PNNL-37073

Facility Energy Decision System

Release 8.2 User's Guide

December 2024

Pacific Northwest National Laboratory
Richland, WA USA

U.S. DEPARTMENT OF ENERGY

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Facility Energy Decision System (FEDS) Release 8.2

1 Introduction to FEDS

The Facility Energy Decision System (FEDS) is a building energy simulation and analysis software system designed to provide a comprehensive approach to fuel-neutral, technology-independent, integrated energy resource planning and acquisition. It offers 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, large federal installations, and communities. FEDS assists energy managers, engineers, and building owners understand energy use within their facilities and identify cost-effective approaches for enhancing energy efficiency and resilience.

FEDS has been developed at the Pacific Northwest National Laboratory (PNNL) with support from a number of agencies including the U.S. Department of Energy Federal Energy Management Program, Rebuild America Program, U.S. Army (Office of the Deputy Assistant Secretary of the Army for Energy and Sustainability, Construction Engineering Research Laboratory, Installation Management Command, Forces Command, Reserve Command, and Office of Energy Initiatives), Defense Commissary Agency, Defense Logistics Agency, U.S. Naval Facilities Engineering Systems Command, U.S. Air Force Office of Energy Assurance, Tennessee Army National Guard, U.S. Coast Guard, U.S. General Services Administration, U.S. Agency for International Development, and Public Services and Procurement Canada. Additional input has been contributed by select commercial, municipal, non-profit, and educational licensees.

The scalable FEDS approach allows data input to range from minimal to highly detailed. With limited inputs, FEDS can be used as a top-down, first-pass energy systems analysis and energy resource acquisition decision tool for buildings and facilities. Providing FEDS with more detailed input allows the user to generate optimized building retrofits and provides actionable information on project recommendations, including energy, electric demand, cost, and emissions impacts.

Users may enter only high-level information (e.g., 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 hourly energy simulation and optimization models estimate the current and proposed energy use and 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 building and related energy system parameters. The result provides more accurate and robust technology selection and supporting 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 FEDS.pnnl.gov for additional information and notices regarding software updates or licensing.

1.1 General Description of FEDS

FEDS provides a flexible and comprehensive building and campus energy resource planning approach to help meet a variety of energy management needs and goals. The basic intent of the model is to provide information needed to determine the minimum life-cycle cost (LCC) configuration of an installation's or campus' 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 FEDS Release 8

FEDS 8 introduced the latest generation of the Facility Energy Decision System building energy analysis software, focusing on enhancing the user experience and utility for meeting evolving needs. Key improvements include an updated graphical user interface, new control retrofit options, detailed hourly profile input and output capabilities, updated technology performance and cost data, and more.

1.2.1 New Improved Graphical User Interface

FEDS 8 features a new and more modern graphical user interface (GUI) for an improved user experience and greater stability. The new GUI updates a number of the options of the prior version such as the locking of inputs and provides new feature enhancements. A new model navigation pane offers quick and intuitive access to the entire case at a glance and click of the mouse. A summary results page provides quick access to both tabular and graphical display of energy use by fuel type, in annual or monthly totals, to quickly see how your model is performing. An improved display of integrated help, tracking of input changes, and other updates offer improved support and clearer guidance on model status. Additionally, FEDS 8 provides improved performance with Windows 10 and accommodates a much larger range of display resolutions and settings than previous versions.

1.2.2 HVAC and Lighting Control Measures

FEDS 8 adds HVAC and lighting control measures to its suite of energy efficiency retrofit options that can be evaluated automatically. These include:

- Heating and cooling zone temperature setback
- Ventilation scheduling
- Lighting occupancy control

New inputs have been added to support these new retrofit measures. On the HVAC side, this includes control method and number of thermostats. For lighting, additional inputs include space type, presence of existing lighting controls, number of sensors required, and controlled utilization factors to allow detailed modeling of the impact of controls.

1.2.3 Hourly Profile Input and Output Capability

FEDS 8 adds an option for advanced hourly input of select model parameters for more detailed specification and modeling. This includes support for real-time electricity pricing, occupancy characteristics, heating and cooling setpoints, lighting and other equipment utilization, and hot water demand. Further, hourly energy use details are available for the site, each building, and each technology, for both baseline and post-retrofit scenarios, which are useful in evaluating the daily and seasonal consumption patterns as well as the impact of efficiency measures on electric loads and resilience requirements.

1.2.4 Updated Regional Costs, Technology Cost and Performance Modeling

The FEDS regional labor rates, material cost factors, and sales tax rates have been fully updated, at both the state and intra-state levels (based on the zip code). Additionally, a number of updates are included for the technologies that FEDS models and evaluates as energy efficiency measures. A significant improvement was made to the chiller cost and performance models. LED and other lighting costs were reviewed and updated. The costs of advanced storm window panels were also reviewed and updated based on latest data, among other technologies. Finally, the project cost model was improved to report a breakdown of implementation cost components related to Materials and Equipment, Labor, and Indirect Costs, on the retrofit CSV report.

1.2.5 Completely Updated Emissions Tracking

The tracking of air emissions related to building system energy use has been fully updated. FEDS now tracks and reports emissions impacts for carbon dioxide, sulfur oxides, nitrogen oxides, nitrous oxide, methane, and total greenhouse gases (CO_2 equivalent). Emissions factors for each pollutant were updated to reflect the latest data including electricity generation resource mix, for each U.S. state and Canadian province. See section 4.1.6 for more information.

1.2.6 New Reports

High level tabular and graphical reporting of the simulation energy use by fuel type has been added within the FEDS application for both baseline and post-retrofit results. Text-based reports can now be created in either portable document format (PDF) or rich text format (RTF) for improved readability without extra formatting. Additionally, a new report has been added to further assist federal agencies in meeting EISA 2007 Section 432 and Energy Act of 2020 auditing and energy efficiency assessment requirements. This new spreadsheet output summarizes the results of an EISA-compliant assessment, to facilitate reporting to the Compliance Tracking System (CTS). The report automatically compiles the details from the assessment to assist in the reporting of assessed floor area and identified energy savings potential. Measures are also categorized in the CTS format, across all buildings evaluated, to provide the count of each type of measure identified. The FEDS software has been proven as a tool for assisting agencies in meeting their EISA auditing requirements, and now this additional reporting option will help ease the associated reporting requirement.

1.2.7 Other Additions and Enhancements

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

- A weather station import capability has been added to allow for seamless use of additional available weather station data
- A new input allows the specification of minimum contract demand, as applicable to some electric rates
- Specific DOE/EIA energy price escalation rate projections can be specified via the addition of an explicit energy rate sector input (allowing users to select from residential, commercial, or industrial rates)
- The number of thermal zones that can be modeled for a building increased from 5 to 20

- White roofs can be modeled with a new roof color input option
- Improved modeling of exterior lighting operation, according to seasonally variable hours of darkness
- Building HVAC operation can be controlled seasonally, and for specific thermal zones
- Updated equipment performance and other inference data improvements
- Additional reporting detail including monthly electricity peak demand, billed demand, and use area annual operating hours.

1.3 FEDS 8.2 Updates

FEDS 8.2 includes a number of updates and enhancements, plus fixes to issues identified in earlier FEDS 8 versions. Key enhancements from FEDS 8.1 are also identified.

1.3.1 Open Optimized Case

A new **'Rebase Optimized Case**' feature allows users to create a new case from the results of an optimized case (including all selected retrofit measures).

1.3.2 New Fuel Type Availability Option

A new option for the building **Fuel Availability inputs** allows more nuance to fuel switching. Selecting the new 'Existing' option will permit FEDS to consider a replacement technology using that fuel type ONLY for equipment currently using that fuel (i.e., FEDS won't recommend switching to that fuel outside of equipment that currently use it).

1.3.3 HVAC Pairing Improvements

The automated pairing of heat and cool technologies has been expanded and a new 'Do not pair this tech' option has been added to increase flexibility.

1.3.4 Inference Improvements

The Run Year now defaults to the current year but may be changed by the user. The inferred LED lighting fixture configuration has been updated to take the space type into account. Prior improvements were made to HVAC system operational parameters and lighting occupancy sensors utilization reductions based on space type.

1.3.5 Updated Energy Escalation Rates

This version of FEDS incorporates the latest DOE discount rate and energy escalation rate projections as reported by the *Energy Price Indices and Discount Factors for Life-Cycle Cost Analysis* (*Annual Supplement to NIST Handbook 135)*. This includes expanded support for more detailed fuel price escalation projections across the nine Census Divisions, in addition to the prior four Census Regions. FEDS cases with a run year of 2024 or later will apply the new Census Division projections.

1.3.6 Expanded Support for Custom Weather Data [FEDS 8.1]

The FEDS weather import process was improved to handle a broader set of customized EPW weather files and data formatting.

1.3.7 New Retrofit Options [FEDS 8.1]

Electric space heating and water heating technology options were added. LED lighting retrofit options were added to several baseline fixtures that did not previously have them.

1.3.8 Report Updates

The use area header detail for the technology specific hourly profile output CSV file has been improved. Also formatting updates and fixes to the ERCIP and other text reports have been implemented.

Updates from FEDS 8.1 include:

- The study period for each retrofit measure was added to the detailed retrofit project spreadsheet report.
- The Compliance Tracking System (CTS) report was updated to match the latest version of the CTS reporting template.
- Additionally, the per tech consumption profiles were updated to multiply the hourly consumption values by the number of buildings in each building set.

1.3.9 Software Component Updates

All third-party software that FEDS relies on were reviewed and updated to the latest versions for improved performance and security, and will continue to be updated regularly.

1.3.10 Bug Fixes

Several software errors were resolved in the following areas of the GUI: hot water system input access, navigation panel display, time-of-day electric rate period specification, and Cancel operations when navigating away from a screen with unsaved changes. Other fixes were made to improve the usability and navigation of the GUI, via expanded input validation, and notifications regarding central plant optimization results.

2 Getting Started

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

2.1 Computer Requirements

The following minimum computer platform specifications are recommended for the FEDS 8 software:

- A Windows-based personal computer running Windows 10 or later
- 1.6 GHz or faster processor
- 8+ GB of RAM
- 2+ GB of available hard disk space – for installing the FEDS program and storing FEDS input and output files
- Microsoft Excel is needed to display the Summary Results and create the Compliance Tracking System (CTS) output report but is otherwise not required to run FEDS.

2.2 Installing FEDS

1. Run the FEDS setup file provided by download or CD.
2. Follow the prompts to complete installation. The default location for installing the application is C:\Program Files (x86)\FEDS 8, however, other locations may be specified.

Note: to reduce hard drive space requirements the setup process allows for the installation of a subset of the available weather files (select the regions that are applicable for your building(s)). If weather stations for regions or time periods beyond those offered by the setup process are desired, use the Import EPW Weather File option from within the FEDS application as described in Section 3.7.2.

2.3 Developing a FEDS Model

The basic steps for developing a FEDS model include creating a new case or opening an existing case, specifying site and building parameters, and updating inferences. Figure 2.1 shows the opening page of the FEDS application, from where a new case can be created, or an existing case opened.

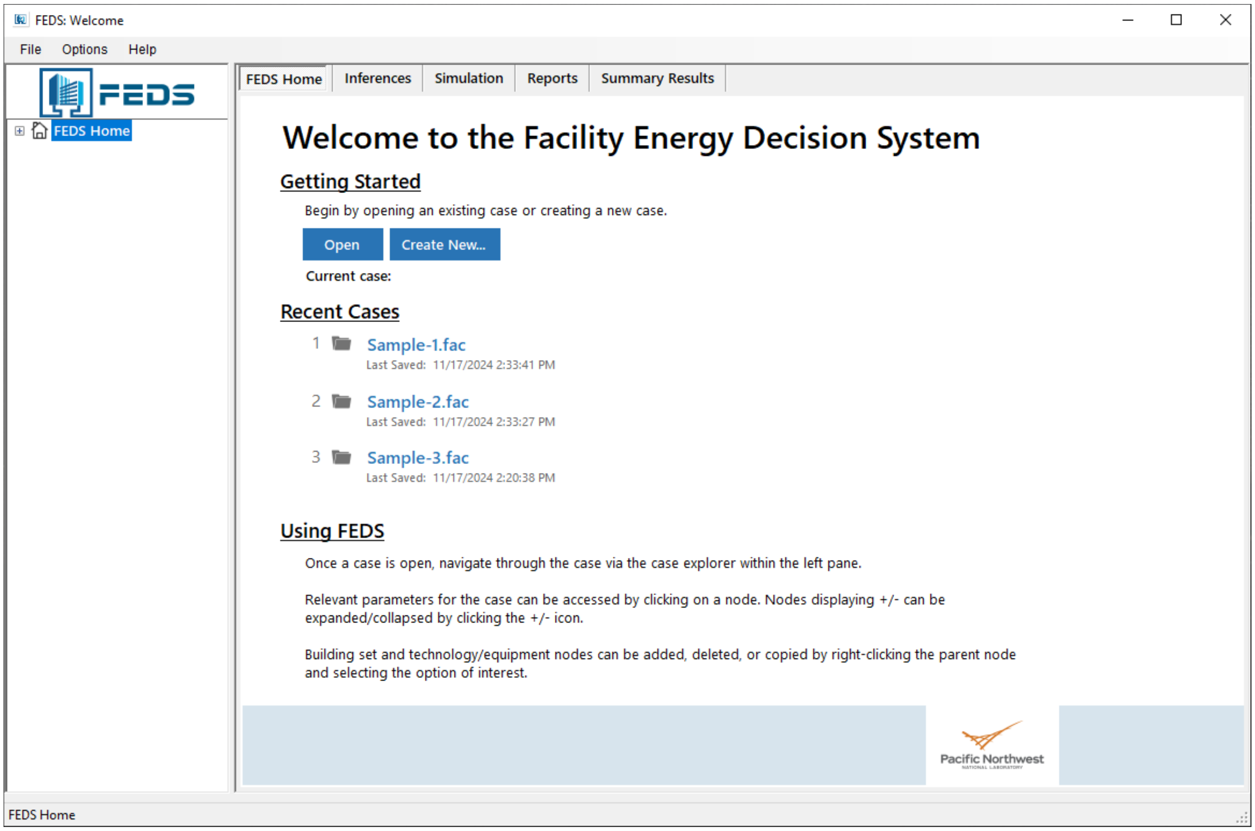

Figure 2.1 FEDS Home Screen

2.3.1 Create New Case

To create a new case, press the **Create New** button from the Getting Started section of the FEDS Home page OR select the **New case…** option from the *File* menu. The *New Case Selection* screen will appear and prompt for a case name and path, as illustrated in Figure 2.2.

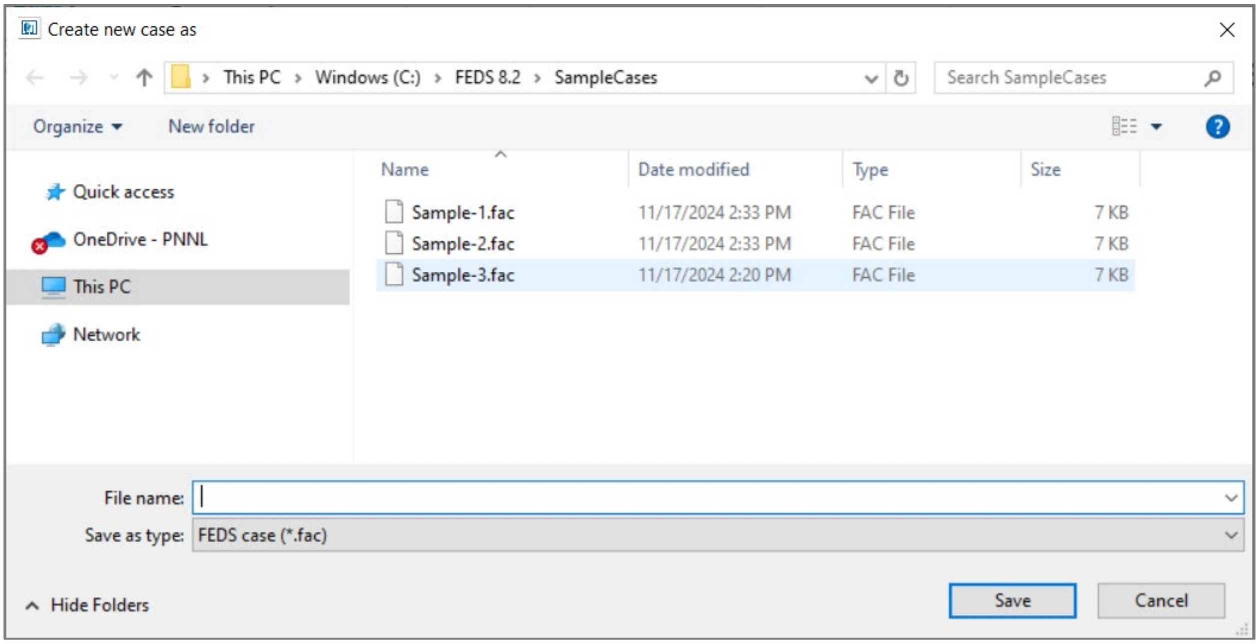

Figure 2.2 New Case Selection Screen

For each case, FEDS creates 17 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}.dbp	{casename}.nep
{casename}.ecn	{casename}.plk
{casename}.elk	{casename}.plt
{casename}.elp	{casename}.rcf
{casename}.emi	{casename}.rrs
{casename}.eng	

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 43 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.

2.3.2 Open Existing Case

To open a previously created case, select **Open** from FEDS Home OR select the **Open case…** option from the *File* menu. The *Existing Case Selection* screen will appear and prompt you for the location and name of the case (see Figure 2.3). 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 they do not automatically appear within the Open Case window, navigate to the FEDS \Cases folder (the default location is %UserProfile%\Documents\FEDS 8\Cases, where %UserProfile% typically represents C:\Users\<username>\). For more information about the sample cases, see Description of Sample Cases in Section 2.5.

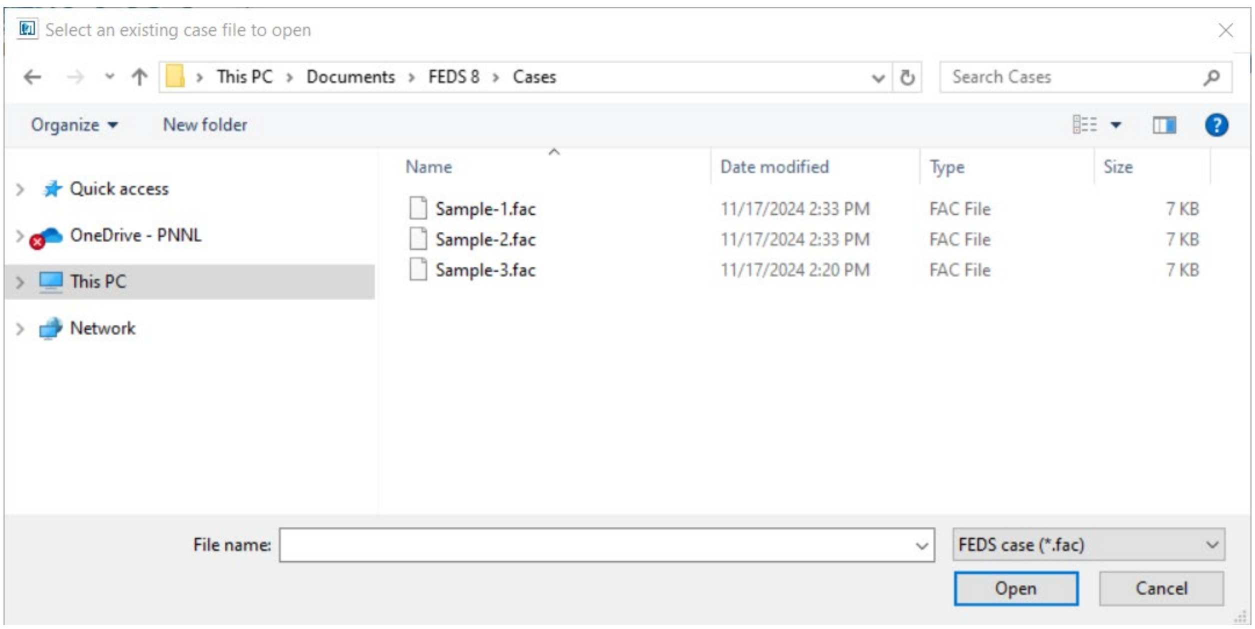

Figure 2.3 Existing Case Selection Screen

2.3.3 Converting Older FEDS Case Files

In order to run FEDS 8 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 older FEDS input files for use with the latest version.

Convert case files ("*.fac") created with FEDS 7.1 or a previous version to FEDS 8 format as follows:

1. Follow procedure for Open Existing Case in Section 2.3.2.
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 8\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: When running a converted model in a newer version of the FEDS application, expect to see changes to both inferred inputs and resulting output values due to model and data updates and improvements.

2.3.4 Building a Model

Once you have started FEDS and have opened or created a case, an outline for developing and refining the model (which can represent a single building or large multi-building campus) is as follows (refer to the listed sections for more information):

1. Specify facility information, such as location, weather station, energy prices (see Section 4.1).
2. Define parameters for any central plans and thermal distribution loops (see Section 4.2).
3. Enter or modify input data for each building or group of similar buildings (see Section 4.3).
4. Update inferences (see FEDS Home functions in Section 3.1).
5. Examine resulting inferences, make appropriate changes, update inferences again, and repeat process until satisfied with the model input data.

For more detailed information on these steps, see FEDS Process in Section 5.

2.4 Running FEDS Simulation

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. Select the Calibration analysis type or exclude all building sets from optimization (see the discussion of this in Sections 3.1 and 6).

2. Run FEDS (see FEDS Home overview in Section 3.1.
3. 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. Review and reconcile model inputs based on calibration results and uncover any input errors or omissions (see FEDS Output discussion in Section 8.
4. Correct any input errors and continue to calibrate the model until satisfied that it reasonably represents reality.
5. Set simulation parameters as appropriate (as described in Section 6).
6. Change analysis type to 'Optimization' (or remove building set exclusions) and run FEDS.
7. Open and review output reports to examine FEDS recommendations (see FEDS Output in Section 8).

For more detailed information on these steps, see FEDS Process in Section 5.

2.5 Sample Cases

When FEDS is installed 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 accessed using the **Open case** option to review on a screen-by-screen basis how data files are constructed.
- They may be run through FEDS inference, simulation, and optimization engines 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.
- The sample cases can serve as a starting point for developing your own models. Use the **Open case** followed by **Save case as…** option from the *File* menu to create a copy of the sample case with a new name to avoid overwriting the sample case data. The newly copied case can then be edited and modified as needed to develop your own case. This method provides a potential shortcut when compared to creating a new case from scratch. However, it is important to pay close attention to the inputs that require changes.

2.5.1 Sample-1

This case file contains the example of a single 40,000 ft^2 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.

2.5.2 Sample-2

The example in this case file is a complex consisting of two 50,000 ft^2 office buildings, six 50,000 ft^2 warehouses, ten 2,000 ft^2 single family (detached) residences, and three multi-family (five or more unit) buildings with an average floor area of 26,667 ft^2. 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 water heaters, and all 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 multi-family buildings were constructed in 1984. One of the buildings (24,000 ft^2) is all electric, with electric resistance heating and electric water heaters. The other two buildings (28,000 ft^2 each) are heated with natural gas and have gas water heaters. All three buildings cool with window air conditioners. The lighting is 10% fluorescent and 90% incandescent. The buildings are occupied from 5 pm to 7 am on the weekdays and continuously occupied during the weekends.

2.5.3 Sample-3

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 4.3.5). 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 two 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 5.8). 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 4.3.4).

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 three 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.

3 FEDS Application Overview

This section provides a brief overview of and orientation to the FEDS application, including structure, case and screen navigation, special buttons and indicators, menu items, and program functions. Information is available within the FEDS application 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 5.

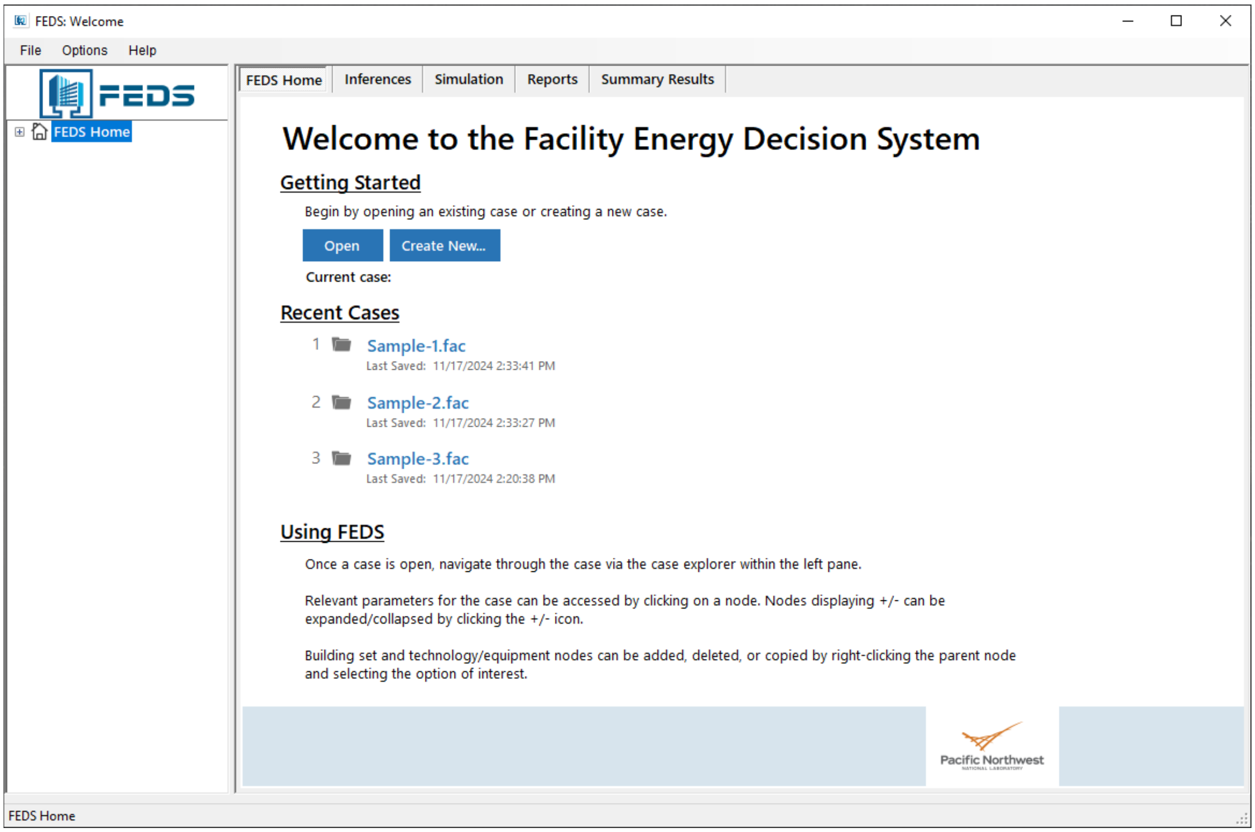

Figure 3.1 FEDS Home Screen

3.1 FEDS Home

After launching FEDS, you will see the *FEDS Welcome or Home* screen as shown in Figure 3.1. From this screen, you may Open an existing case or Create a new case. Once a case has been loaded or created, you can access the case navigation pane to explore the range of possible inputs and settings. In addition, a number of case and program functions can also be accessed using the menu bar or options under the FEDS Home node. For instance, the following options are accessible from within the FEDS Home (either via the navigation pane on the left or from the tabs at the top of the FEDS Home window): Inferences, Simulation, Reports, and Summary Results.

3.1.1 Inferences

Generate inferences for all or select buildings in the case, along with central plant and thermal loops, and the inferable facility inputs (Figure 3.2). Updating inferences also performs checks on inputs to trap any errors and report any required inputs that have not been specified. Inferences may also be run for individual building sets from the menu accessed by right-clicking the desired building set's top node within the navigation window.

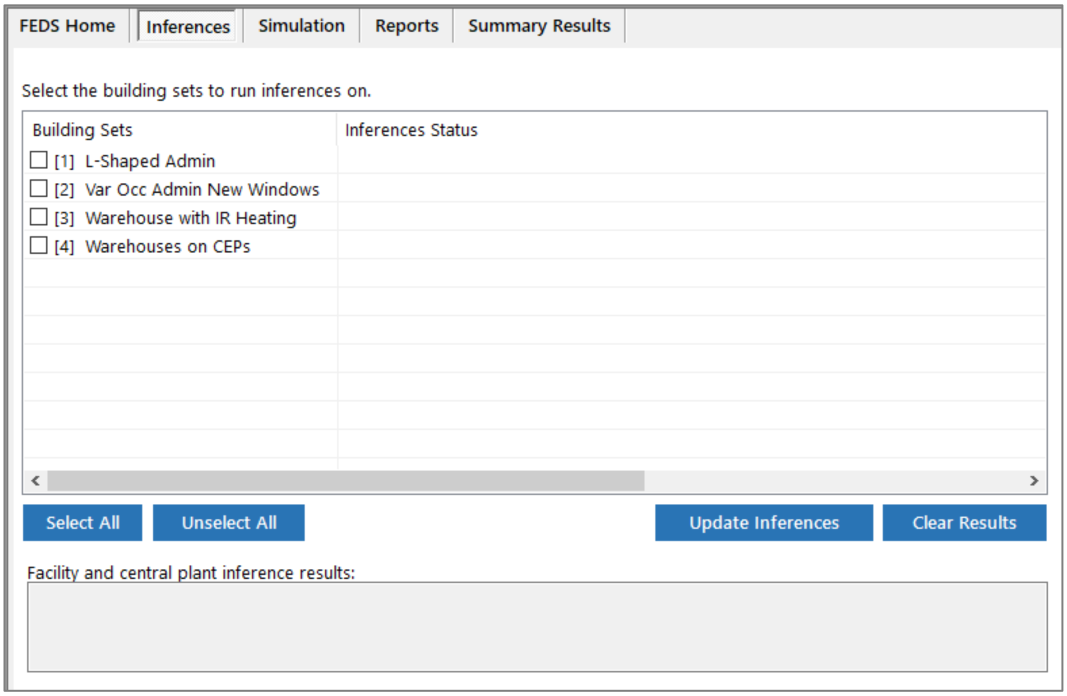

Figure 3.2 Inferences Screen

3.1.2 Simulation

Specify simulation parameters (e.g., calibration or optimization analysis type), exclude building sets, restrict retrofits, and run FEDS (Figure 3.3). Running FEDS initiates the baseline energy simulation to estimate current energy use and the optimization engine to evaluate energy efficiency measures and simulate their performance. A calibration analysis can also be performed in order to help compare FEDS energy simulation results with actual metered energy use. For more information on the simulation settings and options, visit Section 6.

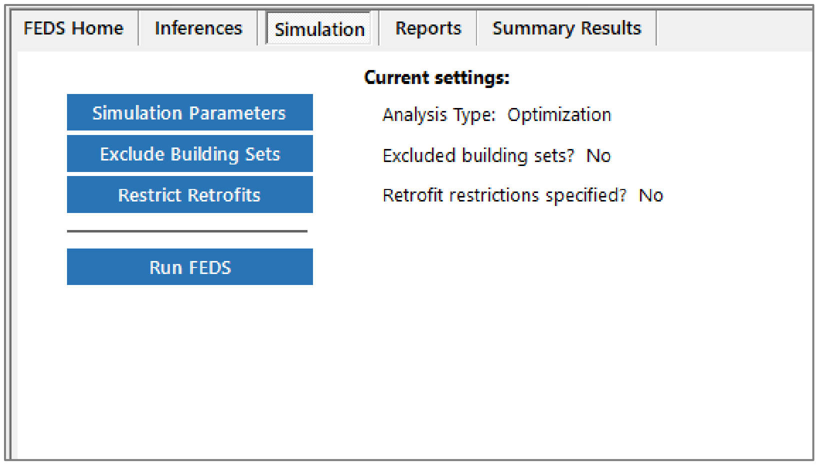

Figure 3.3 Simulation Settings

3.1.3 Reports

Access, create, and open a variety of FEDS report options (Figure 3.4). For more information, see FEDS Output in Section 8.

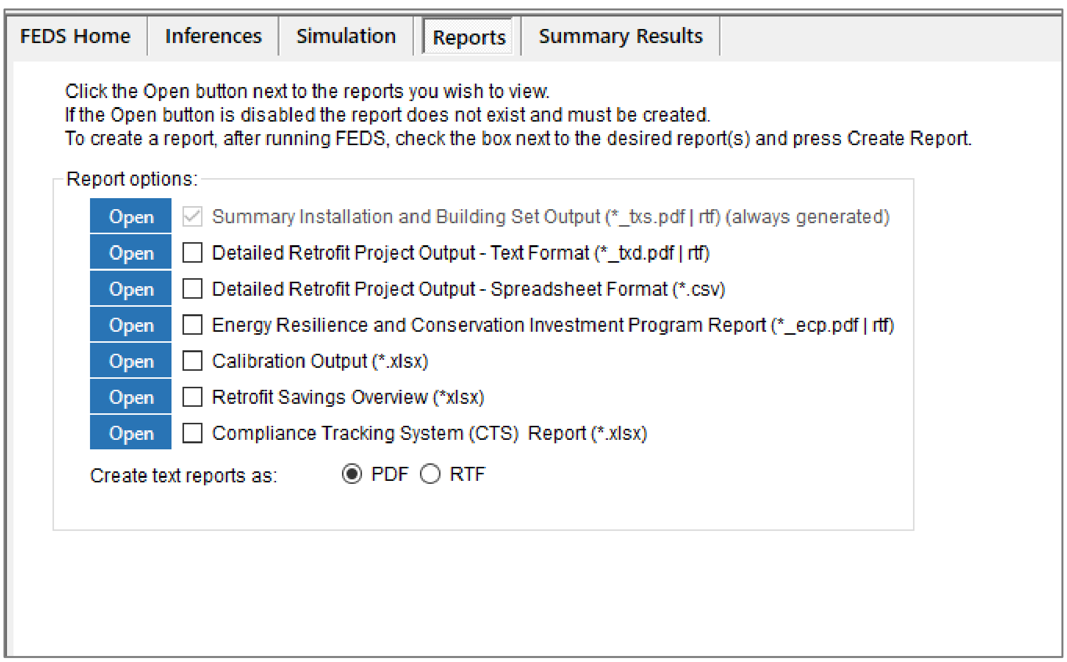

Figure 3.4 Report Options

3.1.4 Summary Results

View high level results of the latest FEDS simulation, showing annual and monthly energy use and electric peak demand, in tabular or graphical format, as shown in Figure 3.5. Note: Microsoft Excel is required in order to view the Summary Results.

Figure 3.5 Summary Results

3.2 Case Navigation

A new feature of FEDS 8 is the case navigation pane at the left of the FEDS application window. As shown in Figure 3.6, the navigation pane offers direct access to each component of a FEDS case. The navigation pane presents a standard hierarchical structure that allows the sub-elements under each heading to be expanded or collapsed as desired. The number of available sub-elements varies according to the content. Right-clicking select elements with the mouse will bring up a menu of possible options for expanding or collapsing the navigation tree, and adding, copying, and deleting model components.

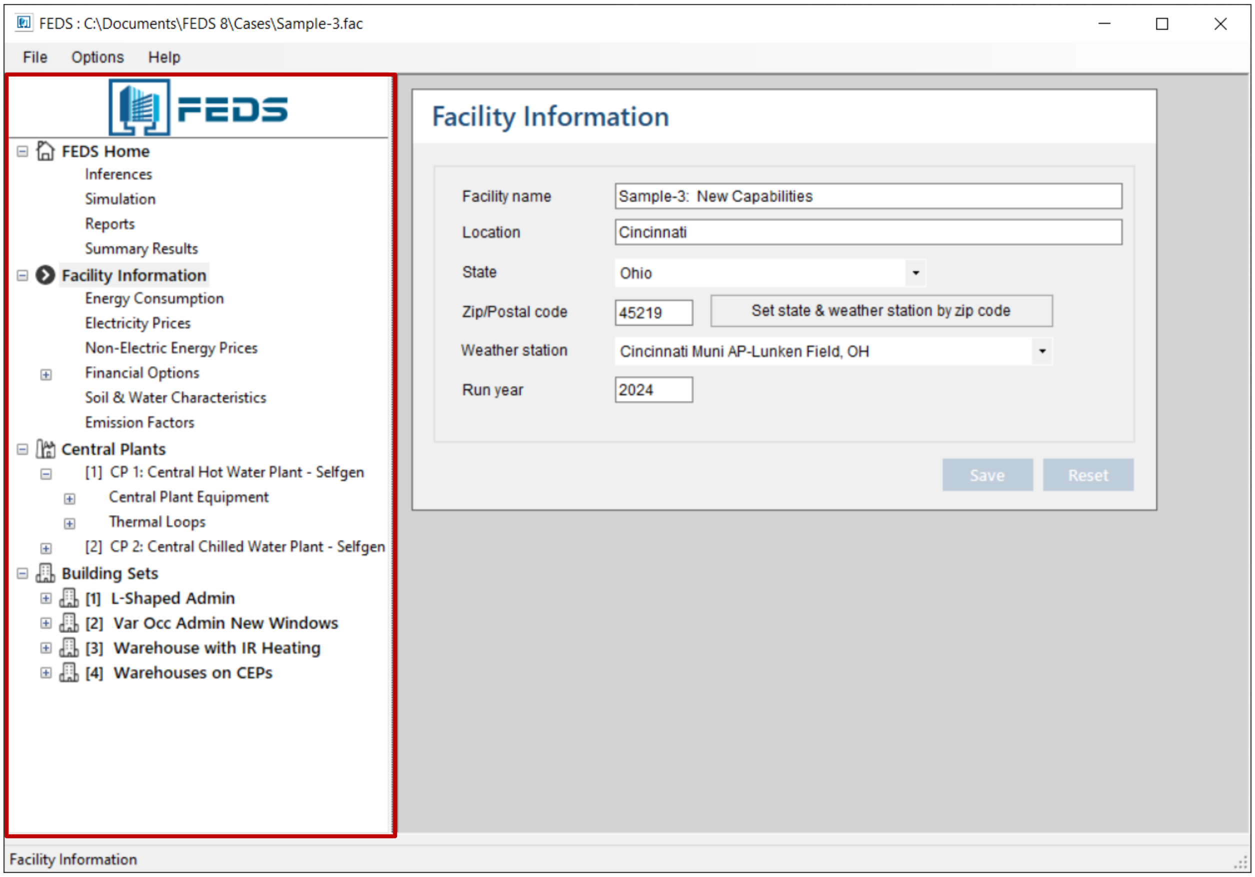

Figure 3.6 FEDS Navigation Pane

Each main component is highlighted here:

- **FEDS Home**: The FEDS Home page, where a new case can be opened or created. Additionally, access to the following capabilities is provided:
  - ***Inferences***: Generate inferences for all or select buildings in the case, along with central plant and thermal loops, and the inferable facility inputs.
  - ***Simulation***: Specify simulation parameters (e.g., calibration or optimization analysis type), exclude building sets, restrict retrofits, and run FEDS.
  - ***Reports***: Access, create, and open a variety of FEDS report options.
  - ***Summary Results***: View high level results of the latest FEDS simulation, showing annual and monthly energy use and electric peak demand, in tabular or graphical format.
- **Facility Information**: Specify information on the site, such as name, location, zip code, weather station. Additional screens of inputs at this level include:

- *Energy Consumption: Document actual energy consumption by fuel type (not required).*
- ***Electricity Prices**: Specify electricity rate details.*
- ***Non-Electric Energy Prices**: Input prices for all other fuel types used.*
- ***Financial Options**: Funding source, discount rate, fuel price escalation rates, and any screening thresholds for projects.*
    - ***Regional Costs**: View and update labor rates, materials cost multipliers, taxes and overheads that apply to project costs in your location.*
    - ***Retrofit Cost Multipliers**: Set cost multipliers as needed, to adjust the project costs estimated by FEDS, for specific end uses and technologies.*
- ***Soil & Water Characteristics:** Soil type and other characteristics relevant to the performance of ground-coupled heat pump systems, plus groundwater temperature which is also used to calculate water heating energy.*
- ***Emissions Factors: E**missions factors for 6 pollutant types.*

- ***Central Plants***: Define information for any central plants and thermal distribution loops serving the site being modeled. There will be a central plant node for each central plant defined within the case (and none if no central plants are modeled). For each central plant there may be one or more Central Plant Equipment records defined, as well as multiple Thermal Loop records.

  New central plant records can be created by right-clicking on the main Central Plants node, and selecting 'Add Plant'. The same can also be done for central plant equipment and thermal loop records. Records of each type may also be copied or deleted by right-clicking the mouse on the specific record you wish to copy or delete.[1]

- ***Building Sets***: A FEDS case can contain any number of building sets. There are a number of input screens associated with each building set that enable the specification of pertinent information from building type, size, and vintage to the characterization of use, occupancy, geometry, construction and envelope, lighting, heating, cooling, ventilation, hot water, motor, and miscellaneous equipment.

  New building sets can be added by right-clicking the mouse on the main Building Sets node and selecting 'Add Building Set'. Existing building sets can be copied or deleted by right-clicking on the desired building set and selecting 'Copy' or

[1] Central plant records can also be added in two other ways: 1) a default central plant is created when inferences are updated on buildings using a central fuel (steam, hot water, chilled water) with no source loop identified, and 2) a 'purchased fuel central plant' is automatically created when a fuel price is saved for a purchased central fuel.

'Delete'. Building sets can also be imported from other FEDS cases using the Import Building Sets option (see Section 3.7.1). For building technology records (e.g., lighting, heating, cooling, hot water, motors, miscellaneous equipment), right-clicking will also allow you to add, copy, and delete. The right-click menu also provides the option to update inferences for the current building set.

Remember: Right-click select navigation pane nodes to Add, Copy, or Delete a record or Update Inferences for a specific building set.

3.3 Screen Navigation and Operation

FEDS 8 is a menu-driven Windows application and is designed to be operated with a mouse and keyboard (as well as just a keyboard). 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 and often open a new window, e.g., selecting 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 mutually exclusive, that is, selecting one item will deselect a previously selected item.
- **Radio buttons**: Radio buttons are selected in a similar manner as check boxes (using the mouse or arrow keys); however, only one option may (and must) be specified.
- **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 (or ENTER) will select the item.

3.4 Save, Reset, Close Buttons

Each of the FEDS input screens has a Save and Reset button. These buttons will remain disabled as long as no edits or changes are detected to the inputs on that screen (or underlying screens). When a change is detected, both buttons will become enabled.

<Save> will save the information have entered. **<Reset>** will revert the changes back to their previous state from the last save.

Some input screens will also have Apply, Cancel, and Close buttons. **<Apply>** saves the changes and returns to the parent screen. **<Cancel>** returns to the parent screen without saving, and **<Close>** will close the current window and return you to the parent screen.

3.5 Special Indicators and Input Locking

Inputs that have a blue arrow pointing at them are required inputs and have not yet been satisfied. For a new building set or technology record, required inputs must be provided in order to successfully determine the inferences and run the model. These must be provided by the user and are not inferable by FEDS and, thus, do not have the locking feature associated with them. Once a valid input is provided for a required input and saved successfully, the blue arrow will disappear, indicating that the requirement has been met.

From the case navigation pane, a red symbol next to a given input screen node indicates that one or more required inputs remain that must be specified before FEDS can update inferences or perform a simulation.

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>**. In the unlocked state, these 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. Inputs can also be locked to the current value by clicking directly on the lock icon.

This standard Windows Help icon offers additional context for select inputs and related concepts. Press this button to access guidance about the input or help in understanding how to specify the information.

Recommended Inputs: Inputs without the blue required input arrow or lock icons are highly recommended but <u>not required</u> for FEDS to run. These include user-defined labels for the installation, building set, and technology 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 review and provide this information.

3.6 Help Options

FEDS Help is available via a number of sources:

- The FEDS User's Guide may be accessed from the *Help* menu or by pressing **<Ctrl+F1>**.
- Context-sensitive help for each input is also available. 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>**. OR simply hover the mouse pointer over the input text. 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.
- On some screens additional context is provided by a blue question mark help icon. Clicking on this will open a window containing information relevant to the current input screen or concept.

3.7 Application Menu Options

The FEDS application currently includes the following menu bar items: File, Options, and Help.

3.7.1 File Menu

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

- ***New case [Ctrl+N]*:** Allows you to create a new case. See Create New Case in Section 2.3.1.
- ***Open case [Ctrl+O]*:** 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 2.3.2 and Converting Older FEDS Case Files in Section 2.3.3.
- ***Save case [Ctrl+S]*:** 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 [Ctrl+I]*:** An import tool to allow building sets from other existing cases 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. When this function is selected, a case navigation window will open in order to identify the case containing the building sets to be imported into the current FEDS case. Note that 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 process will only import the building set data, and no facility data (energy prices, financial parameters) or central plant and loop inputs will be imported.

- ***Recent****:* Lists as many as ten most recently opened FEDS cases, for ease in opening them.
- ***Exit [Alt+F4]:*** Closes the current FEDS case and shuts down the FEDS application. This can also be accomplished via the close application X at the top right of the application window.

3.7.2 Options Menu

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

- ***Input Profiles*****:** Provides access to the hourly profiles for more detailed specification of select parameters (e.g., electric rates, building occupancy, heat/cool setpoints, light and equipment utilization rates, water temperature).
  - View/Modify Profiles (Export): writes the select facility and building input profiles to disk (in CSV format, within the folder where the case files are stored) for viewing and editing. Any changes made to the input profiles must be saved by changing the Apply Profile Type for the edited profiles from "FEDS" to "User". The edited CSV files must then be saved and imported back into FEDS.
  - Save Profiles (Import): reads the facility and building input profiles back into FEDS for use in subsequent simulations. Any user altered profiles, denoted by "User" in the Apply Profile Type profile column header value, will be locked and remain unchanged by FEDS. Any unlocked profiles identified by "FEDS" in the Apply Profile Type header will continue to be updated by FEDS as related input change and inferences are updated.

  Exporting the profiles will create one CSV file for the facility level inputs, providing access to the following parameters at the hourly level:

  - electric rate (¢/kWh)
  - groundwater temperature (°F)
  - dry bulb temperature (°F)
  - relative humidity (%)
  - atmospheric pressure (psia)
  - sky clearness

A separate CSV file for each building set will also be generated, and provide access to view and or adjust the following building and use-area level inputs at the hourly level:

- operating status (none, low, high) [by use area]
- #occupants [by use area]
- heating thermostat setpoint (°F)
- cooling thermostat setpoint (°F)
- design outdoor ventilation air multiplier
- lighting utilization [by tech]
- miscellaneous equipment utilization [by tech]
- cold water temperature (°F)
- hot water demand (gal) [by use area]

Examples for when specifying hourly input profiles may be beneficial include:

- Complex electricity pricing: specify real-time electric rates or other complex structures that cannot be specified via the regular inputs.
- Special weather: customize or edit the weather data used for the simulation.
- Occupancy: model variations to operating hours and/or number of occupants beyond what the regular and variable occupancy inputs provide.
- Generation: include the impacts of generation from solar PV, wind, or other source by modeling as a negative miscellaneous equipment load and specifying hourly utilization rates.

- ***Import EPW Weather File:*** This option allows users to apply weather data for other locations or time periods to their FEDS simulations and analyses. The weather station data must be in standard EPW file format. Review the additional help provided from the import screen when selecting this option.
- ***Rebase Optimized Case:*** This option allows users to capture the optimal state of a previously run FEDS case and open it within a new baseline FEDS model. All selected retrofit measures identified for the optimized case will appear as existing in the new 're-based' case generated by this process. See the additional help provided from the Rebase Optimized Case selection screen for more information.
- ***Autosize Nav Menu:*** This user option, when turned on, will automatically size the width of the navigation pane to show the full length of description text. Auto-sizing can also be accomplished manually by double-clicking the right border of the navigation pane.

- ***Highlight Selected Input Label:*** Selecting this option will highlight the text label of the current selected (active) input cell in a combination of blue text and grey background. The purpose is to aid in tracking the current input. Unchecking this option will turn off this feature.

3.7.3 Help Menu

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

- ***User's Guide [Ctrl+F1]:*** An electronic pdf version of the FEDS User's Guide can be accessed by selecting this option.
- ***About FEDS:*** The About FEDS page lists information about the current FEDS version, sponsors, copyright notice, and a link to the FEDS website.

3.8 Display Modes

In previous versions of FEDS (e.g., FEDS 7.1 and earlier) there were two modes available for displaying available model inputs: Minimum Set and Maximum Detail display. As of FEDS 8, the minimum set display option has been removed and all inputs are viewable. However, keep in mind that ***only the required inputs*** (designated by the blue arrow - see Section 3.5) must be specified and any of the other inputs can be left for FEDS to infer. Thus, only the display option has changed and not the behavior or performance of the FEDS Inferences.

4 FEDS Inputs

This section highlights the input options that define a FEDS case. These are grouped according to facility, central plant and thermal distribution loop, and building inputs.

4.1 Facility Information

After launching FEDS, you will see the *FEDS Welcome or Home* screen. From here, the Facility Information screen (shown in Figure 4.1) may be accessed by clicking on the appropriate node from the navigation pane on the left side of the FEDS application window. This screen prompts you for general descriptive information about the site, such as its name, location, zip code, and weather station.

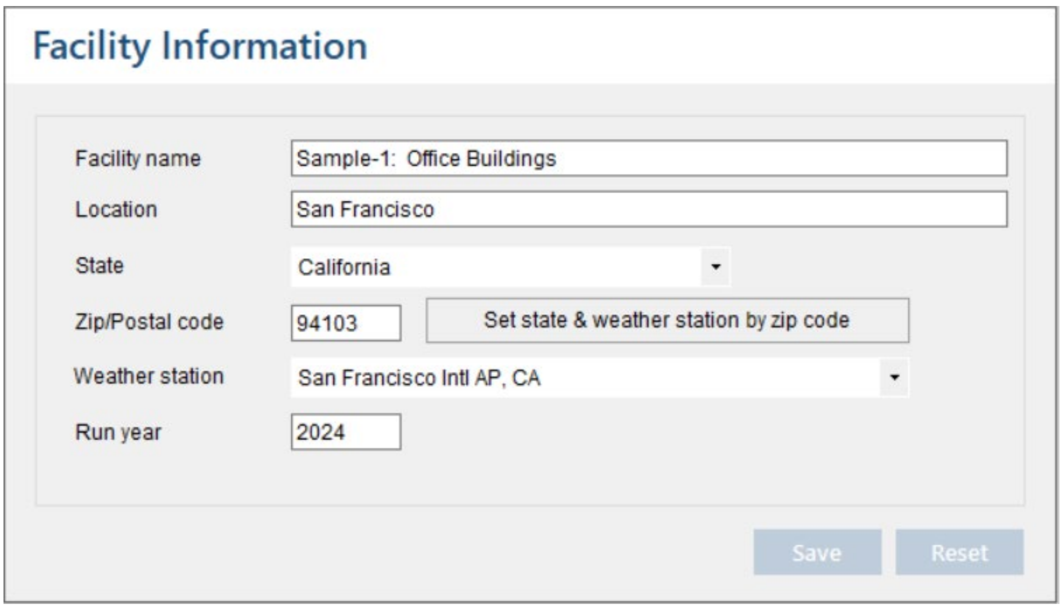

Figure 4.1 FEDS Facility Information Screen

The following additional facility level input screens can be accessed beneath the Facility Information node in the navigation pane.

4.1.1 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.

4.1.2 Electricity Prices

These data include detailed electric rate structure information for flat and time-of-day rates, demand ratchets, and minimum demand, as applicable. The electric rate schedule for the buildings being modeled should be analyzed to determine the appropriate marginal rate inputs. Typically, the buildings modeled together in a single

FEDS case should all be served by the same billing meter (especially if there are demand charges), and the same rate structure.

4.1.3 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) 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.

4.1.4 Financial 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.

Two additional financial input screens are accessible as sub-nodes. These are the Regional Costs and Retrofit Cost Multipliers inputs. These provide the user access to FEDS' internal project cost assumptions 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.

Regional Costs

This screen (see Figure 4.2) displays relevant project cost data for the site including fully burdened 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 "Other (global multiplier)" input is a value applied to the total cost of all retrofit projects considered during optimization. It can 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.

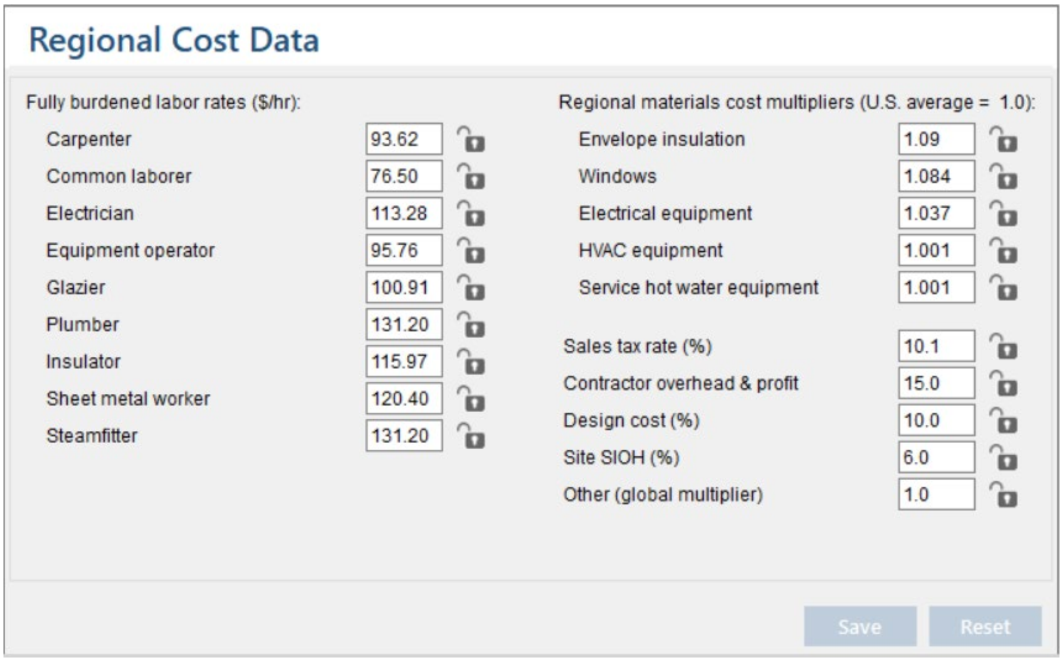

Figure 4.2 Regional Cost Data

Retrofit Cost 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. 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 4.3.

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.

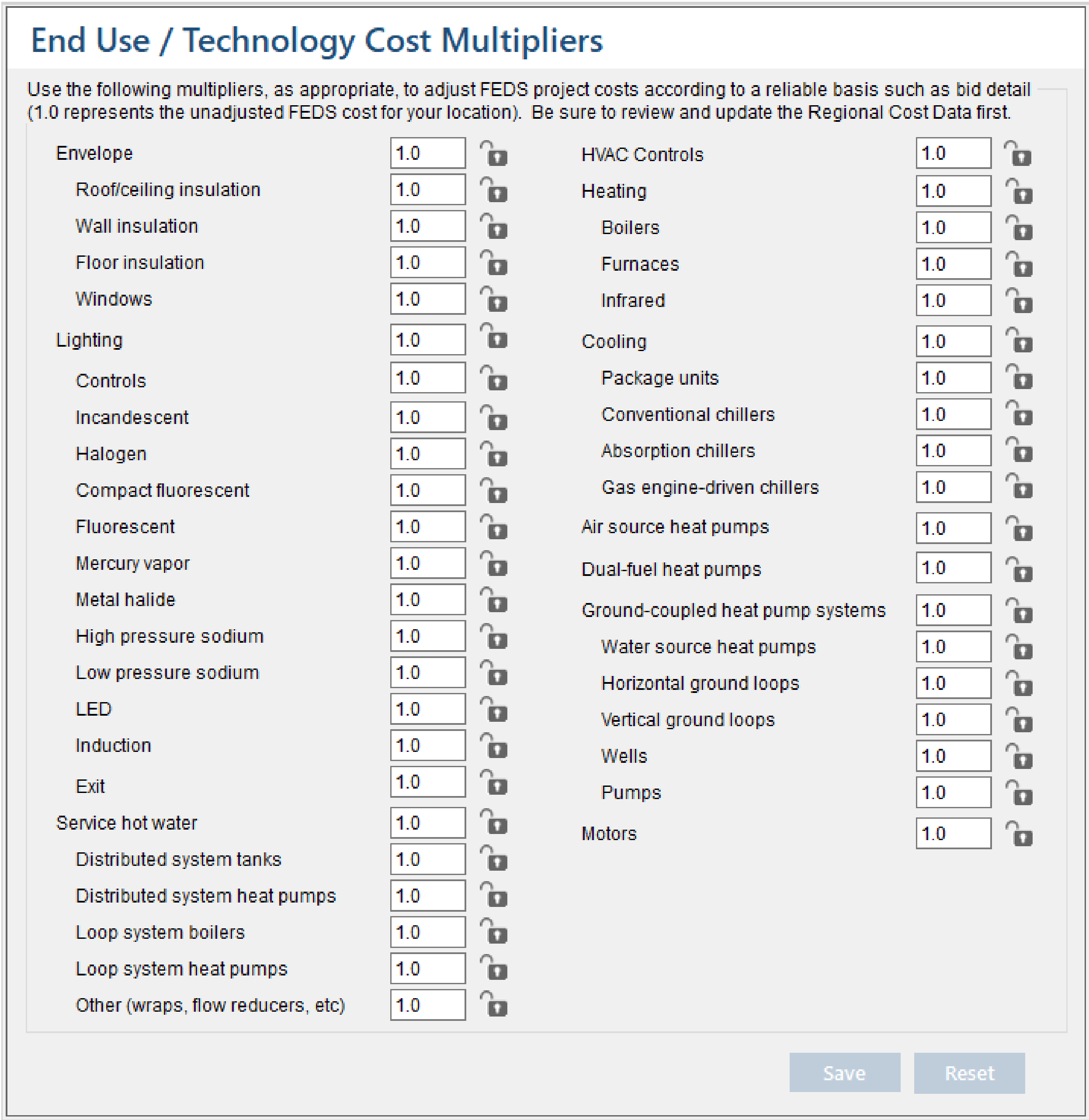

Figure 4.3 End Use/Technology Multipliers

4.1.5 Soil & Water Characteristics

This screen provides access to the hydrogeologic characteristics 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.

4.1.6 Emissions Factors

Along with energy consumption and costs, FEDS also tracks and reports the estimated emissions impacts of selected retrofits and upgrade packages. FEDS provides the ability to view and modify the emissions factors for 6 pollutant types (carbon dioxide, sulfur oxides, nitrogen oxides, methane, nitrous oxide, and total greenhouse gases in carbon dioxide equivalent) for each purchased fuel type available in FEDS. These represent full fuel-cycle factors and are inferred based on the state or province in which the facility is located.[2] For most locations outside of the United States and Canada, FEDS infers emissions factors based on the U.S. average values. However, in order to provide greater flexibility and accuracy in modeling site specific emissions and variations in electricity source fuel mix, the option to override these inferred factors is provided (see Figure 4.4). 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.

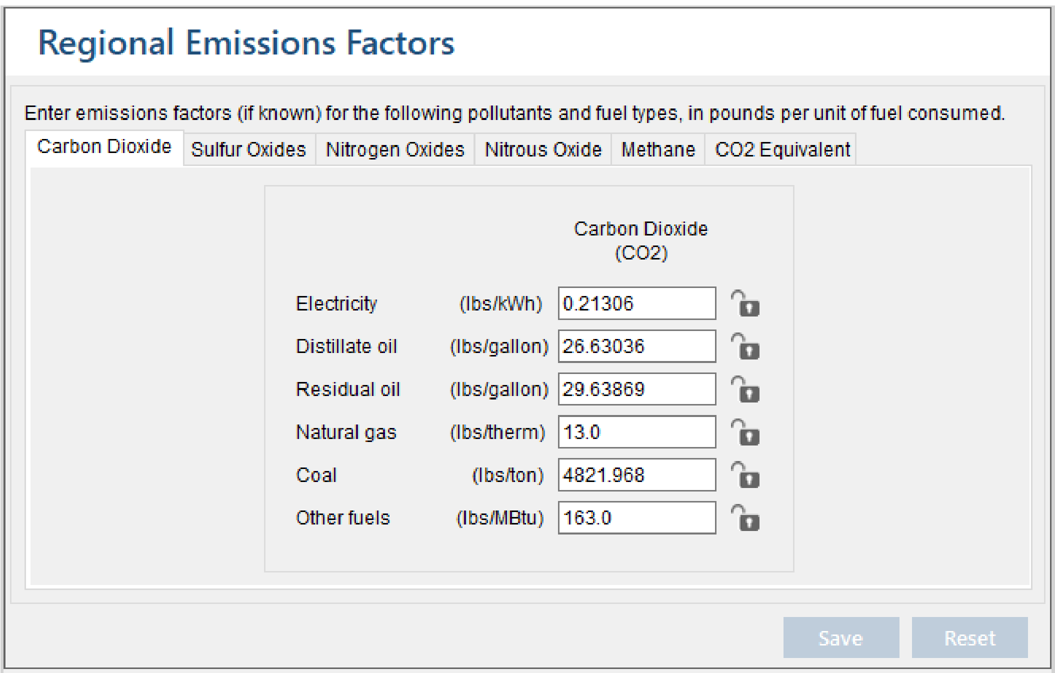

Figure 4.4 Regional Emissions Factors

4.2 Central Plants

The central plant inputs are optional and allow users with central energy plants to appropriately model the energy required to generate and transmit the fuels to their buildings. FEDS will calculate the input energy requirements and also evaluate

[2] 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: N. Leslie. 2019. *Full-Fuel-Cycle Energy and Emission Factors for Building Energy Consumption – 2018 Update.* American Gas Association.

opportunities for trimming loops or abandoning entire plants in favor of in-building boilers and chillers. The Central Plant 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.

Central plants can be added, copied, or deleted via the central plant node menu, accessed by right-clicking on the appropriate central plant node.

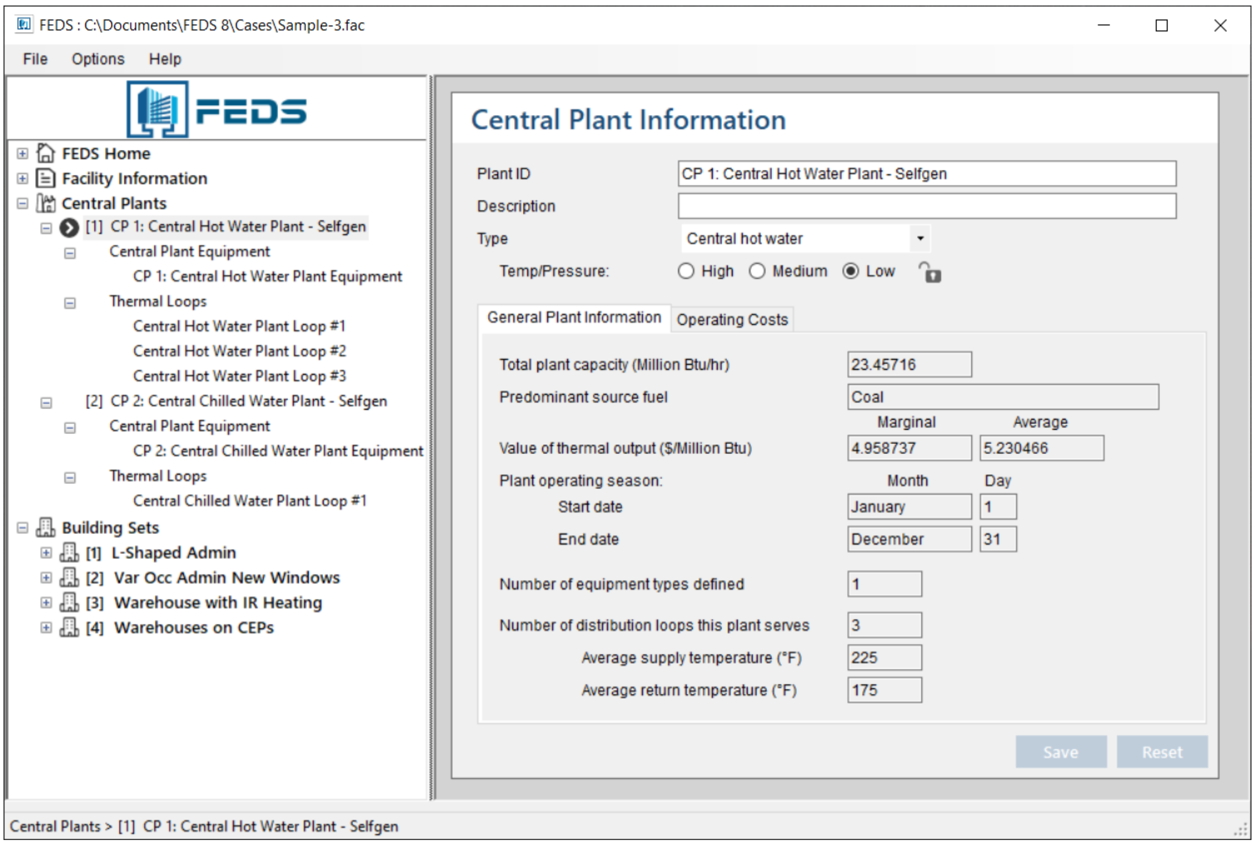

Figure 4.5 Central Plant Inputs

4.2.1 Central Plant Equipment

The central plant equipment inputs allow users to specify the characteristics of the equipment in the central plant for generating the steam, hot water, or chilled water produced by the plant. Boilers or heat exchangers can be specified for steam or hot water plants, while a variety of chillers can be specified for chilled water plants. Multiple equipment records can be created to represent a mix of different equipment and/or fuel types combining to provide the total output. Central plant equipment records can be added, copied, or deleted by right-clicking on the appropriate node in the navigation pane and selecting the preferred option.

4.2.2 Thermal Distribution Loops

The distribution lines that deliver the central fuels to the buildings are defined here, with several parameters related to the size, length, temperature, and insulation of both supply and return runs. Multiple distribution loops may be defined for each central plant, and the Loop ID is used to identify (via the 'source loop' inputs at the building technology level) the loop that delivers the central fuel to specific buildings and loads. Loops may be added, copied, or deleted via the menu that appears when right-clicking on the appropriate thermal loop node in the navigation pane.

4.3 Building Sets

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. A building set will often consist of a single building but can represent a group of buildings with similar characteristics. See Section 5.3 for more information.

Clicking on a building set node (beneath the man Building Sets node) on the navigation pane will open the *Building Set: General Information* screen for the selected building set. If no building sets are currently defined in the case, they can be added by right-clicking on the Building Sets node and selecting 'Add Building Set'. Each building set has its own *General Information* screen so while there will only be one *Facility Information* screen per case, the number of Building Set records is essentially unlimited.

Tip: Screening assessments of sites with many buildings will often use building sets to model common building types together. As more data is gathered and more detailed analysis is performed, the number of buildings modeled together in a building set is often reduced to better model the differences and develop more accurate and actionable results.

For more detailed assessments, buildings are often modeled as single buildings. In some cases, single buildings can also be modeled as multiple, separate building models. This can be useful to model sections of a building with differing construction, geometry, HVAC systems, or even use type and occupancy if there are more than two prominent use areas.

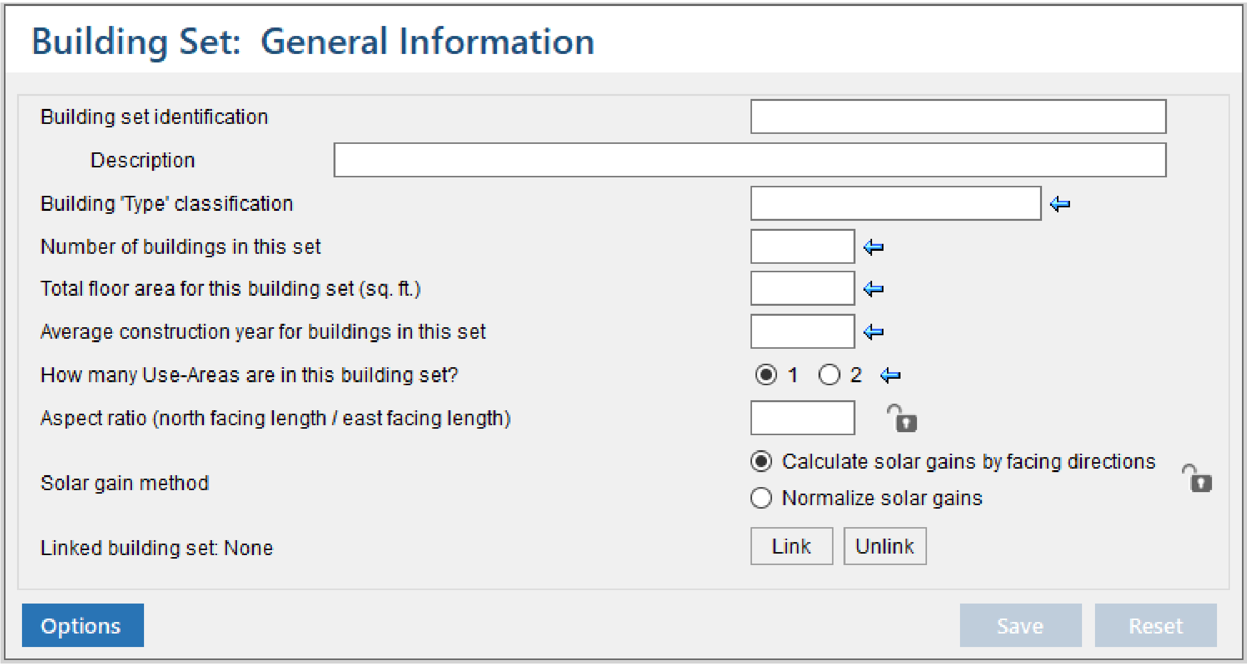

Figure 4.6 FEDS Building Set Inputs Screen

4.3.1 Required Building Inputs

The following are required inputs for each building set:

- **Building Type**: These include 16 civilian (commercial and residential), and 26 military types, which are listed in Table 4.1. 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. See Appendix E for a listing of building and use area types along with examples.
- **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). If no start and end time is specified FEDS will assume the building is unoccupied.
- **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.

Table 4.1 FEDS Building Types

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

4.3.2 Inferable Building Inputs

Any input that has a lock icon beside it is inferable by FEDS (see Section 3.5 for an example and description of the locks). That means that if the user does not input a value, FEDS will automatically generate and populate the input with the most likely value considering all of the other related parameters. Therefore, the inability to collect or confirm a detailed building system parameter will not impede a user from developing and simulating a model. The inferred values will appear on the screens where they can be evaluated and changed if necessary. Given the very small number of required inputs, the bulk of inputs in FEDS are inferable, and cover the full range of building characteristics, from occupancy, geometry, construction and envelope, lighting, HVAC, water heating, and miscellaneous equipment. The following are examples of select inferable FEDS inputs:

- **Building Occupancy**: The number of occupants present during occupied and unoccupied periods, plus sensible and latent occupant heat gains, are inferable by FEDS. Seasonal and variable operation can also be specified for each use area. More information on the Occupancy inputs is found in Section 4.3.4.
- **Building Geometry**: The number of thermal zones, floors, percentage of wall area that is glass, and floor-to-ceiling and floor-to-floor heights. Additionally, an *Advanced Geometry* option allows users the ability to specify detailed building geometry parameters at the specific zone and/or orientation level (see Section 4.3.5 for more information).
- **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.
- **Fuel Availability:** The availability of each fuel type to the current building set.
- **Lighting:** Fixture type, configuration, utilization, heat to space, presence of controls. Comprehensive listing of fixture configurations in Appendix H.
- **Heating and Cooling:** Set points, equipment types, efficiencies, etc.
- **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.
- **Motors**: Electric motor parameters and operating characteristics.
- **Miscellaneous Equipment**: Equipment capacity densities and utilization factors for all other miscellaneous loads (of any specified fuel type). Miscellaneous equipment records are automatically generated for each FEDS building set (by use area) and inferred according to the specific use area type. Categories include refrigeration, food preparation, and other (which includes computer/office equipment, etc.).

4.3.3 Use Areas

FEDS allows the modeling of buildings with up to two distinct uses and occupancy patterns within each building set. For single use buildings sets, FEDS will infer the use area type to be the same as the building type. However, the user can change this. A reason to select a use area type that is different from the building type would be if the building is currently being used for a purpose other than it was originally built for. In general, the building type describes the construction of the building and helps to define construction and geometry characteristics while the use area impacts the operational characteristics of the space, such as occupancy, equipment utilization, and HVAC space temperature setpoints. As an example, barring a major renovation, a building constructed as a warehouse, but now serving primarily as an office space may best be modeled as a warehouse building type and office use area type.

An example of a dual-use building 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 use area 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.*
- Motor types, size, utilization and load factors
- Miscellaneous equipment types, fuel types, capacity densities and utilization factors.

4.3.4 Occupancy

Standard Occupancy

The standard occupancy inputs (Figure 4.7) consist of occupancy hours (typical occupancy start and end hours) for each standard day type (weekday, Saturday, Sunday). The option to specify whether the standard work week consists of 5 days or 4 days is also possible. Within a 4-day work week, weekdays are defined as Monday-Thursday, and Friday/Saturday hours are specified together.

Seasonal/Variable Operation

These inputs can be used to specify the months and days of each type that the building set is occupied according to the standard occupancy schedule. This can be useful when modeling school or other buildings that are shut down for part of the year, as well as buildings that experience highly variable use throughout the year (e.g., seasonal camp or retreat facilities, extended retail hours, training periods at National Guard facilities). 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 Season thermostat setpoint for freeze protection). Under the

Low occupancy setting, the non-operating periods are modeled the same as the unoccupied periods of the standard operating schedule (e.g., with reduced occupants, thermostat setback if defined, and reduced lighting and equipment utilization).

Figure 4.8 highlights the seasonal and variable operation inputs. This example shows the inputs for a building that is shut down for two and a half months during the summer. If the shut-down begins on Saturday June 20th and runs through the end of August, the inputs could be specified as shown. Sixty-eight percent (15 of the 22) of June weekdays follow the standard operating schedule, along with half of the four Saturdays and four Sundays. As all days in July and August are non-operating, zeros can be input for each day type or the 'Non-operating?' box can be checked next to those months.

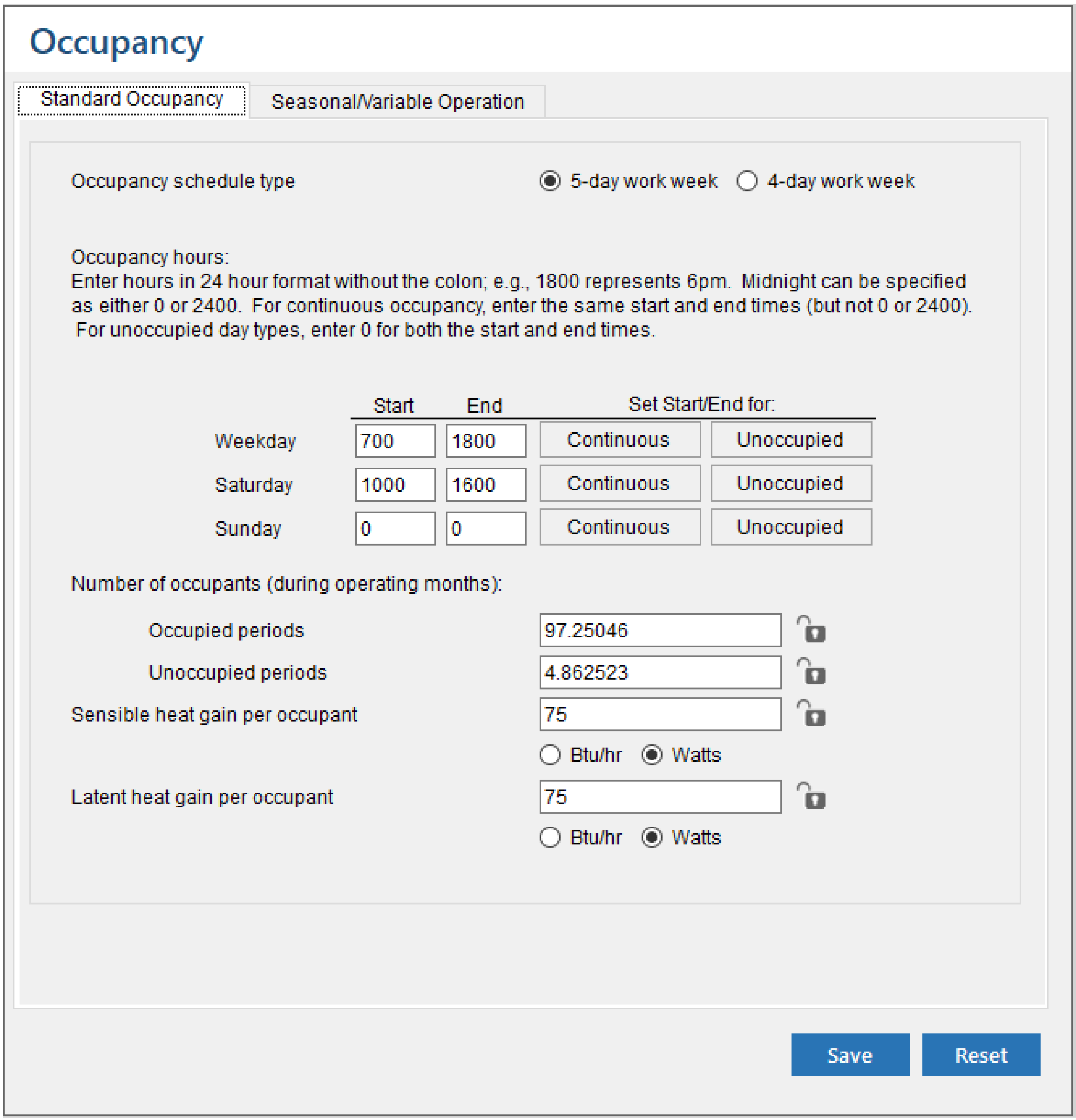

Figure 4.7 FEDS Standard Occupancy Inputs

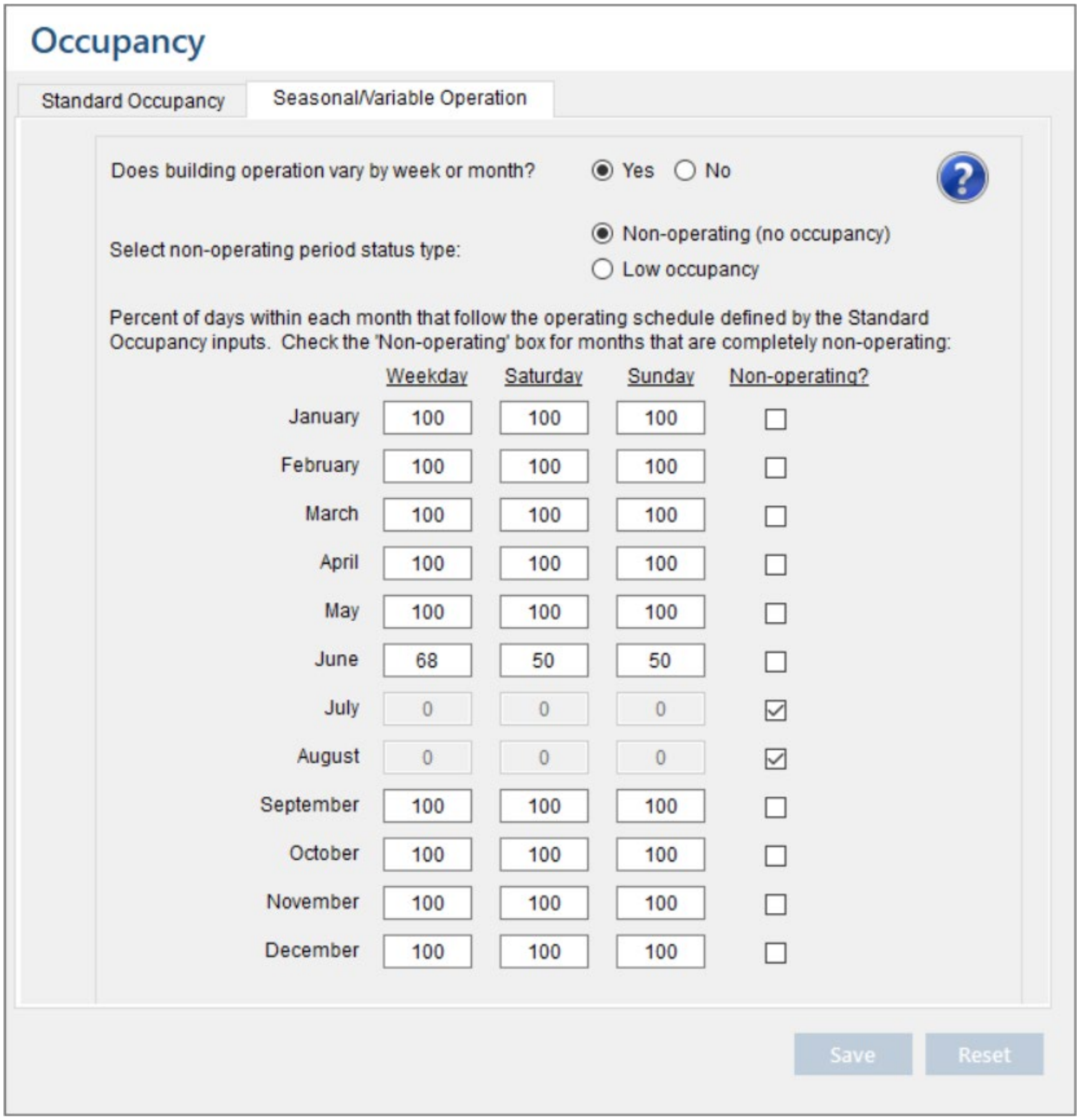

Figure 4.8 FEDS Seasonal/Variable Operation Inputs

4.3.5 Geometry

There are several approaches for defining the geometry of a building in FEDS, each providing successively greater detail.

Standard Geometry

The standard assumption for building geometry in FEDS is of a rectangular prism. The footprint of the prism is defined by the combination of building floor area and the aspect ratio (ratio of north/south facing length to east/west length). Additional geometric details are There provided via the Geometry inputs, such as number of thermal zones, number of floors, and floor-to-floor and floor-to-ceiling height.

Linked Building Sets

Linked Building Sets (see Figure 4.9) is feature that facilitates added flexibility in modeling unique building geometries. This allows you to model L- or T-shaped buildings that are adjacent to one another, sharing common wall space (such as a warehouse with a small office built onto one side). Buildings that are stacked on top of one another can also be easily modeled, sharing common roof and floor area. The difference between linked building 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 potentially having their own separate HVAC systems.

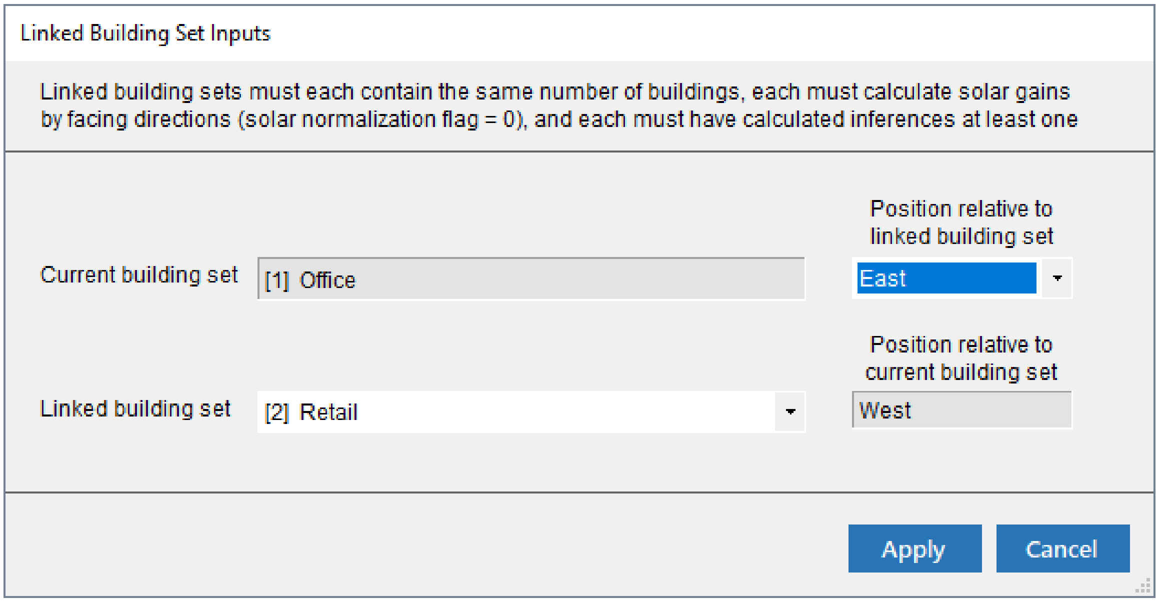

Figure 4.9 Linked Building Set Inputs

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 relative positions, and click **<Apply>**.
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.

Advanced Geometry

Beyond both the Standard Geometry and Linked Building Set features, 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.

Figure 4.10 shows an example Advanced Geometry input screen from the Sample-3 case. The following parameters may be specified for each zone:

- Gross exterior wall area (by facing direction)
- Exterior window area (by facing direction)
- Roof area
- Total floor area
- Ground-level floor area
- Exterior perimeter length
- Conditioned air volume
- Zone conditioning status

The zone conditioning status options allow users to specify whether each individual zone is heated, cooled, and ventilated. An option to specify a season for heating and cooling is also possible. For buildings with two use areas defined, another input allows you to identify specific zones as serving a given use area.

To use Advanced Geometry, the following steps are recommended:

1. Define and verify all standard geometry inputs first, including building size, aspect ratio, number of thermal zones, number of floors, glass area fraction, floor-to-floor and floor-to-ceiling height, to the best of your ability.
2. Update inferences for the building to check for errors and to populate current geometry settings.
3. Select the Use Advanced Geometry setting from the Geometry input screen.

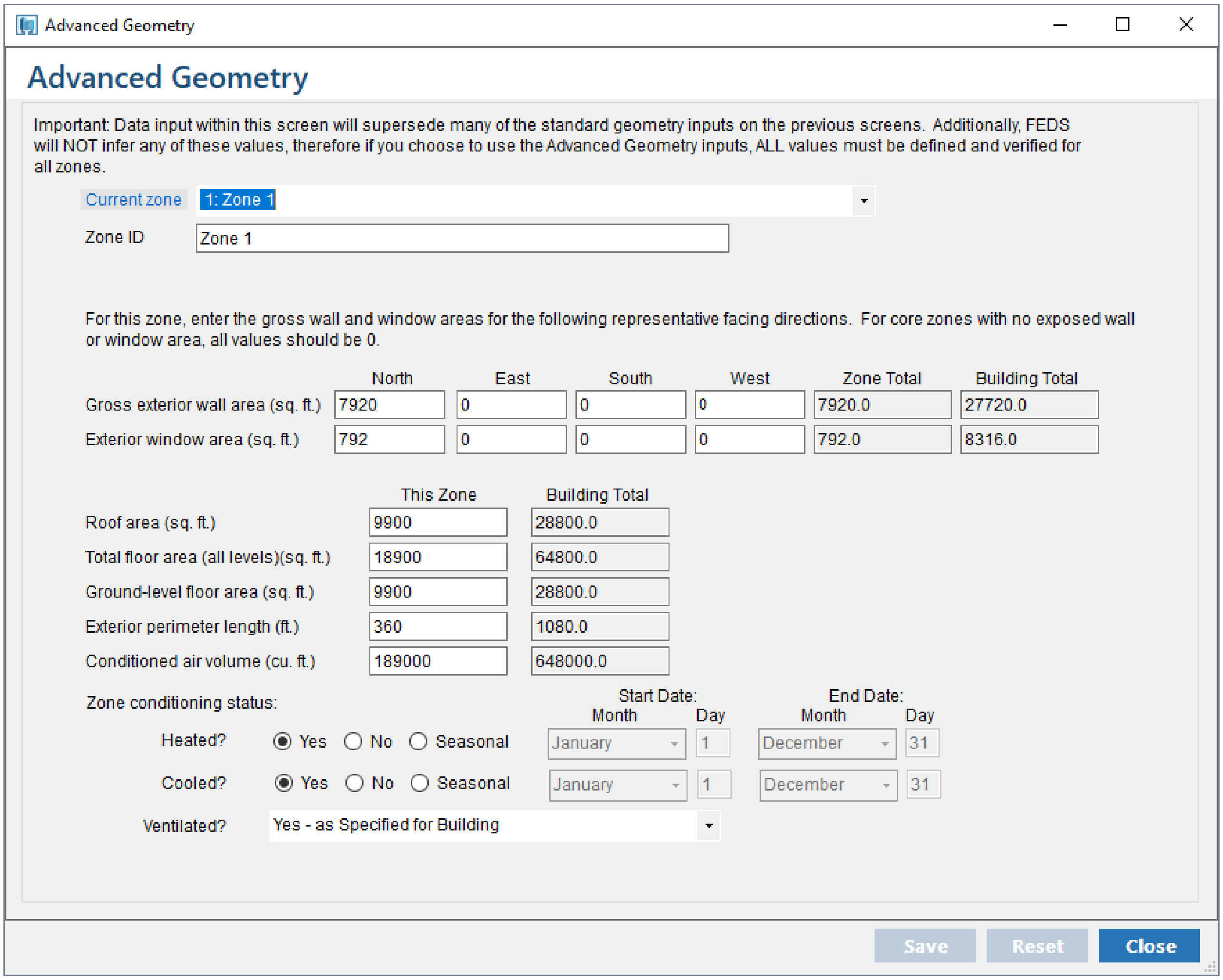

Figure 4.10 FEDS Advanced Geometry Inputs Screen

None of the Advanced Geometry inputs are inferable. All parameters will be defined initially based on standard geometry settings and the updating of inferences. Any changes made to the Advanced Geometry inputs will be final for as long as the 'Use Advanced Geometry' setting is selected. Therefore, it is strongly recommended to input all basic geometry inputs and update inferences first before entering Advanced Geometry. If mistakes are made, all Advanced Geometry settings can be cleared by deselecting the Use Advanced Geometry option and updating inferences. That will reset all Advanced Geometry inputs back to the values calculated based on the basic building specifications and assumed rectangular geometry.

Advanced Geometry can be applied for a range of purposes, from simply specifying varying window areas to modeling highly complex building geometries.

Tip: Input all basic geometry inputs and update inferences first before entering Advanced Geometry.

4.3.6 Building Envelope

The Building Envelope Characteristics input screen is shown in Figure 4.11. Here, inferred parameters for roof, floor, wall, and window types and thermal performance can be viewed and adjusted. Each can be accessed from the appropriate tab at the top of the screen.

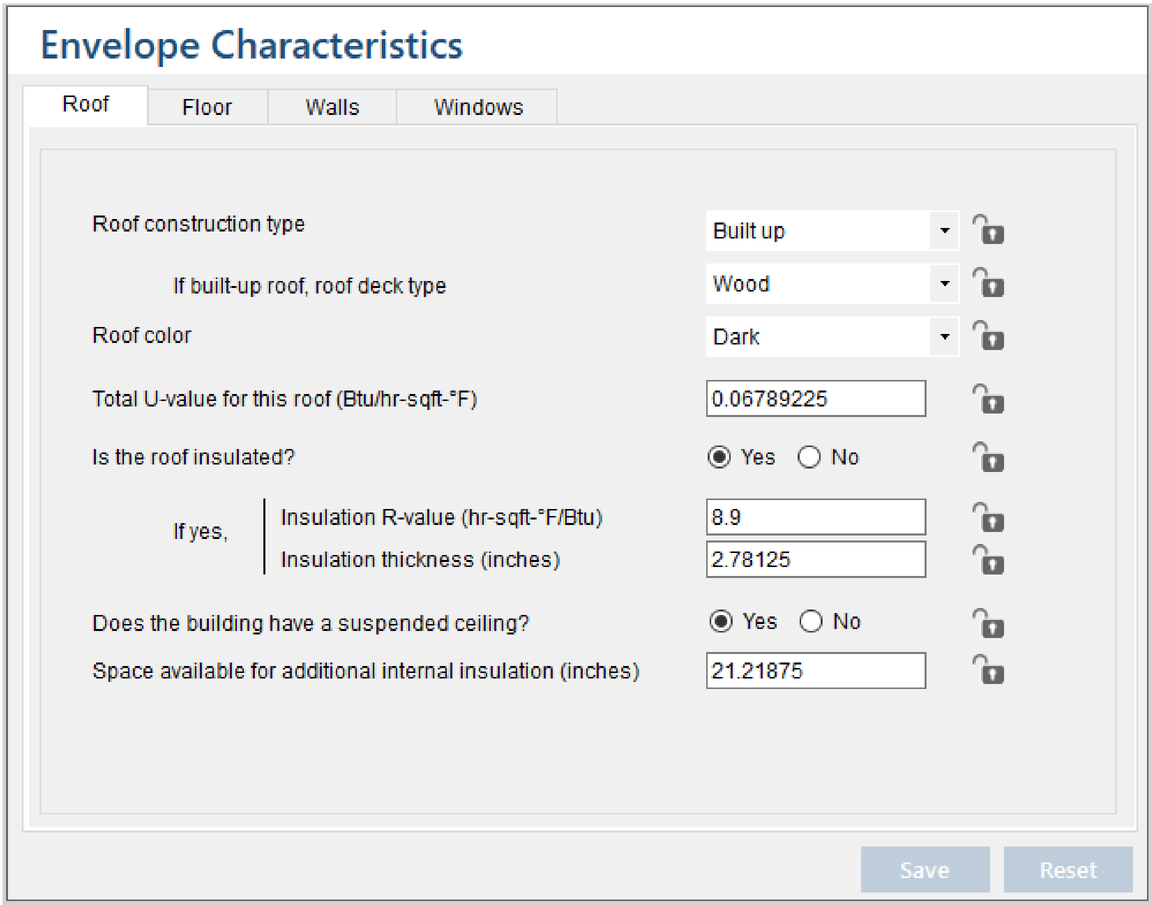

Figure 4.11 FEDS Building Envelope Inputs

4.3.7 Fuels

The Fuel Availability input screen is shown in Figure 4.12. Here, for the fuel types that are available to this building set can be reviewed and updated. The possible selection for each fuel type are:

- Yes – the fuel is available to the buildings in this building set
- No – the fuel is NOT available, and any equipment that uses this fuel type will not be considered during the automated EEM optimization
- Existing – this fuel type is available to the building(s), however, FEDS will only consider retrofit measures using this fuel type for existing equipment already using this fuel. Switching from another fuel to this fuel type will not be evaluated.

These inputs are used during optimization to identify which fuel types and equipment measures may be considered as applicable. Typically, all fuel types that are used in the building(s) should be selected. However, to evaluate fuel switching opportunities, fuels that do not currently serve the building(s) can also be selected if connecting them may be an option. These values are inferred to 'Yes' for each fuel type that has a price specified within the Facility Inputs, plus electricity which is always inferred as available.

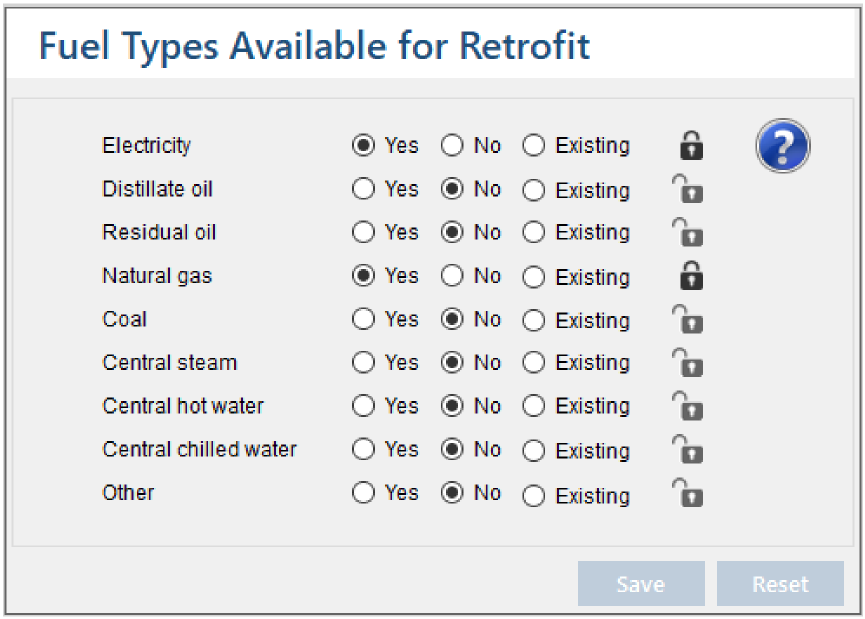

Figure 4.12 FEDS Fuel Availability Inputs

4.4 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 4.2 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.

Table 4.2 Maximum Technology Records by End Use

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

4.4.1 Lighting

The Lighting screen (Figure 4.13) provides access to inputs for modeling the lighting technology configurations within most buildings. Clicking the 'Select a light technology' or clicking within the technology configuration cell will open a lighting technology selection wizard, shown in Figure 4.14. This wizard is designed to aid in the selection of the appropriate lighting configuration based on the specification of relevant characteristics such as lighting technology, number of lamps, lamp size, wattage, fixture size, ballast type, etc. With each selection of criteria, the list of Figure Configurations at the top of the screen narrows to show the configurations matching the selected criteria. Clicking on the desired configuration and pressing **<Continue>** will select the configuration and return to the main lighting record input screen.

Additional lighting inputs of note include fixture location (interior or exterior), fixture density, information on lighting controls, and fixture utilization. The number of lighting fixtures can be specified either as a density (fixtures per square foot of floor area) or a direct count (fixtures per use-area). The presence of lighting controls can be specified, and if automated controls are not currently present, users may select the type of control technology (e.g., occupancy sensors) to be evaluated by FEDS during the automated project optimization and selection process. The space type input helps FEDS to estimate the potential savings associated with the deployment of lighting controls within spaces. This helps to infer the utilization factors which represent the percentage of time (on average) that the lights are on during both the occupied and unoccupied periods. An input of 100% for both occupied and unoccupied utilization factors means that the lights operate all the time (except if some days are defined as non-operational in the Seasonal/Variable Operation inputs). The Existing utilization factors identify current operation while the With Controls factors specify the utilization of the lights when the selected or desired controls are in use. This allows users to adjust the impact of lighting control options to specific lighting configurations based on the actual configuration and expected performance. The 'Number of sensors required' input is used by FEDS to estimate the cost of deploying lighting sensors to the modeled lighting specified by this record.

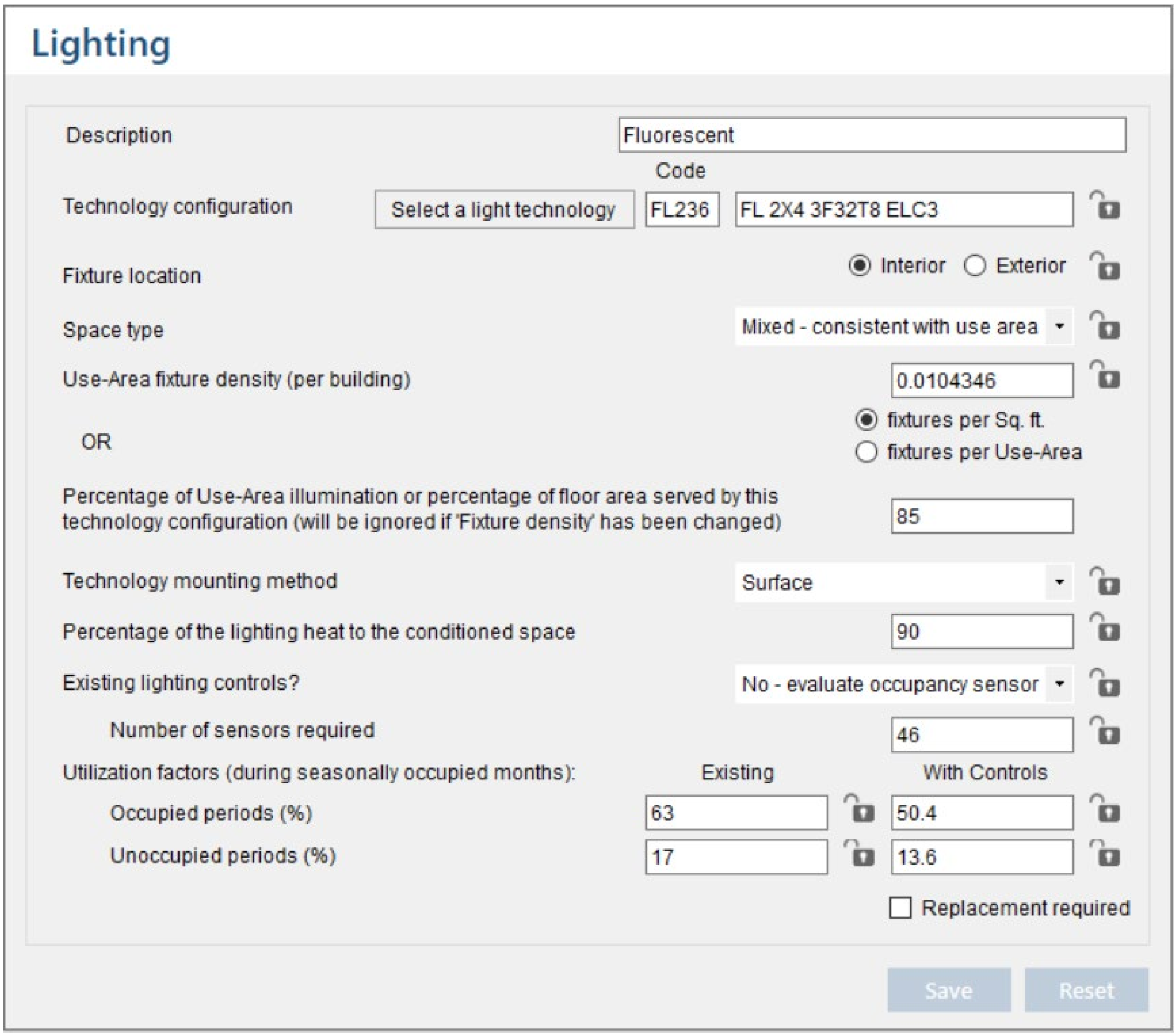

Figure 4.13 FEDS Lighting Inputs

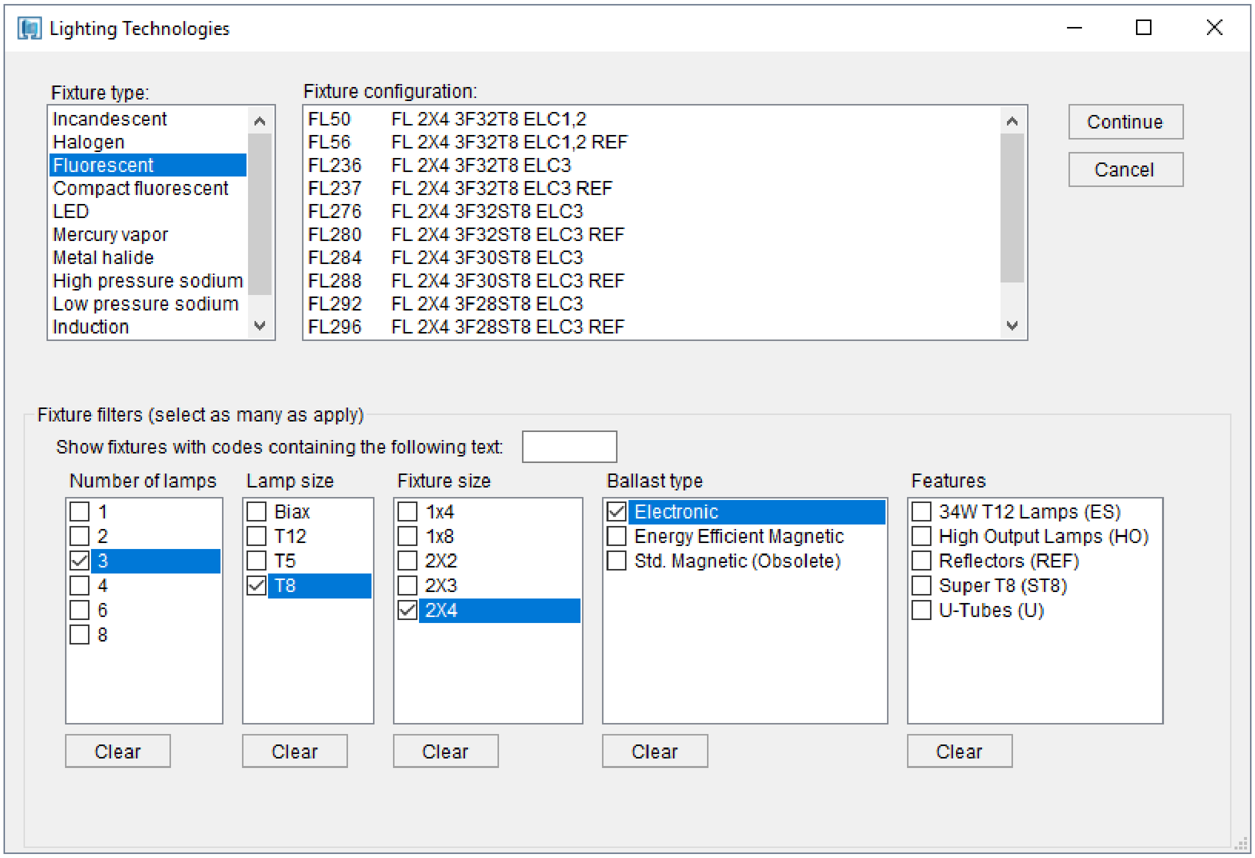

Figure 4.14 FEDS Lighting Fixture Configuration Selection

4.4.2 HVAC

FEDS HVAC inputs encompass heating and cooling end use and control settings, heating and cooling equipment records, plus ventilation options.

Heating and Cooling End-Use and Control Settings

The end use and control settings for heating and cooling (Figure 4.15) define whether heating or cooling exists in the buildings that comprise the building set, how the zone temperature is controlled, and what the setpoints are. The ‘Portion of building in this set that are NOT heated/cooled’ are used to specify which buildings or portion of buildings are not conditioned. The ‘Whole buildings’ option should be selected if entire buildings within the building set are conditioned with the same technologies (different buildings can be conditioned with different technologies. Otherwise, if portions of individual buildings are conditioned by different technologies select the ‘Percentage of each building served option’.

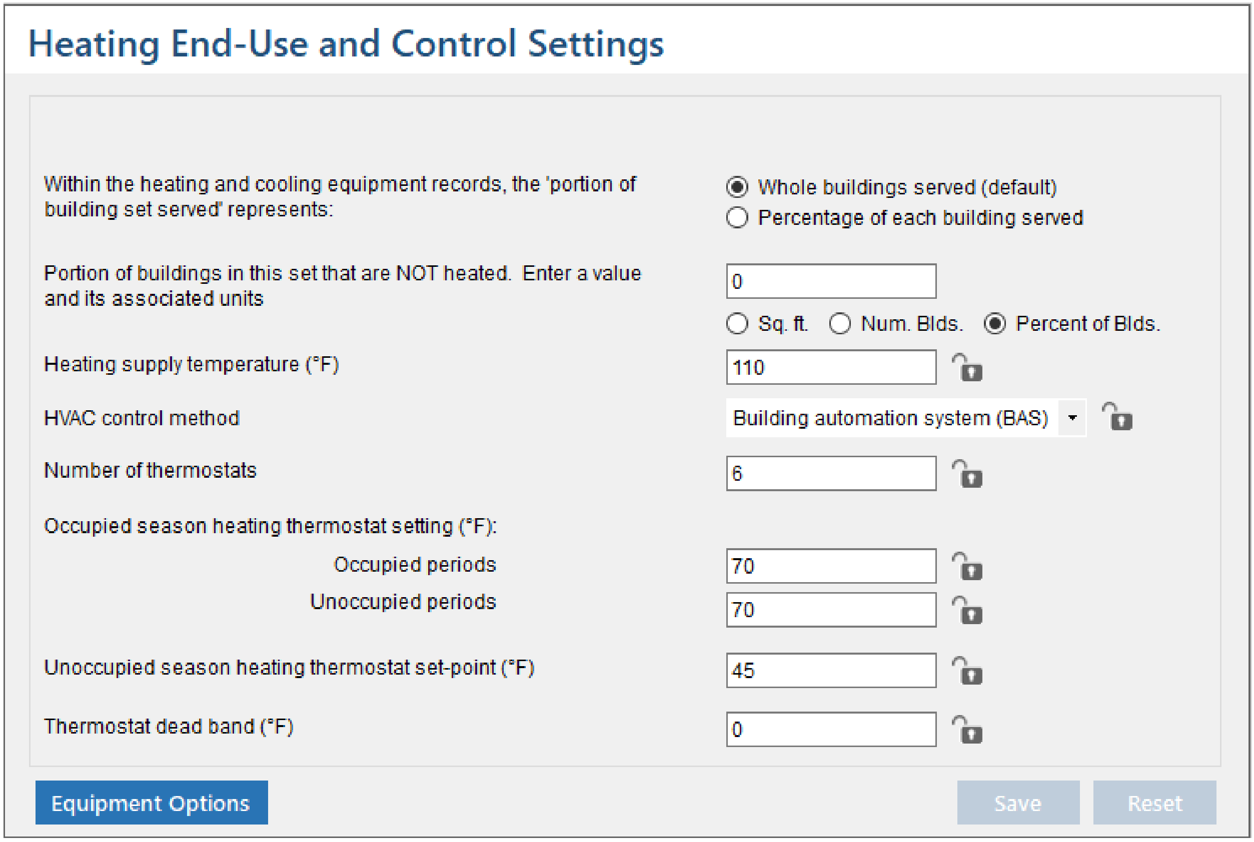

Figure 4.15 FEDS Heating End-Use and Control Settings

Heating and Cooling Equipment

Details of the heating and cooling equipment are specified within the equipment records. There can be up to 10 records specified per building set, to represent different technologies serving the different buildings within the set or technologies serving different parts of each building. This option is determined by the setting of the 'Portion of building set served representation' which is accessible from the Heating and Cooling End-Use and Control Settings. Parameters for each heating and cooling record depends on the selected fuel and equipment types. The example for a building chiller is shown in Figure 4.16.

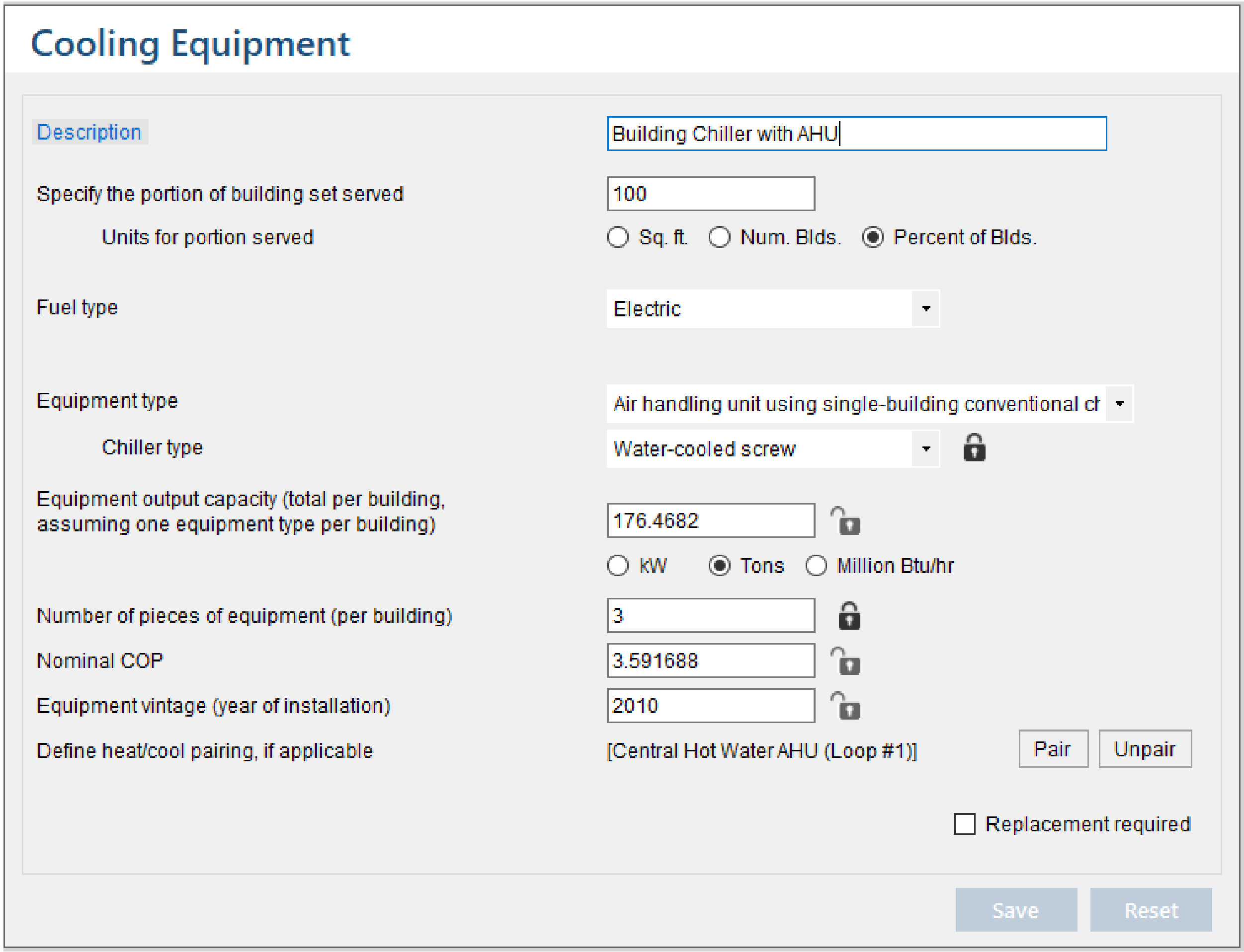

Figure 4.16 FEDS Cooling Equipment Inputs

Ventilation

The ventilation inputs allow specification of characteristics of all force-air conditioning and outdoor air ventilation. As shown in Figure 4.17, this includes system type, control mode, design supply air, design outdoor ventilation air, infiltration rate, plus details on the fan and fan motor. A number of technology options are available from the 'Operational & Control Technologies' tab, including terminal reheat, economizers, demand-controlled ventilation, and active dehumidification.

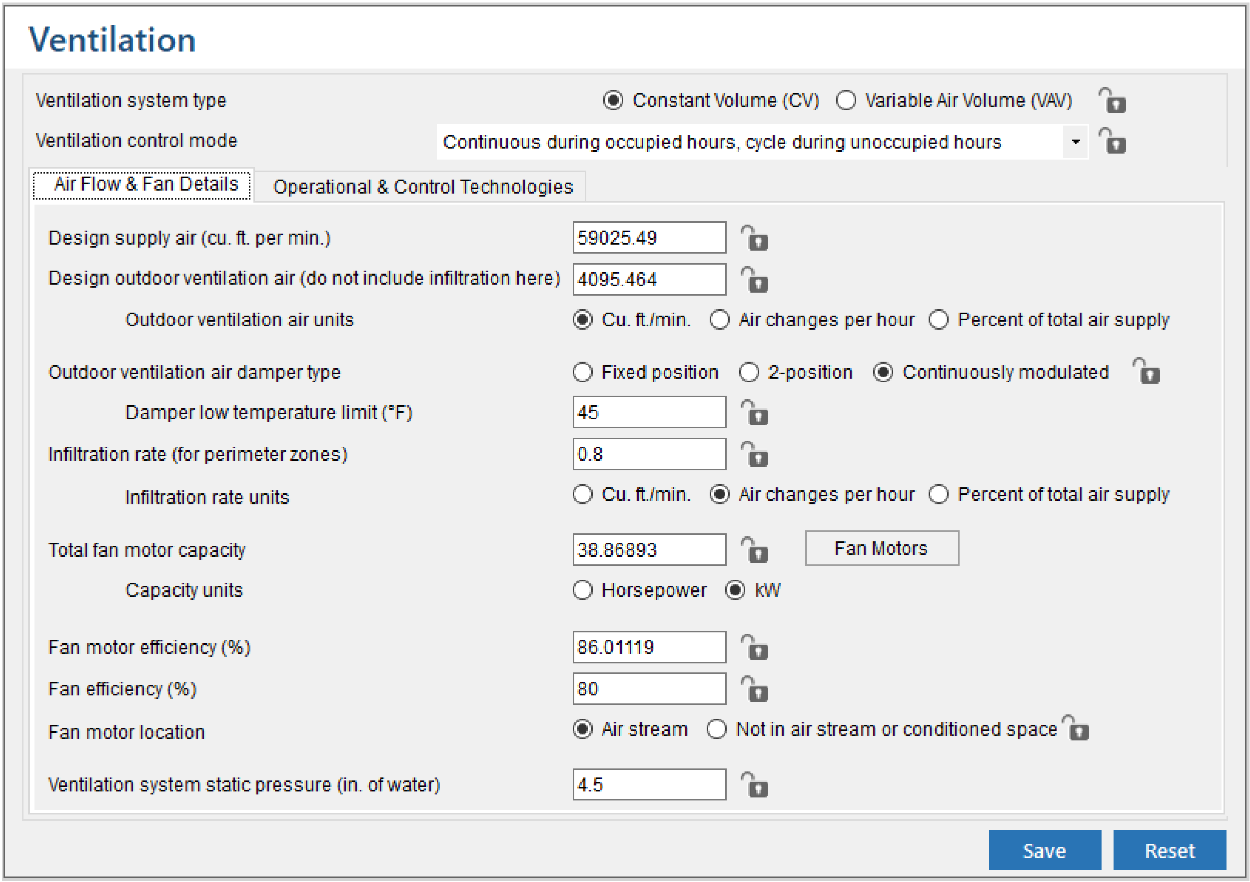

Figure 4.17 FEDS Ventilation Inputs

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).

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. The Pair HVAC Technologies screen is shown in Figure 4.18. Corresponding heat pump records are automatically paired upon updating inferences. FEDS will now also attempt to pair non-heat pump technologies based on matching portion of building set served.

How to pair or adjust the pairing of 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. This will bring up the *Pair HVAC Technologies* screen.
2. 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 **<Apply>**. Each technology must serve the same portion of the building set to be valid.

3. If the pair was accepted, the name of the paired technology will appear in the heat/cool pairing box.

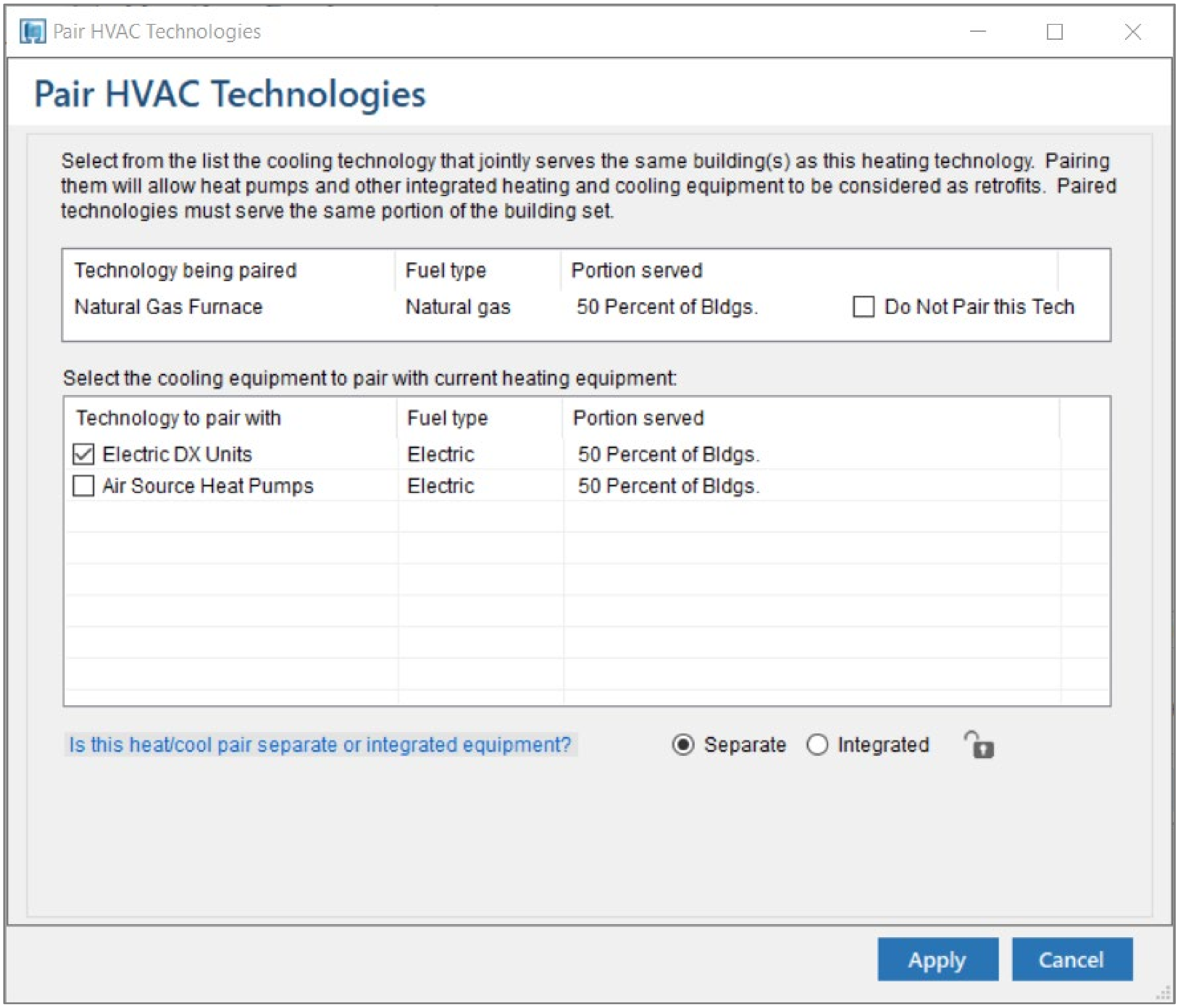

Figure 4.18 FEDS Heat/Cool Equipment Pairing

You may pair most combinations of heating and cooling technology as long as they serve the same portion of the building set. Pairing heat pumps requires that additional rules be met (e.g., each side must have the same fuel, equipment type, loop type, as applicable). FEDS will automatically attempt to establish pairs when inferences are updated. Existing pairs can be changed by either selecting a new equipment pairing or selecting the 'Do Not Pair this Tech' option, to prevent any further automated pairing for the current technology.

A 'Separate' pair refers to heating and cooling that are provided by completely separate equipment (e.g., a separate boiler and chiller). 'Integrated' pairs are equipment that deliver heating and cooling from the same equipment (e.g., a gas pack or rooftop air conditioning unit with internal gas burner).

4.4.3 Service Hot Water

Service hot water, often known as domestic hot water, is potable water heated for various purposes including bathing, cleaning, food preparation, etc. The service hot water inputs include a combination of end-use inputs and technology inputs. The end-use inputs define the hot water demand in gallons of hot water per day by day type for each use area, as well as the number of faucets and showerheads, and percentage that are water efficient. The service hot water equipment records define the characteristics of the water heaters, boilers, or heat exchangers that supply the hot water. These are defined as either distributed or loop hot water systems. Distributed systems typically consist of a 50- to 80-gallon tank in which the water is heated and stored to serve a small portion of a large building or the entirety of a smaller building. Instantaneous or on-demand water heaters can be modeled as a distributed system with a very small (<1 gallon) storage capacity. Loop systems are designed to heat water which is then typically stored is a separate tank and recirculated throughout the building. Because of this, loop systems are assumed to serve all use areas within a building.

Like heating and cooling, the service hot water inputs include the specification of the portion of the building set served. This is to specify which whole buildings have any hot water service rather than define the specific floor area where hot water is provided. The end use inputs for each use area should be used to define the hot water demand by occupants within each use area.

Tip: FEDS assumes that if a building has service hot water it is available to the entire building (i.e., to all occupants within the building).

4.4.4 Motors

FEDS models non-HVAC electric motors based on the inputs specified within the Motor end use. Figure 4.19 shows the parameters available for each motor record. Note that for motors, utilization and load factors may be specified either as a single pair of values (for occupied and unoccupied states) or as a monthly duty cycle with unique values for each month.

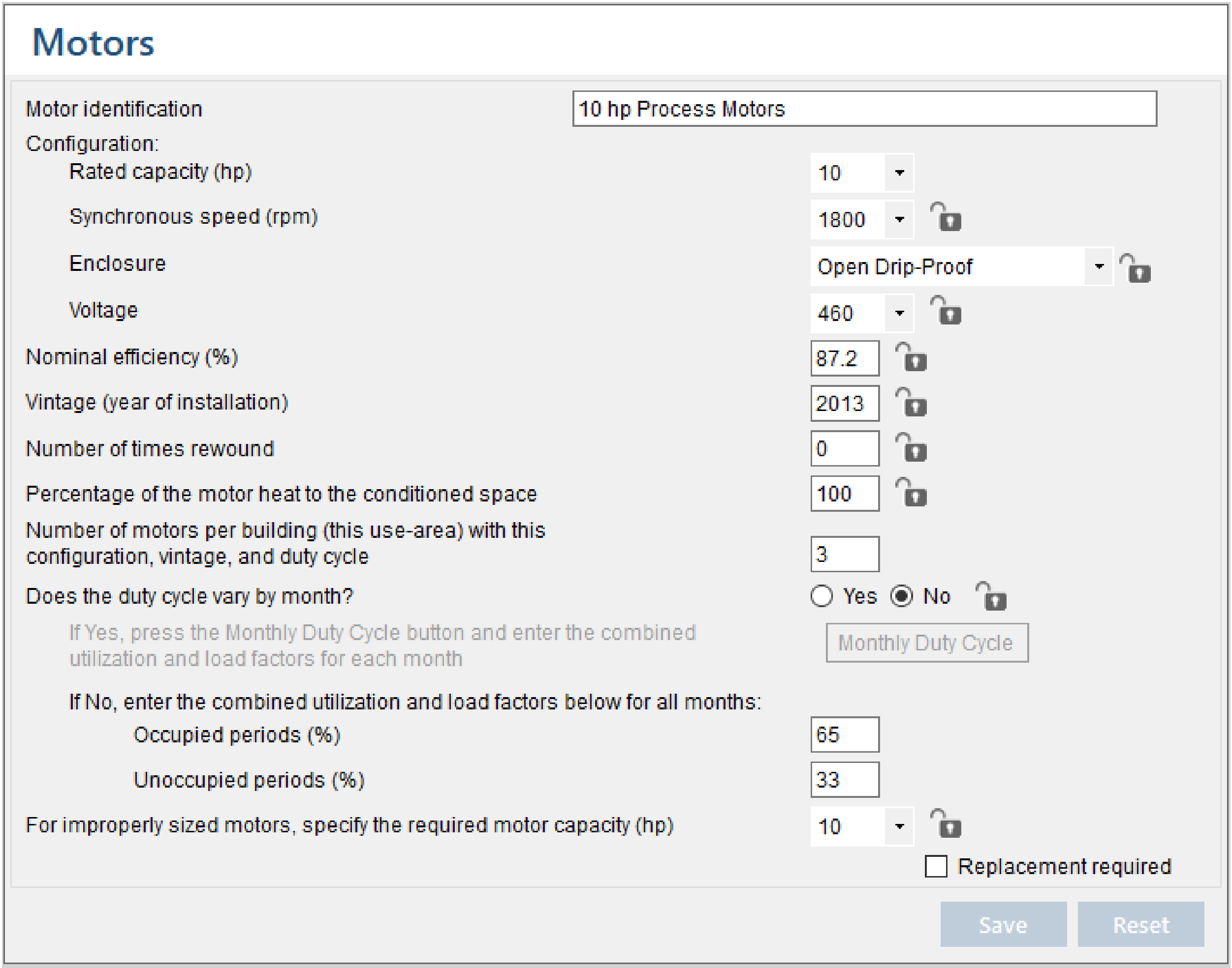

Figure 4.19 FEDS Motor Inputs

4.4.5 Miscellaneous Equipment

An example miscellaneous equipment record is show in Figure 4.20. FEDS automatically creates a set of three miscellaneous equipment records for each use area, when inferences are first updated. This includes a Refrigeration, Food Preparation, and Other record. Parameters including capacity density and utilization and load factors are inferred to be representative for each use area.

FEDS simulates the energy use and demand from plug and process load equipment to incorporate into the whole building energy simulation. However, no retrofits are currently evaluated. FEDS infers this information to assist with the modeling of whole building energy use without requiring a detailed inventory of this equipment. Where the inferred records do not appear to be representative of the equipment in a building, or where additional plug or process loads exist, the inferred records can be edited or deleted, and new records added.

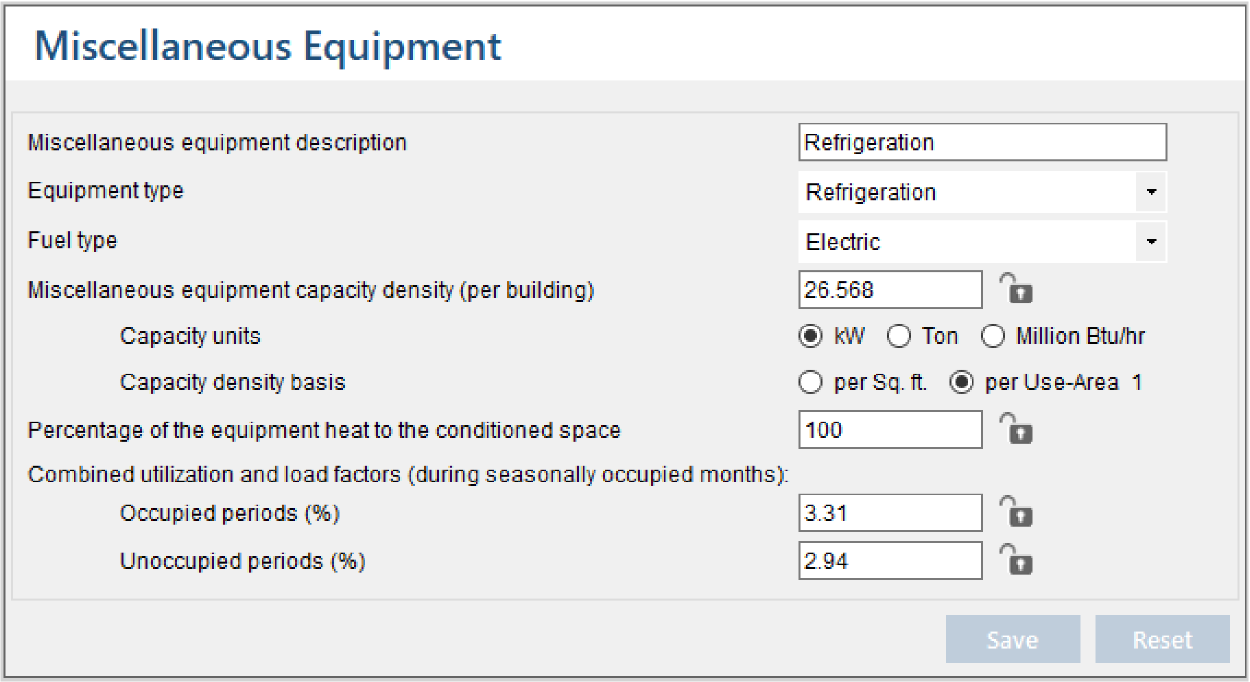

Figure 4.20 FEDS Miscellaneous Equipment Inputs

Tip: When auditing, note how the density of plug and process loads compares to what is typical for the building and use area type(s). It is easier to add, edit, or adjust the inferred miscellaneous equipment inputs than build them from the ground up.

5 FEDS Process

Briefly summarized, the typical FEDS analysis process will usually consist of the following steps. However, due to its flexible design, certain applications may omit or include additional or alternate steps.

1. Collect site and building data
2. Evaluate marginal energy prices
3. Determine building set breakdown
4. Complete an initial opportunity screening
5. Gather additional data about the buildings and central energy plants to be modeled
6. Enter additional building system detail and update and/or modify FEDS inferred data with more detailed building and technology system characteristics
7. Perform QA/Calibration
8. Set desired simulation parameters
9. Run FEDS on validated building models
10. Identify projects

Each of these steps is described in the next sections.

5.1 Step 1: Data Collection

The first step is to gather information about the building(s) to be modeled. This begins with details including location, building type, size, vintage, occupancy, plus basic geometry, construction characteristics, and information on lighting, heating, cooling, hot water. Additionally, electric rates and fuel prices are also important.

Example data collection forms are installed with FEDS and can be found in the FEDS \Data Collection Forms folder (e.g., %UserProfile%\Documents\FEDS 8\Data Collection Forms).

5.2 Step 2: Define Energy Rates

Energy rates are important for evaluating energy efficiency measures. Therefore, having a detailed understanding of electricity and other energy prices is critical to properly valuing savings. Rather than applying an average or blended rate of electricity, request a detailed explanation of rates from your utility or search online for the relevant rate schedule. With recent bills in hand, analyze the rates to define the appropriate marginal cost of both energy and demand, including any seasonal and time-of-day rates, demand ratchets, and any minimum or contract demand. For all fuels, identify and exclude any fixed charges that cannot be impacted by reducing energy use. Focus on defining the marginal value of each fuel – the savings that would accrue by reducing energy use by one unit of measure (e.g., kWh, therm, gallon, million Btu).

5.3 Step 3: Identify Building Sets

FEDS is designed to model sites of all sizes, from single buildings and small sites with a handful of buildings, to very large campuses and installations with hundreds or thousands of buildings. For small sites, a FEDS model will typically be built for each building. However, for larger sites, depending on its size and the goals of the assessment, it may not be practical or necessary to model each building individually. For very large campuses and installations, there are often groups of buildings that are similar in construction and use characteristics that lend themselves to be reasonably modeled together. FEDS therefore supports the grouping of buildings that can be categorized together into sets. This is particularly useful for performing a screening assessment of a larger site. Grouping similar buildings into sets can facilitate the modeling and analysis of such sites without a significant loss of detail at this level.

The following example illustrates how and why building types are broken into building sets. A sample 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 in Table 5.1. With 6 size categories and 8 vintage categories, there are potentially 48 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 for a large site 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.

Table 5.1 FEDS Size and Vintage Categories

Size Categories (ft^2)	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 - 2005
	2005+

5.4 Step 4: Opportunity Screening

FEDS is designed to be scalable and support a top-level screening as a preliminary indication of what actions should be initiated, with minimal data collection and modeling effort. This enables users to quickly assess the potential return on investment before expending additional resources to collect additional data and refine the analysis as required before a project is designed and implemented. When entering only the required inputs, FEDS draws upon numerous assumptions about the "typical" stock of U.S. buildings, with only minimal energy price and installation configuration information needed as input.

FEDS uses the small set of required inputs 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.

The benefits of high-level screening analysis 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 at this level can provide utility, institution, agency, energy, resource, or installation managers with a simple 3- to 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 results from a screening 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 limited information, it is most appropriately applied to installations with large numbers of buildings.

5.5 Step 5: Gathering Additional Data

Results from the initial 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 focus for additional data-gathering. This effort may be as minimal as confirming the heating and cooling equipment types and the construction characteristics with a quick walk-through or drive-by, or it may involve such detail as determining actual lighting densities by counting light fixtures and confirming technology configurations and controls.

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 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 folder.

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.

5.6 Step 6: Build a More Detailed and Robust Model

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 detailed and comprehensive 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 a reasonable value based on parameters including construction type, location, presence and thickness or R-value of insulation.

Following is a brief list of commonly suggested areas to evaluate:

- **Solar gain method**: Select "Calculate solar gains by facing directions" if most buildings in the set are oriented similarly. Select "Normalize solar gains" for sets of buildings with different orientations.
- **Occupancy inputs**: You may specify the number of occupants during occupied and unoccupied periods, as well as seasonal/variable occupancy for the ability to model buildings that are used only part of the year.
- **Geometry**: Geometry inputs should be reviewed and updated as appropriate. Thermal zoning, number of floors, window fraction, and floor-to-floor and floor-to-ceiling heights. As needed, linked buildings or advanced geometry specifications could be considered.
- **Fuel availability**: When considering fuel-switching retrofits at, it is assumed that the fuels available to the installation are available to each building on the installation. 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 inferred construction types and materials used for the walls, roof, floor, and windows. You may also specify different insulation R-values and thicknesses or simply specify the overall U-value for windows, walls, roof, and floor (if known). 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. FEDS provides 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 to identify which equipment serves the same areas.
- **Ventilation system**: Fan and fan-motor capacities and efficiencies, as well as the ventilation system control mode, among many other parameters, may be adjusted. 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.
- **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.
- **Miscellaneous equipment**: You may change the inferences for miscellaneous equipment densities, utilization levels, and heat to space, and add records for other equipment types or delete records for equipment that is not present.

Update inferences. Any additional information that you provide is used by FEDS to recalculate (where appropriate) any dependent inferred values. Inferences for a particular building set may be updated by selecting **<Update Inferences>** from the menu accessed by right-clicking on the building set node within the navigation window. You may update all installation and building set inferences for the case from the Inferences screen under FEDS Home.

Repeat. 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.

5.7 Step 7: QA & Calibration

Building a more robust FEDS model starts with reviewing inferred parameters, collecting additional building data, and updating relevant inputs. Performing quality assurance (QA) checks follows to be sure that all intended inputs have been specified. This includes reviewing energy rates, occupancy hours, and for dual use buildings ensuring that occupant, lighting, hot water, motor, and miscellaneous equipment details are provided. The building set input summary (available from the main Building Set node on the navigation window) as well as the first several pages of the TXS report can offer good options for reviewing inputs.

Model calibration is also important to ensure that the model is reasonably accurate. This can be reviewed by performing a calibration run and comparing the resulting energy use metrics against metered energy use for the buildings(s). Set the Analysis Type to ‘Calibration’ (or exclude all building sets from optimization - see Section 6.1) and then run FEDS to perform a baseline simulation and review resulting 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. Lacking metered energy consumption detail, reviewing the energy use intensity for each building (and end use) is a useful way to compare the relative consumption of each building. Based on these results, selected building inputs can be adjusted and the models re-simulated to assess the impact.

Most users will find that FEDS simulates the energy use of many buildings within 10-15% of actual energy use with minimal effort. A difference of 5% or less (even approaching 0%) is possible with additional effort and increased knowledge of the building systems and operation. The goal of calibration is to create a robust model that has a high probability of behaving similarly under simulation as the real building. Any model can be made to match actual energy use; the challenge is to do so without pushing inputs or behavior outside of the bounds of plausibility. This process takes some experience to master, and the objective of the analysis should be kept in sight to guide what level of calibration is warranted.

5.8 Step 8: Set Simulation Parameters

After you are satisfied with your inputs and believe that you have modeled the buildings accurately based on reasonable QA and calibration effort, you should review and set the optimization parameters to best suit your analysis objectives. Review the following optimization parameter options:

- Specify the funding source (e.g., appropriated or alternative financing). See Section 7.
- Set financial screening options as described in Section 4.1.4.
- Exclude building sets that you do not want to consider retrofits for as described in Section 6.2.
- Restrict retrofit technologies or end uses that you do not want to evaluate as described in Section 6.3.

- Alter cost data (labor rates, end use materials multipliers, tax rate, etc.) to match your locale. See Section 4.1.4.
- Review emissions factors for your locale as described in Section 4.1.6.
- Choose whether the spreadsheet output lists the optimal retrofit only or the top 3 retrofits. See Section 6.1.2.
- Set any "Replacement required" (i.e., force retrofit) flags for those technologies 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.

5.9 Step 9: Run FEDS

Once you have performed reasonable QA and calibration of your model, and reviewed and set appropriate simulation parameters, it is time to run FEDS to evaluate savings measures. Return Analysis Type to 'Optimization' (or remove the building set exclusions) and select "Run FEDS" from the *Simulation screen within the FEDS Home*. 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 iterative optimization process follows, in which numerous candidate energy efficiency measures are successively evaluated for each end use technology and envelope component, by performing an annual hourly energy simulation to estimate the savings from each individual option and identify the package of measures offering the lowest life-cycle cost. 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 lamps or fixtures with new high-efficiency LED lamps or 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 (e.g., in-building boilers, chillers, etc.). 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 project capital cost, operation and maintenance cost changes, and changes in the energy costs to determine the cost-effectiveness of potential measures. 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 *Reports* screen accessed from the *FEDS Home* as described in Section 8.

5.10 Step 10: Identify Projects

The results of the FEDS simulation and optimization process can be used to identify and justify prospective energy efficiency projects. A number of projects will likely be identified by FEDS, based on the opportunity to improve building construction, system efficiency, and/or operation. The Summary Installation and Building Set Output (TXS) provides the high-level view of results, costs, and savings potential – at the individual building and end use level as well as for the total site. The identified cost-effective projects that together represent the lowest life-cycle cost are detailed on the TXD and CSV reports.

In addition to the projects identified by the automated FEDS optimization process, additional measures can be evaluated via parametric analysis. In this more manual process, two versions of a building model can be created. One will represent the baseline building as it currently exists (the model evaluated in Step 9). In addition to running this model through an optimization analysis, the model can also be copied (using the Save case as function) for implementing selective changes to represent a potential measure. These two models can then be simulated; comparing their resulting baseline energy consumption and costs will provide an estimate of savings. This would then need to be compared against estimated implementation costs to determine cost-effectiveness.

More information on the output from FEDS simulations is presented in Section 8.

6 FEDS Simulation Settings

This section provides an overview of the operation and effective use of the features accessible within the Simulation Settings. These are accessed from the Simulation area of the FEDS Home.

6.1 Simulation Parameters

The Simulation Parameters (Figure 6.1) provides access to inputs that define key parameters of the FEDS simulation process. This includes the Analysis Type (Optimization vs. Calibration) as well as options that help specify the simulation year.

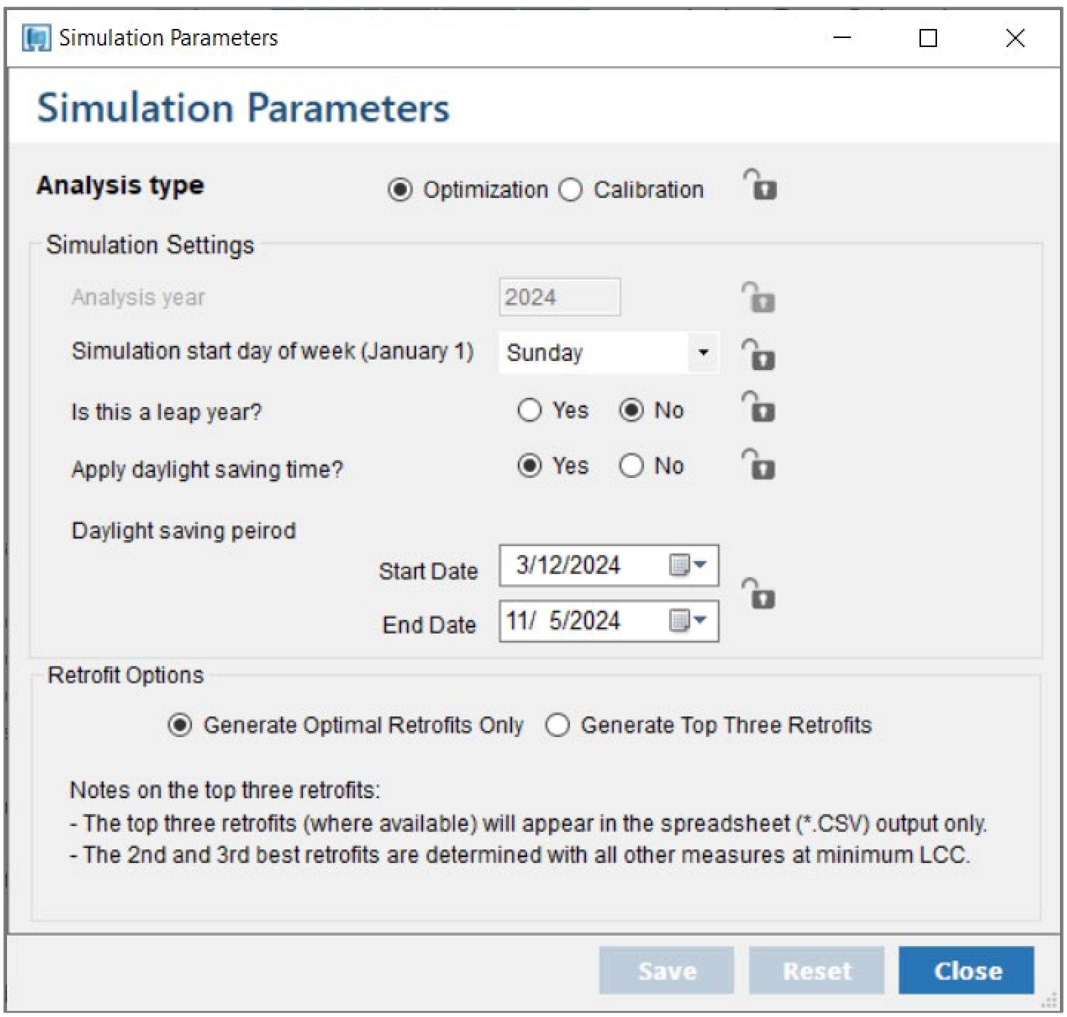

Figure 6.1 Simulation Parameters Screen

6.1.1 *Simulation Settings*

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 calibration spreadsheet output 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 or 366 days for the year.

Apply daylight saving time? – Similarly, this option allows you dictate whether the simulation considers daylight 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.

6.1.2 *Retrofit Options*

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.

"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.

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.

6.2 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 (Figure 6.2).

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.

Tip: 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.

This can also be accomplished by selecting the 'Calibration' Analysis Type.

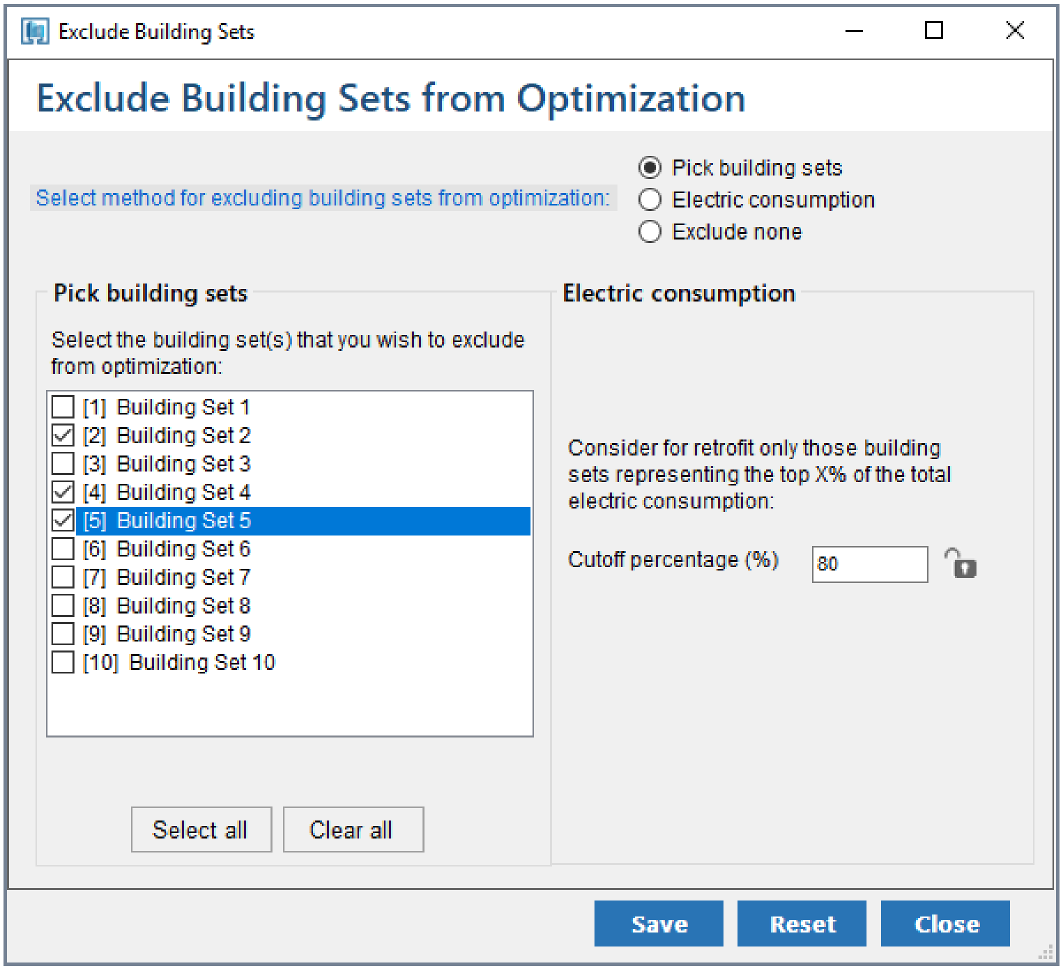

Figure 6.2 Exclude Building Sets from Optimization Screen

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.

6.3 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 **<Unselect all>** buttons can aid in this process. Symbols to the right of the building set name identify sets that have been excluded from optimization ("[X]") and sets with existing retrofit restrictions defined ("[R]"). In Figure 6.3, sets 2, 3, and 8 have been excluded while sets 1, 5, and 9 each have at least one retrofit restriction currently defined.
2. On the right half of the screen is an expandable list of retrofit options, grouped by end use. Select the end use category or specific retrofit technologies to eliminate from evaluation during optimization.
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). The **<Collapse all>** and **<Expand all>** buttons can aid in accessing the desired list elements. Click on the boxes next to the end use, technology, and measure to restrict it for the selected building set(s). **<Unselect all>** will remove all selected items.
4. Pressing **<Save>** at this point will save the specified restrictions. **<Reset>** will revert 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 **<Close>**.

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

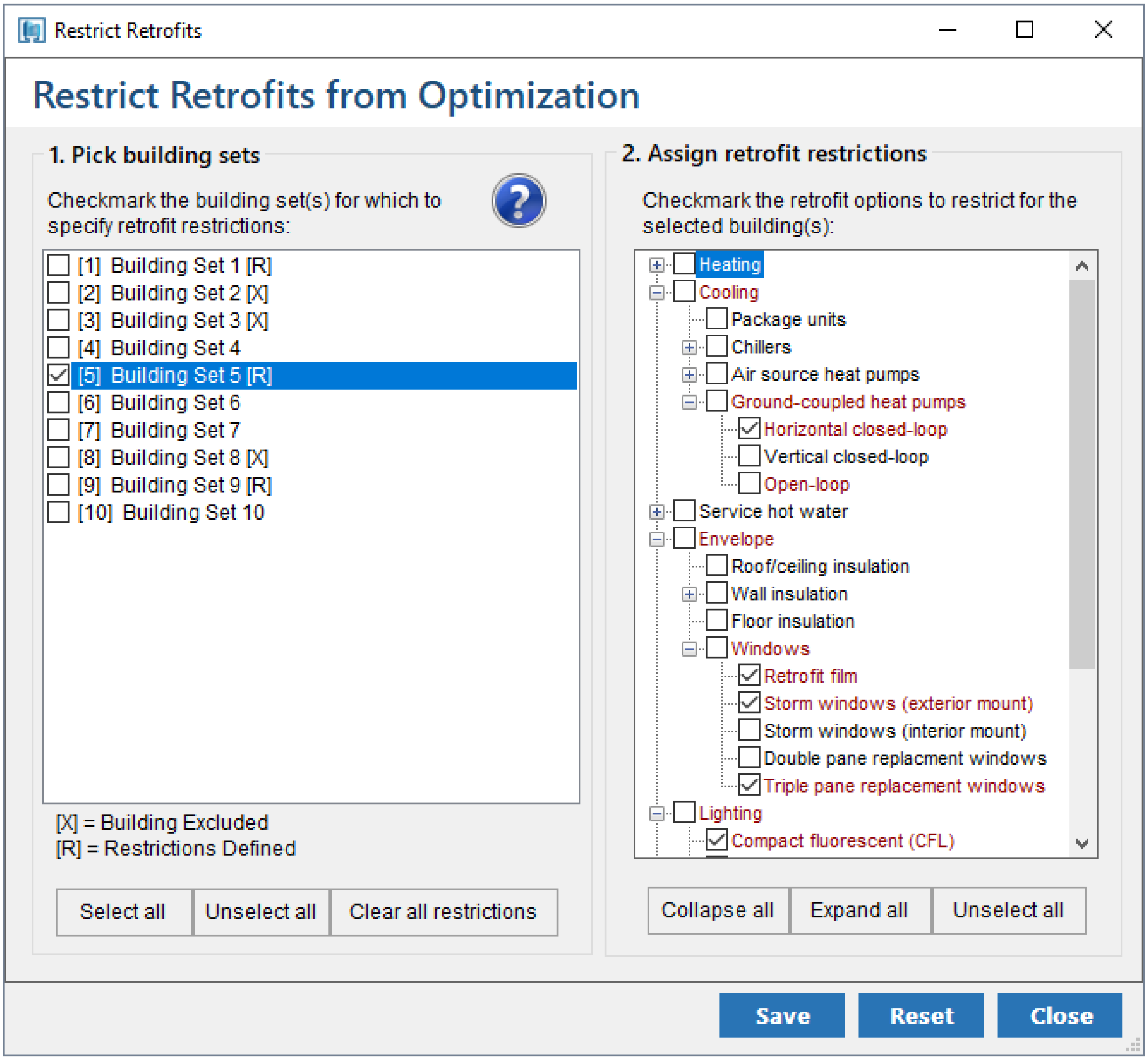

Figure 6.3 Restrict Retrofits from Optimization Screen

Viewing and Clearing Retrofit Restrictions

Restrictions can be added to single buildings or groups of buildings. However, the complete set of restricted retrofits can only be viewed for individual building sets (i.e., one building set at a time). 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 in the retrofit window and specific retrofits may be added or deleted by clicking the selection box next to each. When a retrofit is restricted for a given building, the box to the left of its name will be checked. Additionally, red text will highlight the selected technologies as well as the parent technology type and end use, to indicate where restrictions are set.

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 building is selected on the building set list.***

<Clear all 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 **<Clear all restrictions>** button.

7 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, utility energy service contracts (UESC), and energy savings performance contracts (ESPC).

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

- having the site continue to operate the baseline equipment and when it fails to replace it with the minimum life-cycle cost equipment, and
- 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.

7.1 Alternative Financing Inputs

The alternative financing inputs may be accessed by selecting "Financial Options" under the *Facility Information*. The following screen (Figure 7.1) will appear:

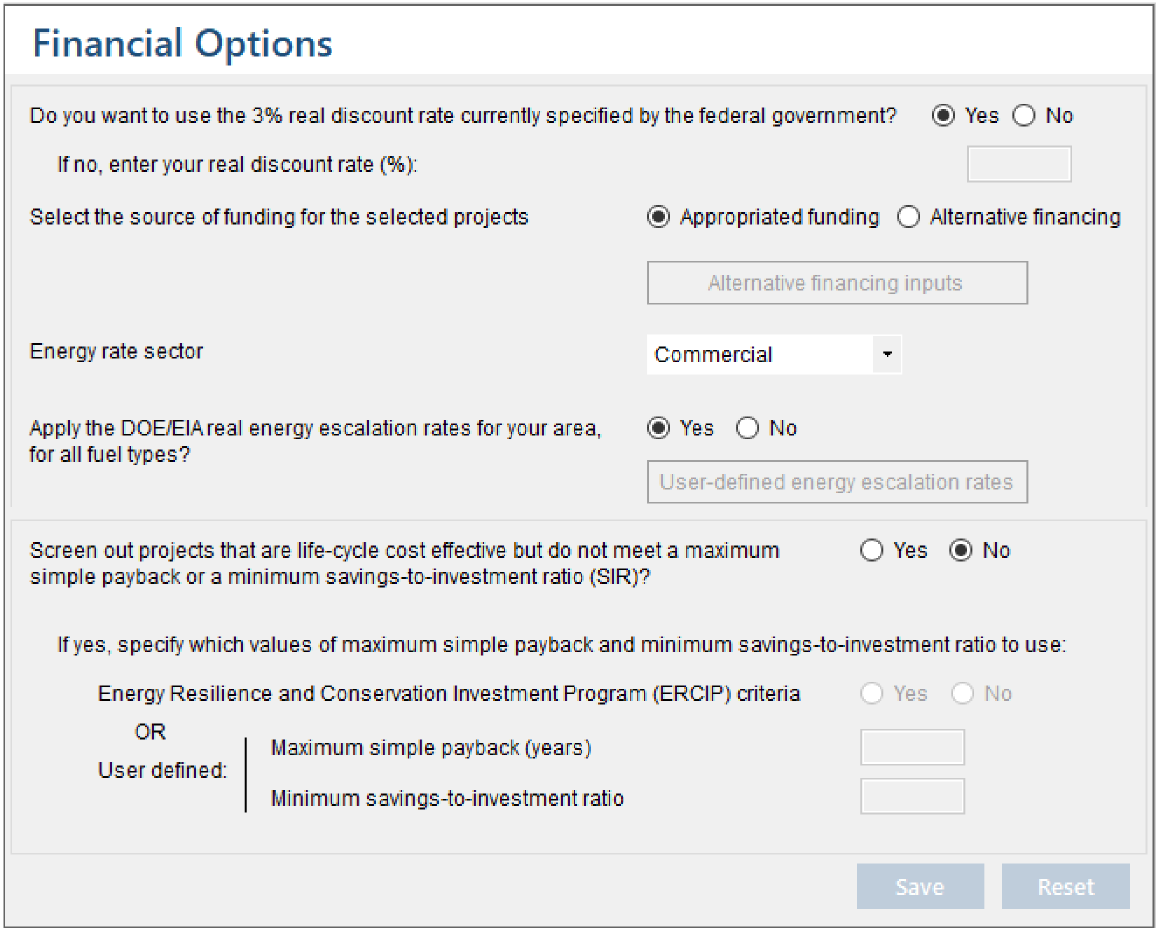

Figure 7.1 Financial Parameters and Screening Options Screen

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 (Figure 7.2):

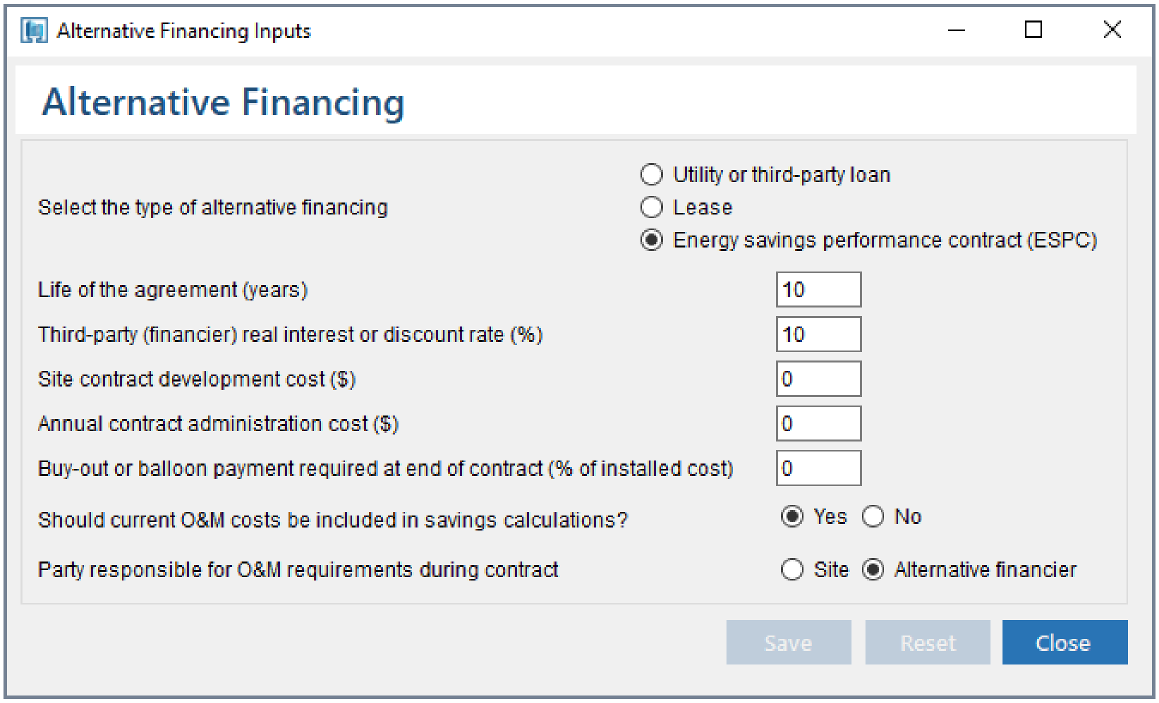

Figure 7.2 Alternative Financing Screen

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 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.)

7.2 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 Resilience Conservation Investment Program (ERCIP) funding represent different and incompatible funding mechanisms.

8 FEDS Output

Upon completion of a successful FEDS run, a number of relevant reports will be generated automatically. Additional output reports may be generated at any time, or refreshed as needed. From the FEDS Home, select **Reports**. The following report types are available (as shown in Figure 8.1):

- Summary Installation and Building Set Output (txs) – *always generated*
- Detailed Retrofit Output – Text Format (txd)
- Detailed Retrofit Output – Spreadsheet Format (*.csv)
- ERCIP Format Output (ecp)
- Calibration Output (*.Calib.xlsx)
- Retrofit Savings Overview (*.Retrofit.Savings.xlsx)
- Compliance Tracking System (CTS) Report (*.CTS.xlsx)

FEDS provides direct access to the report files from the Report screen. To open a report, simply click the Open button 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 PDF reader), you will be prompted to select the application you wish to use to open and view the report.

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

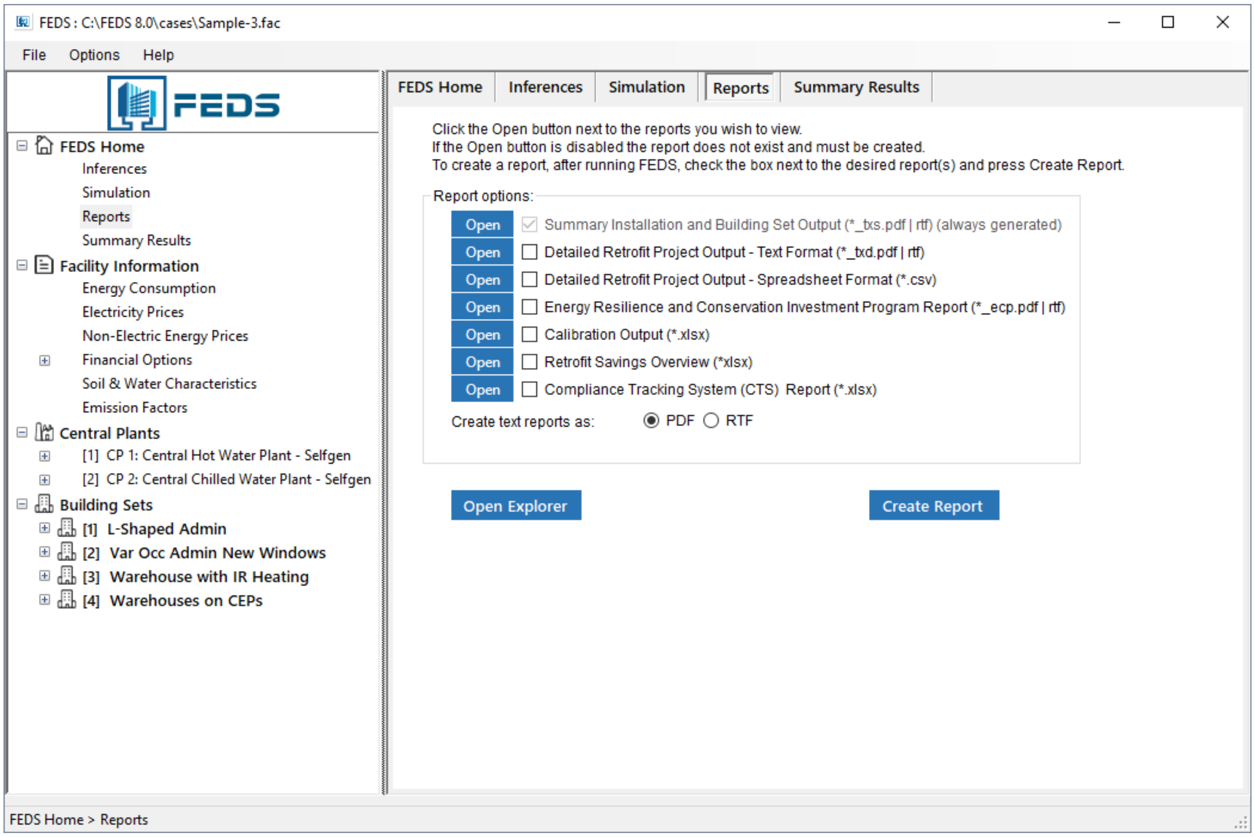

Figure 8.1 Report Options Screen

8.1 Summary Installation and Building Set Output (TXS Report)

The text-based summary ("txs") report presents a summary of the installation and building set energy, demand, dollar, and air pollution emissions impacts. This report is automatically generated by FEDS at the end of each FEDS run and any time any report format is created. It can be created in either portable document format (PDF) or rich text format (RTF) according to the setting specified on the reports screen. The output file is structured as follows:

Page 1: A summary of the **site energy-use characterization** provided in the input file.

Page 2: A summary of the **electricity price and schedule information** specified in the input file.

Page 3+: A summary of the **site building characteristics** specified in the input file. This includes the number of buildings, floor area, construction date, space heating technology, space cooling technology, and service water heating technology.

Page 4+: A summary of **additional site building characteristics** including indoor lighting technology and building operating hours. In addition to start and end time for each day type within each building and use area, identifiers for 5- or 4-day workweeks and the use of variable occupancy are presented, plus the number of calculated annual operating hours.

Page 5+: A summary of the **site economic data** specified 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 Simulation 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 FEDS Simulation Settings (Section 6).

Page 6: Reports the **highest level of identified resource savings potential**, as shown in Figure 8.2. 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 8.2 Example TXS Output Report

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. Additionally, a listing of simulated site peak demand, billing demand, and demand cost, by month, for both existing and post-retrofit scenario, is presented.

Page 9: **Annual installation emissions by pollutant type** (SO_x, NO_x, N_2O, CH_4, CO_2, CO_{2e}). 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 overall installation cost and, thus, will not necessarily precisely match the values reported on the TXD report, which are calculated at the margin based on the impact from each retrofit. There is one page of results 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 ft^2 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 ft^2 of floor area. Both existing and post-retrofit values are printed.

8.2 Text-Based Detailed (TXD) Retrofit Project Report

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 8.3 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 5.8 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: FL236:  FL 2X4 3F32T8 ELC3 (H)
Percent of Building Set Served by this Technology: 80.00%
Retrofit Technology: LD301:  LED 59W 2x4 Retrofit Panel (6227 Lumens) plus occupancy controls (J)

                                     Existing                 Retrofit              Difference
Retrofit Technology
 Watts/fixture                           96.0 (P)                 59.0 (Q)                 -37.0
 Operating hours/Year                   2,948 (R)                2,359 (S)                  -590
 Fixtures in this Bldg. Set               982 (N)                  982 (O)                     0
 Vintage                                 1977 (M)                  New
 Remaining Life (years)                    25                       25

Technology Energy Use/Demand (This technology)
 Energy (user units)                  277,967 (T) (kWh) (U)    136,667 (V) (kWh) (W)    -141,300
 Energy (MBtu)                            949                      466                  -482 (X)
 Electric Peak Demand (kW)                 59                       29                   -30 (Y)
 Coincident Peak Demand (kW)               59                       29                   -30

Building Set Energy Use/Demand (All technologies at minimum LCC except those being retrofit)
 Heating (MBtu)                           758                      836                    78
 Cooling (MBtu)                           390                      338                   -52
 Ventilation (MBtu)                       901                      901                     0
 Lighting (MBtu)                        1,194                      712                  -482
 Misc. Equip. (MBtu)                    1,793                    1,793                     0
 Motors (MBtu)                              0                        0                     0
 Service Water Heating (MBtu)              42                       42                     0
  Total (MBtu)                          5,078                    4,622                  -455 (Z)
  Peak Electric Demand (kW)               366                      328                   -38 (AA)

Air Pollution Emissions (All technologies at minimum LCC except those being retrofit)
 Carbon Dioxide (tons)                  179.9                    167.8                 -12.1 (AF)
 Sulfur Oxides (lb)                     136.3                    124.5                 -11.8 (AG)
 Nitrogen Oxides (lb)                   407.1                    382.8                 -24.3 (AH)
 Nitrous Oxide (lb)                       5.9                      5.6                  -0.3 (AI)
 Methane (lb)                         1,127.5                  1,084.8                 -42.7 (AJ)
 CO2 Equivalent (tons)                  196.9                    184.1                 -12.8 (AK)

Building Set Energy/Demand Cost--First Year
(All technologies at minimum LCC except those being retrofit)
This technology
 Energy                          $     27,797               $     13,667               $    -14,130 (AB)
 Annual Electric Demand          $      3,148               $      1,548               $     -1,600 (AC)
Balance of Building Set
(All technologies other than those being retrofit--includes systems and retrofit interactions)
 Energy                          $    107,205               $    106,619               $       -586 (AD)
 Annual Electric Demand          $     15,454               $     15,073               $       -381 (AE)

Life-Cycle Costs Savings       Present Values       Annualized Values
 Installed Cost                  $   -279,023 (AL)          $    -16,024 (AM)
 Annual Maintenance              $          0 (AN)          $          0 (AO)
 Non-Annual Maintenance          $    149,658 (AP)          $      8,595 (AQ)
 Energy/Demand                   $    291,039 (AR)          $     16,714 (AS)
    Total LCC Savings (NPV)      $    161,674 (AT)          $      9,285 (AU)
    Simple Payback (years)              11.0 (AV)
    AIRR (percent/year)                  4.9 (AW)
    SIR                                  1.6 (AX)

Installed Capital Cost:          $    279,023 (AY)
```

Figure 8.3 Example Output of the TXD Report (The characters in parentheses represent the spreadsheet column indicator where the data will reside once opened in a spreadsheet program.)

8.3 Detailed Retrofit Project Report – Spreadsheet (CSV) Format

The "Detailed Retrofit Output - Spreadsheet (*.csv)" option from the *Reports* 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 8.3. 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 8.3, 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 5.8.
- 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 6.1.2.
- End-use Retrofit Restrictions (Column L) – This field displays information pertaining to the Exclude Building Sets and Restrict Retrofits from Optimization settings that may be specified from the Simulation screen under FEDS Home. The information in this field 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.
- Additional Installed Cost Detail (Columns AZ - BB) – These additional fields detail the makeup of the total installed capital cost presented in Column AY. These include the Materials Cost (AZ), Labor Cost (BA), and Indirect Cost (BB) consisting of overheads.
- Fuel Savings (MBtu/Yr) and Value of First Year Fuel Savings ($) (Columns BC - BT) – 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).*

8.4 ERCIP Report

Selecting the "ERCIP report" option will generate a life cycle cost analysis summary in the format and calculation method prescribed for the Energy Resilience and Conservation Investment Program (ERCIP). This file contains three pages of information for each retrofit project identified by FEDS. Figure 8.4 shows examples of output for the three pages of an ERCIP 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.

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

```
Technology Retrofit Information for Building Set #3: Office
Sample-2 Building Set 3:  Office
End Use: Lights
Use Area: Office
Equipment Description: Main Office Lights
Existing Technology: FL236:  FL 2X4 3F32T8 ELC3
Percent of Building Set Served by this Technology: 80.00%
Retrofit Technology: LD301:  LED 59W 2x4 Retrofit Panel (6227 Lumens) plus occupancy controls


                         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:                 LD301:  LED 59W 2x4 Retrofit Panel (6227 Lumens) plus
                                      occupancy controls
Project Number:
Total Investment:                    $    279,023
MBtu/Yr Saved:                                455
Discounted MBtu Savings:             $    176,884
Discounted Demand Savings:           $     23,646
Discounted Total Energy Savings:     $    200,530
Discounted Total Non-Energy Savings: $    122,084
First Year Dollar Savings:           $     27,577
Simple Payback in Years:                    10.12
Discounted Total Net Savings:        $    322,614
Savings To Investment Ratio (SIR):           1.16
Point Of Contact:                    I.M. Somebody
Phone Number:                        (123) 456-7890
```

ERCIP Page 1 and Page 2 Output

Figure 8.4 Example Output of {Casename}.ecp Report

```
                         Energy Life Cycle Cost Analysis Summary

Location:    Seattle                          Region:        4            Project No:
Category:     6                               Economic Life: 15           Project Title: Lighting
Systems
FY:          2025                             Date:          18-Nov-2024

Prepared By: I.M. Somebody
State:       WA

1. Investment Costs
   A. Construction Cost                                  $   240,537
   B. SIOH ( 6.00%)                                      $    14,432
   C. Design Cost (10.00%)                               $    24,054                   Funding Amount
   D. Energy Credit Calc (1A+1B+1C)                                      $   279,023     $   279,023
   E. Salvage Value of Existing Equipment                                $         0
   F. Public Utility Company Rebate                                      $         0
   G. Total Investment (1D-(1E+1F))                                      $   279,023

2. Energy Savings(+) or Cost(-)
   Analysis Date Savings, Unit Costs & Discounted Savings

                            Cost          Savings        Annual $        Discount        Discounted
   Fuel                   $/MBtu(1)      MBtu/Yr(2)     Savings(3)       Factor(4)       Savings(5)

   A. Electricity       $     29.30           518      $    15,187          12.01       $   182,370
   B. Distillate Oil    $     21.27             0      $         0          11.64       $         0
   C. Residual Oil      $      0.00             0      $         0          13.59       $         0
   D. Natural Gas       $      7.50           -63      $      -471          11.64       $    -5,486
   E. Coal              $      0.00             0      $         0          11.98       $         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                                   $     1,981          11.94       $    23,646
   K. Subtotal                                  455    $    16,696                      $   200,530

                            Cost          Savings        Annual $        Discount        Discounted
                          $/Mgal(1)      Mgal/Yr(2)     Savings(3)       Factor(4)       Savings(5)
   L. Water                                            $         0          11.94       $         0
   M. Total                                            $    16,696                      $   200,530

3. Non-Energy Savings(+) or Cost(-)

   A. Annual Recurring(+/-)                                                             $         0
     (1) Discount Factor                                                    11.94
     (2) Discounted Savings/Cost (3Ax3A1)                                               $         0

   B. Non-Recurring Savings(+) or Cost(-)

                          Savings $      Year of          Discount               Discounted Savings
   Item                    Cost(1)     Occurence(2)       Factor(3)              (+) or Cost(-) (4)

   d. Total             $   163,214                                                 $   122,084

   C. Total Non-Energy Discounted Savings/Cost (3A2+3Bd4)                               $   122,084

4. First Year $ Savings (2P3+3A+(3Bd1/Yrs Econ Life))                                   $    27,577

5. Simple Payback (1G/4)                                                                      10.12

6. Total Net Discounted Savings (2P5+3C)                                                $   322,614

7. SIR (If < 1.25 Project Does Not Qualify)
   SIR = (6/1G)                                                                                1.16
```

ERCIP Page 3 Output

Figure 8.4 Example Output of {Casename}.ecp Report (cont'd)

8.4.1 *Differences Between ERCIP Output and Other FEDS Output*

There are at least two reasons why the ERCIP 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 ERCIP results with the "*.txd" and "*.csv" results. The differences arise because the ERCIP specification directs that some LCC 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 ERCIP reporting. This affects the discounted savings computed for the five ERCIP fuels and for the non-recurring maintenance savings.
- In the ERCIP 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 ERCIP 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.

8.5 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 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 Parameters* which is accessed from the Simulation screen under FEDS Home).

8.6 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 Annual Energy Use (MBtu)
- Energy Savings (MBtu/yr)
- Energy Savings (%)
- Energy / Demand Savings ($/yr)
- Estimated Investment ($)
- Simple Payback (yrs)
- SIR
- Carbon Reduction (tons CO_{2e})

An example of the Retrofit Savings Overview report is shown below in Figure 8.5, 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. Consult the *.txs report 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 Annual Energy Use (MBtu)	Energy Savings (MBtu/yr)	Energy Savings (%)	Energy / Demand Savings ($/yr)	Estimated Investment ($)	Simple Payback (Years)	SIR	Carbon Reduction (tons CO2e/yr)
L-Shaped Admin	5,958	1,500	25.18	31,476	196,782	6.50	1.84	209
Var Occ Admin New Windows	4,406	977	22.17	-6,218	495,617	20.75	0.68	210
Warehouse with IR Heating	7,420	130	1.75	10,247	7,464	1.18	13.57	42
Warehouses on CEPs	15,613	2,680	17.17	108,401	314,673	2.31	7.16	943
Site Total	**33,396**	**5,287**	**15.83**	**143,905**	**1,014,536**	**5.17**	**3.01**	**1,403**

Figure 8.5 Example Output of {Casename}.Retrofit.Savings.xls Report

8.7 Compliance Tracking System (CTS) Report

A CTS format report has been developed to assist federal agencies in meeting EISA 2007 Section 432 auditing requirements. This new spreadsheet output summarizes the results of an EISA-compliant assessment, to facilitate reporting to the Compliance Tracking System (CTS). The report automatically compiles the details from the assessment to assist in the reporting of assessed floor area and identified energy savings potential. Retrofit measures identified by FEDS are categorized and compiled within the CTS format, across all buildings evaluated, to provide a summary of the number of measures and impact from each group. The report can assist agencies in submitting required documentation into the CTS. Note: Microsoft Excel is required for FEDS to generate the CTS report.

8.8 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 the other files that make up a FEDS case.

To open a report simply click the 

button 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 selected to create the text-based report files (e.g., *.txs, *.txd, *.ecp) in PDF format, the application you have designated to read PDF files will launch to allow report viewing, editing, and printing. The spreadsheet files (e.g., *.xlsx, *.csv) should open within a spreadsheet application.

Text-Based Reports

The *.txs, *.txd, and *.ecp reports will open in an application appropriate for the format selected (either PDF or RTF).

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.)

8.9 Hourly Energy Profile Output

Additional advanced output offered by FEDS includes hourly profiles of energy use based on the FEDS simulation. These profiles are output in CSV format and available at the site, building, and individual technology aggregation levels, for both baseline and post-retrofit simulations. This output can be valuable for more detailed evaluation, e.g., to analyze results over various timeframes, size loads for resilience or renewable energy systems planning, or export hourly loads to other modeling systems.

The hourly energy consumption profile output files are generated with each FEDS run within the same folder as the current FEDS case. These output files include:

- Facility Profiles:
    - Baseline: "{casename}-FacBaseConsProf.csv"
    - Post-retrofit: "{casename}-FacOptConsProf.csv"
- Building Profiles:
    - Baseline: "{casename}-BldgBaseConsProf.csv"
    - Post-retrofit: "{casename}-BldgOptConsProf.csv"
- Technology Profiles:
    - Baseline: "{casename}-PerTechConsProfsBase.csv"
    - Post-retrofit: "{casename}-PerTechConsProfsOpt.csv"

The capability goes beyond that of the typical FEDS user and therefore a detailed description of the format of these files is not offered here at this time. For more information please contact FEDS Support at FEDS.Support@pnnl.gov.

Appendices

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 *Opportunity Screening*

FEDS provides a user-friendly tool for analyzing energy use and the potential for energy-efficiency retrofit projects at large multi-building campuses or 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. 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 *Detailed Analysis and Project Assessment*

FEDS is also designed to allow a user to identify specific projects that are cost-effective and appropriate to a single building or a multiple building site. 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 screening capability less appropriate for single buildings than when it is used to model multi-building installations. Of course, accuracy is improved if actual parameter values are specified to override the inferred values.

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

- CBECS 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
- Heating
- Cooling

- Ventilation
- Service hot water
- Electric motors
- Miscellaneous equipment.

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 fueled 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.[3] 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.

[3] 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.

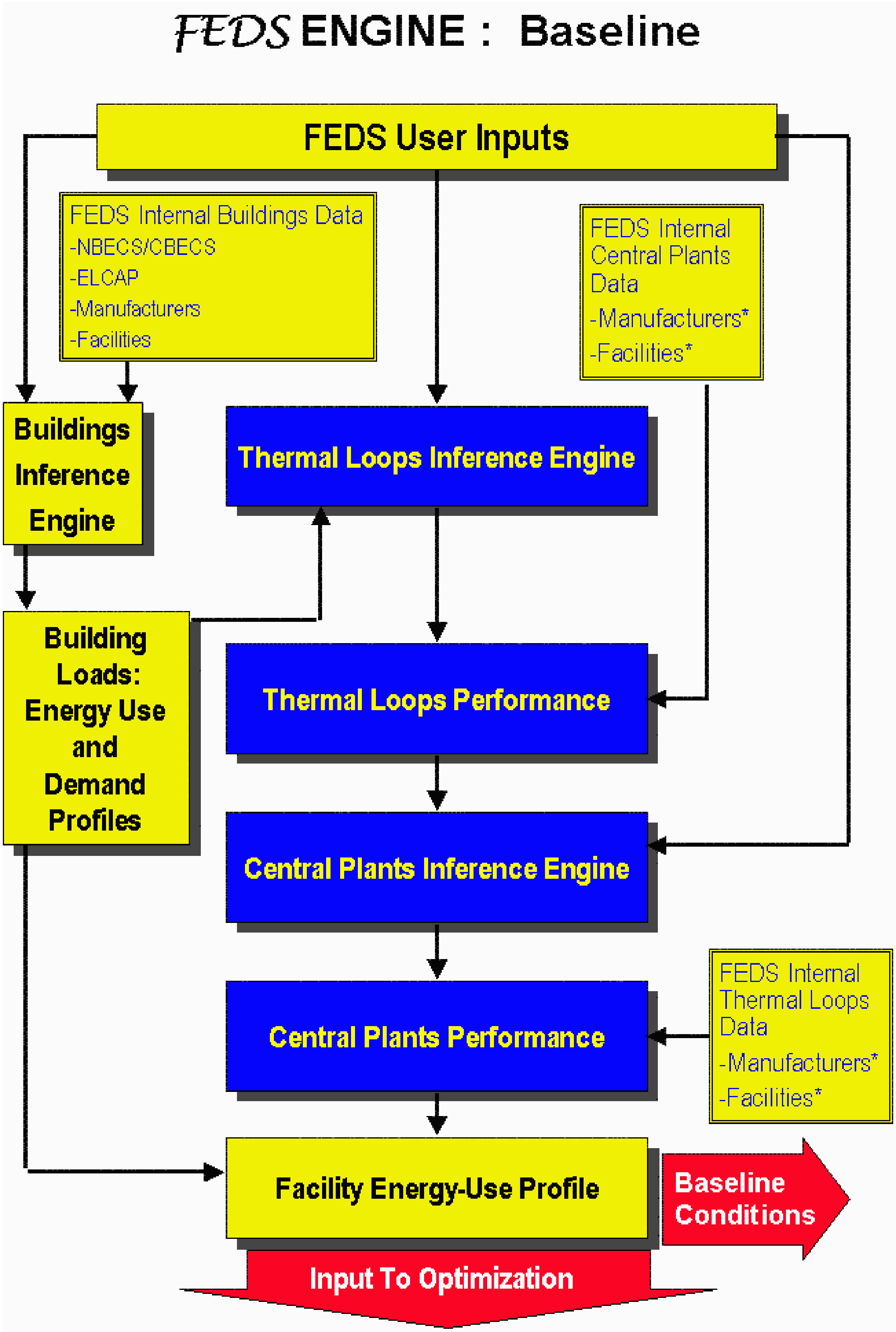

Figure A.1 FEDS Baseline Process

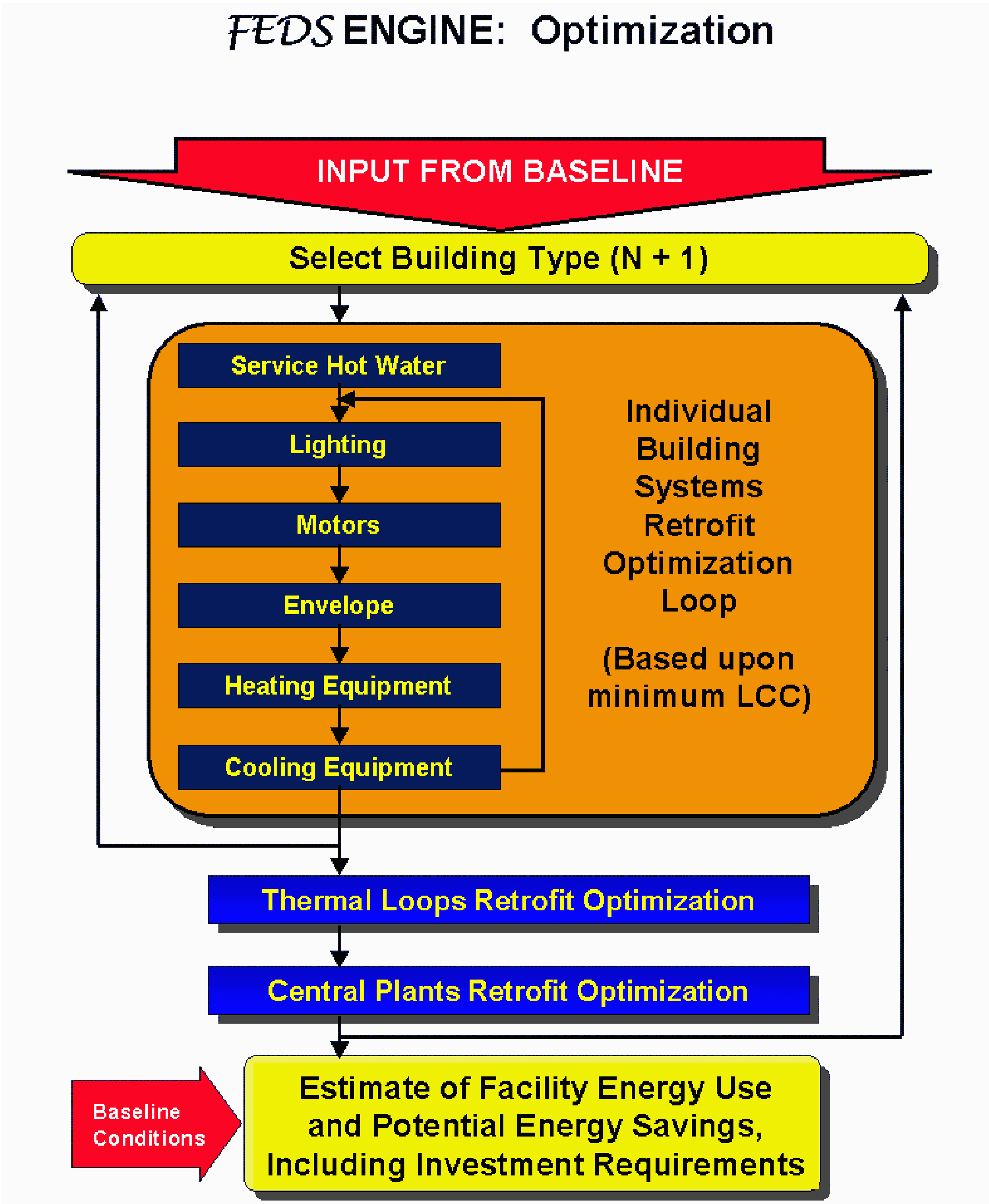

Figure A.2 FEDS Retrofit Optimization Process

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 HVAC Control Retrofits

The following HVAC control options are now available for evaluation by FEDS where viable (depending on current control technology, settings, and building types).

- Thermostat setback: decreasing the unoccupied period heating temperature set point and increasing the unoccupied period cooling temperature set point up to the specified value as compared to the occupied period settings.
- Ventilation scheduling: schedule ventilation system operation based on building occupancy, where applicable.

B.2 Heating Retrofits

The available heating retrofit options 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.3 Cooling Retrofits

The available cooling retrofit options 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.4 Envelope Retrofits

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.5 Service Hot Water Retrofits

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.6 Lighting Retrofits

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.

Lighting controls may also be evaluated as a retrofit technology, where applicable. Occupancy-based controls can be considered for select baseline lighting technology configurations as specified within the lighting technology input screens. For lighting that is noted to not have existing controls but should be evaluated, FEDS will estimate the cost to install the specified number of sensors and apply savings consistent with the difference between the existing and “With Controls” utilization factors from the lighting technology record inputs.

B.7 Ventilation Retrofits

Currently, the only automated ventilation system retrofit is for ventilation system scheduling, which is included in the HVAC control retrofits described in Section B.1. The impact of additional measures or adjustments (including weatherization to reduce infiltration, adding or improving economizer or demand-controlled ventilation performance, and more) can be evaluated manually via parametric analysis (i.e., by making the expected change to the FEDS inputs and comparing the resulting energy use and costs for the baseline and modified scenarios).

B.8 Miscellaneous Equipment Retrofits

Currently, automated miscellaneous equipment (plug-load) retrofits are not available. Savings estimates for select plug load management options can be modeled parametrically by making the expected change to the FEDS inputs and comparing the resulting energy use and costs for the baseline and modified scenarios.

Tip: See Section 5.10 for more information on performing parametric analyses to assess the impact of changes including potential retrofit projects that are not automatically evaluated by FEDS.

B.9 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 %UserProfile%\Documents\FEDS 8\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 Stations

There are 1,116 weather files that are included with FEDS 8 (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. Figure D.1 presents a map of the locations of TMY3 weather stations across the United States, published by NREL. The complete set of weather station file names and locations as included with FEDS is listed in Table D.1. These weather data for building energy simulation are intended to represent a typical meteorological year rather than a specific year's weather.

Additional weather files for other locations or time periods are available from a variety of sources. These data files can be added for use by FEDS with the ***Import EPW Weather File*** option, described in Section 3.7.2. Note that only files in standard EPW format are compatible with FEDS.

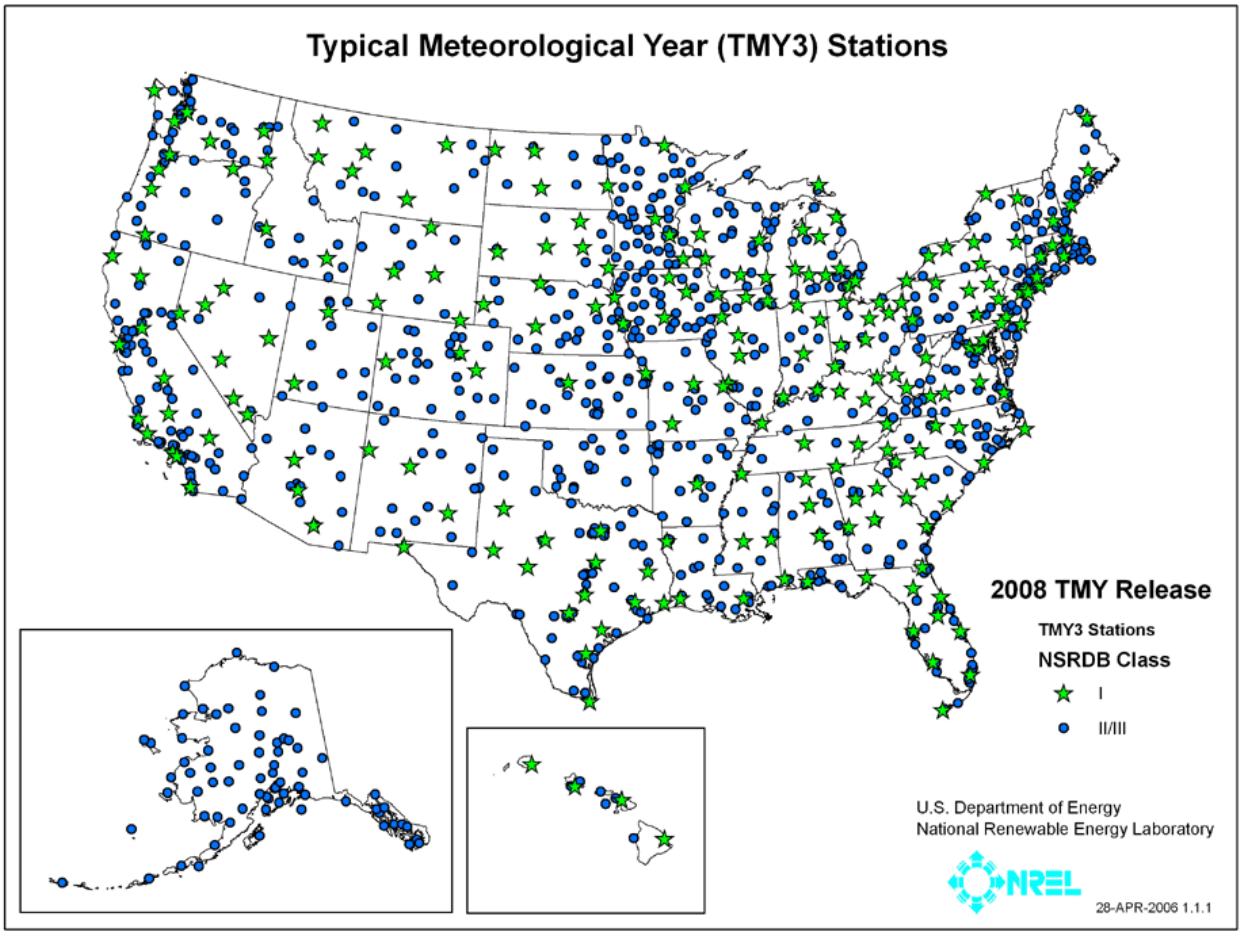

Figure D.1 Locations of Typical Meteorological Year weather stations across the United States (from http://rredc.nrel.gov/solar/old_data/nsrdb/1991-2005/tmy3/usTMYmaps3medium.gif)

Table D.1 Weather Stations Included with FEDS 8

State	Locations		
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 RgnlAP	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	Kirksville 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 Lemberton 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
	Draughon-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	Rhinelander-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
	Kuujjuarapik	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.

Civilian / Military class: These classes describe general characteristics of the buildings but should serve only as initial guidance, and not the determining factor. If a suitable building or use-area type exists within both classes, select that one that most closely corresponds to the class of the site being modeled. However, a "military" class building or use-area type may be the most appropriate choice for a non-military building or use-area (and vice versa) when no better option exists within the other class.

E.1 Civilian Building and Use-Area Types

The civilian building and use-area types are the same as evaluated by the U.S. Energy Information Administration in the CBECS 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: retails 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 is has living quarters for two, three, or four families or households

5 or More Unit Multifamily
Examples: apartment building
Characteristics: structure that is 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: data centers, 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: dependent schools, dependent 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 **4**F40T12 STD2 REF). The number of lamps can vary from one to four lamps per fixture.

Table G.1. Fixture Dimensions

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

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 eights of an inch; e.g., a T12 lamp has a diameter of 12/8 or 1.5 inches. Table G.2 lists the possible lamp types and their descriptions.

Table G.2. Lamp Types

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

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

Table G.3. Ballast Type

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

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
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

Abbreviation		Description
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
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)

Abbreviation		Description
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
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
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

Abbreviation		Description
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
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

Abbreviation		Description
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
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

Abbreviation		Description
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
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

Abbreviation		Description
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
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

Abbreviation		Description
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
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

Abbreviation		Description
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
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 28-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 28-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

Abbreviation		Description
LD202	LED 23Wx3 4' 30W ST8/32W T8 REF Lamp Repl (2550 Lumens/Lamp)	Three 4-foot 23-watt LED replacement lamps for 28-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 28-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
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

Abbreviation		Description
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
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

Abbreviation		Description
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
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

Abbreviation		Description
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
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 – Lighting 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 performs hourly calculations 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: FEDS applies a lighting density that assumes the buildings have the "correct" lighting levels according to the percentage of floor area input. However, that assumption can be overridden by entering 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, if a space is over-lit by 30%, the percent illumination input can be increased by 30%.

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. If hot water is available only in a breakroom and restrooms that represent 5% of a building's floor area, it is important to specify that the building is fully served by hot water.

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 Inference Errors

Inferences are updated at two points: when you explicitly request an inference update and at the start of a FEDS simulation run. Updating inferences catches any input errors and makes sure that all required inputs are 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 errors messages typically identify the source of the error and the solution.

"Missing minset at level [default level, NOTE: not used], missing [description] [tech #]." ***A required input has not been entered. Make sure that all inputs with a blue arrow 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***.

"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.***

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).***

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.3 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 (or use area). You created a new building set and did not visit the Lighting Inputs (or forgot to add lighting records for a second use area). The model assumed there were no lights in the building set or use area. ***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 (or use area). You created a new building set (or use area) 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:

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

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.

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

where:

AV_j	=	Annualized value of cost element j.

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

Several 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*

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

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:

ΔCF_{energy}	=	The difference between building's first year energy cost without the retrofit and with the retrofit (existing - retrofit)
ΔCF_{demand}	=	The difference between building's first year demand cost without the retrofit and with the retrofit (existing - retrofit)
$\Delta AV_{O\&M}$	=	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
$\Delta AV_{non\text{-}ICR\ non\text{-}annual\ O\&M}$	=	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.

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

where:

SIR	=	Savings to investment ratio
$PV_{Installed\ Cost}$	=	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.

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

where:

AIRR = Adjusted internal rate of return.

Appendix L – Miscellaneous Resources

L.1 FEDS Support

Contact FEDS.Support@pnnl.gov with comments or questions on FEDS applications, issues, training, and more. We would love to hear what you are using FEDS for and welcome your suggestions.

Training workshops sponsored by the Federal Energy Management Program or other agencies are occasionally available. Additionally, customized training is available to meet your needs. Please contact FEDS Support with inquiries or requests.

L.2 FEDS Website

The FEDS website is located at FEDS.pnnl.gov and provides access to additional information and resources:

L.2.1 *How to Get FEDS*

Visit FEDS.pnnl.gov/Licensing for information on how to get FEDS. U.S. federal and state agencies, as well as federal contractors qualify for a free copy; other users can review licensing options and submit a license request.

L.2.2 *Software Updates*

Updates to the FEDS software are posted when available. Check in to see what's new.

L.2.3 *Frequently Asked Questions*

Visit FEDS.pnnl.gov/FAQs for a listing 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.

L.3 Data Collection Forms

Examples of FEDS data collection forms have been installed to your FEDS \Data Collection Forms folder (default location is %UserProfile%\Documents\FEDS 8\Data Collection Forms). These are forms developed by FEDS users to collect building data used by FEDS – whether in a walk-through building audit or remote data collection process. Two different versions are available: a single page version listing the required FEDS building parameters and a multi-page detailed version, with a more comprehensive data listing. 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/.

Appendix M – Third-Party Open Source Component Acknowledgements

This version of FEDS relies on the Open Source software components listed here. Details and terms for each common license type used by multiple components are disclosed in full within the following subsection. These tools are reviewed frequently for available updates.

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Appendix N – FEDS Glossary

Abandonment Value	The dollar value associated with abandoning a central plant or one or more of its thermal loops in favor of decentralizing and installing individual building-level boilers and/or chillers. A positive abandonment value suggests that decentralization makes economic sense.
AC	Air conditioning
ACH	Air changes per hour
AIRR	Adjusted internal rate of return. See Appendix K for more details.
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.
Aspect Ratio	Ratio of a building's north facing length to the east facing length; used to specify geometric orientation.
Btu	British thermal unit
Building Set	A group of like buildings that are modeled together in FEDS. Buildings with similar size, vintage, function, and occupancy schedule can be grouped into a single building set to improve modeling efficiency. For more detailed modeling and analysis, a building set will often consist of a single building or even a portion of a building.
Calibration	The process of refining select building inputs in order to develop a model whose simulated energy use and demand more closely tracks the metered energy consumption of the actual building or site. The Calibration Analysis Type will simulate the baseline building conditions only, and not perform an optimization of retrofit measures. The Calibration Report is a spreadsheet formatted report that focuses on the simulated energy use by fuel type and end use for each building.
Capacity	The amount of energy, divided by the time, a piece of equipment would use if it were to run continuously at rated conditions.
CBECS	Commercial Buildings Energy Consumption Survey
Central Plant	A plant producing steam, hot water, or chilled water that is supplied to one or more buildings via a distribution loop. These

are typically external to the served buildings, as opposed to boilers and chillers located within the building they serve.

Cfm Cubic feet per minute

CDD Cooling degree day

Consumption The energy input required, after adjustments for efficiency, in order for the energy-using equipment to meet the load.

Contract Demand A minimum monthly electric demand specified in an electric rate schedule, defining the lowest monthly billing demand for a billing meter. One potential impact on a retrofit project is that if monthly peak demand is reduced to a level below the contract demand, the value of billing demand savings will be limited by the contract demand.

COP Coefficient of performance; a unitless measure of efficiency commonly used for cooling, refrigeration, and heat pump equipment, defined as the ratio of useful heating or cooling provided to the work or energy required.

Crossover Temperature The outdoor air temperature at which a dual-fuel heat pump switches operation from the heat pump to the backup technology.

CSV Report The FEDS comma-separated values report presents details on each identified retrofit measure, similar to the TXD report but in spreadsheet format.

CTS Compliance Tracking System; managed by DOE FEMP, the system tracks performance of energy and water evaluations, project implementation and follow-up measures, for federal agencies.

Day Type A modeling day in FEDS (e.g., weekday, Saturday, or Sunday), defined by a specific set of operating hours, and number of occupants for both operating and non-operating periods.

DCV Demand controlled ventilation

Demand Ratchet An electric demand billing method in which the billed demand is the minimum of the actual demand and some fraction of the peak demand in previous months.

Distributed Hot Water A hot water system where the water is heated in a storage tank and distributed, on demand, to end-use locations in a building. Numerous tanks may be located throughout a large building, each serving a small area.

DOE FEMP	The U.S. Department of Energy Federal Energy Management Program
DX	Direct expansion (type of cooling technology)
EIA	Energy Information Administration
EISA 2007	Energy Independence and Security Act of 2007 https://www.govinfo.gov/content/pkg/PLAW-110publ140/pdf/PLAW-110publ140.pdf
Energy Act of 2020	https://www.directives.doe.gov/ipt_members_area/doe-o-436-1-departmental-sustainability-ipt/background-documents/energy-act-of-2020
EPW	Energy Plus Weather; the format of weather station data used for FEDS simulations. The EPW file defines the hourly weather characteristics for each simulation, including dry bulb temperature, humidity, atmospheric pressure, sky cover, etc.
ERCIP	Energy Resilience and Conservation Investment Program; a DoD-specific project funding mechanism.
Exclude Building Sets	FEDS offers users the ability to specify buildings to exclude from the optimization analysis which identifies cost-effective energy efficiency opportunities.
Facility	A collection of one or more buildings modeled in a FEDS case. FEDS Facility Information (e.g., location, weather, energy prices, etc.) applies to all the buildings modeled at the site. Typically, all of the buildings served by a single billing meter should be modeled together in a single FEDS case.
FEDS	Facility Energy Decision System
FEDS Thermal Zones	Zones are portions of the building that are individually controlled by the HVAC system. Zones are assumed to be adiabatically isolated from each other.
Gpm	Gallons per minute
Heat/Cool Pair	A combination of heating and cooling technology serving the same space within a building set which together may be considered for replacement with a heat pump. Heat/cool pairs may be defined as *integrated pairs* (individual equipment capable

	of providing both heating and cooling service, e.g., heat pumps or packaged rooftop units with integrated gas burners) or *separate pairs* (separate heating and cooling equipment serving the same space, e.g., separate furnaces and air conditioners).
HDD	Heating degree day
Heat-To-Space	The heat contributed to the conditioned space by the equipment in question (e.g., lights, motors, plug loads).
HVAC	Heating, ventilation, and air conditioning
Inferences	Parameter values not entered by the user that are filled in (i.e., inferred) by FEDS from other inputs, based on the most likely parameter value approach.
ksf	Thousand square feet
kW	Kilowatt (measure of electrical power or demand)
KWh	Kilowatt-hour (measure of electrical energy)
LCC	Life-cycle cost
Linked Building Set	A geometric description of two buildings (sets) sharing a common (adiabatic) portion of wall or roof/ceiling area.
Linked HVAC System	A heating and/or cooling coil that is integrated with the ventilation system, using conditioned air for distribution.
Load	The required energy output for an end-use.
Lock	Each inferable FEDS input has a lock associated with it which identifies its current state. The lock shows whether the input has been specified by the user (locked), or has been inferred and will continue to be inferred by FEDS (unlocked).
Loop Hot Water System	A hot water system where the water is typically heated external to the storage tank(s) and moved continuously through a large building (e.g., hotel or hospital) via a pumped circulation system.
LPG	Liquefied petroleum gas
Maximum Detail	User interface display mode in which all minimum set inputs and all inferable inputs (white input cells) of the model are shown and available for changing.

MBtu	Million Btu (*Note: the HVAC industry often uses 'MBtu' for thousand Btu and 'MMBtu' for million Btu. FEDS uses 'kBtu' for thousand Btu and 'MBtu' for million Btu and aims to spell the units out in most instances.)*
Minimum Set	The set of inputs that must be provided by the user in order for a FEDS model to update inferences or run; these inputs are distinguished by a blue arrow next to the input cell indicating values that must be specified by the user.
Miscellaneous Equipment	Miscellaneous equipment represents a mix of plug and process load equipment common to the building, that exist outside of the lighting, HVAC, SHW, and motor end uses. 'Refrigeration', 'Food Preparation', and 'Other' miscellaneous equipment records are automatically generated and inferred by FEDS. Additional records can be added, or the inferred records deleted or modified as appropriate to model the energy used by these types of equipment.
NPV	Net present value. See Appendix K for more details.
OAT	Outdoor air temperature; under the FEDS simulation the hourly OAT is defined by the specified weather file (see EPW).
Occupancy Unit	The number of occupant living quarters in a multi-family residential building, barracks, or lodging facility. This value is used for estimating the number of pieces of equipment within a building (e.g., HVAC units, thermostats, water heaters, faucets, showerheads).
Occupant Heat Gain	The typical rate at which occupants give off heat to the surrounding space. This varies according to activity level. Sensible heat gain directly impacts air temperature while latent gains contribute moisture.
O&M	Operations and maintenance
Optimization	A comprehensive iterative process during which a range of retrofit technology and control options are evaluated for energy savings and cost-effectiveness against the baseline building configurations. The performance of each building and the entire site is evaluated by detailed hourly simulation of system loads, energy consumption, electric demand, and energy costs. The selected package of measures is the most lifecycle cost-effective

set of options as determined by comparing the calculated savings to estimated project costs.

PNNL Pacific Northwest National Laboratory

Profile A shorthand term that typically describes a vector of 24 values, indexed by hour of the day.

Record (Central plant, thermal loop, building set, or technology) – the set of inputs/parameters describing a particular technology, building set, central plant, or thermal loop. There are limits to the number of technology records that can be defined, but no hard limit to the number of building set records that can be modeled in FEDS.

Restrict Retrofits An option to prevent specified types or categories of retrofit measures from being evaluated by FEDS during the optimization process.

SHW Service hot water; the building end use that supplies service or domestic hot water to building occupants, for handwashing, bathing, cooking, dishwashing, and other common services.

Simple Payback The ratio of the total installed cost to the first-year savings. See Appendix K for more details.

Simulation The process of performing an analysis of building system loads and energy consumption, based on the specified combination of hourly weather data and building construction, equipment, and operational characteristics.

SIR Savings-to-investment ratio. See Appendix K for more details.

Solar Normalization A method in FEDS to avoid biasing the solar gains calculation (which is dependent on orientation) when the orientation is not known or there are multiple buildings of different orientations in a building set.

Therm A common measure of natural gas; 100,000 Btu

Thermal Loop A distribution system that supplies steam, hot water, or chilled water produced by a central energy plant to a group of buildings.

Thermostat Dead Band Number of degrees below (above) the thermostat set-point that the inside temperature must fall (rise) before the heating (cooling) system begins supplying heat (cool) again.

Thermostat Setback An HVAC control measure that turns down the heating set point temperature (and increases the cooling set point temperature) by a few degrees or more during unoccupied periods.

TMY Typical meteorological year; common type of weather data used in building energy simulation.

TXD Report Detailed text-based retrofit project report.

TXS Report Summary text-based report with total project costs and overall NPV, energy, demand, dollar, and emissions savings for each building and entire site.

Use Area Part of a building dedicated to a particular use; defined by its use type and occupancy characteristics. The use area type may be different than the building type (i.e., the use the building was originally built for). There are a maximum of 2 use-areas per building set.

%UserProfile% The Windows environment variable representing the standard file storage location for the current user. For most systems, this is C:\Users\<username>\ where <username> represents the actual user account name.

Utilization Factor Utilization factors specify the typical portion of time that a given type of equipment (lighting, motor, miscellaneous equipment) operates during the building's or use area's occupied or unoccupied periods. When specified for a set of multiple equipment, the utilization factor can similarly specify the percentage of the equipment (e.g., lighting fixtures) that are typically operating at one time during the noted occupancy period type. Note that the two utilization factors (for occupied and unoccupied periods) are independent and do not need to add to 100%.

Ventilation Scheduling An HVAC control measure that turns off the ventilation system during unoccupied periods; the system will operate only when demand for heating or cooling is required to maintain the thermostat set point.