs.***

Residential and Dual-Use Combinations: The model will allow you to use residential building or use-area types in dual-use buildings, that is, a residential building type that is dual use or a nonresidential building type with a residential use-area type. Because there are significant differences in some of the assumptions behind the design and operation of these building types, unreasonable inferences and/or output may occur. ***Exercise care when using residential building or use-area types in dual-use combinations. After updating inferences, check all inferred values for reasonableness.***

Truncation of Occupancy Hours and Time-of-Use Hours: The user interface will allow you to enter occupancy hours and time-of-use hours in the electric rate schedule in other than whole hours (e.g., 1230). The model does hourly calculations only and will truncate the input hours (e.g., 1230 becomes 1200). ***Be aware of this limitation and ensure that the total number of hours is correct.***

Lighting Percentage of Use-Area Illumination: At minimum set, it is assumed that all buildings have the “correct” lighting levels; hence, the percentage of illumination is required to add up to 100%. At maximum detail, you can enter the number of fixtures, or fixtures per square foot, for any lighting technology; illumination from the fixtures is not required to match the “correct” lighting level (the space may be over-lit or under-lit). Similarly, you can increase or decrease the percentage of illumination for any technology to indicate that a space is under-lit or over-lit. For example, you might have entered at minimum set that 30% of the illumination was provided by incandescent and 70% by fluorescent. If the space is over-lit by 30%, at maximum detail, you could enter 39% for incandescent and 91% for fluorescent.

SHW—Buildings Without SHW: This input is intended to indicate whole buildings within a building set that do not have service hot water. Whether the input is provided as “percentage of buildings,” “number of buildings,” or “square footage of buildings,” it indicates the portion of the buildings within the building set that do not have SHW.

SHW in Dual-Use Buildings:

Loop systems are entered only in Use-Area 1. Any loop SHW system in a dual-use building is assumed to serve both use areas. If there is no SHW consumption in a use area, set the consumption and storage capacity for that use area to zero.

The percentages for “portion of the building set served” must add up to 100% for both use areas. The portion of buildings with no SHW value is added to both use areas, as is any loop SHW system. The rest of the SHW is provided by distributed systems within each use area.

Multiple Technologies (Heat, Cool, SHW) in a Single Building: The values for equipment and output capacities should typically be entered on a per-building basis as if it were the only technology in the building.

For heat or cool: if there are multiple technologies serving an individual building, or each building in the building set, select the ‘Percentage of each building served’ option from the heating or cooling end use inputs. Specifying this option for the ‘Portion of building set served’ will enable FEDS to adjust technology capacities so that they are represented properly for serving a portion of each building in the set.

For SHW: assume, for example, that there are two SHW heaters in a building, one electric and one gas, and they are both 80 gallons. Enter 160-gallons storage capacity for each technology and enter that they each provide 50% of the service.

J.2 Technology Record Errors

"Exceeded list limit" The number of possible technologies for a particular end use has been exceeded. ***Reduce the number of technologies to a value less than or equal to the maximum number provided in Technology Records.***

J.3 Inference Errors

Inferences are updated at two points: when you explicitly request an inference update and just before the optimizer is run. Updating inferences catches any input errors and makes sure that the minimum set of inputs is provided. ***Update inferences often; it will help you to assess the reasonableness of your inputs and catch and errors early.***

Errors that may be caught while updating inferences are described below. One of the items enclosed in brackets [] will be present in the actual error message. These error messages typically identify the source of the error and the solution.

"Missing minset at level [default level, NOTE: not used], missing [description] [tech #]."
A minimum set input has not been entered. Make sure that all blue cells contain data.

"Core zone must be at least 15 x 15. Adjust depth or reduce zone number to 4." ***For the building size and aspect ratio, the length of the short side of the building is less than twice the zone depth plus 15 feet (the minimum core zone width). Go to the Geometry Inputs screen and reset the perimeter zone depth to a value less than one-half the length of the short side of the building minus 15 feet or select 4 zones geometry.***

"Error: fractions for [heat, cool, shw] area [1, 2], add up to [frac <>100%]." **Portions served/unserved by each end-use must add up to 100%. Recheck all equipment records and verify.**

"Error: tech ducting scenario for [heat, cool] [tech #] does not match preceding techs." See [Appendix I](#).

"Error: tech ventilation linking scenario for [heat, cool] [tech #] does not match preceding techs." See [Appendix I](#).

"HVAC equipment requires ventilation, ventilation mode locked as NONE." **Unlock or select different ventilation control mode.**

Heat Pumps

You must make sure that the following heat pump attributes are the same in heating and cooling (for each heat pump system):

Fuel type

Equipment type

Vintage

Loop type for ground-coupled

Number of pieces of equipment.

"Fuel for heat pump (heat #, cool #) set to different values." **Make sure that both heating and cooling have the same fuel for the heat pump.**

"[Heat, Cool] Tech # is an unpaired heat pump technology (check attributes which would keep a pair from being inferred)." **Make sure that both heating and cooling technologies are the same, the vintage is the same, and if it is a ground-coupled heat pump that the loop type is the same.**

"Number of equipment for heat # [number of heating equipment] and cool # [number of cooling equipment] do not match." **Make sure that both heating and cooling have the same number of pieces of equipment for the heat pump.**

"Fractions for heat # [heat pump heating fraction for this technology] and cool # [heat pump cooling fraction for this technology] do not match." **Make sure that both heating and cooling have the same value for the portion of the building set served by the heat pump.**

"Equipment vintage for heat # and cool # locked to different values." **Make sure that both heating and cooling have the same equipment vintage for the heat pump.**

"[Air, water] source heat pump fraction mismatch in Heat and Cool end uses." **The portion served by heat pumps must be equivalent for heating and cooling for each type (air and water source).**

"Internal error routine: shw-UserTemp Adjustment Factor, supply temperature < ground water temperature." **Service hot water system supply temperatures must be greater than the ground water temperature.**

Central Plants and Thermal Loops

"Central plant inferences cannot be run until the sum of equipment percentages = 100%." **Make sure that equipment percentages for each central plant add to 100%.**

"The following records have 'central' fuels that are not also used in heat/cool/shw: Bld Set #: (set number) end use : (central fuel) Inference cannot continue until this is corrected" **Change the fuel source or make sure that heat/cool/shw is from that fuel source.**

"The following central plants do not have loops associated with them: #. Central plant inferences cannot be run until loops are assigned to these central plants." **Add loops or remove the central plant.**

"The following thermal loops are not linked to any HVAC, SHW, or other Central Plants: #. Inferences for these loops cannot be run until they are connected to a building or Central Plant load." **Add a load or remove the loop.**

"Note: Inferences will not be run for unconnected loops having a supply pipe length equal to 0." **Either add a load, increase the loop length, or delete the loop.**

"The following purchased fuel prices must be specified in the 'Installation Non-electric price' input screen: (central fuel)." **Add fuel prices for purchased fuels in the Non-electric price input screen.**

"The following specified purchased fuel prices require a central plant and thermal loop reference this fuel: (central fuel)." **Add a central plant, thermal loop, and load for this fuel or set the energy price to 0.**

J.4 Changes to Locked Inputs

Inputs that are locked in FEDS are by definition fixed and will not be changed. There are however, a couple of instances when you might see a change to a locked value.

Design Outdoor Ventilation Air: You entered a percentage for the design outside air, but after updating inferences, you notice that the number you entered is somewhat different. Because the total supply air depends on the amount of outside air, and you entered the outside air as a percentage of the total supply air, this is an iterative calculation and will not return the exact entered value. If you are not satisfied with the returned value, go to the *Ventilation End Use Inputs* screen, enter the percentage, and update inferences. Repeat this process until the percentage is satisfactory.

Lighting Use Area Fixture Density: You entered fixture counts for a dual use area building set and later change the use area percentages for use area one and two. Upon updating inferences, the supposedly locked lighting fixture counts are changed. This occurs because lighting fixture counts are stored on a fixture per square foot basis, and

changing the square footage in each use area via the use area percentages (or by changing the total building set floor area for a single or dual use building set) the fixture count displayed on the lighting screen changes to reflect the change in floor area. While the only way to prevent this from happening is to not change the floor area and use area percentage inputs, it is important to be aware of this if you have input lighting in terms of fixture counts and subsequently need to change either of these parameters - revisit the lighting fixture density inputs and correct as necessary.

J.5 Unexpected Results

The following describe some of the more common situations when the results from a FEDS run show something unexpected and suggest an input error. Some of the more usual causes of such problems are described along with their solutions.

No Retrofits Are Selected: You run a case and no retrofits (or only a couple of lighting retrofits) are selected. While this is a possible outcome, it could also mean that no energy price information was provided. FEDS interprets this to mean that all fuels that are available to the building(s) are free, so the only cost effective retrofit projects would be those that save enough in maintenance or replacement costs to justify their purchase and installation. ***Check both the marginal electric and non-electric energy price inputs to ensure that the appropriate values have been provided.***

All Retrofits Are Electric: Your output shows that all retrofits are electric but you expected to see different fuels for a particular building set. You created a new building set and did not visit the *Fuel Type Inputs* screen. The model assumed that the only fuel available for retrofits was electricity. ***Go to the Non-Electric Energy Price Inputs screen and make sure that prices are entered for all available fuels and go to the Fuel Type Inputs screen and select the fuels that are available to that building set.***

Low Energy Use in All End Uses: Your output shows low energy use in all end uses for a particular building set. You created a new building set and did not visit the *Occupancy: General Inputs* screen. The model assumed that the building was unoccupied. ***Go to Occupancy Inputs and enter the occupancy hours for that building set.***

Lighting Energy Use: Your output shows 0 consumption for lights and/or that exit signs are not present for a particular building set. You created a new building set and did not visit the Lighting Inputs. The model assumed there were no lights in the building set. ***Go to the Lighting Inputs and create the necessary records for the lighting types that you have.***

Miscellaneous Equipment Energy Use: Your output shows 0 consumption for miscellaneous equipment for a particular building set. You created a new building set and did not visit the *Miscellaneous Equipment Inputs* screen. The model assumed there was no miscellaneous equipment. ***Go to the Miscellaneous Equipment Inputs screen and create the necessary records for the types of miscellaneous equipment that you have.***

Appendix K – FEDS Life-Cycle Cost Algorithms

The basic life-cycle cost algorithms used in FEDS and the economic figures-of-merit produced are explained below:

K.1 Annualized Costs

Annualized costs are computed by taking the present value of all the cash flows over the analysis period associated with a cost element and then annualizing the present value.

K.2 Cost Elements

There are four cost elements considered in the life-cycle cost analysis: installed cost (always zero for the existing technology), annual operating and maintenance (O&M) costs, non-annual O&M costs, and energy costs. Interim capital replacement costs, when appropriate, are included explicitly under non-annual O&M or implicitly in the annualized installed cost (when the retrofit life is less than the remaining life of the existing equipment). Salvage value/decommissioning costs are assumed to net to zero.

K.3 Present Value

The present value of each cost element is calculated as follows:

$$PV_j = \sum_{i=1}^n \frac{CF_{j,i} \times (1 + esc_{j,i})}{(1 + k)^i}$$

where:

PV_j	=	Present value of cost element j
n	=	Analysis period
$CF_{j,i}$	=	Cash flow for cost element j in year i (by convention, cash inflows have a positive sign and cash outflows a negative sign)
$esc_{j,i}$	=	Escalation rate for $CF_{j,i}$ if CF is first year cost (e.g., energy cost)
k	=	Discount rate.

K.4 Annualizing

The annualized value of each cost element is calculated from the present value.

$$AV_j = PV_j \times \frac{k \times (1 + k)^n}{(1 + k)^n - 1}$$

where:

AV_j	=	Annualized value of cost element j.
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K.5 Total Annualized Life-Cycle Cost

The total annualized life-cycle cost for the baseline or retrofit is the sum of the present values of the cost elements.

$$TAV_j = \sum_{all\ j} AV_j$$

where:

TAV = Total annualized value of all cost elements.

K.6 Economic Figures of Merit

A number of different economic figures-of-merit are calculated for each retrofit: total life-cycle cost savings or net present value (NPV), simple payback, savings-to-investment ratio (SIR), and adjusted internal rate of return (AIRR).

K.6.1 Net Present Value

The NPV represents the increase in wealth (deficit reduction) from doing the project. NPV is the difference between the LCC of the existing technology and the LCC of the retrofit technology. Only projects with positive net present values are selected by FEDS. This is the sole selection criterion by which FEDS selects retrofits, but it is subject to payback and SIR constraints as described below.

$$NPV = \sum_{all\ j} \sum_{i=1}^{n,existing} \frac{AV_{j,retrofit} - AV_{j,existing}}{(1+k)^i}$$

where:

NPV = Net present value
n,existing = Analysis period for existing technology
AV_{j,retrofit} = Annualized value of cost element j for the retrofit existing technology
AV_{j,existing} = Annualized value of cost element j for the existing technology.

K.6.2 Simple Payback

$$Simple\ Payback = \frac{Installed\ Cost}{\Delta CF_{energy} + \Delta CF_{demand} + \Delta AV_{O\&M} + \Delta AV_{non-ICR\ non-annual\ O\&M}}$$

Simple payback, the ratio of the total installed cost to the first year savings, is a commonly used economic metric for retrofit selection even though it often leads to the incorrect decision. Because payback ignores lifetime, real escalation, and discounting, it does not lead to the minimum life-cycle cost or maximize wealth. Optimization in FEDS can be constrained using simple payback. The user enters that maximum allowable simple payback and the model does not consider any retrofits that have paybacks greater than the entered value. This constrains the model to select the retrofit with the

maximum NPV that has a payback less than the entered value; it does not select the minimum payback retrofit.

where:

$\Delta CF_{\text{energy}}$	=	The difference between building's first year energy cost without the retrofit and with the retrofit (existing - retrofit)
$\Delta CF_{\text{demand}}$	=	The difference between building's first year demand cost without the retrofit and with the retrofit (existing - retrofit)
$\Delta AV_{\text{O\&M}}$	=	The difference between building's annualized O&M cost without the retrofit and with the retrofit (existing - retrofit)--this is equivalent to the first year annual O&M savings if there is no real escalation of annual O&M costs
$\Delta AV_{\text{non-ICR non-annual O\&M}}$	=	The difference between building's annualized non-annual O&M cost that are not interim capital replacements without the retrofit and with the retrofit (existing - retrofit)--e.g., lighting lamp and ballast replacements.

K.6.3 Savings-to-Investment Ratio

Savings-to-investment ratio (SIR) is a useful method for ranking positive net present value projects that are not mutually exclusive.

When available appropriations will not permit all cost-effective energy conservation measures to be undertaken, they shall be ranked in descending order of their savings-to-investment ratios, or the adjusted internal rate of return, to establish priority. If available appropriations cannot be fully exhausted for a fiscal year by taking all budgeted energy conservation measures according to their rank, the set of energy conservation measures that will maximize net savings for available appropriations should be selected.

Optimization in FEDS can be constrained using SIR; the user enters that minimum allowable SIR.

$$SIR = \frac{NPV - PV_{\text{Installed Cost}}}{- PV_{\text{Installed Cost}}}$$

where:

SIR	=	Savings to investment ratio
$PV_{\text{Installed Cost}}$	=	PV of installed cost (a cash outflow and thus a negative number by convention).

K.6.4 Adjusted Internal Rate of Return

The adjusted internal rate of return (AIRR) is an approximation of the actual internal rate of return. An approximation is used because the internal rate of return is an iterative calculation that can have multiple results. The AIRR is a reasonable approximation of the actual desired internal rate of return.

$$AIRR = (1 + k) \times SIR^{\left(\frac{1}{n,retrofit}\right)} - 1$$

where:

AIRR = Adjusted internal rate of return.

Appendix L – Miscellaneous Resources

L.1 Data Collection Forms

FEDS MinSet Form.pdf and FEDS Audit Form.pdf have been installed to your FEDS\Documents\Data Collection Forms directory (default location is C:\FEDS 7.0\Documents\). These are examples of data forms developed by FEDS users to collect building data used by FEDS. Two different versions are available: a single page minimum set version and a multi-page detailed version, listing data that are applicable to each level. These may be printed and used during data collection activities.

The files are in pdf format and may be viewed by opening them with the Adobe Acrobat Reader. If you need to download the Acrobat Reader, visit <http://get.adobe.com/reader/>.

L.2 Frequently Asked Questions

There is a page on the FEDS web site listing a number of FAQs along with detailed answers on all aspects of the FEDS software. The page provides useful information and tips for effectively using FEDS, and is updated as common questions arise. Visit <http://www.pnnl.gov/feds/faqs.stm>.