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OpenEIS 2.0: Users Guide

June 2017

W Kim
RG Lutes
JN Haack
N Radhakrishnan
S Katipamula

Prepared for the U.S. Department of Energy
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Pacific Northwest National Laboratory
Richland, Washington 99352

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1.0 Introduction

OpenEIS (Open Energy Information System) is an open-source software tool for analyzing building energy and operational data to identify efficiency improvement opportunities. Continuous monitoring and analysis can increase whole building energy efficiency by up to 20%. However, most building managers and operators do not have cost-effective access to commercial tools and algorithms for identifying potential savings. Conversely, diagnostic methods developed by the Department of Energy's National Laboratories, by university researchers, and by publicly funded research projects do not have a common distribution path by which to put new tools in the hands of building managers and their operations staff.

In response, OpenEIS was created to provide standard methods for authoring, sharing, testing, using, and improving algorithms for operational building energy efficiency with building managers and building owners. OpenEIS is designed as a no-cost/low-cost solution that will propagate the fault detection and diagnostic (FDD) solutions into the marketplace by providing state-of-the-art analytical and diagnostic algorithms. As OpenEIS penetrates the market, demand by control system manufacturers and integrators serving small and medium commercial customers will help push these types of commercial software tool offerings into the broader marketplace.

One of the largest obstacles to data analytics (including, but not limited to, building energy and efficiency related analysis) is overcoming incomplete and non-uniform raw data. Few (if any) tools allow a user to merge data from multiple sources (with possible gaps in the data) and obtain one uniform data set. Due to disparity in data sets, gaps, and other problems the efforts required to merge and 'fix' these problems can consume untold hours before the data is usable. OpenEIS overcomes this functionality drawback with multiple aggregation filters for use in merging data, aggregating trend data from high sampling frequency to a lower sampling frequency, and other manipulations to easily create usable data sets that are suitable for immediate value-added analysis.

OpenEIS is compatible with the Green Button data format. The Green Button initiative gives utility customers easy access to their electricity usage data. This data is provided as a text file in a format that is standard across multiple utilities. This data file can then be shared with third party developers who can provide valuable context, analysis, and other functions based on that usage data.

Although OpenEIS was initially developed for building systems, it can easily be extended to include analysis tools for other types of systems and devices (i.e., nearly any device or system where data is trended). OpenEIS is compatible with most operating systems and can be run on Windows, Mac, and Linux operating systems. OpenEIS can also be deployed in the Cloud. OpenEIS uses a standard browser as a user interface. Although it has been tested with all major browsers, Google Chrome is recommended for the best results.

1.1 Organization of the User Guide

OpenEIS user's guide consists of 10 sections in addition to this Introduction: (1) Installation of the OpenEIS, (2) Running the OpenEIS (startup and configuration), (3) Create a New Project, (4) Upload Raw Data Files, (5) Create a New Data Map, (6) Create a New Data Set, (7) Manipulate a Data Set, (8) Select and Run Analysis Applications, (9) Collect and Visualize Results, and (10)Description of Analyses.

2.0 Installation of the OpenEIS

This section describes the software requirements for OpenEIS and instructions on how to install OpenEIS on Windows, Mac, and Linux.

2.1 OpenEIS Installation on Windows

The following steps describe how to install the OpenEIS on Windows:

Step 1. Download the OpenEIS Microsoft Software Installer 2.6-RC3 (openeis-setup_2.6-1498-3229b6a.exe) from the following link: https://github.com/VOLTTRON/openeis/releases.

Step 2. Locate the file you have downloaded, and double click on it to start the installation, then click 'Run' or 'OK' on the pop-up (Figure 1). Note that the file name shown in Figure 1 will be different because the tool is being constantly updated.

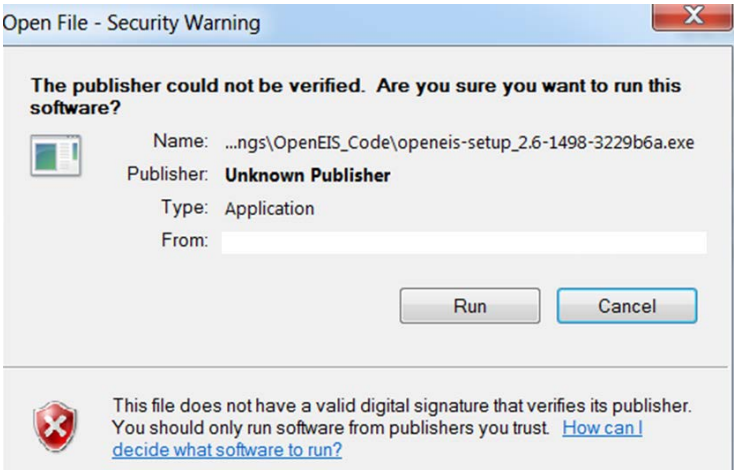


Figure 1. OpenEIS Installation on Windows - Start the Installation Process

Step 3. Select the location for installation (the default will be: C:\OpenEIS-2.6) (Figure 2) and click 'Next'.

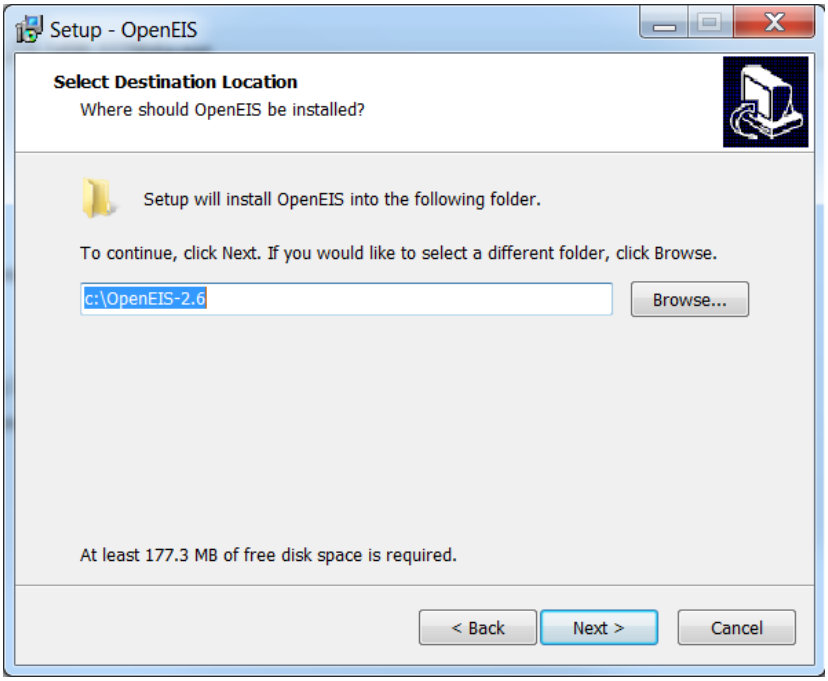


Figure 2. OpenEIS Installation on Windows - Choose an Installation Location

Step 4. Click 'Install' button to begin the installation process (Figure 3).

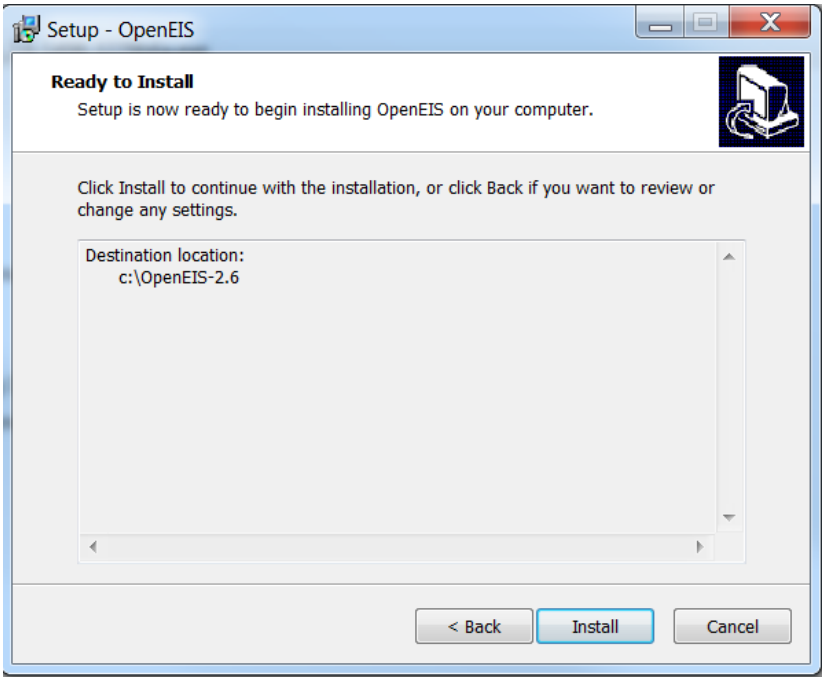


Figure 3. OpenEIS Installation on Windows - Ready to Install

Step 5. Check ‘Launch application’ and click ‘Finish’ button on the last dialog. This will complete the OpenEIS installation process (Figure 4).

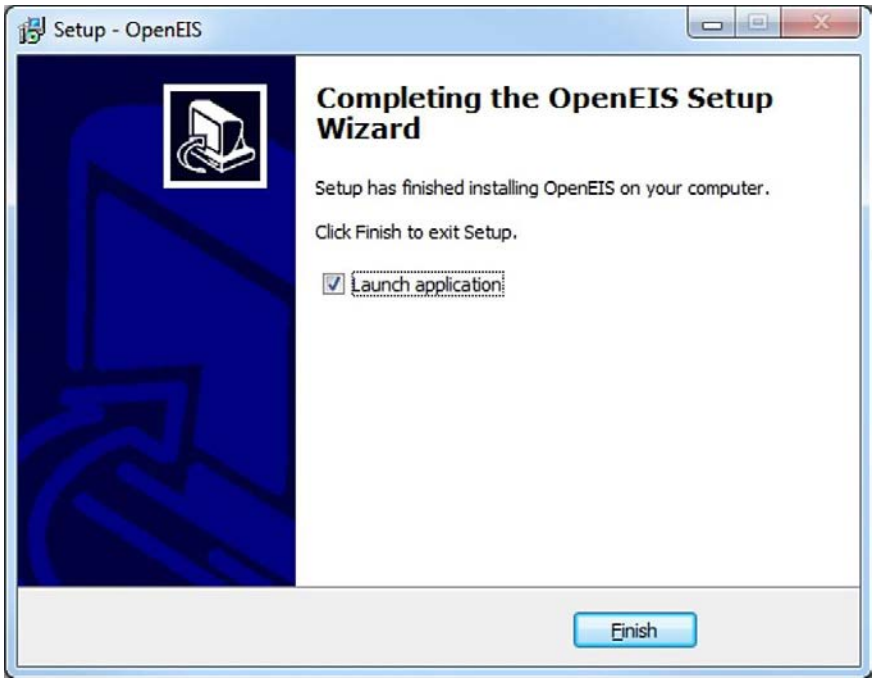


Figure 4. OpenEIS Installation on Windows - Installation Complete

2.2 OpenEIS Installation on Mac and Linux

The following steps will describe how to install the OpenEIS on Mac or Linux.

2.2.1 Software Requirements

Python is a general-use, high-level programming language. Many of the applications and tools developed for the OpenEIS are written in Python. The OpenEIS requires Python 3.3 or greater. Python is available for download at:

https://www.python.org/downloads/

Python is typically included in most Linux distributions (e.g., Ubuntu) or one can install Python with the Linux distributions respective package manager. Additionally, ‘python3.x-dev’ is required for some Linux distributions (Debian based Linux distributions: Ubuntu, Debian, Linux Mint, etc.). The ‘3.x’ should match the version of Python 3 on your system (i.e., 3.3 or 3.4).

2.2.2 Installation Steps

After Python has been installed, the OpenEIS can be downloaded and installed. The following steps will document the installation process:

Step 1. Navigate to https://github.com/VOLTTRON/openeis to download OpenEIS as a zip file. On the web page, click 'Clone or download' and select 'Download ZIP' (Figure 5).

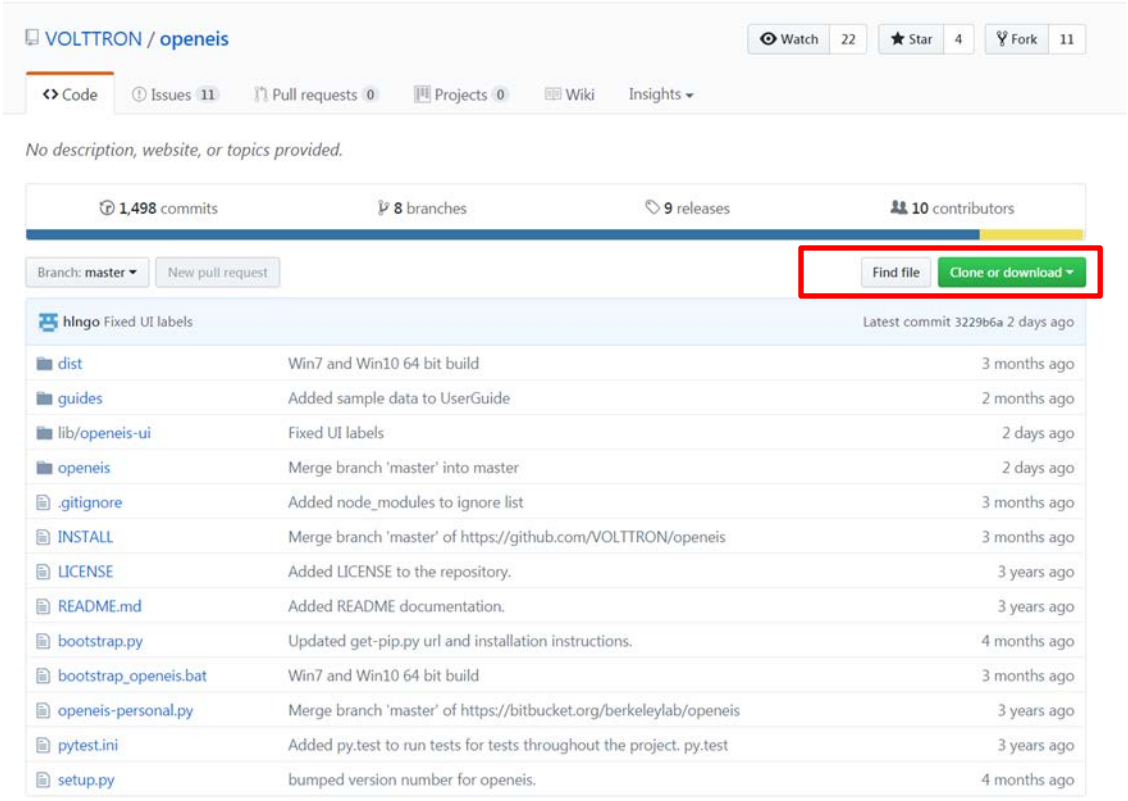


Figure 5. OpenEIS Installation on Mac or Linux - OpenEIS Download Page

Step 2. Navigate to the directory where the zip file was downloaded and extract the contents of the zip file to a directory of your choice. For this example the zip file will be extracted to:

- /home/USER-NAME/

Step 3. Open a terminal window and navigate to the base directory for the OpenEIS project (/home/USER-NAME/openeis-1.x/) and enter the following command (Figure 6):

- python3 bootstrap.py

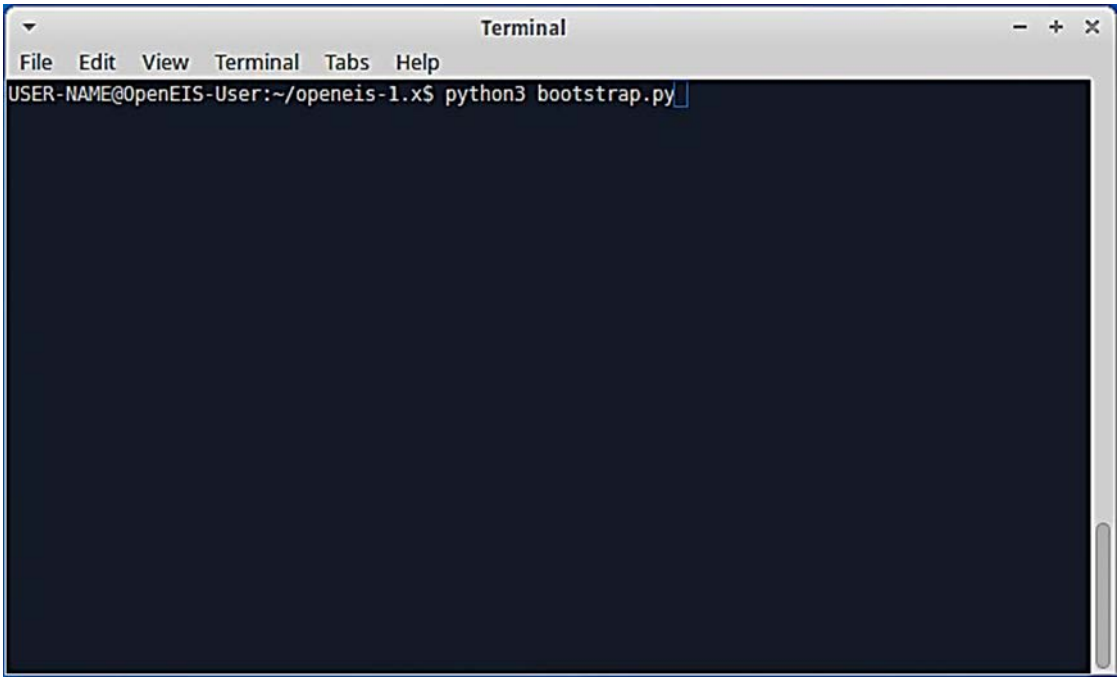


Figure 6. OpenEIS Installation on Mac or Linux - Building Project and Dependencies

The bootstrap.py script performs three tasks:

- Creates a Python virtual environment (using venv) in the env directory for project.
- Installs pip and setuptools by downloading and executing the get-pip.py script from the pip repository.
- Uses pip to install OpenEIS and dependencies into the virtual environment**.**

Step 4. The bootstrap script may take several minutes to run. Be patient and allow the script to finish. If there are not any errors in the terminal output, then the script was successful. The terminal output upon completion will appear similar to Figure 7.

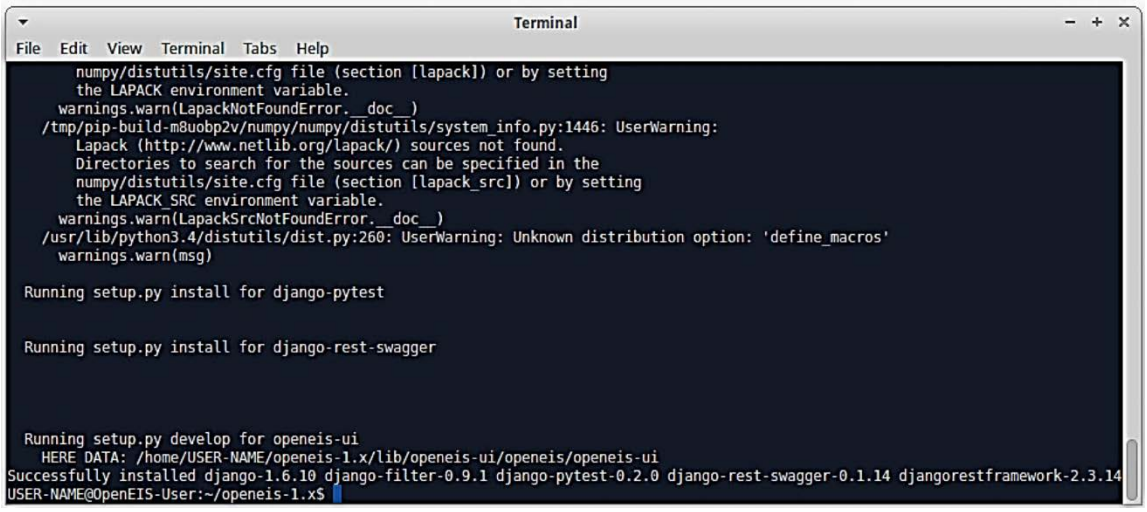


Figure 7. OpenEIS Installation on Mac or Linux - Bootstrap Process Is Complete

3.0 Running the OpenEIS

This section details the post installation steps necessary to use the OpenEIS. These steps include creating a user account, running the OpenEIS, and project configuration.

3.1 Start the OpenEIS on Windows

To start the OpenEIS in Windows:

Step 1. Run OpenEIS by double-clicking the file start-openeis.bat from the installation folder (C:\OpenEIS-0.2\start-openeis.bat; the folder name may be different based on the version installed).

Step 2. Use the URL http://127.0.0.1:54620/ to run OpenEIS on other web browsers if necessary. It is highly recommended to use Google Chrome for running OpenEIS. The OpenEIS user interface is dispayed in a web browser and the login page is loaded, as shown in Figure 8.

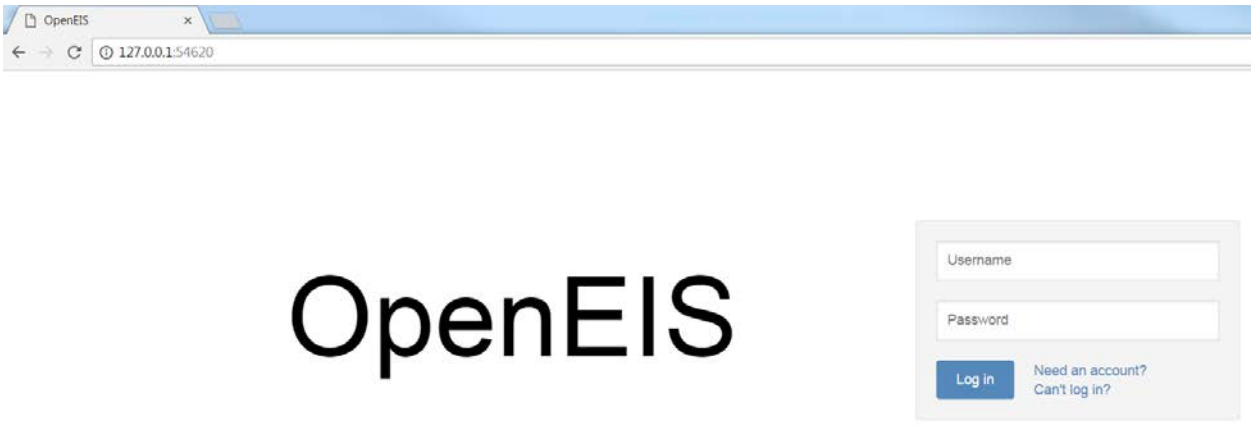


Figure 8. Running the OpenEIS - User Interface

3.2 Start the OpenEIS on Linux or Mac

To start the OpenEIS in Linux or Mac:

Step 1. Open a terminal window and navigate to the base OpenEIS directory (/home/USER NAME/openeis-1.x).

Step 2. Enter the following command:

- .env/bin/activate

The terminal output will appear similar to Figure 9. Note the '(OpenEIS)' appears at the head of the command prompt when activation was successful.

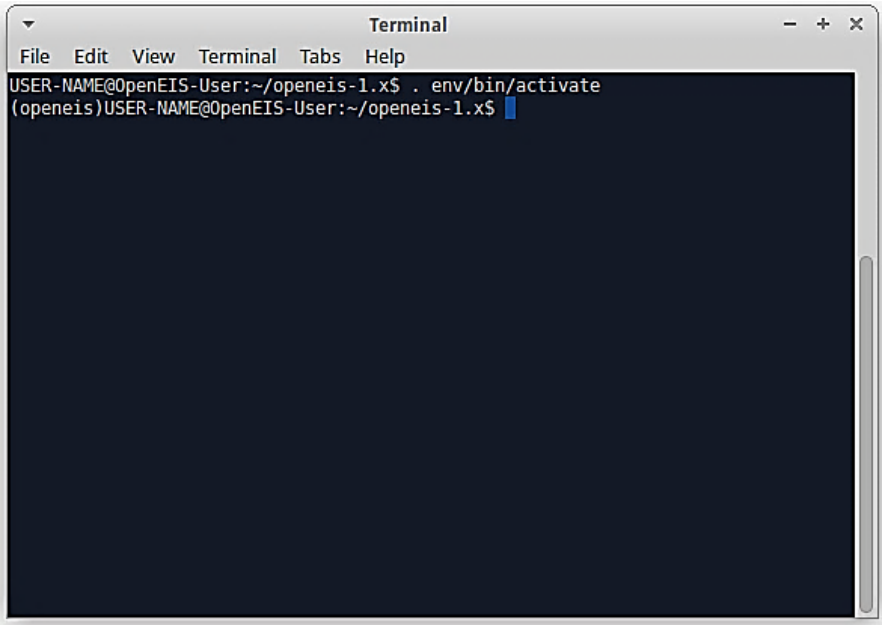


Figure 9. Running the OpenEIS - Startup on Linux or Mac

Step 3. After activating the OpenEIS a user account can be created and a database initialized. Enter the following command in the terminal:

- openeis syncdb

The user will be prompted to create a superuser account; enter '**yes**' and follow the remainder of the prompts to create a user name and user password.

Step 4. Enter the following command in the terminal:

- openeis runserver

The terminal output should appear similar to Figure 10.

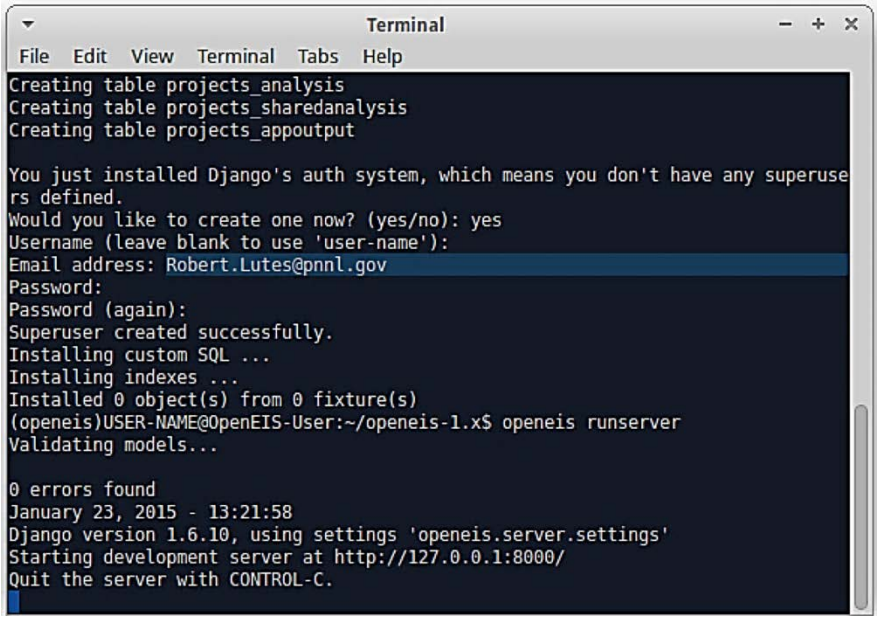


Figure 10. Running the OpenEIS - Running Server on Linux or Mac

Step 5. Open a web browser and enter the URL: http://localhost:8000 (Figure 11).

One can now proceed to create a new project (Section 4.0). Section 3.3, 'Create OpenEIS Account', can be skipped because the user account was already created (Section 3.2, Step 3).

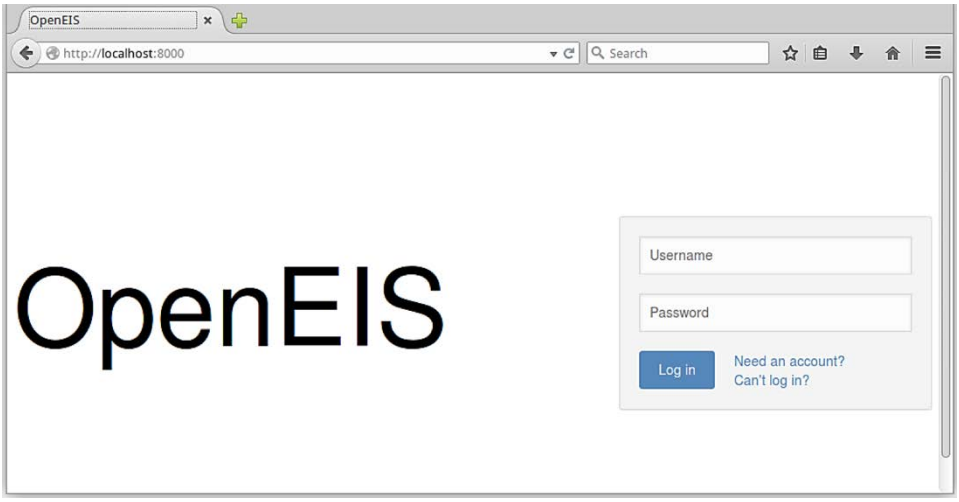


Figure 11. Running the OpenEIS - User Interface

3.3 Create OpenEIS Account

If you have an existing OpenEIS account, use your credentials to log in. If you do not have an existing account, create an account using the following steps.

Step 1. Select 'Need an account' next to the 'Log in' button (Figure 12).

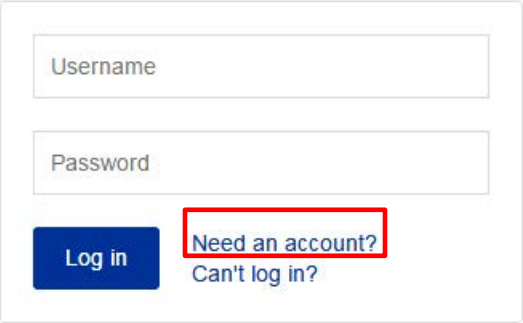


Figure 12. Running the OpenEIS - Creating an Account

Step 2. Fill out the 'Get an account' form and click 'Sign-up' (Figure 13). You will be automatically logged into the OpenEIS after completing the form.

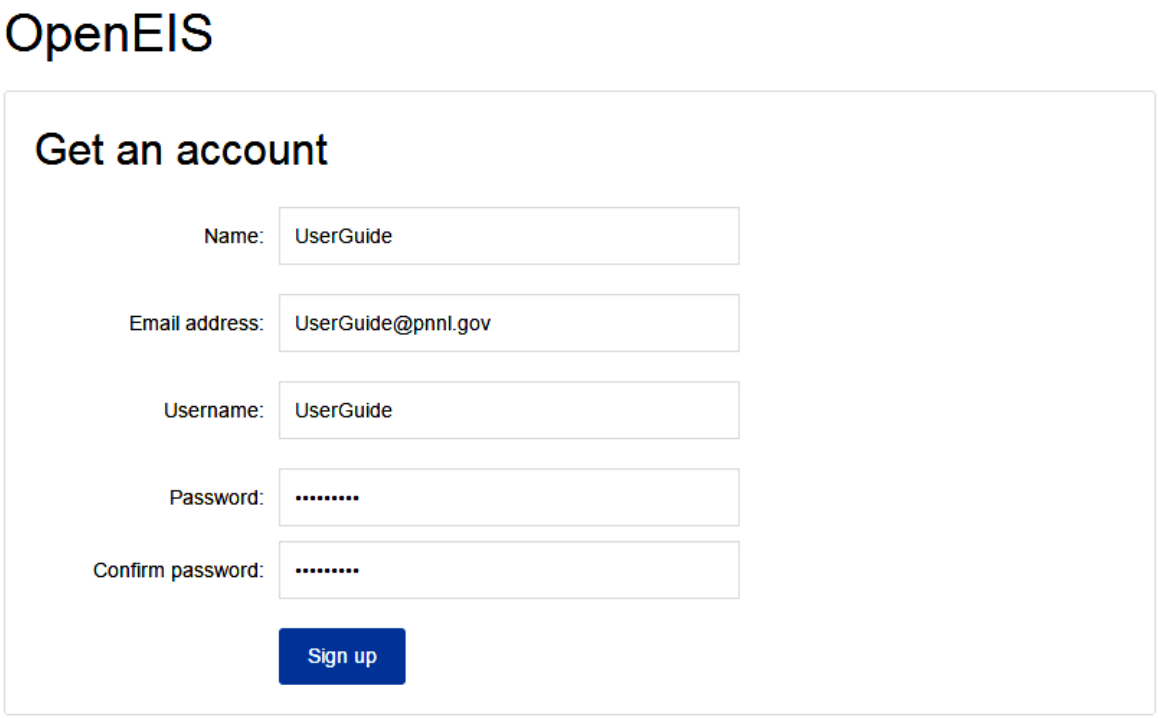


Figure 13. Running the OpenEIS - Creating an Account (Continued)

Step 3. After successful authentication, the OpenEIS project page is displayed (Figure 14). The 'Account: UserGuide' shown on the upper right hand corner in Figure 14 denotes the user currently logged in.

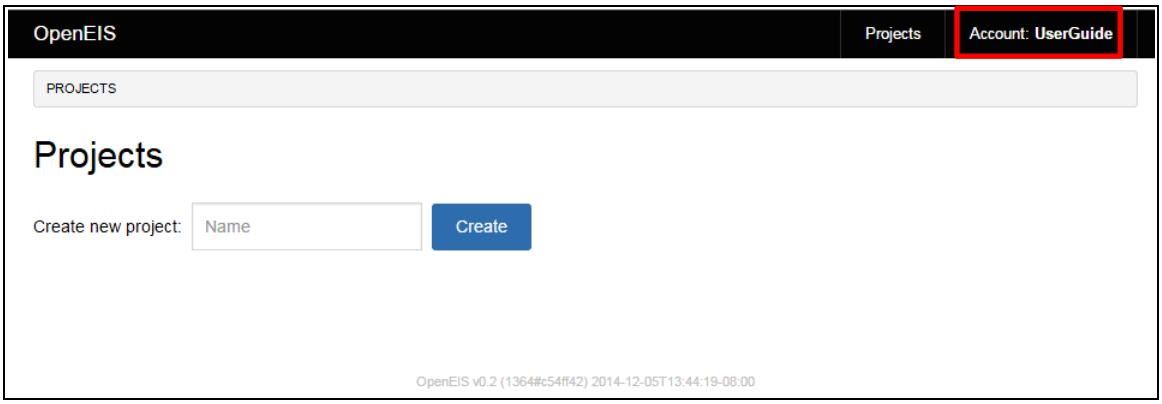


Figure 14. Running the OpenEIS - Creating an Account (Continued)

4.0 Create a New Project

This section explains how to create a project in the OpenEIS.

Step 1. Enter a new OpenEIS project name and click the ‘Create’ button (Figure 15).

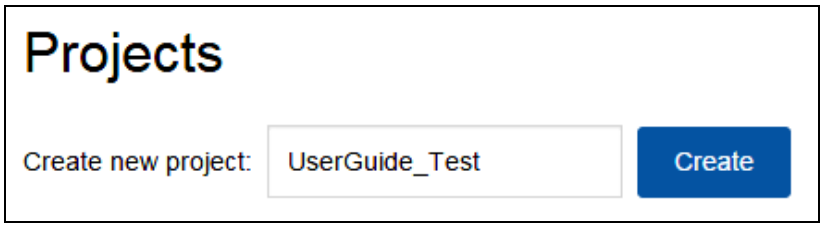


Figure 15. Create a New Project - Name the Project

Step 2. The options next to the project name allow the user to rename (‘Rename’), delete (‘Delete’), and copy (‘Clone’) the project (Figure 16).

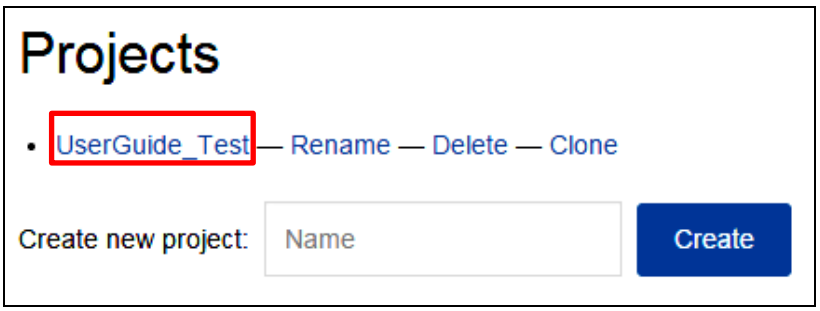


Figure 16. Create a New Project - Project Actions

Step 3. Click the project name ‘UserGuide_Test’ in the blue text (Figure 16). This takes the user to the OpenEIS main page (Figure 17).

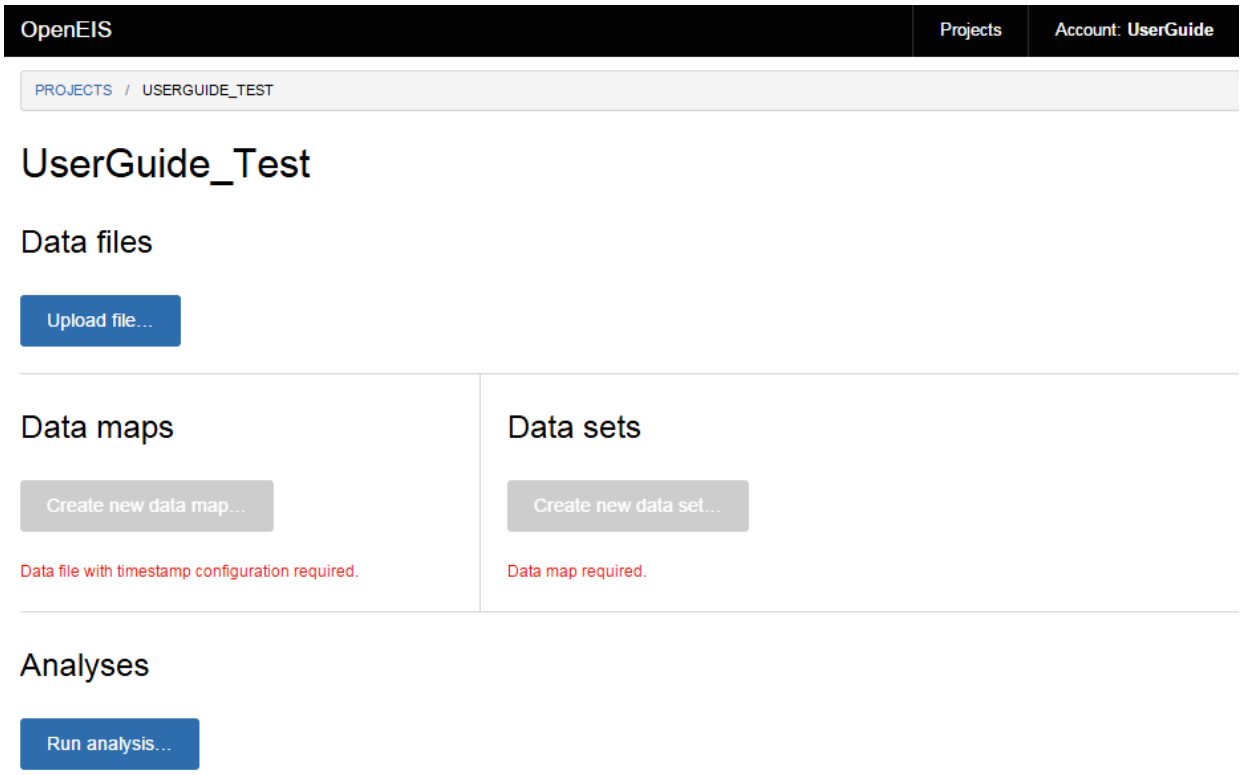


Figure 17. Create a New Project - Main Project Page

5.0 Upload Raw Data Files

The first step in utilizing the OpenEIS as an analysis tool is uploading data. Once data is uploaded into the OpenEIS, the data processing filters and analytic applications become available.

5.1 Upload Raw Data File with 24-hr based Timestamp

The following steps describe the uploading process of a raw data file with a 24-hour based timestamp.

Step 1. Click the 'Choose File' button (Figure 18) to upload a raw data file. An example file, 'UserGuide_Temperature_Dataset.csv', is included with the installation in <installation folder>/ OpenEIS-2.6/docs/. Navigate to this file and click 'Open'.

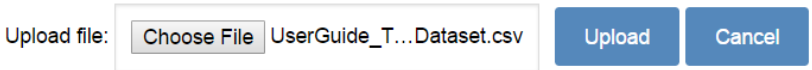


Figure 18. Upload Raw Data File – Choose File

Step 2. Click the 'Upload' button. A pop-up window titled 'Configure timestamp' will appear (Figure 19). The timestamp is 24-hour based.

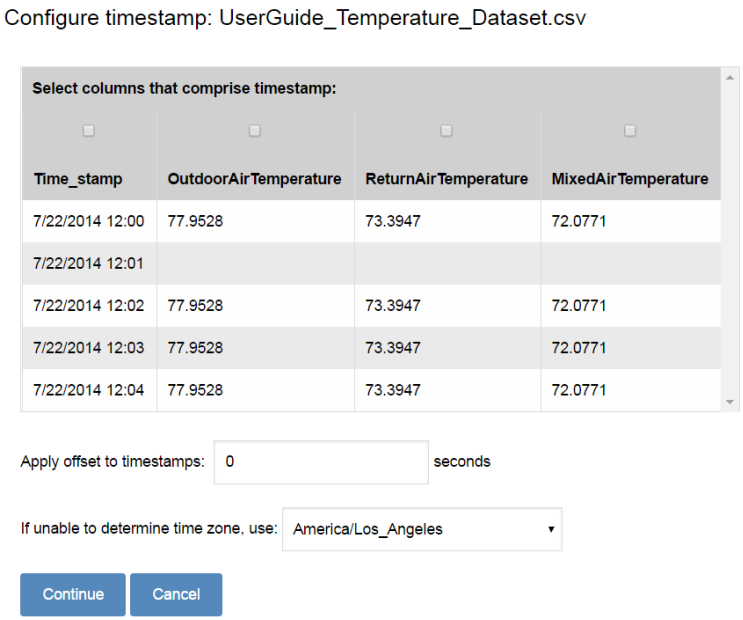


Figure 19. Upload Raw Data - Timestamp Selection

Step 3. Enter a value in the 'Apply offset to timestamps' field, if the user desires to offset the timestamp (positive offset or negative offset by a constant number of seconds.

Step 4. Manually select the time zone according to the local time of the data obtained (Figure 19). If a time zone is not selected, UTC (Coordinated Universal Time) is selected as the default and the timestamps will be automatically converted to UTC.

Step 5. Select the time column checkbox and click the ‘Continue’ button. If there is more than one time column, select all that apply (Figure 20). For example, if the date and time are in separate columns, select all columns that apply to the timestamp.

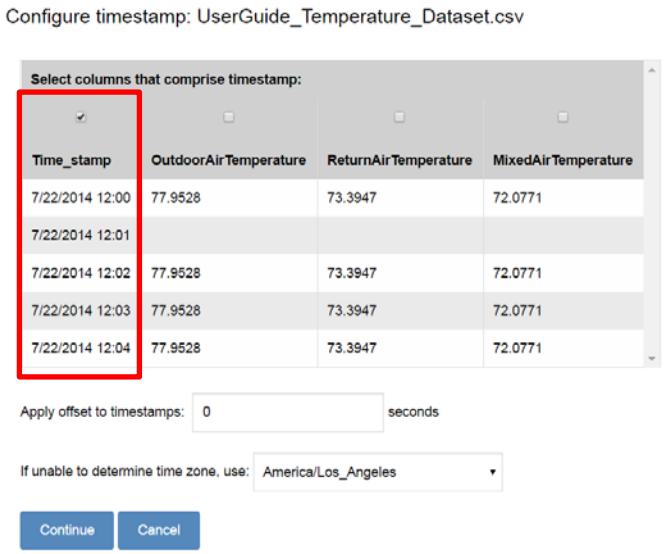


Figure 20. Upload Raw Data - Timestamp Selection (Continued)

Step 6. ‘Raw’ and ‘Parsed’ timestamp appear on a new pop-up window (Figure 21). ‘-07:00’ at the end of each ‘Parsed’ timestamp indicates the time difference between the UTC and selected time zones. If the ‘Parsed’ timestamp is correct, then click the ‘Yes, save configuration’ button.

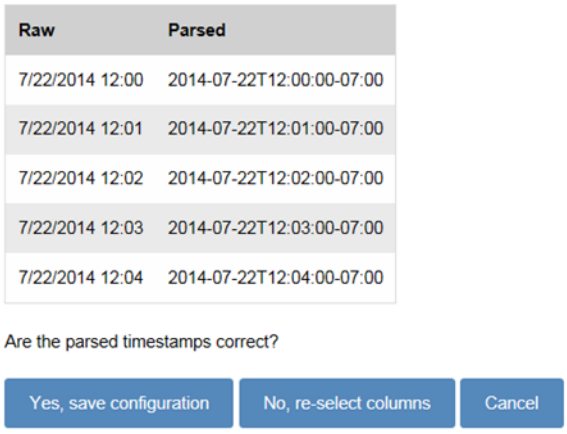


Figure 21. Upload Raw Data -Timestamp Selection (Continued)

When the data file is successfully uploaded, the screen will look like Figure 22.

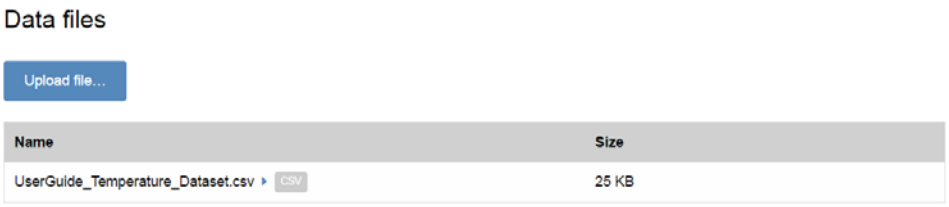


Figure 22. Upload Raw Data - Data File Input Complete

Step 7. As shown in Figure 23, the triangular button next to the input data file provides additional options to reconfigure the timestamp ('Configure timestamp'), download the data file ('Download'), rename the data file name ('Rename'), and delete the data file ('Delete').

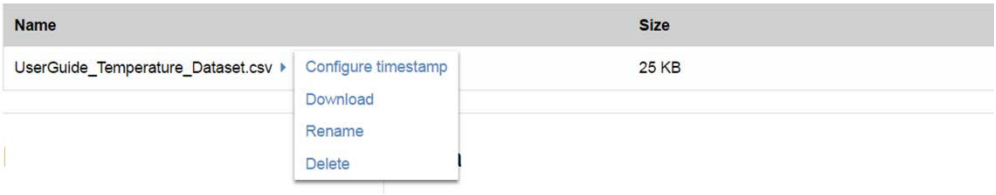


Figure 23. Upload Raw Data - Data File Additional Options

5.2 Upload Raw Data File with AM/PM Timestamp

The following steps describe the uploading process of a raw data file with AM/PM timestamp:

Step 1. Select the 'Choose file' button to upload the raw data file included with the installation at <installation folder>/OpenEIS-2.6/docs/UserGuide_Signal_Dataset.csv. Select this file and click 'Open'.

Step 2. Click 'Upload' button. A pop-up window, 'Configure timestamp', appears (Figure 24).The timestamp is displayed in AM/PM format.

Step 3. Enter a value in 'Apply offset to timestamps' if the user desires to offset the timestamp (positive offset or negative offset by a constant number of seconds). For instance: Enter a value of (-) 360 for an offset of negative 360 seconds (negative 6 minutes) or enter a value of (+) 600 seconds for an offset of positive 600 seconds (positive 10 minutes).

Step 4. Manually select the time zone according to the local time of the data obtained (Figure 24). If a time zone is not selected, UTC is selected as default.

Step 5. Select the time column checkbox. If there is more than one time column, select all that apply and click the 'Continue' button (Figure 24).

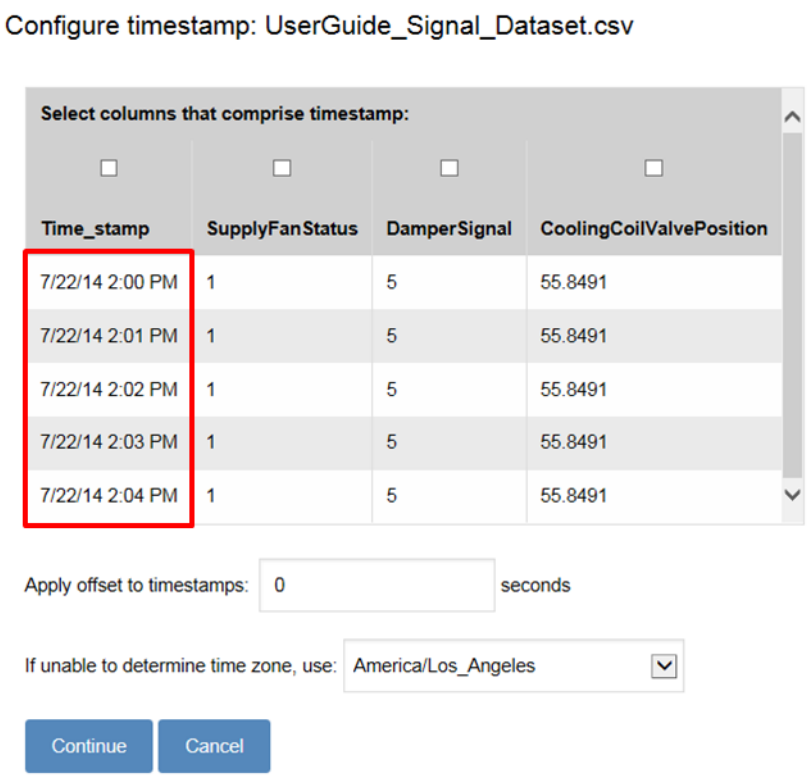


Figure 24. Timestamp Configuration

Step 6. The configured timestamp is then displayed (Figure 25). The 'Raw' timestamp is shown on the left and the 'Parsed' timestamp is shown on the right. Click 'Yes, save configuration' button.

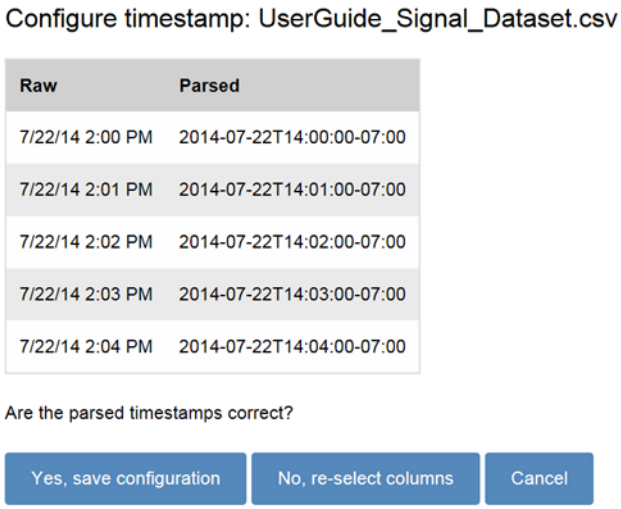


Figure 25. Timestamp Configuration - Raw Timestamp and Parsed Timestamp

Step 7. Data file is successfully uploaded (Figure 26).

Name	Size
UserGuide_Temperature_Dataset.csv ▸ CSV	25 KB
UserGuide_Signal_Dataset.csv ▸ CSV	5 KB

Figure 26. Create the Second File

Step 8. Repeat the above steps for four files included with the installation at <installation folder>/OpenEIS-2.6/docs/. The four files are as follows:

1. UserGuide_AHU.csv
2. UserGuide_setpoint.csv
3. UserGuide_WholeBuilding.csv, and
4. UserGuide_lighting.csv.

5.3 Support File Formats in the OpenEIS

Date and timestamp can be in any number of different formats. OpenEIS automatically converts a date or time value into a standard timestamp format. If the year, month, date, hour, minute, and/or second are separated by columns, make sure the order is descending, as shown in Figure 27.

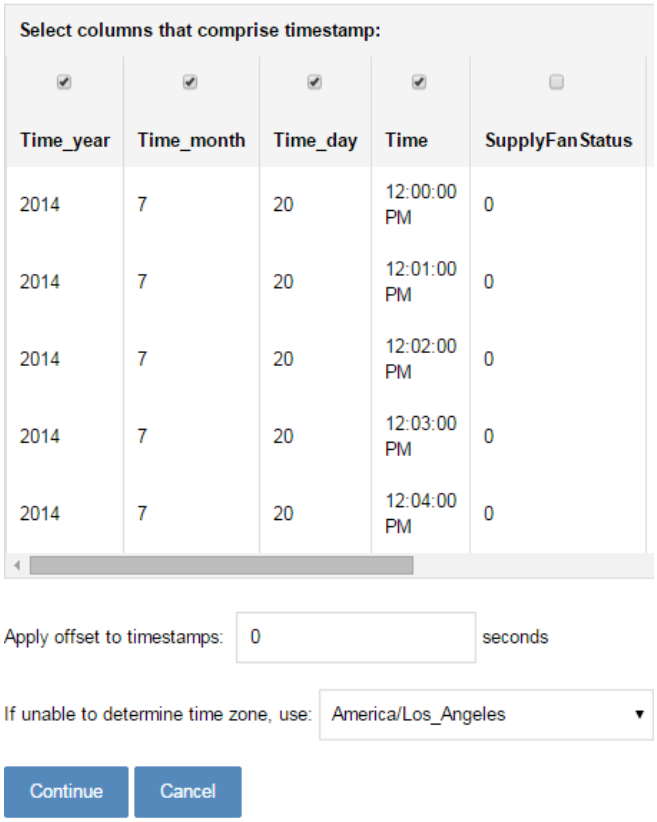


Figure 27. Different Timestamp Formats

The OpenEIS supports different file formats such as xls, csv, and Green Button data (Figure 28 and Figure 29).

```
<?xml version="1.0" encoding="UTF-8"?>
<feed xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
    <id>02DE26E4C0620004E0530A974A064158</id>
    <title>SMT Green Button Report: Interval</title>
    <updated>2014-09-11T12:04:00Z</updated>
    <link href="/ThirdParty/83e269c1/Batch" rel="self"/>
  - <entry>
        <id>02DE26E4D336000AE0530A974A063C17</id>
```

Figure 28. Green Button Data Format

Select columns that comprise timestamp:

Start Timestamp	Duration (Seconds)	End Timestamp	Cost - US Dollar	Value - Real energy (Watt-hours)
2013-09-10 00:15:00	900	2013-09-10 00:30:00		1045
2013-09-10 00:30:00	900	2013-09-10 00:45:00		585
2013-09-10 00:45:00	900	2013-09-10 01:00:00		171

Figure 29. Green Button Data Converted to OpenEIS Format

6.0 Create a New Data Map

This section describes the procedure to create a new data map in OpenEIS. After the raw data is uploaded, the element names in the user's import data file (as indicated by the column headers) are mapped to the standard OpenEIS names. These standard names allow OpenEIS applications to use the data without additional configuration.

Step 1. Click the 'Create new data map…' button (Figure 30).

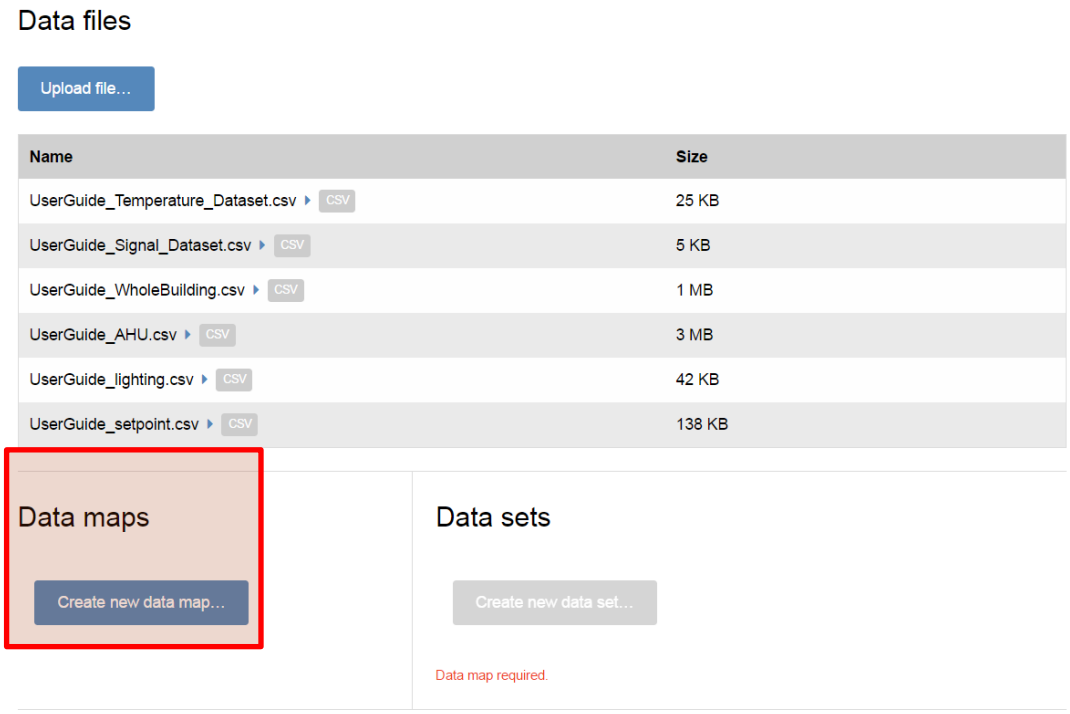


Figure 30. Create a New Data Map

Step 2. The 'New data map' page is displayed. By default, a building called 'New building' is created (Figure 31).

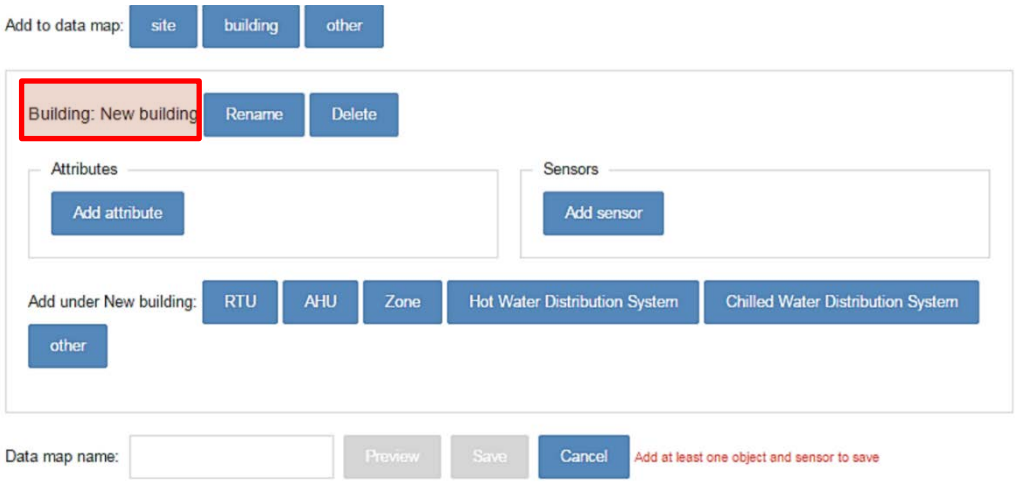


Figure 31. Create a New Data Map - 'New Data Map' Page

Step 3. Click the 'Site', 'Building', and/or 'Other' buttons on top of the screen if users have more sites, buildings, and/or other information to add.

6.1 Change Building Name

This section describes the procedure to change a building's name.

Step 1. Click the 'Rename' button to change the building name. The default building name is 'New building' (Figure 32).

Figure 32. Create a New Data Map - Changing the Building Name

Step 2. Enter a new name for the building in the 'Name' text box and click the 'OK' button (Figure 33).

Figure 33. Create a New Data Map - Changing the Building Name (Continued)

Step 3. The updated building name is now reflected on the 'New data map' page (Figure 34).

Figure 34. Create a New Data Map - Changing the Building Name (Continued)

6.2 Set Building Attributes

This section describes the procedure to set the 'time zone' that corresponds to the time the user wants to use and/or export. The default time zone set by OpenEIS is UTC. Time zone must be manually selected for the location of data obtained or the timestamps will automatically change according to UTC.

Step 1. Click 'Add attribute' button to select the local time zone (Figure 35).

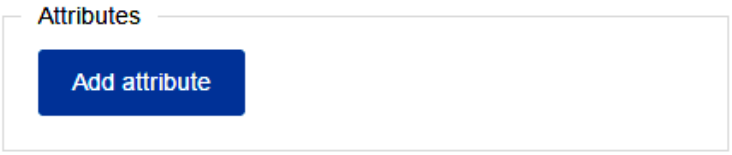


Figure 35. Setting Time Zone Attribute for a Data Map

Step 2. Select 'timezone' in the 'New attribute' drop-down menu, as shown in Figure 36.

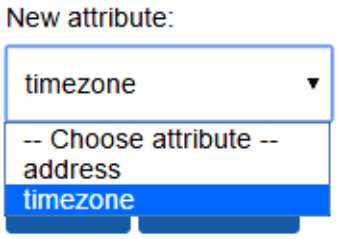


Figure 36. Setting Time Zone Attribute for a Data Map (Continued)

Step 3. Select the appropriate time zone from the 'timezone' drop-down menu and click on 'Add' to update the change. Figure 37 shows the selection of timezone 'US/Pacific'.

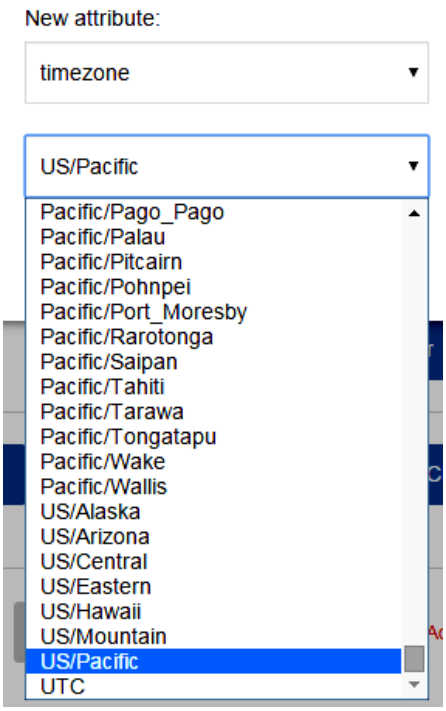


Figure 37. Setting Timezone Attribute for a Data Map (Continued)

Step 4. The selected time zone is added to the 'Attributes' section of the 'New data map' page (Figure 38). If the time zone is incorrect, click the 'Delete' button and redo Step 3.

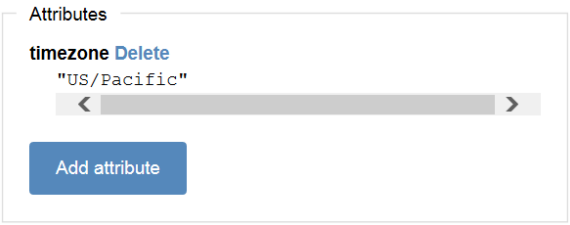


Figure 38. Setting Time Zone Attribute for a Data Map (Continued)

6.3 Add Building Level Sensors

This section explains the procedure to associate a user's data with a sensor at the building level (e.g., building power meter) based on a data file that is included in the OpenEIS installation: 'UserGuide_WholeBuilding.csv'. The following describes the steps involved in mapping building data, imported previously, to common OpenEIS names.

Step 1. Click 'Add sensor' button from 'Sensors' under the 'New building' menu displayed on the right side of Figure 31.

Step 2. Select a standard name from the drop-down menu under 'New sensor'.

Step 3. Select the raw data file from the first drop-down menu under 'Source'.

Step 4. Select the name of the column header on the raw data file to map to the standard name chosen in Step 2.

Step 5. Select the corresponding unit from the drop-down menu under 'Value unit.'

Step 6. Click the 'Add' button to complete the mapping for this point (Figure 39).

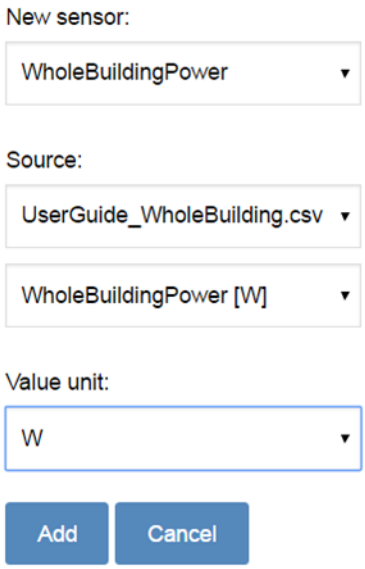


Figure 39. Sensors Related to Overall Building Mapping

Step 7. Repeat Steps 1 through 6 to add the following sensor mapping.

- WholeBuildingElectricity [kWh] in 'OpenEIS' → WholeBuildingElec in UserGuide_WholeBuilding.csv
- WholeBuildingGas [kBtu] in 'OpenEIS' → Boiler Gas in UserGuide_WholeBuilding.csv
- HVACStatus [status] in 'OpenEIS' → HVACStatus in UserGuide_WholeBuilding.csv
- OutdoorAirTemperature [ºC] in 'OpenEIS' → OutdoorAirTemperature in UserGuide_WholeBuilding.csv
- WholeBuildingPower [kW] in 'OpenEIS' → WholeBuildingPower in UserGuide_WholeBuilding.csv
- LightingStatus [status] in 'OpenEIS' → Lighting Status in UserGuide_lighting.csv

6.4 Add Building Equipment

Building systems typically consist of heating, ventilation, and air conditioning equipment. Building equipment can be broadly categorized into two systems: (1) conditioned air delivery systems and (2) chilled/hot water distribution systems. Conditioned air delivery systems consist of devices such as air handling units (**AHUs**), packaged roof top air conditioners or heat pumps (rooftop units; **RTUs**), and the zone terminal boxes (**Zones**) that control air flow to the various spaces in a building. Chilled and hot water distribution systems provide chilled and hot water for the cooling and heating needs of the building. These systems include devices such as chillers, boilers, cooling towers, fans, and pumps.

This section explains the procedure to associate a user's data with building equipment based on data files that are included in the OpenEIS installation: (1) UserGuide_Temperature_Dataset.csv and (2) UserGuide_Signal_Dataset.csv. The following describes the steps involved in mapping AHU data, imported previously, to common OpenEIS names.

Step 1. Click the 'AHU' button from 'Add under 'UserGuide_Building' menu (Figure 40).

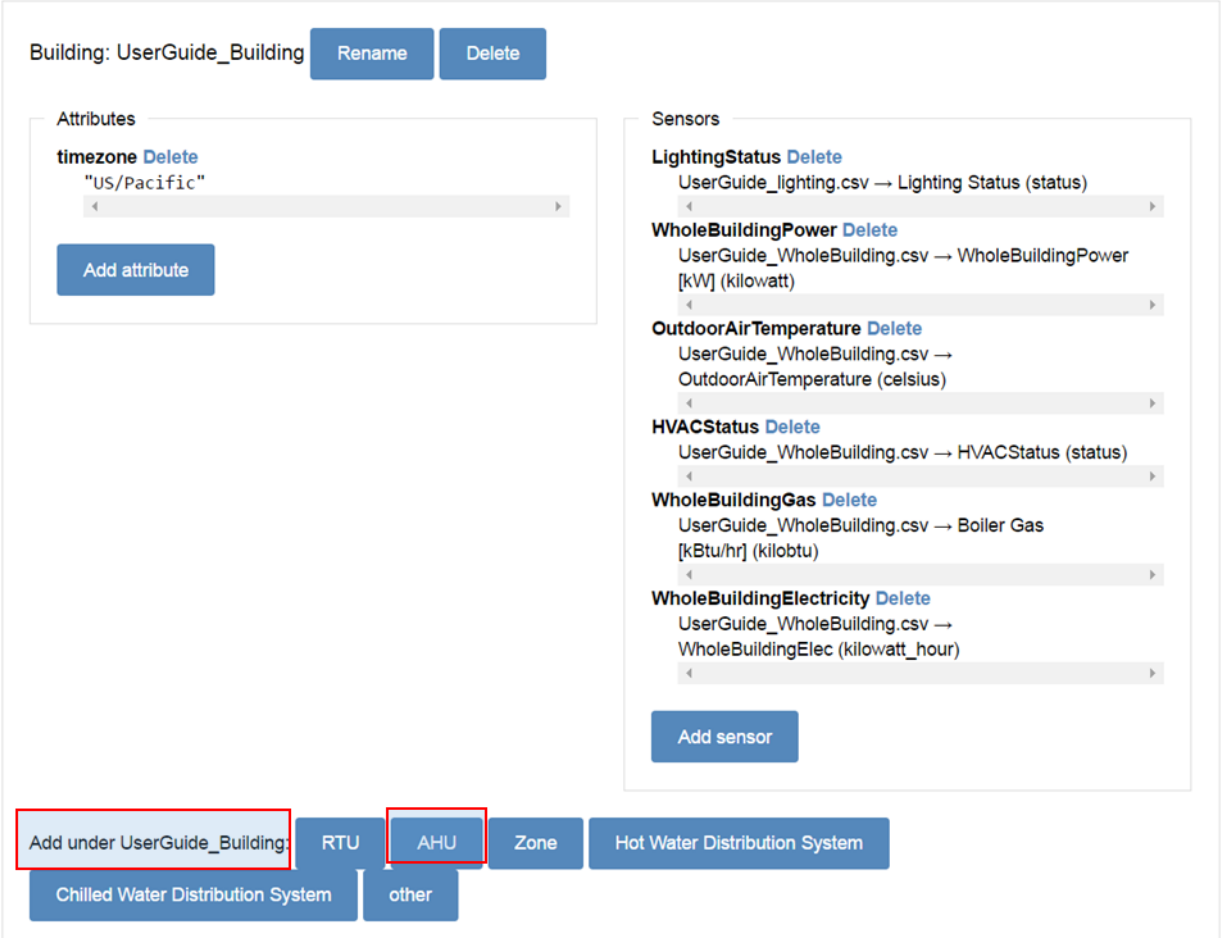


Figure 40. AHU Selection

Step 2. A pop-up window will appear that allows you to enter a name for the AHU (Figure 41). Enter 'AHU8' and click the 'OK' button.

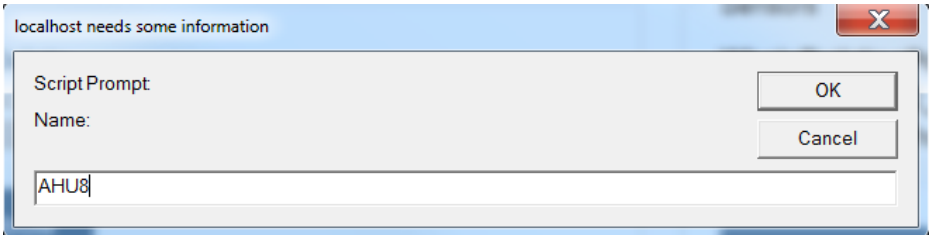


Figure 41. Enter AHU Name

Step 3. Click the 'Add sensor' button (Figure 42).

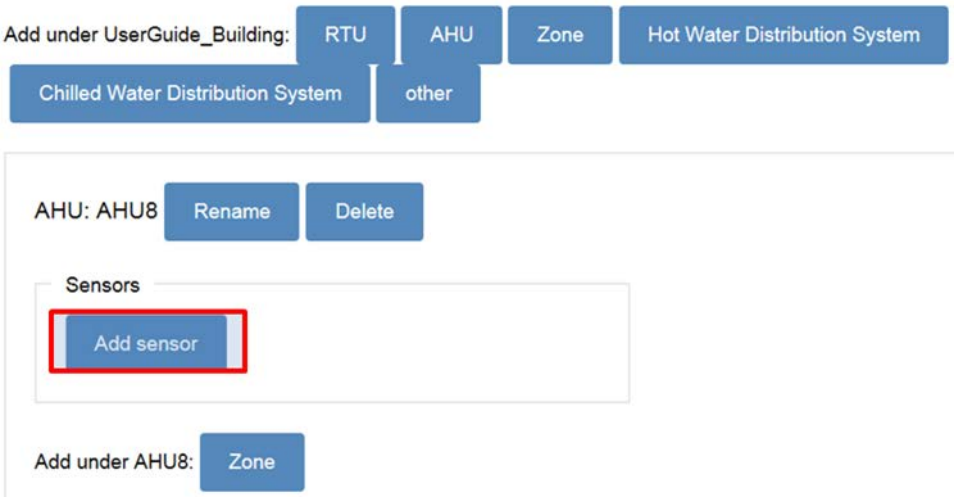


Figure 42. AHU Sensor Selection Menu

Step 4. Select a standard name from the drop-down menu under 'New sensor'. Each piece of equipment (i.e., AHU, RTU, Zone, hot water distribution system, and chilled water distribution system) has a different set of available sensors (Figure 43).

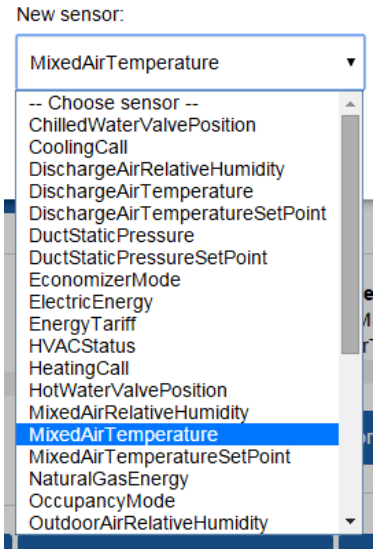


Figure 43. Select 'MixedAirTemperature' in OpenEIS

Step 5. Select the raw data file from the first drop-down menu under 'Source' (Figure 44).

Step 6. For the subsequent entry, select the name of the column header in the raw data file to map to the standard name chosen in Step 4.

Step 7. Select the unit from the drop-down menu under 'Value unit'.

Step 8. Click the 'Add' button to complete the mapping for this point.

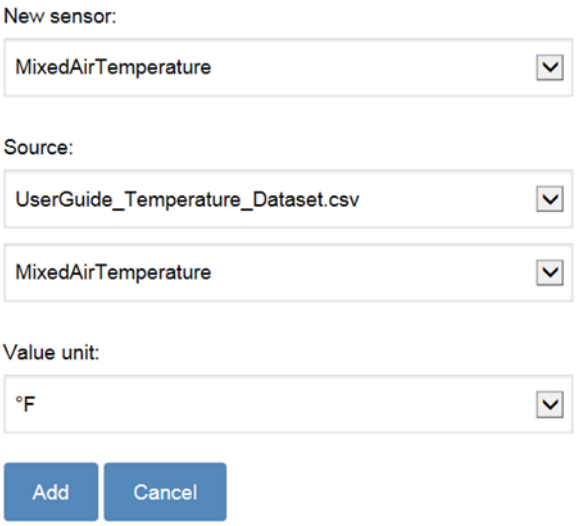


Figure 44. Mapping of User Defined Mixed Air Temperature Data Column from the Data File to the Standard OpenEIS Name 'MixedAirTemperature'

Step 9. Confirm the 'MixedAirTemperature' mapping summary (Figure 45). If the information is incorrect, click on 'Delete' button.

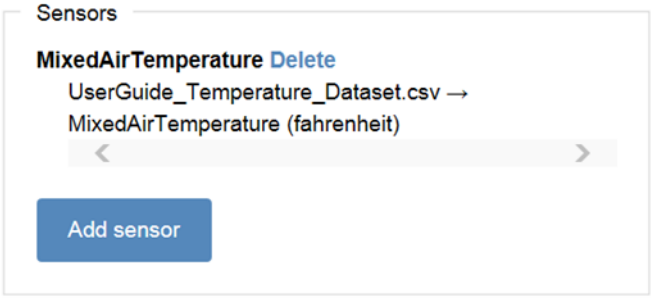


Figure 45. Confirm the Mapping Previously Described in Figure 44

Step 10. Repeat Steps 1 through 9 of this section until all equipment related sensors are added. Each element name from the two raw data files is mapped to the corresponding standard name in OpenEIS.

- MixedAirTemperature [Fahrenheit] in 'OpenEIS' → MixedAirTemperature in UserGuide_Temperature_Dataset.csv
- OutdoorAirTemperature [Fahrenheit] in 'OpenEIS' → OutdoorAirTemperature [Fahrenheit] in UserGuide_Temperature_Dataset.csv
- ReturnAirTemperature [Fahrenheit] in 'OpenEIS' → ReturnAirTemperature [Fahrenheit] in UserGuide_Temperature_Dataset.csv
- CoolingCall [Percent] in 'OpenEIS' → CoolingCoilValvePosition in UserGuide_Signal_Dataset.csv
- SupplyFanStatus [Status] in 'OpenEIS' → SupplyFanStatus in UserGuide_Signal_Dataset.csv

- OutdoorDamperSignal [Percent] in ‘OpenEIS’ → DamperSignal in UserGuide_Signal_Dataset.csv.

6.5 Adding Building Equipment with Zone Sensors

Zone sensors and zone related data (e.g., terminal-box damper commands, space temperatures, thermostat temperature set points, etc.) can be mapped within the OpenEIS as a sub-system of a building, RTU, AHU, or other. This section is based on a data file that is included in the OpenEIS installation: ‘UserGuide_AHU.csv’. The following describes the steps involved in mapping zone data, imported previously, to common OpenEIS names.

Step 1. Click the ‘AHU’ button from ‘Add’ under the ‘New building’ menu.

Step 2. A pop-up window will appear that allows you to enter a name for the AHU. Enter ‘AHU9’ and click the ‘OK’ button.

Step 3. Repeat Steps 1 through 9 of Section 6.4 until all equipment related sensors are added. Each element name from the data files is mapped to the corresponding standard name in OpenEIS.

- MixedAirTemperature [Fahrenheit] in ‘OpenEIS’ → MixedAirTemperature in UserGuide_AHU.csv
- OutdoorAirTemperature [Fahrenheit] in ‘OpenEIS’ → OutdoorAirTemperature in UserGuide_AHU.csv
- ReturnAirTemperature [Fahrenheit] in ‘OpenEIS’ → ReturnAirTemperature in UserGuide_AHU.csv
- CoolingCall [Percent] in ‘OpenEIS’ → CoolingCoilValvePosition in UserGuide_AHU.csv
- SupplyFanStatus [Status] in ‘OpenEIS’ → SupplyFanStatus in UserGuide_AHU.csv
- SupplyFanSpeedCommand [Percent] in ‘OpenEIS’ → SupplyFanSeed in UserGuide_AHU.csv
- OutdoorDamperSignal [Percent] in ‘OpenEIS’ → DamperSignal in UserGuide_AHU.csv
- DuctStaticPressure [atm] in ‘OpenEIS’ → DuctStaticPressure in UserGuide_AHU.csv
- DuctStaticPressureSetPoint [atm] in ‘OpenEIS’ → DuctStaticPressureStPt in UserGuide_AHU.csv
- ZoneTemperature [Fahrenheit] in ‘OpenEIS’ → ReturnAirTemperature in UserGuide_AHU.csv
- DischargeAirTemperature in ‘OpenEIS’ → SupplyAirTemperature in UserGuide_AHU.csv
- DischargeAirTemperatureSetPoint in ‘OpenEIS’ → SupplyAirTemperatureStPt in UserGuide_AHU.csv.

Step 4. Click ‘Zone’ button (Figure 46). The system prompts for a name. Enter ‘Zone1’ and click ‘OK’, and then Click ‘Add sensor’ button.

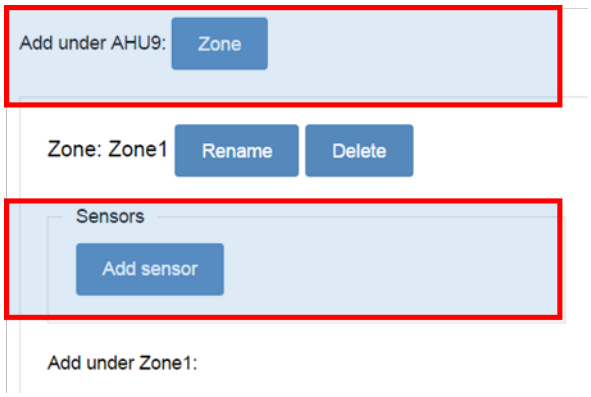


Figure 46. Zone Selection

Step 5. Select a standard name from the drop-down menu under ‘New sensor’ (Figure 47).

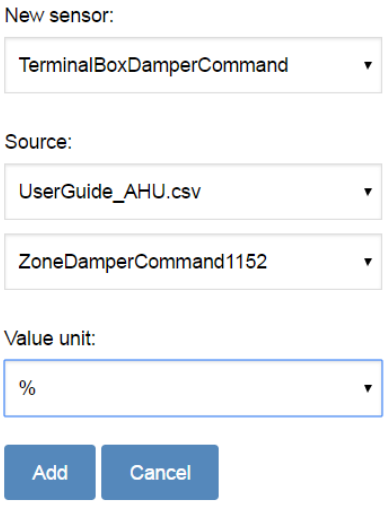


Figure 47. ‘TerminalBoxDamperCommand’ Mapping between User’s File and OpenEIS

Step 6. Select the raw data file from the first drop-down menu under ‘Source’.

Step 7. Select the name of the column header in the raw data file to map to the standard OpenEIS name chosen in Step 3.

Step 8. Select the unit from the drop-down menu under ‘Value unit’.

Step 9. Click the ‘Add’ button to complete the mapping for this point.

Step 10. Repeat Steps 1 through 7 until all equipment related zone sensors and data are added. For the purpose of this user guide, add the following sensors for Zone 1.

- DischargeAirTemperature [Fahrenheit] in ‘OpenEIS’ → SupplyAirTemp in UserGuide_AHU.csv

- DischargeAirTemperatureSetPoint [Fahrenheit] in ‘OpenEIS’ → SupplyAirTempStPt in UserGuide_AHU.csv
- TerminalBoxReheatValvePosition [%] in ‘OpenEIS’ → HotWaterPumpVFDCommand in UserGuide_AHU.csv.

6.6 Save a Data Map

Step 1. Enter the data map name in the text box and click the ‘Save’ button to save the data map into OpenEIS (Figure 48).

Figure 48. Save Data Map as ‘AHU_UserGuide’

Step 2. The new data map is saved and displayed (Figure 49). The triangle button next to project name provides the options to view (‘View’), edit (‘Edit copy’), rename (‘Rename’), and delete (‘Delete’) the data map.

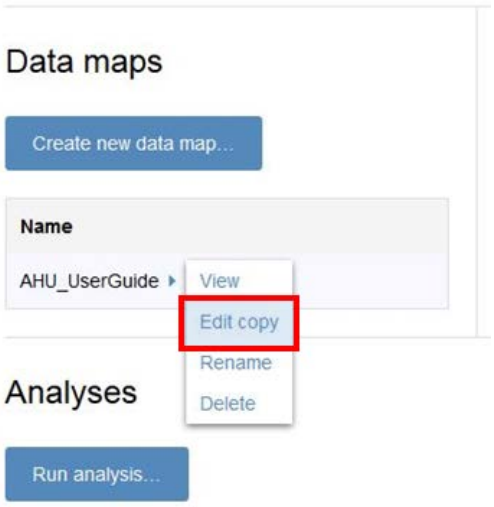


Figure 49. ‘AHU_UserGuide’ Data Map Available Actions

Step 3. Click ‘Edit copy’ action for the ‘AHU_UserGuide’ data map. Users should be aware that the ‘Edit copy’ action does not overwrite the original data map. The process creates a copy, and then allows a user to edit the copy.

Step 4. Delete the building level sensors (Section 6.3) and building equipment with zone sensors (Section 6.5). The ‘Edit copy’ action allows a user to add or delete sensors from the chosen data map. The data map is edited to contain only AHU8 data, as shown in Figure 50.

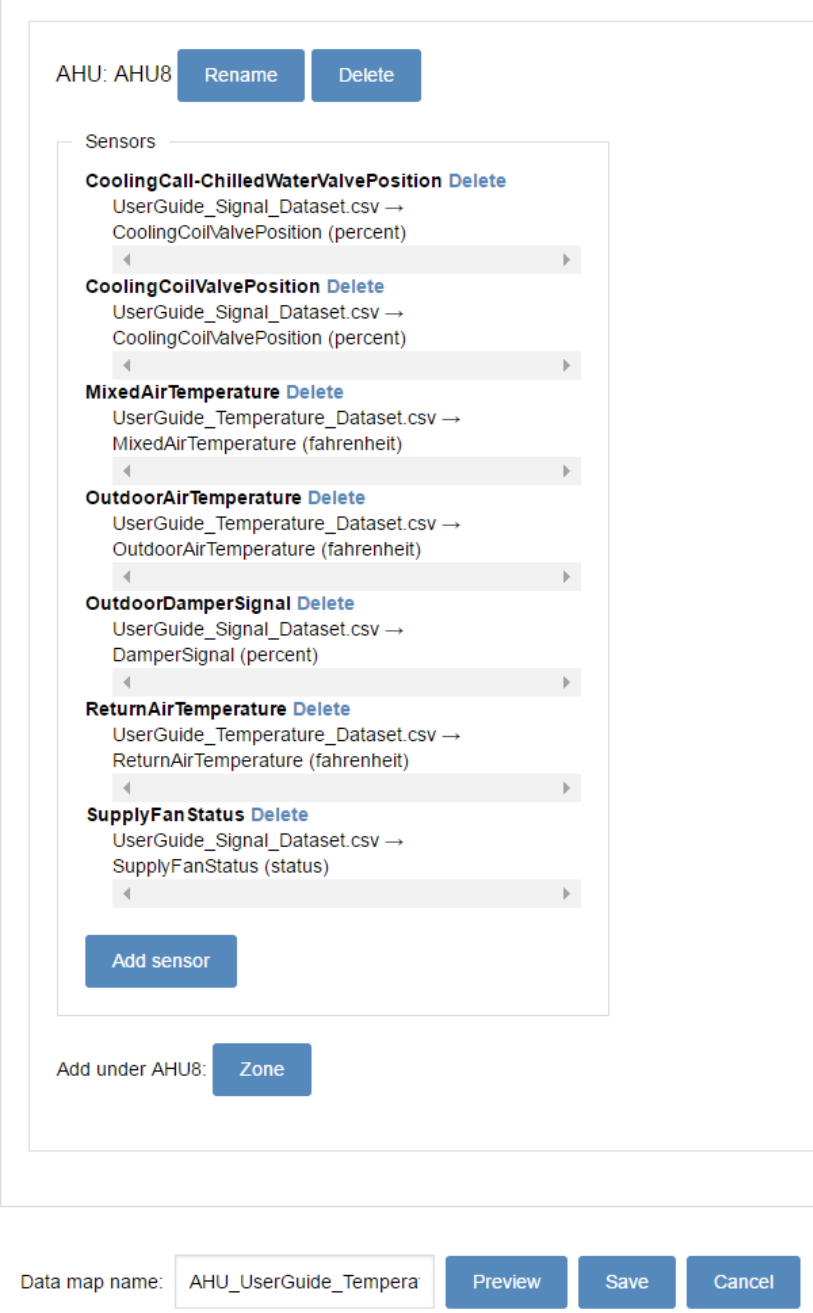


Figure 50. 'Edit Copy' Action for a Data Map

Step 5. Enter the data map name ('AHU_UserGuide_Temperatures') in the text box and click the 'Save' button to save the data map into OpenEIS. Figure 51 shows the results of saving the edited data map. The same options are now available for both data maps; the triangle button next to the project name provides the options to view ('View'), edit ('Edit copy'), rename ('Rename') and delete ('Delete') the data map.

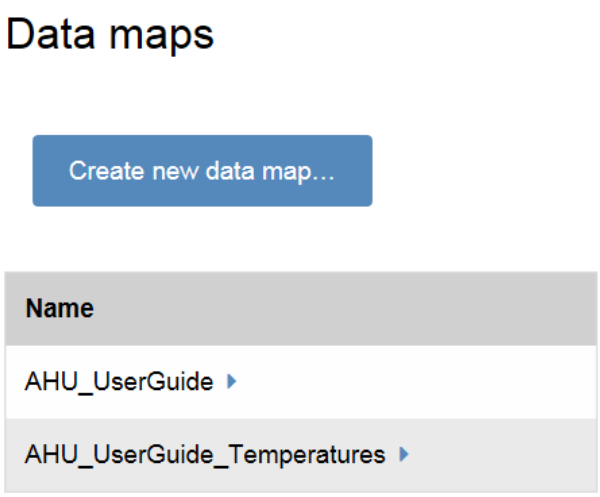


Figure 51. 'Edit Copy' Action on a Data Map – Saving the New Data Map

7.0 Create a New Data Set

This section explains the procedure to create a new data set from the raw data files that have already been uploaded into OpenEIS (Section 5.0). The data set is created by applying a data map (point name from imported file column header mapped to an OpenEIS standard name) to one or more previously uploaded data files. The following steps are used to create a data set.

Step 1. Click the 'Create new data set…' button under 'Data sets' (Figure 52).

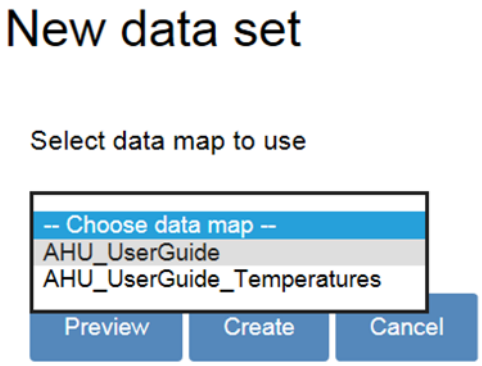


Figure 52. 'Create a New Data Set'

Step 2. Select the "AHU_UserGuide" data map created in Section 6.0 from the drop-down menu (Figure 53). The user is prompted to select files to be used. Each selection is accompanied by the data it contains.

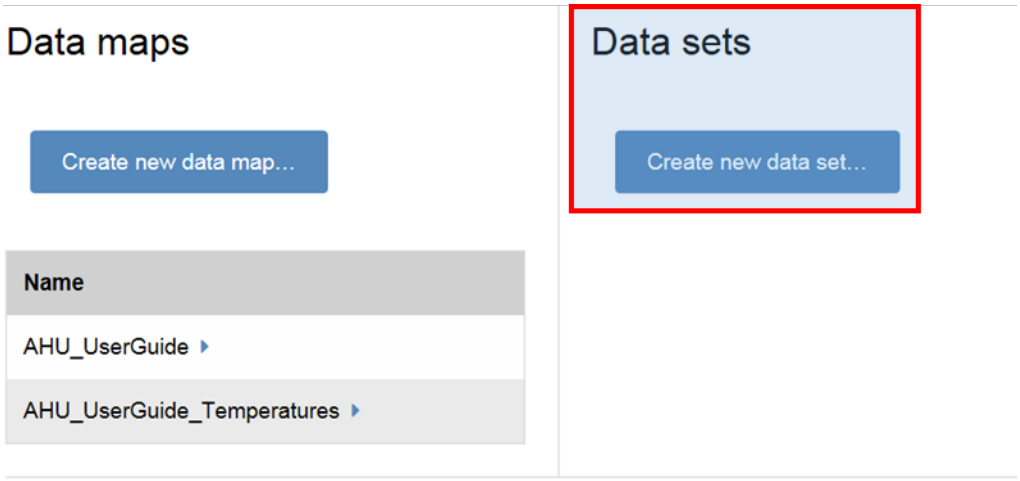


Figure 53. Data Map Selection

Step 3. Click the 'Create' button after selecting the appropriate data files from each drop-down menu (Figure 54). The raw data files are mapped to the corresponding 'File "#"' in OpenEIS as follows:

- 'UserGuide_ligting.csv" → File "0"

- UserGuide_WholeBuilding.csv" → File "1"
- UserGuide_AHU.csv" → File "2"
- UserGuide_Signal_Dataset.csv" → File "3"
- UserGuide_Temperature_Dataset.csv" → File "4".

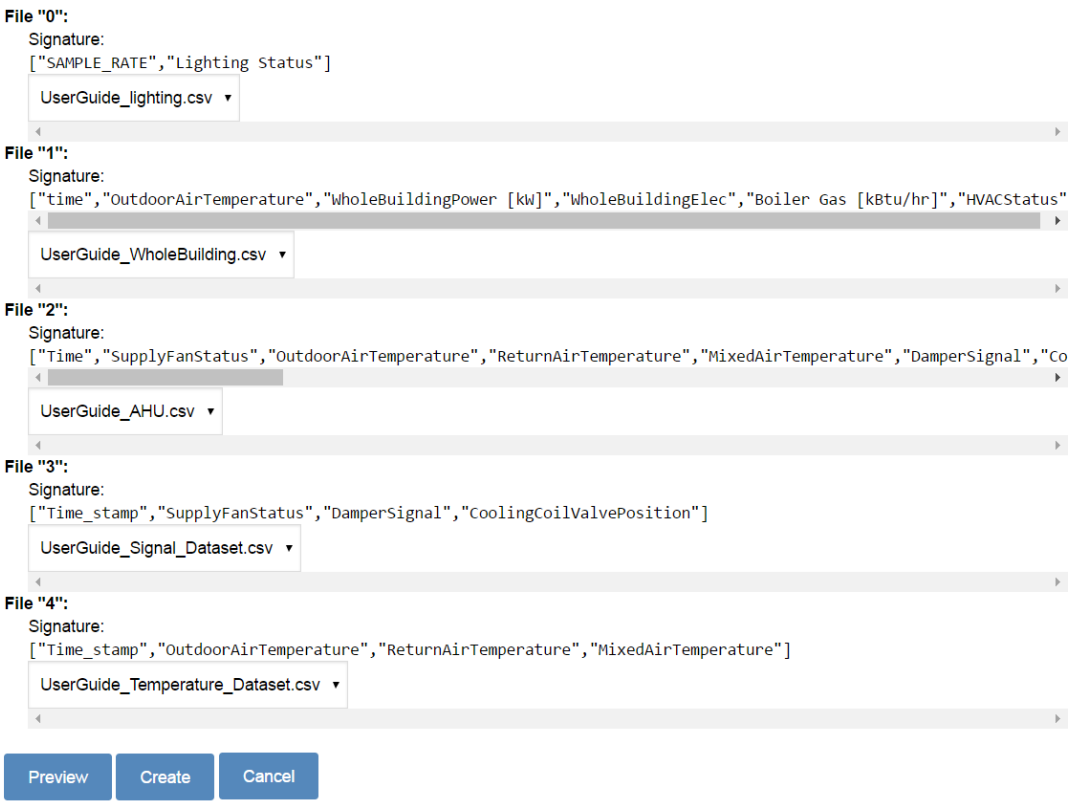


Figure 54. Data Set Mapping between User's Data File and OpenEIS

Step 4. Confirm the data set summary: data set name ('AHU_UserGuide'), process status ('complete'), and error ('None') (Figure 55). Note that this process could take several seconds to complete.

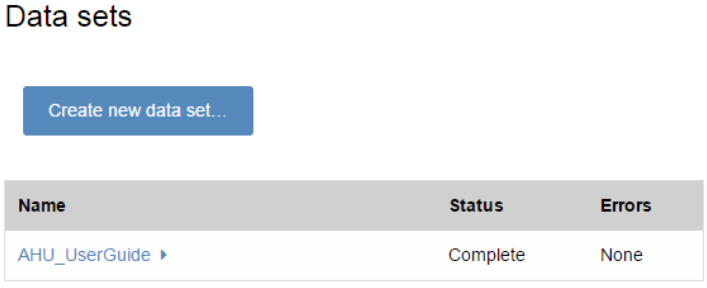


Figure 55. Data Set Output

Step 5. The triangle button next to the file name provides the options to view the data ('View'), manipulate the data ('Manipulate'), download the data set ('Download'), rename the data set ('Rename'), and delete ('Delete') the data (Figure 56).

Figure 56. Data Set Option

Step 6. Repeat Steps 1 through 4 to add the "AHU_UserGuide_Temperature" data set.

Step 7. Click the 'View' button to look at the "AHU_UserGuide_Temperature" data set. Two data files with differing timestamps are merged into a single data set (as shown in Figure 57).

Data set: AHU_UserGuide_Temperature

time	UserGuide_Building/AHU8/CoolingCall-ChilledWaterValvePosition	UserGuide_Building/AHU8/CoolingCoilValvePosition	UserGuide_Building/AHU8/MixedAirTemperature
2014-07-22T12:00:00-07:00			72.0771
2014-07-22T12:01:00-07:00			
2014-07-22T12:02:00-07:00			72.0771
2014-07-22T12:03:00-07:00			72.0771
2014-07-22T12:04:00-07:00			72.0771
2014-07-22T12:56:00-07:00			72.3228
2014-07-22T12:57:00-07:00			72.3228
2014-07-22T12:58:00-07:00			
2014-07-22T12:59:00-07:00			72.4047
2014-07-22T13:21:00-07:00			72.4047
...			
2014-07-22T14:00:00-07:00	55.8491	55.8491	72.8552

Figure 57. Data Set Views

8.0 Manipulate a Data Set

This section explains the manipulation functions that can be used for data processing. Data set manipulation can be performed after creating a "AHU_UserGuide_Temperature" data set (Section 7.0). The data processing (data manipulation) filters allow the user to 'clean-up' data; that is, fill in missing data and perform other aggregations (average, interpolate) to make data more useful for analysis within the OpenEIS or with other analysis tools outside the OpenEIS. The following filters are available within the OpenEIS:

Fill Filter: OpenEIS provides 'Fill' filters that can fill in the missing data. The 'Fill' filter provides users with the ability to fill in missing values by repeating the last known value or interpolating between the two known values.

- None: Choose 'None' filter to exclude one or more columns in 'Fill' filter.
- Linear Interpolation: Fills in missing values by linearly interpolating values from two adjacent cells. If there are missing data in the specified time period, the last valid value before the missing value and the first valid value after the missing value are used for 'Linear Interpolation'.
- Repeat Previous: Fills in blank cells with last known value (from the previous timestamp) above. The last valid value before the missing value is used for 'Repeat Previous'.

Aggregation Filter: The OpenEIS provides 'Aggregation' filters that can aggregate the data set. The 'Aggregation' filter converts the data set from higher frequency intervals to lower frequency intervals. If the time interval of the raw data file is 1 minute, it can be aggregated into a specified minute, hourly, daily, or monthly data.

- All: Display 'True' or '1' if all elements for the corresponding time period are true (or if all elements for the corresponding time period is empty).
- Any: Display 'True' or '1' if any element for the corresponding time period is true.
- Average: Calculate an average value for the corresponding time period
- Not all: Display 'True' or '1' if all elements for the corresponding time period are not true (or if all elements for the corresponding time period is empty).
- Not any: Display 'True' or '1' if any element for the corresponding time period is not true.
- Sum: Calculate a sum value for the corresponding time period.

Other Filter: OpenEIS provides the 'Rounding' filter under 'Other filters'. The 'Rounding' filter rounds up values according to the selected decimal places. It can be used with other filters at the same time.

8.1 Set 'Fill' Filter

This section explains the process of setting up the 'Fill' filter.

Step 1. Click 'Manipulate' button next to 'AHU_UserGuide' data set (Figure 58).

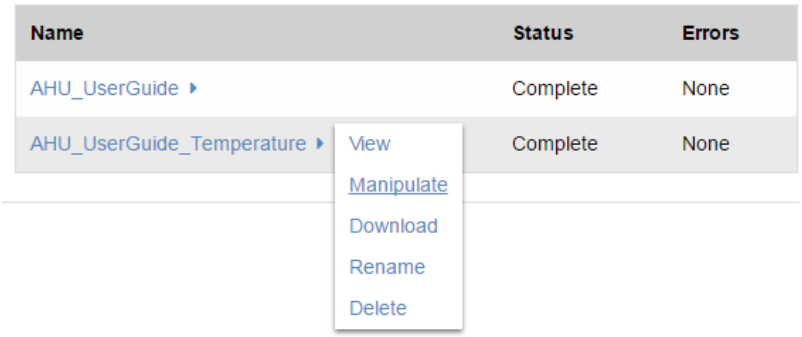


Figure 58. Select ‘Manipulate’ in Data Set Options

Step 2. ‘Manipulate data set’ page is displayed (Figure 59).

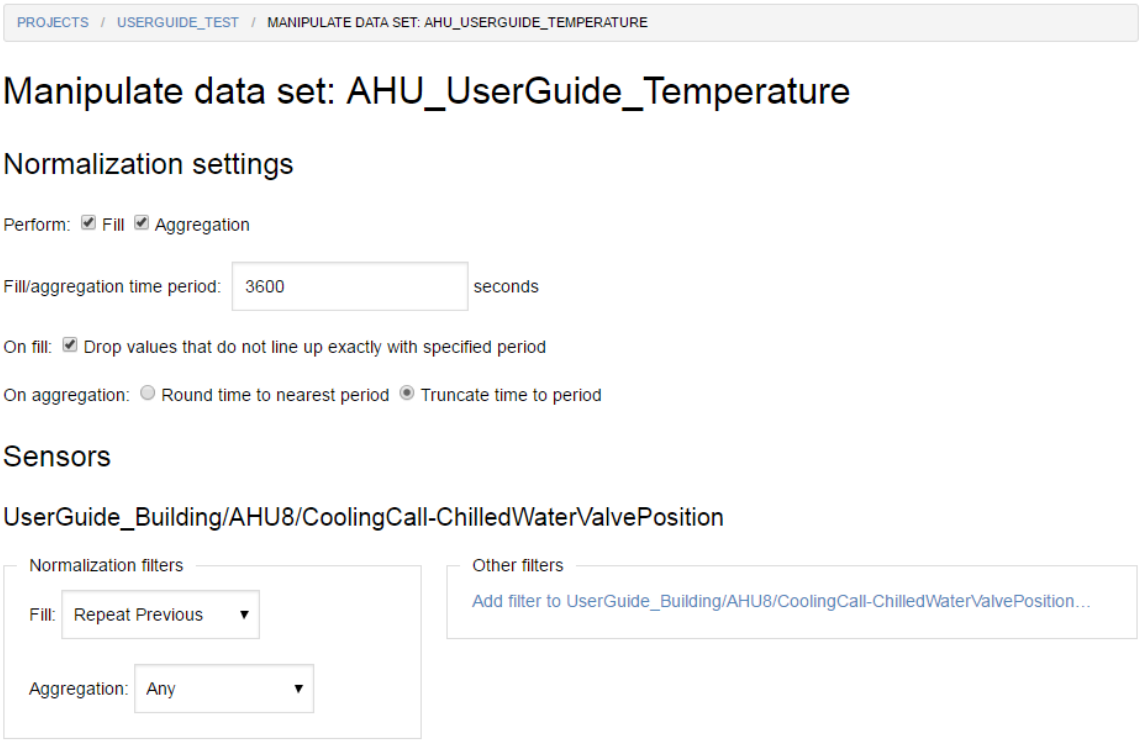


Figure 59. ‘Manipulate Data Set’ Page

Step 3. Under ‘Normalization settings’, deselect the ‘Aggregation’ checkbox (Figure 60). Now, only the ‘Fill’ checkbox is selected.

Step 4. Configure the time period in the ‘Fill/aggregation time period’ text box. See Figure 60 for an example of a valid specified time period (60 seconds).

Step 5. In the ‘On fill’ section, leave the checkbox selected (‘Drop values that do not line up exactly with specified period’) (Figure 60). If the user desires to keep values that do not line up exactly with the specified period, this option should be unchecked.

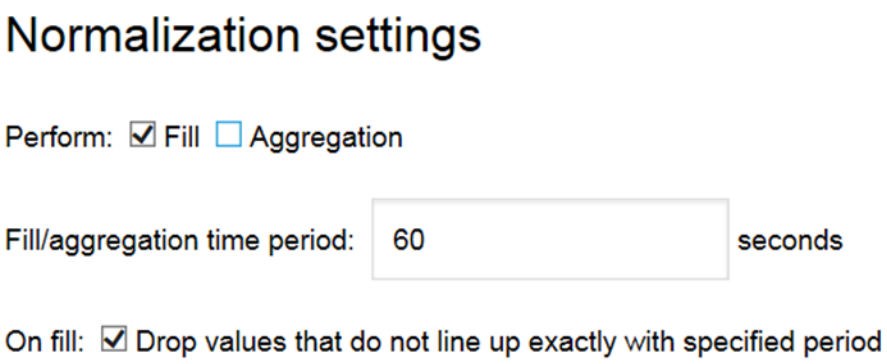


Figure 60. Normalization Settings for 'Fill' Filter

Step 6. Under 'Sensors', select the 'Repeat previous' option in the 'Fill' filter for 'CoolingCall-ChilledWaterValvePosition' (Figure 61). Sensor values are identified with the following naming structure within the 'Manipulate data set' page: "Building/Building Equipment/ Sensor".

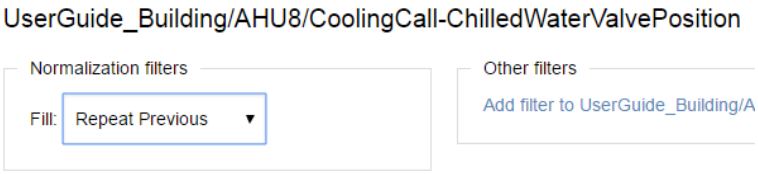


Figure 61. Select 'Repeat Previous' Option in 'Fill' Filter for 'CoolingCall'

Step 7. Select the 'Linear interpolation' option in the 'Fill' filter for 'MixedAirTemperature' (Figure 62).

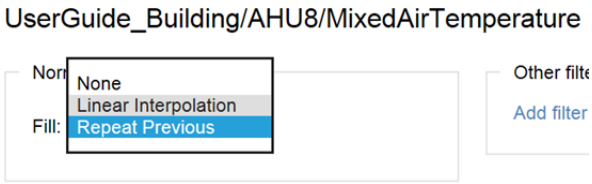


Figure 62. Select 'Linear Interpolation' Option in 'Fill' Filter for 'MixedAirTemperature'

Step 8. Click the 'Add filter to UserGuide_Building/AHU8/MixedAirTemperature' under 'Other filters' (Figure 63).

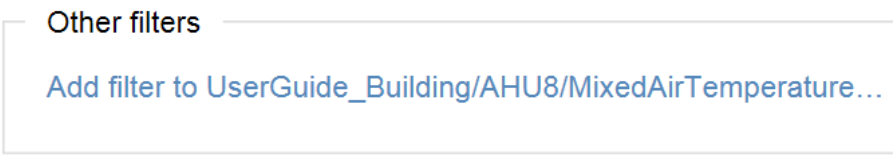


Figure 63. Add 'Other Filters' for 'MixedAirTemperature'

Step 9. Select the 'Rounding filter' in the 'Filter' drop-down menu and specify the number of decimal places as '2' in the 'Rounding places' text box (Figure 64).

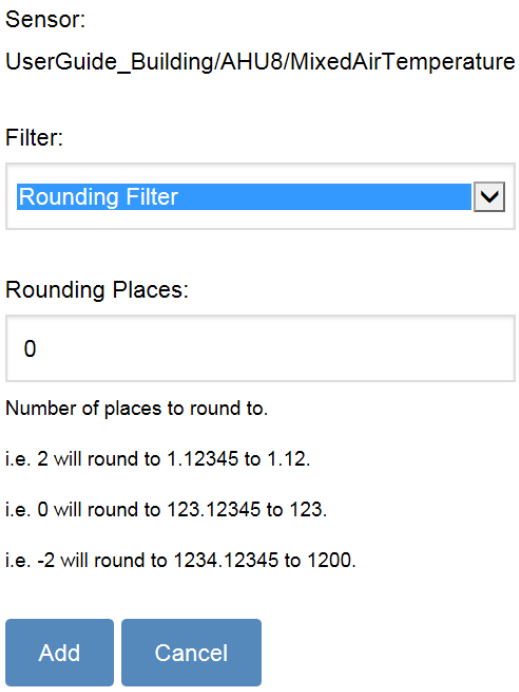


Figure 64. Configuring the 'Rounding Filter' for 'MixedAirTemperature' Sensor

Step 10. Click 'Add' (Figure 64) and the 'Rounding filter' window is closed.

Step 11. Confirm the 'Rounding filter' summary (Figure 65). If the information is incorrect, click on 'Delete' and repeat Step 8 to 10.

Figure 65. 'Rounding Filter' Summary for 'MixedAirTemperature'

Step 12. Select the corresponding option under 'Fill' filter for all other points.

- UserGuide_Building/AHU8/OutdoorAirTemperature →
  Fill: Linear interpolation and Other filters: Round Off with 'places':2
- UserGuide_Building/AHU8/OutdoorDamperSignal →
  Fill: Linear interpolation and Other filters: Round Off with 'places':2
- UserGuide_Building/AHU8/ReturnAirTemperature →
  Fill: Linear interpolation and Other filters: Round Off with 'places':2
- UserGuide_Building/AHU8/SupplyFanStatus →
  Fill: Repeat previous.

8.2 Perform ‘Fill’ Filter

This section explains the process of applying the ‘Fill’ filter.

Step 1. Click the ‘Apply’ button after completing the ‘Fill’ filter set up (Figure 66).

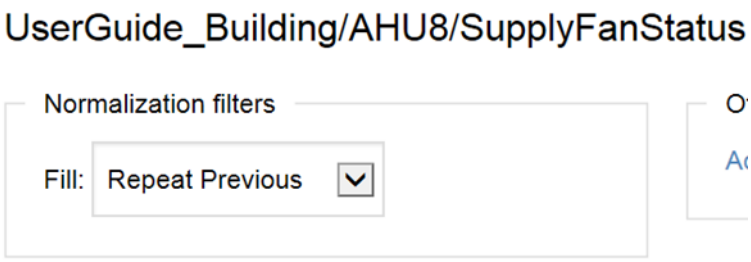


Figure 66. Perform ‘Fill’ Filter

Step 2. The filters are applied and a new data map and data set, containing the results, are created and saved (Figure 67).

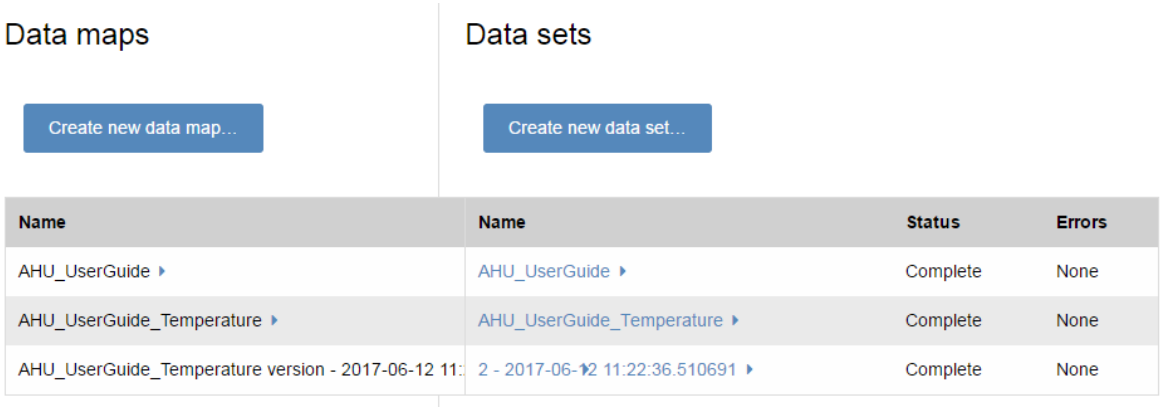


Figure 67. New Data Map and Data Set after Completing ‘Fill’ Filter

Step 3. Rename the data map and data set so that they are easily identifiable for future use. See Figure 68 where the data map and data set are named ‘AHU_UserGuide_Manipulation’ and ‘AHU_UserGuide_Fill’, respectively.

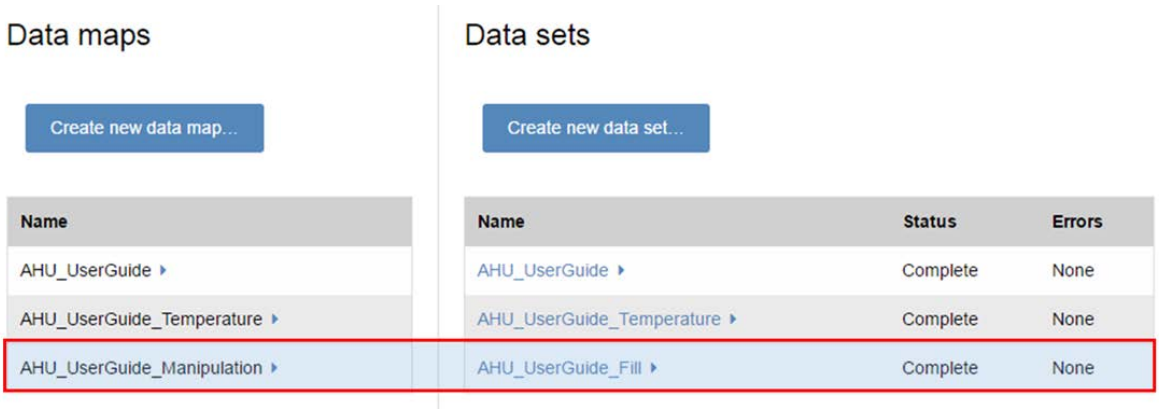


Figure 68. Change Data Map and Data Set Name

Step 4. Click ‘View’ to confirm ‘AHU_UserGuide_Fill’ data set (Figure 69). The ‘Fill’ filter filled in the missing data point from the raw data file (Figure 57).

time	UserGuide_Building/AHU8/CoolingCall-ChilledWaterValvePosition	UserGuide_Building/AHU8/CoolingCoilValvePosition	UserGuide_Building/AHU8/MixedAirTemperature
2014-07-22T12:00:00-07:00			72.08
2014-07-22T12:01:00-07:00			72.08
2014-07-22T12:02:00-07:00			72.08
2014-07-22T12:03:00-07:00			72.08

Figure 69. View ‘AHU_UserGuide_Fill’ Data Set with 1-minute Time Interval

8.3 Set ‘Aggregation’ Filter

This section explains the process of setting up the ‘Aggregation’ filter.

Step 1. Click ‘Manipulate’ next to the newly created ‘AHU_UserGuide_Fill’ data set (Figure 70) from the project home page.

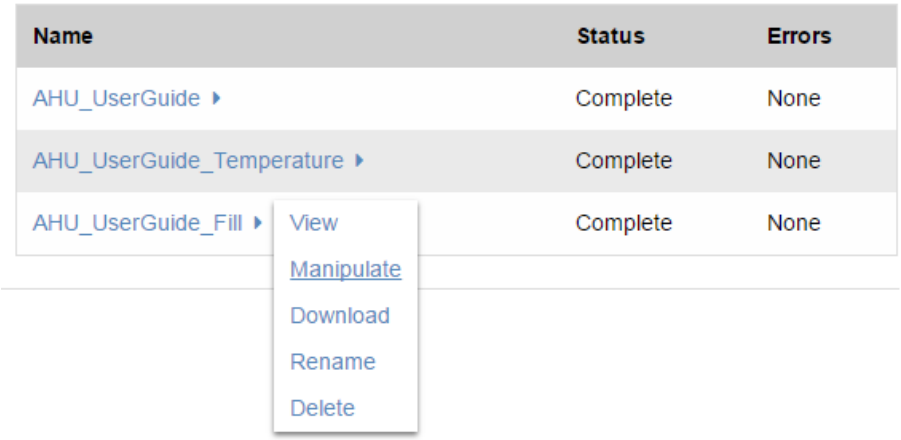


Figure 70. Select 'Manipulate' in 'AHU_UserGuide_Fill' Menu Options

Step 2. Under the 'Normalization settings', deselect the 'Fill' checkbox as shown in Figure 71 (so only the 'Aggregation' checkbox is selected).

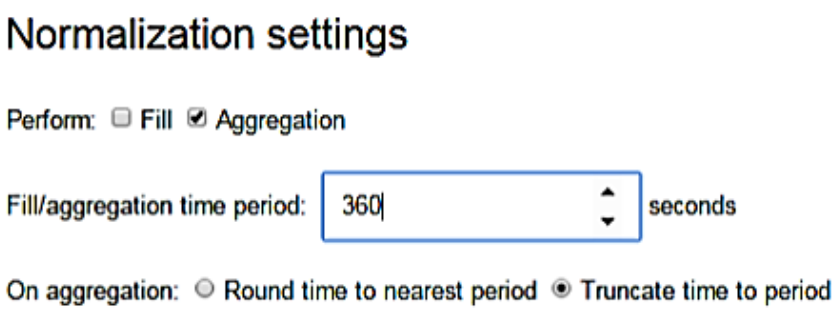


Figure 71. Normalization Settings Change (Aggregation Time Period: 3600 → 360 seconds)

Step 3. Configure the time period in the 'Fill/aggregation time period' text box. Figure 71 shows an example with a specified time interval of 360 seconds.

Step 4. Select the 'Truncate time to period' option under the 'On aggregation' field to specify the aggregation data interval. The following descriptions provide more details:

- Round time to nearest period: Collect the time series values from before and after the selected timestamp that corresponds to the time interval specified by the user.
- Truncate time to period: Collect the time series values from the previous timestamps of the selected point that corresponds to the time interval specified by the user.

Step 5. Select 'All' under the 'Aggregation' drop-down menu for 'CoolingCall-ChilledWaterValvePosition' (Figure 72).

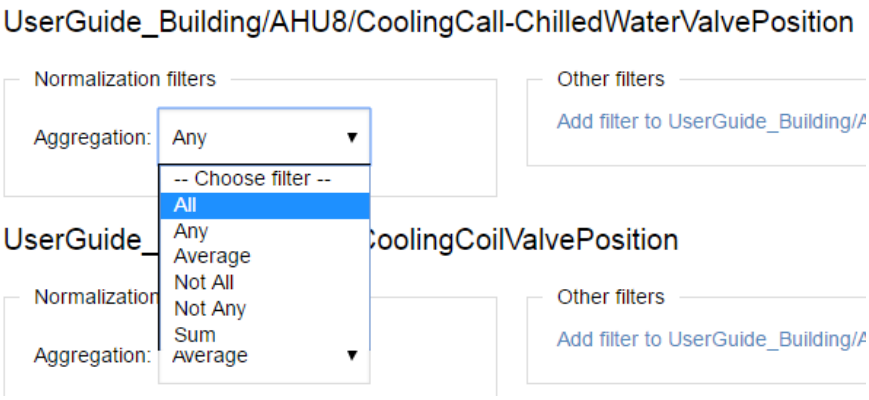


Figure 72. Select ‘All’ Function in ‘Aggregation’ for ‘CoolingCall’

Step 6. Select the corresponding options under the ‘Aggregation’ filter for all other points within this data set.

- UserGuide_Building/AHU8/MixedAirTemperature →

  Aggregation: Average and Other filters: RoundOff with ‘places’:2
- UserGuide_Building/AHU8/OutdoorAirTemperature →

  Aggregation: Average and Other filters: RoundOff with ‘places’:2
- UserGuide_Building/AHU8/OutdoorDamperSignal →

  Aggregation: Average and Other filters: RoundOff with ‘places’:2
- UserGuide_Building/AHU8/ReturnAirTemperature →

  Aggregation: Average and Other filters: RoundOff with ‘places’:2
- UserGuide_Building/AHU8/SupplyFanStatus →

  Aggregation: Any.

8.4 Perform ‘Aggregation’ Filter

This section explains the process of applying the ‘Aggregation’ filter.

Step 1. Click the ‘Apply’ button after completing set-up for each ‘Aggregation’ filter option.

Step 2. A data map and data set are created and saved.

Step 3. Rename the data map and data set so they are easily identifiable for future use. See Figure 73 where the data map and data set are named ‘AHU_UserGuide_Manipulation2’ and ‘AHU_UserGuide_Aggregation’, respectively.

Name
AHU_UserGuide
AHU_UserGuide_Temperature
AHU_UserGuide_Manipulation
AHU_UserGuide_Aggregation

Name	Status	Errors
AHU_UserGuide	Complete	None
AHU_UserGuide_Temperature	Complete	None
AHU_UserGuide_Fill	Complete	None
AHU_UserGuide_Aggregation	Complete	None

Figure 73. New Data Map and Data Set after Completing 'Aggregation' Filter

Step 4. Click 'View' button to confirm 'AHU_UserGuide_Aggregation' has been filtered as desired. The 'Aggregation' filter transforms the data set into a desired form for analysis. See Figure 74 for an example of a data set with a 360-second (6-minute) time interval.

time	UserGuide_Building/AHU8/CoolingCall-ChilledWaterValvePosition	UserGuide_Building/AHU8/CoolingCoilValvePosition	UserGuide_Building/AHU8/MixedAirTemperature
2014-07-22T12:00:00-07:00			72.08
2014-07-22T12:06:00-07:00			72.08
2014-07-22T12:12:00-07:00			72.08

Figure 74. View 'AHU_UserGuide_Aggregation' Data Set with 6-minute Time Interval

8.5 Set 'Fill' & 'Aggregation' Filter

The OpenEIS provides 'Fill' and 'Aggregation' filters in sequential order. First, the 'Fill' filter fills in any missing data. Second, after the missing data are filled in, the 'Aggregation' filter converts the data set from higher frequency intervals to lower frequency intervals (e.g., aggregation from 1-minute trend data to 5-minute trend data). The following steps detail how to consecutively apply the 'Fill' and 'Aggregation' filter to a data set.

Step 1. Select the 'Fill' and 'Aggregation' checkboxes under 'Perform' (Figure 75).

Step 2. Configure the time period in the 'Fill/aggregation time period' text box. A time interval of 3600 seconds is entered into the 'Fill/aggregation time period' text box (Figure 75).

Step 3. Select 'Truncate time to period' option under 'On aggregation' to specify the aggregation data interval (Figure 75).

Step 4. Leave 'On fill' checkbox deselected (Figure 75).

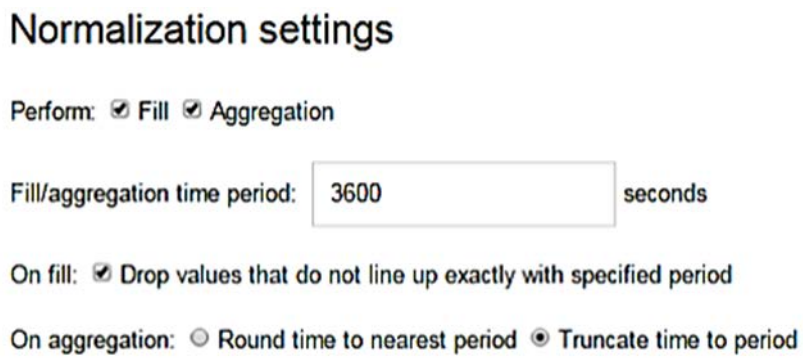


Figure 75. Normalization Settings for 'Fill' and 'Aggregation' Function

Step 5. Select 'Linear Interpolation' option in 'Fill' filter and 'All' option for 'Aggregation' filter for 'CoolingCall' (Figure 76).

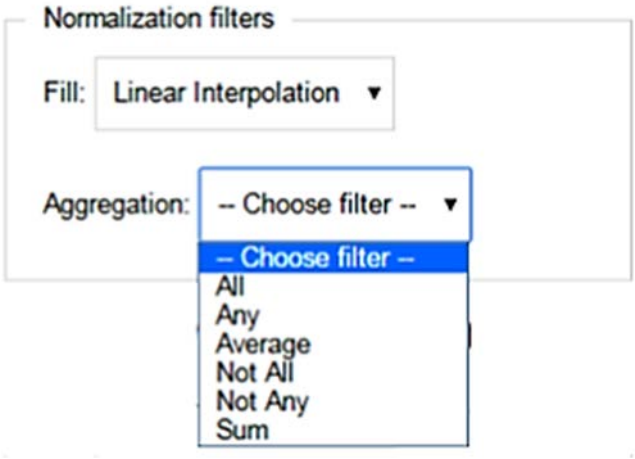


Figure 76. 'Fill' and 'Aggregation' Function List

Step 6. Select the corresponding option under 'Fill' and 'Aggregation' filter for all other points.

- UserGuide_Building/AHU8/MixedAirTemperature →

  (1) Fill: Linear Interpolation, (2) Aggregation: Average and (3) Other filters: RoundOff with 'places':2

- UserGuide_Building/AHU8/OutdoorAirTemperature →

  (1) Fill: Linear Interpolation, (2) Aggregation: Average and (3) Other filters: RoundOff with 'places':2

- UserGuide_Building/AHU8/OutdoorDamperSignal →

  (1) Fill: Linear Interpolation and (2) Aggregation: Average

- UserGuide_Building/AHU8/ReturnAirTemperature →

  (1) Fill: Linear Interpolation, (2) Aggregation: Average and (3) Other filters: RoundOff with 'places':2

- UserGuide_Building/AHU8/SupplyFanStatus →

(1) Fill: Repeat Previous and (2) Aggregation: Average.

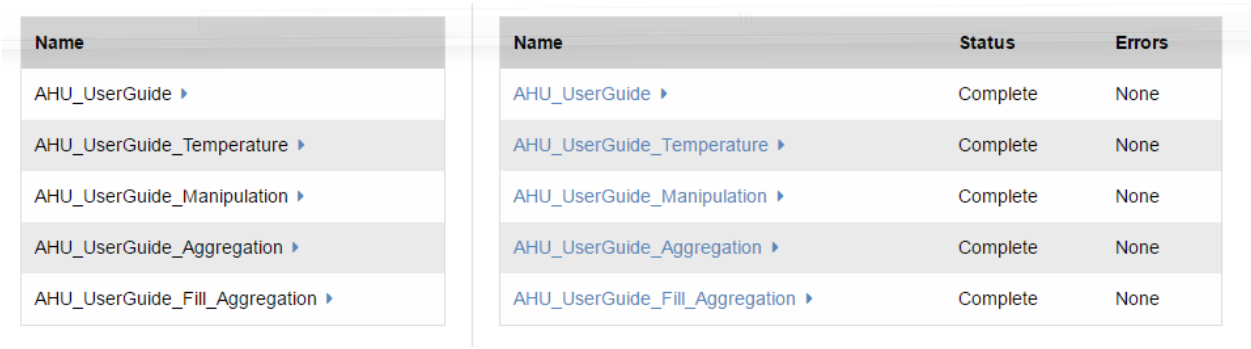
8.6 Perform ‘Fill’ + ‘Aggregation’ Filter

This section explains the process of applying ‘Fill’ filter and ‘Aggregation’ filter consecutively.

Step 1. Click the ‘Apply’ button after completing the ‘Fill’ and ‘Aggregation’ filter set up.

Step 2. A data map and data set are created and saved.

Step 3. Rename the data map and data set names so users can easily identify. See Figure 77 for an example of ‘AHU_UserGuide_Manipulation3’ and ‘AHU_UserGuide_Fill_Aggregation’.



Name
AHU_UserGuide
AHU_UserGuide_Temperature
AHU_UserGuide_Manipulation
AHU_UserGuide_Aggregation
AHU_UserGuide_Fill_Aggregation

Name	Status	Errors
AHU_UserGuide	Complete	None
AHU_UserGuide_Temperature	Complete	None
AHU_UserGuide_Manipulation	Complete	None
AHU_UserGuide_Aggregation	Complete	None
AHU_UserGuide_Fill_Aggregation	Complete	None

Figure 77. New Data Map and Data Set after Completing ‘Fill’ and ‘Aggregation’ Filter

Step 4. Click ‘View’ button (Figure 77) to confirm ‘AHU_UserGuide_Fill_Aggregation’ data set. The ‘Fill’ and ‘Aggregation’ filters are applied to the original data set, creating a new data set in a desired form for analysis. Figure 78 shows an example of the results of applying the ‘Fill’ and ‘Aggregation’ filters to create a data set with 360-second time intervals.

time	UserGuide_Building/AHU8/CoolingCall-ChilledWaterValvePosition	UserGuide_Building/AHU8/CoolingCoilValvePosition	UserGuide_Building/AHU8/MixedAirTemperature
2014-07-22T12:00:00-07:00			72.08
2014-07-22T12:06:00-07:00			72.09
2014-07-22T12:12:00-07:00			72.11
2014-07-22T12:18:00-07:00			72.14
2014-07-22T12:24:00-07:00			72.17
2014-07-22T12:30:00-07:00			72.2
2014-07-22T12:36:00-07:00			72.23
2014-07-22T12:42:00-07:00			72.26
2014-07-22T12:48:00-07:00			72.28
2014-07-22T12:54:00-07:00			72.31
...			
2014-07-22T14:00:00-07:00	1	55.85	72.86

Figure 78. View ‘AHU_UserGuide_Fill_Aggregation’ Data Set

9.0 Select and Run Analysis Applications

This section explains how to configure analysis applications and run the applications using a data set. The OpenEIS provides a number of analysis applications that interact with the data set through the defined application programming interface (API). Because this user guide focuses on the workflow for using the OpenEIS, not all applications are explained in detail.

The retuning commercial building website provides the detailed explanation of PNNL applications from their online reference documentation.

- AIRCx (automatic identification of retro-commissioning [RCx] opportunities) for Air Handling Heating, Ventilation, and Air Conditioning (HVAC) Systems: Detect, diagnose, and automatically provide corrective actions to the problems with an AHU's operation.
- AIRCx for Economizer HVAC Systems: Detect and diagnose problems with outdoor-air ventilation and economizer operations.
- AIRCx for Hot-Water Distributions Systems: Detect and diagnose problems with hot-water system operations.

There are a number of applications that provide analysis of the interval metered data (whole building electricity and gas consumption). These include:

- Cross-sectional Benchmarking: Compare a building's energy efficiency relative to a peer group. The application output shows how much potential there is to improve the building's efficiency.
- Daily Summary: A collection of metrics that summarize daily energy use. Metrics included in the application are load variability, load minimum and maximum, peak load benchmark, daily load ratio, and daily load range.
- Energy Signature and Weather Sensitivity: Monitor and maintain the performance of temperature-dependent whole building loads. Weather sensitivity is a single summary statistic that contextualizes the shape of the energy signature.
- Heat Map: A means of visualizing and presenting information that is contained in a time series load profile (color-code the magnitude of the load).
- Load Duration Curves: Provides the number of hours or percentage of time during which the building load is at or below a certain value.
- Longitudinal Benchmarking: Compares the building energy usage in a fixed period to a comparable 'baseline' period of the same length to determine if performance has deteriorated or improved.
- Sensor Suitcase
  - HVAC: Identify problems in the operation and performance of packaged HVAC RTUs in small commercial buildings.
  - Lighting: Identify problems in the operation and performance of lighting systems in small commercial buildings.
- Time Series Load Profiling: Understand the relationship between energy use and time of day.
- Whole-building Energy Savings: Quantify the energy savings associated with an improvement in building operations or equipment.

Step 1. Click the 'Run analysis…' button under 'Analyses' (Figure 79) from the project home page.

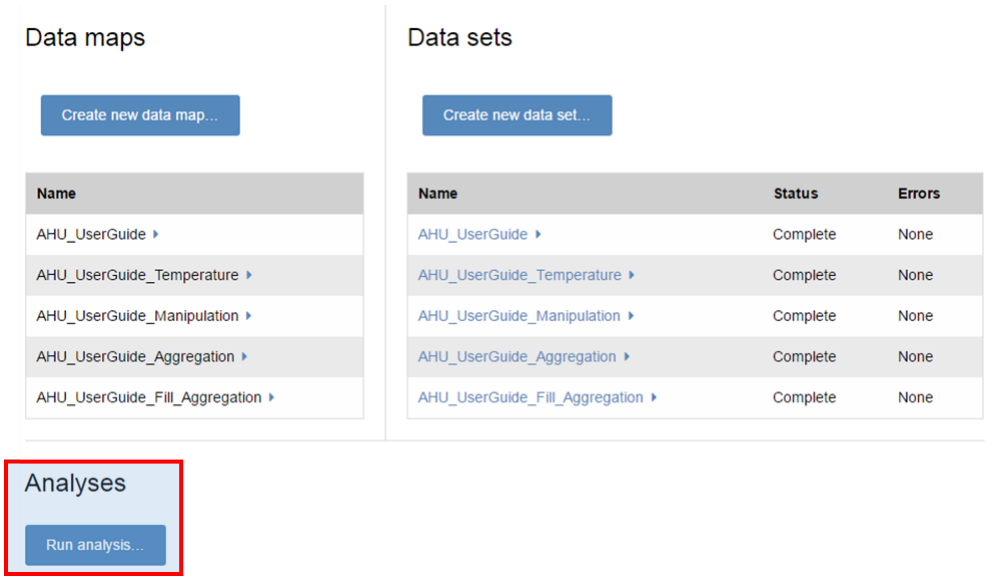


Figure 79. 'Run Analysis' Selection

Step 2. Select the data set name under 'Run analysis on' drop-down menu. Select 'AHU_UserGuide', as shown in Figure 80.

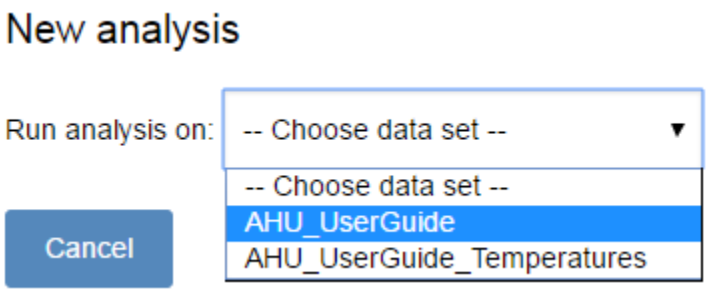


Figure 80. Data Set Selection

Step 3. The 'New analysis' page is displayed in Figure 81.

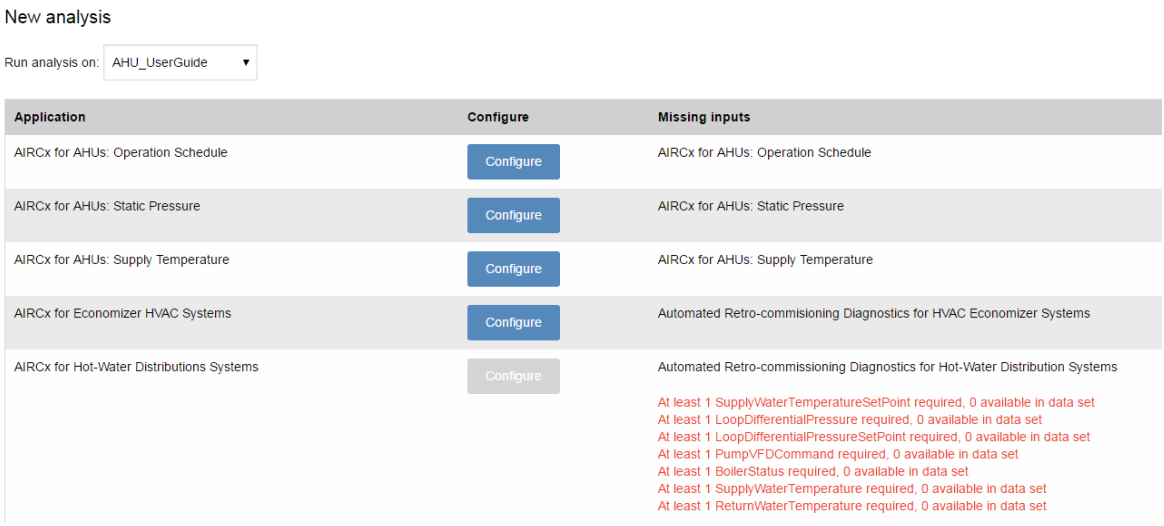


Figure 81. 'New Analysis' Page

Step 4. If the required data inputs for an application are not available in the selected data set, the OpenEIS will indicate that the application cannot be used. The 'Configure' button(s) for the application will not be selectable ('greyed out') and the missing inputs will be shown in red text. Figure 82 shows an example of the 'Configure' menu with the missing required inputs for the 'AIRCx for Hot-Water Distribution Systems' displayed in red. An application with no missing inputs will be displayed with a blue 'Configure' button on the left.

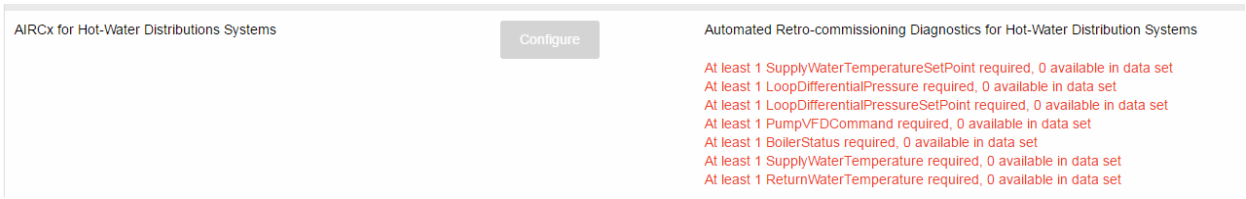


Figure 82. Missing Inputs about 'Hot Water Plant Data Visualization'

Step 5. Click 'Configure' button next to the 'AIRCx for Economizer HVAC systems' application to configure the application inputs and set up parameters (Figure 81).

Step 6. The 'AIRCx for Economizer HVAC economizer systems' application configuration page is displayed (Figure 83). The application configuration page is divided into two parts: a set of parameters for the application and a set of inputs from the new data set.

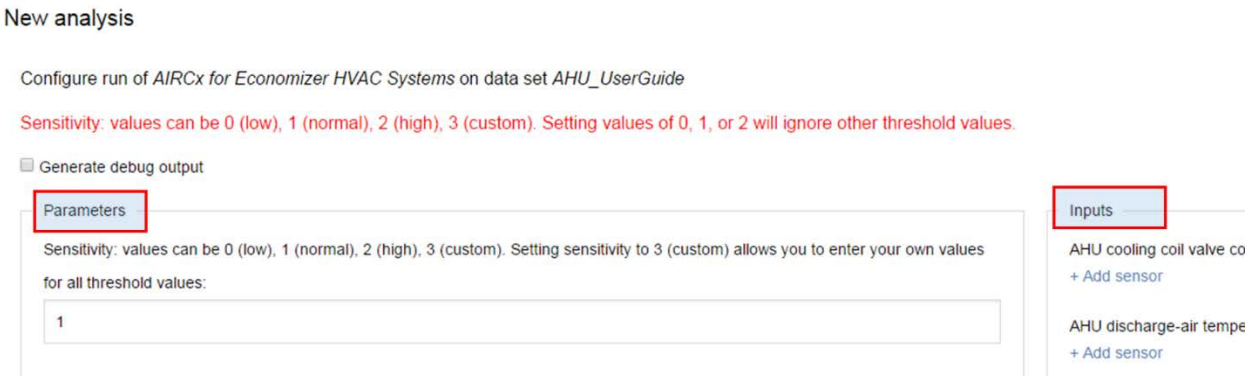


Figure 83. AIRCx for Economizer HVAC Systems Application

Step 7. The default configuration parameters for 'AIRCx for Economizer HVAC economizer systems' will automatically propagate into their respective input boxes, but a user can modify these default settings. Figure 84 shows the configuration menu for 'AIRCx for Economizer HVAC economizer systems'. The descriptions for the parameters associated with HVAC economizer diagnostics are given in the Section 11.0.

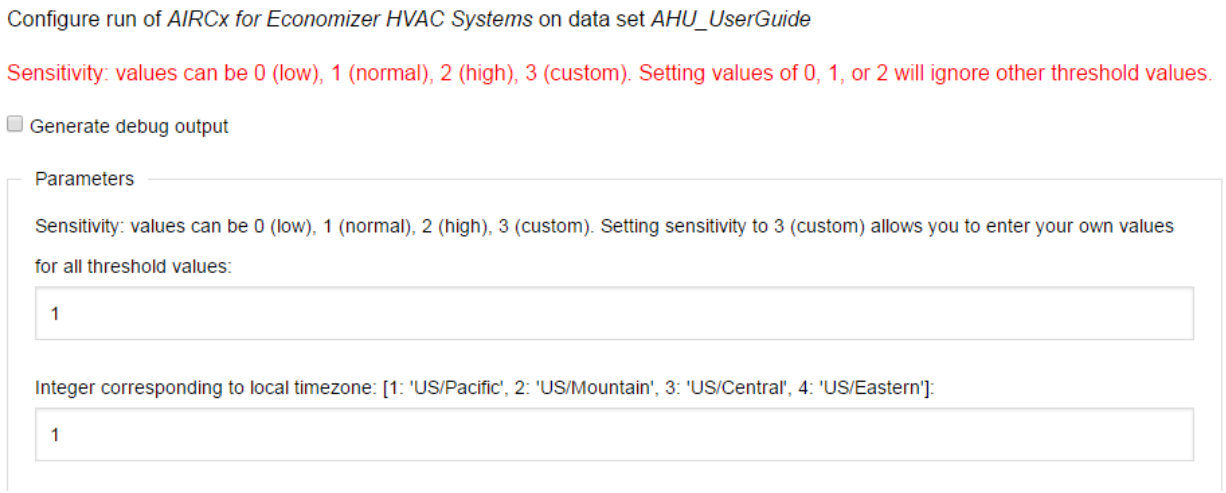


Figure 84. Application Parameter Configuration

Step 8. Select the inputs from each drop-down menu. Click 'Add sensor' under the input 'AHU cooling coil valve command or RTU coolcall/compressor command' and select 'UserGuide_Building/AHU8/CoolingCall-ChilledWaterValvePosition'(Figure 85).

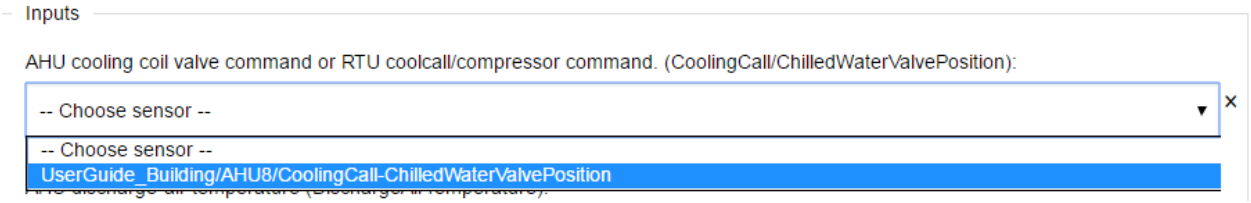


Figure 85. Application Input Configuration

Step 9. After all parameters and inputs are selected, click the 'Run' button to run the application (Figure 86).

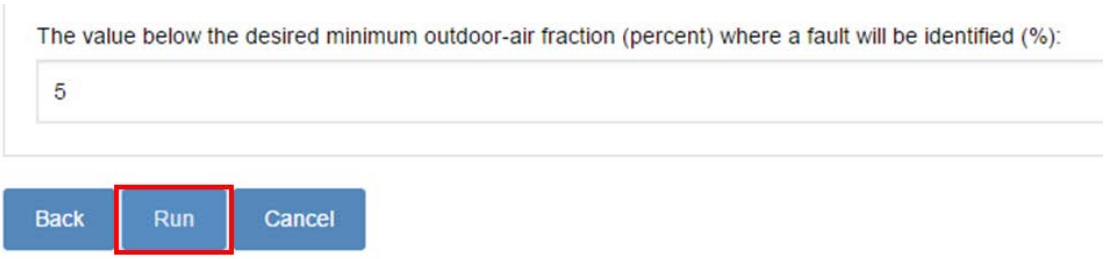


Figure 86. 'Run' Application

Step 10. Check the status of application processing. The status indicates whether the application processing is successful. 'Complete' means the application processing completed successfully (Figure 87). If the application does not complete its run, select 'Download output' to download and view the error log.

Figure 87. Application Output

10.0 Collect and Visualize Results

This section explains how to collect and visualize application results.

Step 1. In the Analyses project home page, the triangle button next to source input file name under ‘Run analyses…’ allows users to view application output (‘View’), download application output (‘Download output’), share the application output (‘Share’), rename the application output (‘Rename’), and delete the application output (‘Delete’) (Figure 88).

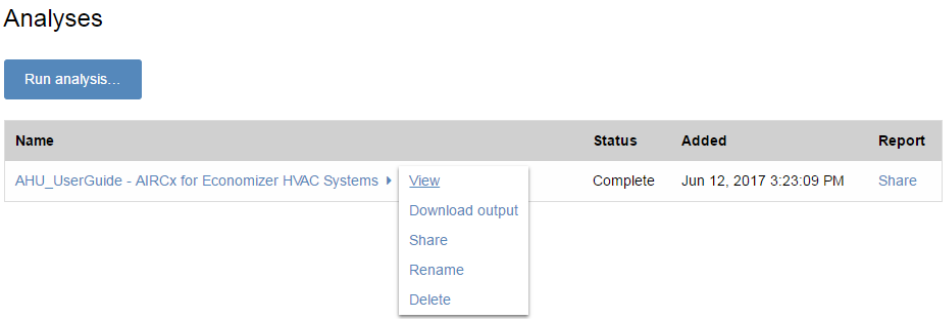


Figure 88. Application Output Options

Step 2. Click ‘View’ button to see the ‘Automated retro-commissioning for HVAC economizer systems’ results (Figure 89). By default, the ‘data’ tab is opened displaying time series data of various inputs to the application.

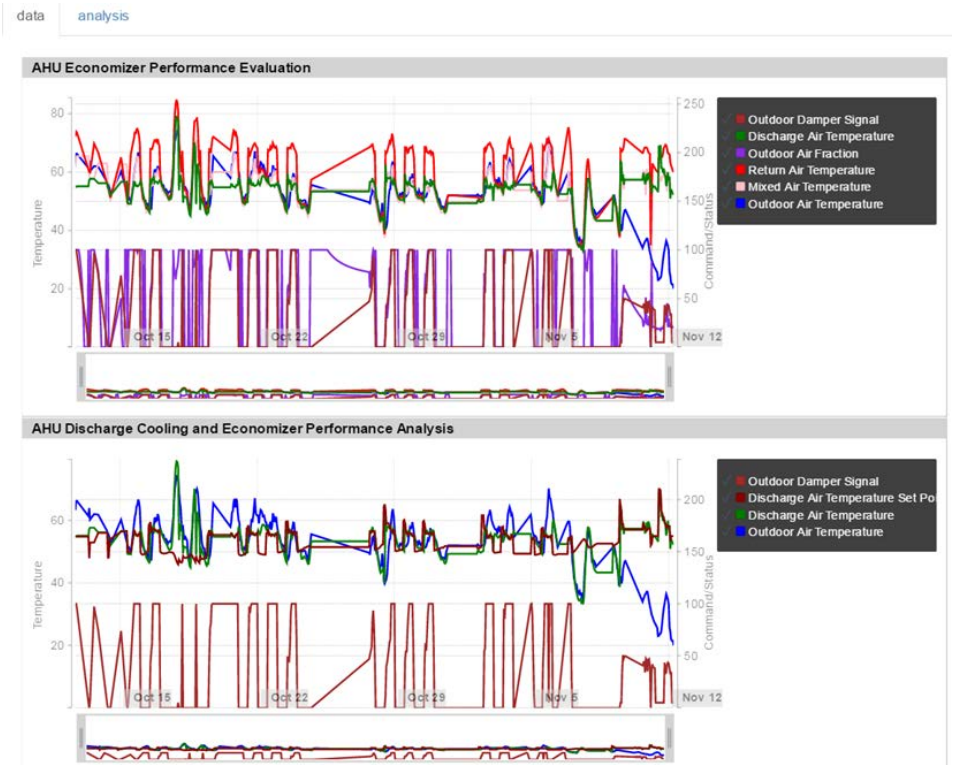


Figure 89. ‘AIRCx for Economizer HVAC Systems’ Results

Step 3. The graphs can be modified by the user according to their need. The specific parameters can be selected/deselected from the legend. A tick against a legend entry indicates that the corresponding graph is included. Clicking on it would deselect the entry; the corresponding graph would disappear and the legend entry would be greyed out. An example screenshot is shown in Figure 90 where 'Outdoor Air Temperature' is deselected as compared to where it is selected in Figure 89.

Figure 90. 'Outdoor Air Temperature' Deselected from Results

Step 4. The time frame for displaying results can be adjusted using the window below the graph as highlighted in yellow in Figure 91. Click on the vertical edges of the window and drag sideways for adjusting displayed time frame. The window can also be moved as a whole for further adjustment.

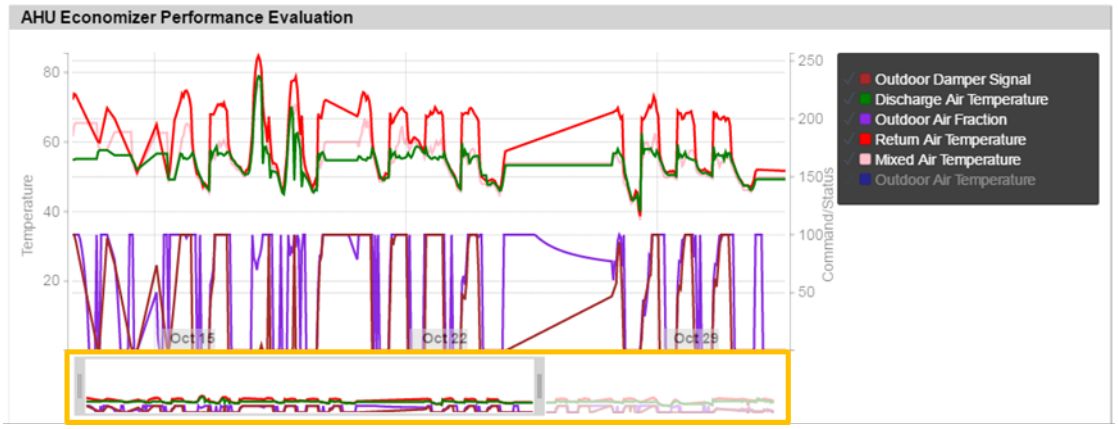


Figure 91. Adjusting Time Frame in Results

Step 5. Click the 'analysis' tab to view the diagnostic results. For more detailed results, move the cursor over any of the circular colored icons. Figure 92 shows the daily results message for the 'AIRCx for HVAC economizer systems' diagnostic 'Economizing when unit should not Dx'.

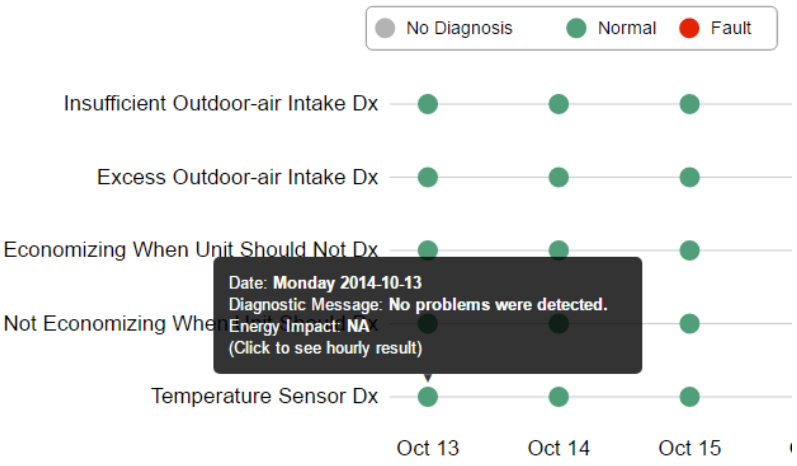


Figure 92. Daily Diagnostic Output

Step 6. To view hourly results for the diagnostic, click on the colored circle icon next to the feature name. See Figure 93 for an example screenshot of 'AIRCx for HVAC economizer systems' hourly results. The hourly diagnostic bar graph is displayed to help analyze trends and patterns.

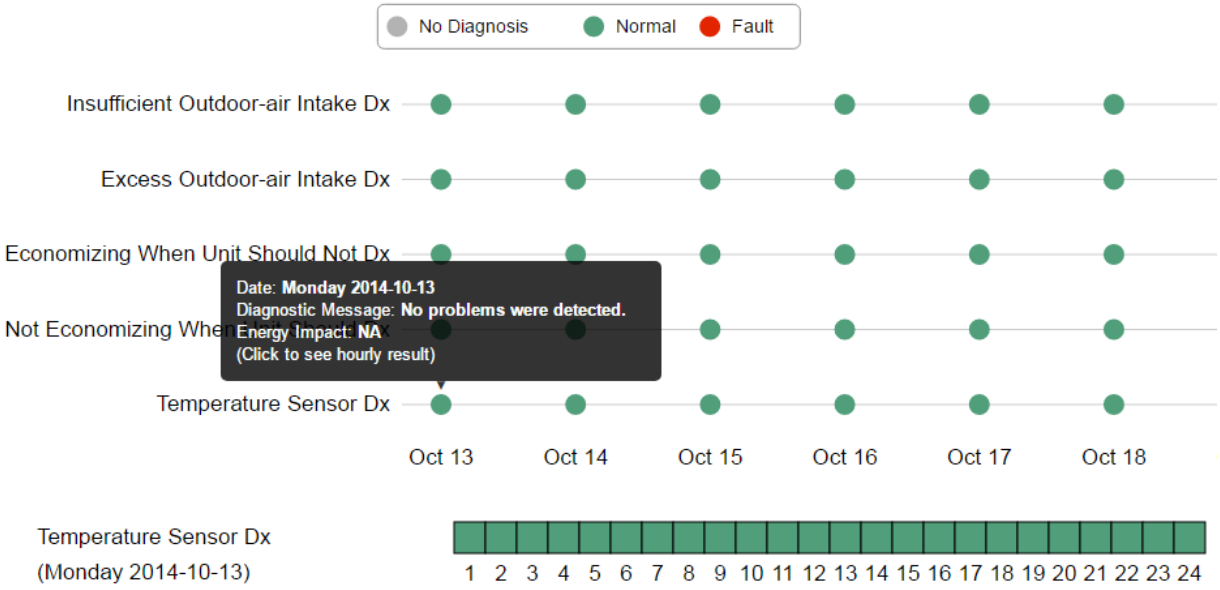


Figure 93. Hourly Diagnostic Output

Step 7. Click on the bar graph. The detailed hourly diagnostic message is displayed (Figure 94).

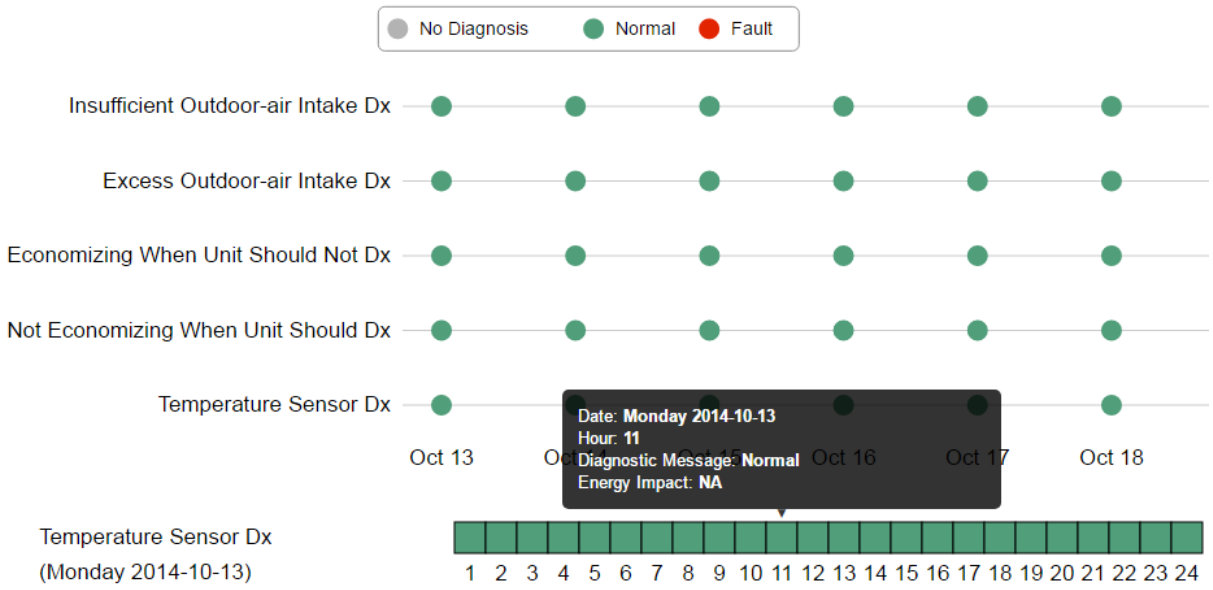


Figure 94. Hourly Diagnostic Output at 8:00 AM

Step 8. On the project home page, for any analysis, click the 'Download output' button to download calculation output in a zip file (Figure 88).

Step 9. Click the 'Share' button to share the application output using the URL provided by the OpenEIS (Figure 95).

Figure 95. URL Link after 'Share' Selection

11.0 Description of Analyses

This section describes the various analyses available in detail with relevant screenshots.

11.1 AIRCx AHU: Static Pressure

Follow the steps described below to detect, diagnose, and automatically provide diagnostic outputs related to an AHU's operation for static pressure

Step 1. In the project home page, click 'Run analysis…'

Step 2. The browser will prompt you for a dataset to run the analysis on. Choose 'AHU_UserGuide' data set.

Step 3. The 'New analysis' page is displayed (Figure 81). If the required data inputs for an application are not available in the selected data set, the OpenEIS will indicate that the application cannot be used. The 'Configure' button for the application will be greyed out and the missing inputs will be shown in red text. An application with no missing inputs is displayed with a blue 'Configure' button on the left.

Step 4. Click the 'Configure' button next to the 'AIRCx AHU: Static Pressure' application to configure the application inputs and set up parameters.

Step 5. The 'AIRCx AHU: Static Pressure' application configuration page is displayed (Figure 96). The application configuration page is divided into two parts: a set of parameters for the application and a set of inputs from the new data set.

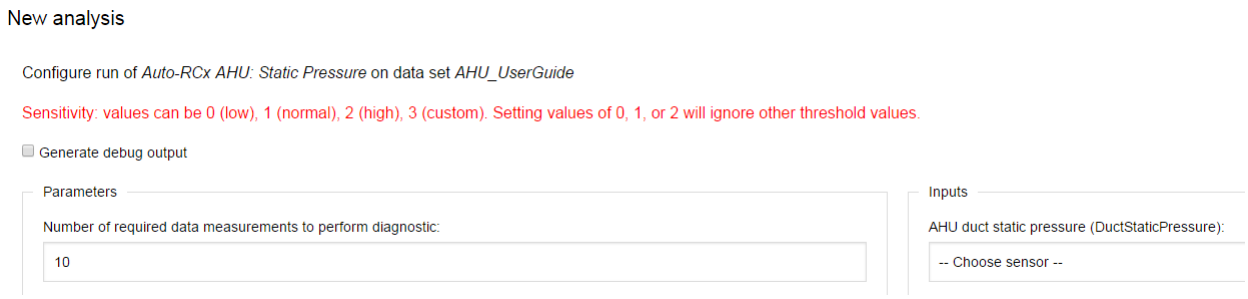


Figure 96. AIRCx AHU: Static Pressure Application

Step 6. The default configuration parameters for 'AIRCx AHU: Static Pressure' will automatically propagate into their respective input boxes but the user can modify these default settings. Figure 96 shows the configuration menu for 'AIRCx AHU: Static Pressure'. A description of the parameters associated with this analysis are given in Table 1.

Table 1. AIRCx AHU: Static Pressure - Parameters

Parameter	Description
Number of required data measurements to perform diagnostic	Minimum number of data measurements to return a conclusive diagnostic check.
Minimum elapsed time for analysis (minutes)	The minimum time frame that the data should cover for successful analysis.
Integer corresponding to local time zone	1: US/Pacific 2: US/Mountain 3: US/Central 4: US/Eastern
Sensitivity	This value provides a means for determining parameter sensitivity. A high sensitivity will identify more faults but may also lead to false positives. Values can be 0 (low sensitivity), 1 (normal sensitivity), 2 (high sensitivity) or 3 (custom)
'Duct Static Pressure Set Point Control Loop Dx' - the allowable percent deviation from the set point for the duct static pressure	If the percent deviation from set point is greater than this value, a fault is generated.
'Low Duct Static Pressure Dx' - zone high damper threshold (%) **	If the average value of the top 50% of highest opened zone damper's is greater than this value then the supply fan is not supplying enough static pressure and the static pressure set point should be increased (retuning opportunity).
'Low Duct Static Pressure Dx' - zone low damper threshold (%) **	If the average value of the bottom 50% of highest opened zone damper's is greater than this value then the supply fan not supplying enough static pressure and the static pressure set point should be increased (retuning opportunity).
'High Duct Static Pressure Dx' - zone damper threshold (%)	If the average value of the top 50% of highest opened zone damper's is less than this value then the supply fan is supplying too much static pressure and the static pressure set point should be reduced (retuning opportunity).
'No Static Pressure Reset Dx' - the required difference between the minimum and the maximum duct static pressure set point for detection of a duct static pressure set point reset (inch w.g.)	If the difference between the minimum and maximum duct static pressure set point (over a pre-determined period, usually 24 hours) is less than this value, a fault is generated.

** The diagnostic check associated with these thresholds is done simultaneously and both must evaluate to a fault condition for conclusive detection of faulty operations.

Step 7. Select the inputs from each drop-down menu. The necessary inputs are displayed with a drop-down menu (Figure 97), while the rest are optional.

Figure 97. AIRCx AHU: Static Pressure Application Input Configuration

Step 8. After all parameters and inputs are selected, click the 'Run' button to run application (Figure 86).

Step 9. Check the status of application processing. The status indicates whether the application processing is successful. 'Complete' means the application processing completed successfully (similar to Figure 87). If the application does not complete its run, select 'Download output' to download and view the error log.

Step 10. Click on the triangles next to the application name under analyses and select 'View' from the drop down menu. The output of the application is displayed (Figure 98). To view hourly results for the diagnostic, click on the colored circle icon next to the feature name (similar to Figure 93).

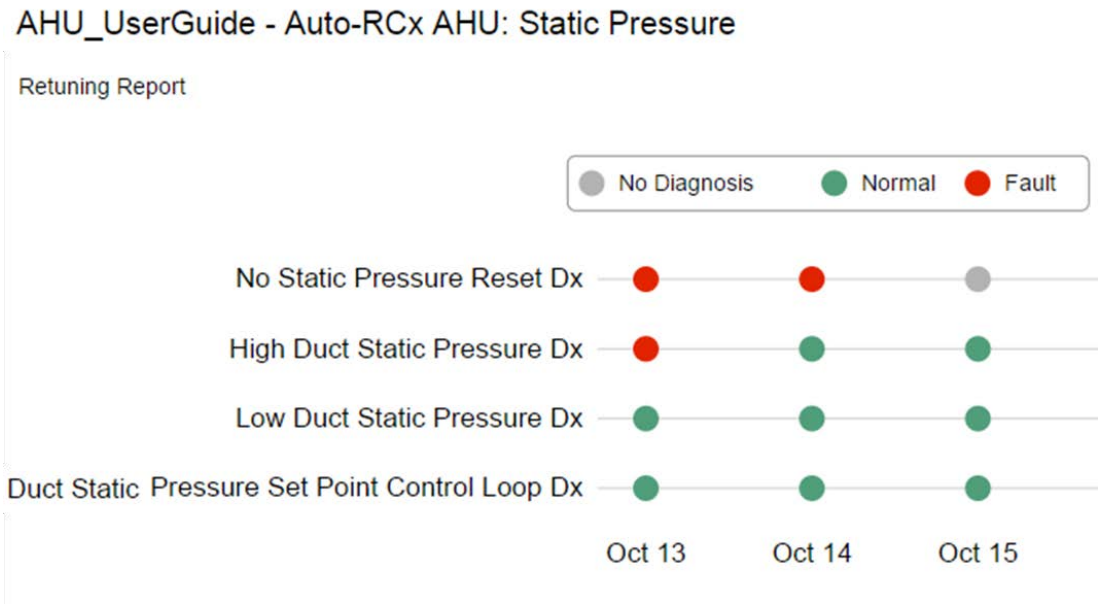


Figure 98. AIRCx AHU: Static Pressure Application Output

11.2 AIRCx AHU: Supply Temperature

Follow the steps described below to detect, diagnose, and automatically provide diagnostic outputs related to an AHU's operation for supply air temperature.

Step 1. In the project home page, click ‘Run analysis …’

Step 2. The browser will prompt you for a dataset to run the analysis on. Choose ‘AHU_UserGuide’.

Step 3. The ‘New analysis’ page is displayed (Figure 81). If the required data inputs for an application are not available in the selected data set, the OpenEIS will indicate that the application cannot be used. The ‘Configure’ button for the application will be greyed out and the missing inputs will be shown in red text. An application with no missing inputs is displayed with a blue ‘Configure’ button on the left.

Step 4. Click the ‘Configure’ button next to the ‘AIRCx AHU: Supply Temperature’ application to configure the application inputs and set up parameters.

Step 5. The ‘AIRCx AHU: Supply Temperature’ application configuration page is displayed (Figure 99). The application configuration page is divided into two parts: a set of parameters for the application and a set of inputs from the new data set.

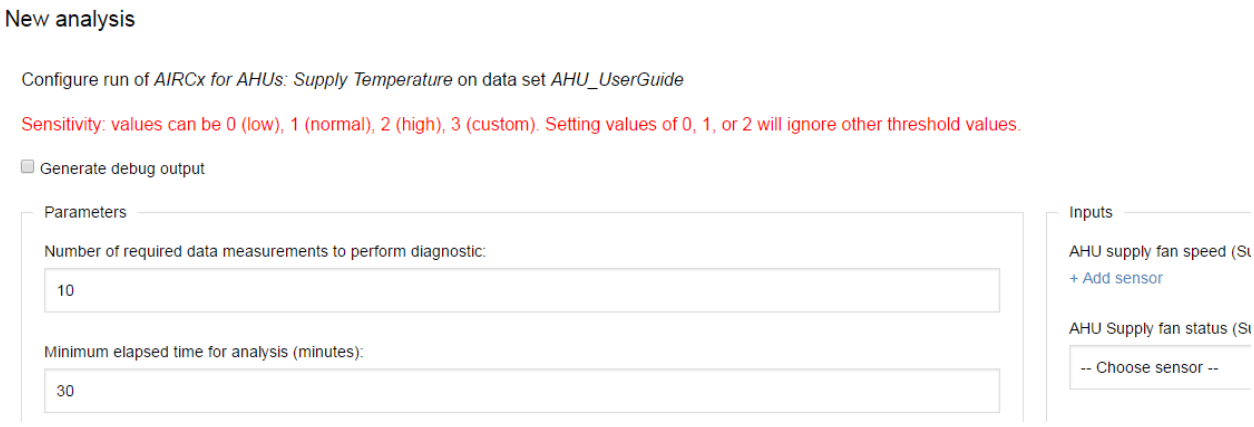


Figure 99. AIRCx AHU: Supply Temperature Application

Step 6. The default configuration parameters for ‘AIRCx AHU: Supply Temperature’ will automatically propagate into their respective input boxes, but a user can modify these default settings. A description of the parameters associated with this analysis are given in Table 2.

Table 2. AIRCx AHU: Supply Temperature - Parameters

Parameter	Description
Number of required data measurements to perform diagnostic	Minimum number of data measurements to return a conclusive diagnostic check.
Minimum elapsed time for analysis (minutes)	The minimum time frame that the data should cover for successful analysis.
Integer corresponding to local time zone	1: US/Pacific 2: US/Mountain 3: US/Central 4: US/Eastern

Parameter	Description
Sensitivity	This value provides a means for determining parameter sensitivity. A high sensitivity will identify more faults but may also lead to false positives. Values can be 0 (low sensitivity), 1 (normal sensitivity), 2 (high sensitivity) or 3 (custom).
'Supply-air Temperature Set Point Control Loop Dx' - the allowable percent deviation from the set point for the supply-air temperature	If the percent deviation from set point is greater than this value, a fault is generated.
Minimum reheat command for zone reheat to be considered ON (%)	If the reheat valve command for a zone exceeds this value then the zone is considered to have reheat ON.
Threshold for average percent of zones where terminal box reheat is ON (%)	'Low Supply-air Temperature Dx' - if the average percent of zones where the zone reheat is ON is greater than this value then the supply-air temperature is too low and the supply air temperature set point should be increased (retuning opportunity). * 'High Supply-air Temperature Dx' - if the average percent of zones where the zone reheat is ON is less than this value then the supply-air temperature is too high and the supply air temperature set point should be decreased (retuning opportunity). **
'Low Supply-air Temperature Dx' - average zone reheat valve command threshold	If the average zone reheat valve command exceeds this value then the supply-air temperature is too low and the supply-air temperature set point should be increased (retuning opportunity). *
'High Supply-air Temperature Dx' - threshold for determining when zone dampers are commanded to value higher than optimum [high zone damper threshold] (%)	If the zone damper command exceeds this value the zone damper is considered to be commanded to a value greater than optimal.
'High Supply-air Temperature Dx' - threshold for determining when the average percent of zones dampers are commanded to value higher than optimum (%)	If the average percent of zones where the zone damper is commanded to a value greater than the [high zone damper threshold] is greater than this value then the supply-air temperature is too high and the supply air temperature set point should be decreased (retuning opportunity).**
'No Supply Temperature Reset Dx' - the required difference between the minimum and the maximum supply-air temperature set point for detection of a supply-air temperature set point reset (°F)	If the difference between the minimum and maximum supply-air temperature set point (over a pre-determined period, usually 24 hours) is less than this value, a fault is generated.

* The diagnostic check associated with these thresholds is done simultaneously and both must evaluate to a fault condition for conclusive detection of faulty operations ('Low Supply-air Temperature Dx').
** The diagnostic check associated with these thresholds is done simultaneously and both must evaluate to a fault condition for conclusive detection of faulty operations ('Low Supply-air Temperature Dx').

Step 7. Select the inputs from each drop-down menu. The necessary inputs are displayed with a drop-down menu (Figure 100), while the rest are optional.

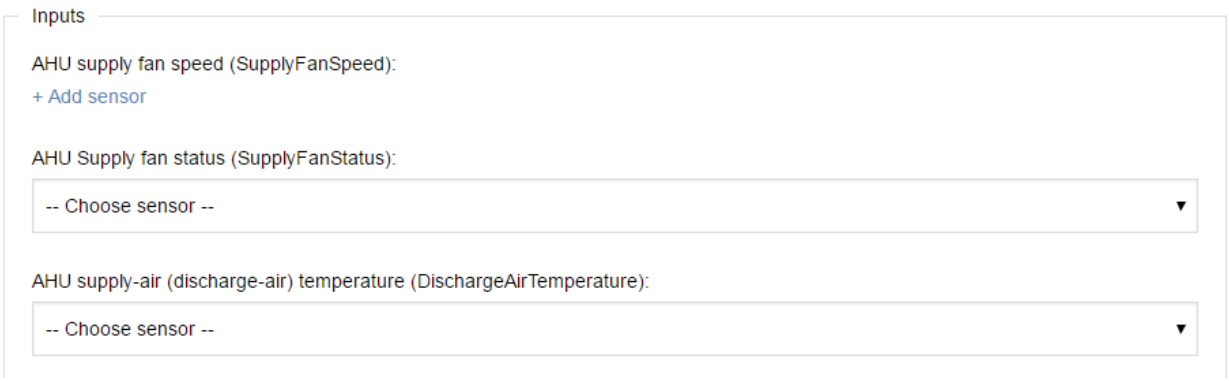


Figure 100. AIRCx AHU: Supply Temperature Application Input Configuration

Step 8. After all parameters and inputs are selected, click the 'Run' button to run the application.

Step 9. Check the status of the application processing. The status indicates whether the application processing is successful. 'Complete' means the application processing completed successfully. If the application does not complete its run, select 'Download output' to download and view the error log.

Step 10. Click on the triangles next to the application name under analyses and select 'View' from the drop down menu. The output of the application is displayed (Figure 101). To view hourly results for the diagnostic, click on the colored circle icon next to the feature name (similar to Figure 93).

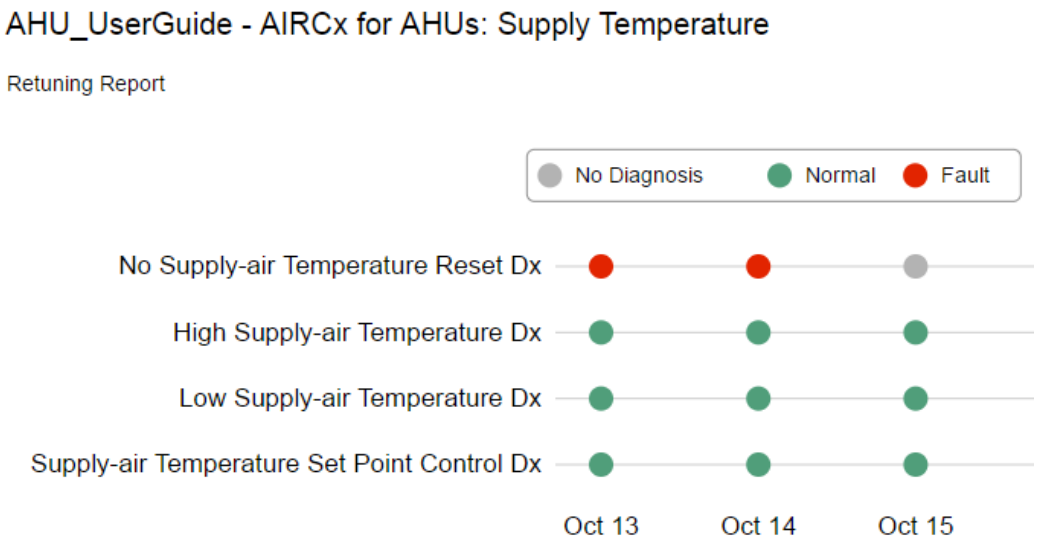


Figure 101. AIRCx AHU: Supply Temperature Application Output

11.3 AIRCx for AHU: Operation Schedule

Follow the steps described below to detect, diagnose, and automatically provide diagnostic outputs to problems with an AHU's operation related to operation schedules.

Step 1. In the project home page, click ‘Run analysis…’

Step 2. The browser will prompt the user for a dataset to run the analysis on. Choose ‘AHU_UserGuide’

Step 3. The ‘New analysis’ page is displayed (Figure 81). If the required data inputs for an application are not available in the selected data set, the OpenEIS will indicate that the application cannot be used. The ‘Configure’ button for the application will be greyed out and the missing inputs will be shown in red text. An application with no missing inputs is displayed with a blue ‘Configure’ button on the left.

Step 4. Click ‘Configure’ button next to the ‘AIRCx AHU: Operation Schedule’ application to configure the application inputs and set up parameters. A description of the parameters associated with this analysis are given in Table 3.

Table 3. AIRCx AHU: Supply Temperature - Parameters

Parameter	Description
Sensitivity: values can be 0 (low), 1 (normal), 2 (high), 3 (custom). Setting sensitivity to 3 (custom) allows you to enter your own values for all threshold values	This value provides a means for determining parameter sensitivity. A high sensitivity will identify more faults but may also lead to false positives. Values can be 0 (low sensitivity), 1 (normal sensitivity), 2 (high sensitivity) or 3 (custom).
Integer corresponding to local time zone	1: US/Pacific 2: US/Mountain 3: US/Central 4: US/Eastern
Threshold for acceptable unoccupied run-time percentage for AHU supply fan (%)	Allowable run-time percentage for the AHU supply fan during unoccupied hours. If the run-time percentage for the supply fan during unoccupied periods exceeds this value a retuning opportunity may exist.
Threshold for the AHU average static pressure during unoccupied periods (inch w.g.)	Threshold for the average static pressure during unoccupied times. If the supply fan is not operating excessively during unoccupied time the average static pressure should not exceeds this value.
Monday occupancy schedule for AHU	Used for detection of excessive supply fan operations during times scheduled as unoccupied.
Tuesday occupancy schedule for AHU	Used for detection of excessive supply fan operations during times scheduled as unoccupied.
Wednesday occupancy schedule for AHU	Used for detection of excessive supply fan operations during times scheduled as unoccupied.
Thursday occupancy schedule for AHU	Used for detection of excessive supply fan operations during times scheduled as unoccupied.

Parameter	Description
Friday occupancy schedule for AHU	Used for detection of excessive supply fan operations during times scheduled as unoccupied.
Saturday occupancy schedule for AHU (default: unoccupied)	Used for detection of excessive supply fan operations during times scheduled as unoccupied.
Sunday occupancy schedule for AHU (default: unoccupied)	Used for detection of excessive supply fan operations during times scheduled as unoccupied.

Step 5. The 'AIRCx AHU: Operation Schedule' application configuration page is displayed (Figure 83). The application configuration page is divided into two parts: a set of parameters for the application and a set of inputs from the new data set.

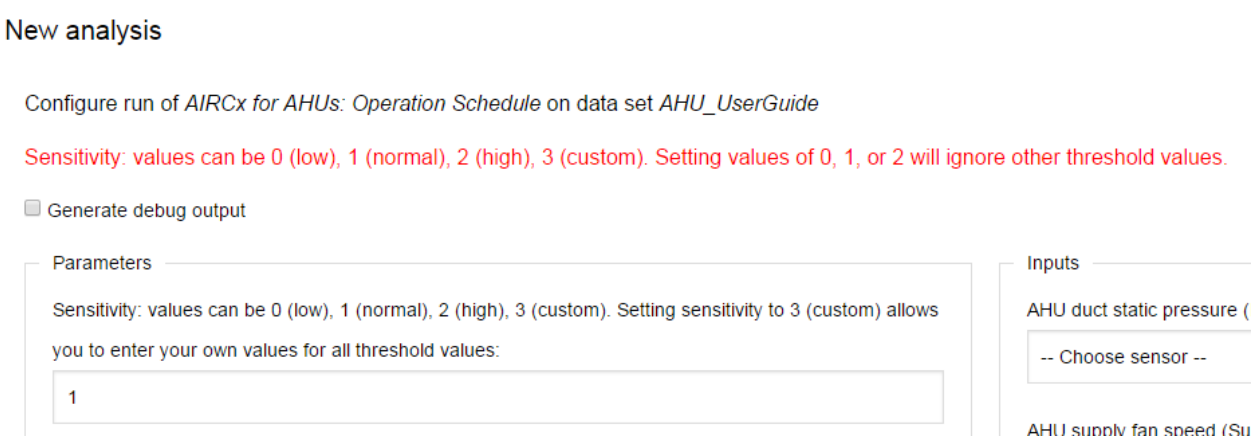


Figure 102. AIRCx AHU: Operation Schedule Application

Step 6. The default configuration parameters for 'AIRCx AHU: Operation Schedule' will automatically propagate into their respective input boxes but a user can modify these default settings. Select the inputs from each drop-down menu. The necessary inputs are displayed with a drop-down menu, while the rest are optional. After all parameters and inputs are selected click the 'Run' button to run the application (Figure 86).

Step 7. Check the status of the application processing. The status indicates whether the application processing is successful. 'Complete' means the application processing completed successfully. If the application does not complete its run, select 'Download output' to download and view the error log.

Step 8. Click on the triangles next to the application name under analyses and select ‘View’ from the drop down menu. The output of the application is displayed (Figure 103). To view hourly results for the diagnostic, click on the colored circle icon next to the feature name (similar to Figure 93).

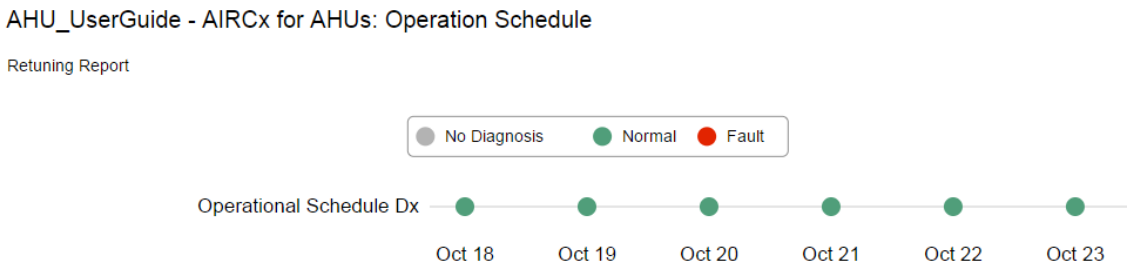


Figure 103. AIRCx AHU: Operation Schedule Application Output

11.4 AIRCx for Hot-Water Distributions Systems

Follow the steps described below to detect, diagnose, and automatically provide diagnostic outputs to problems with hot-water system operations.

Step 1. On the project home page, click ‘Run analysis. The browser will prompt you for a dataset to run the analysis on. Choose ‘AHU_UserGuide’

Step 2. The ‘New analysis’ page is displayed (Figure 81). If the required data inputs for an application are not available in the selected data set, the OpenEIS will indicate that the application cannot be used. The ‘Configure’ button for the application will be greyed out and the missing inputs will be shown in red text. An application with no missing inputs is displayed with a blue ‘Configure’ button on the left. It can be observed that there are seven missing inputs for ‘AIRCx for Hot-Water Distributions Systems’ (Figure 104).

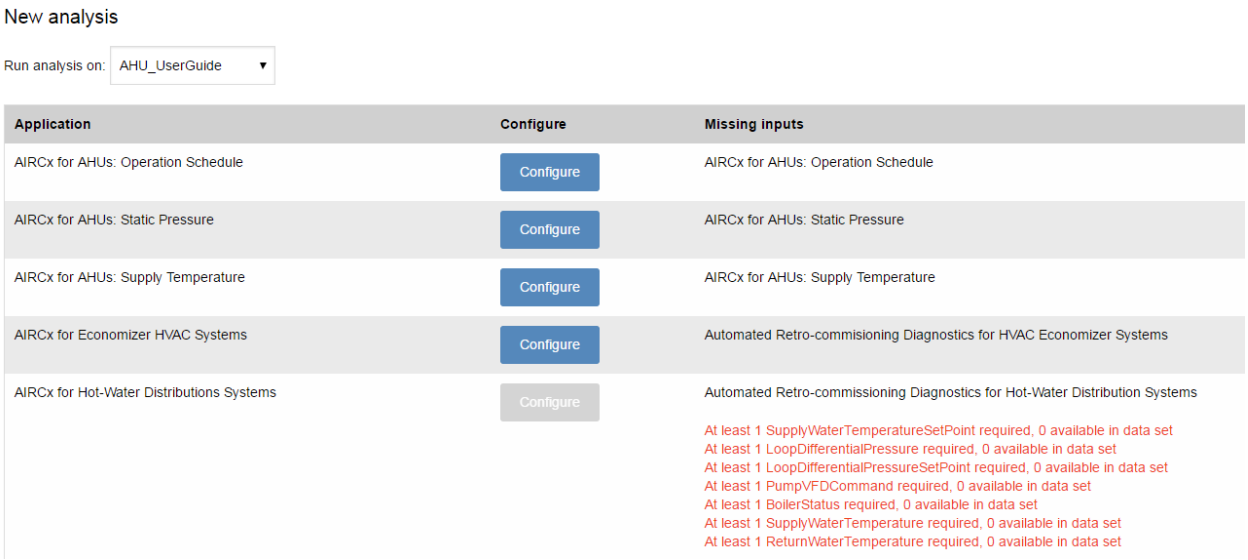


Figure 104. New Analysis Page with Missing Inputs

Step 3. Modify the existing data maps to incorporate these missing inputs. Click ‘Cancel’ at the bottom of the ‘New analysis’ page; the project home page is displayed. Click on the triangle next to ‘AHU_UserGuide’ and select ‘Edit copy’ (Figure 49).

Step 4. In the ‘New data map’ page, select ‘Hot Water Distribution System’ as shown in Figure 105.

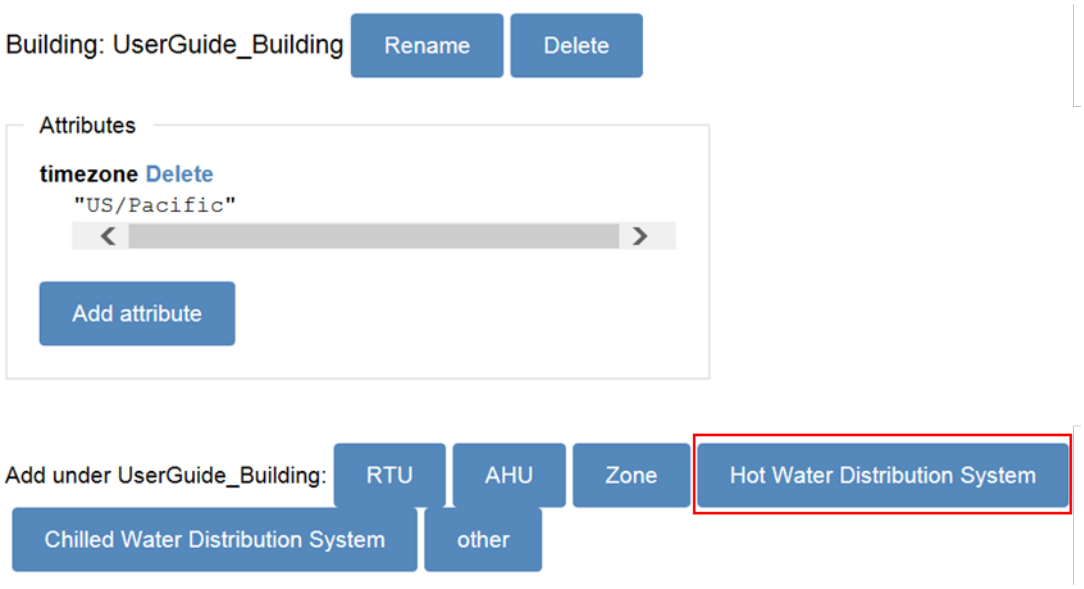


Figure 105. New Data Map Page – Select ‘Hot Water Distribution System’

Step 5. Enter ‘HWS1’ as the name for the new system and click ‘OK’. Under HWS1, click ‘Add sensor’ (Figure 106).

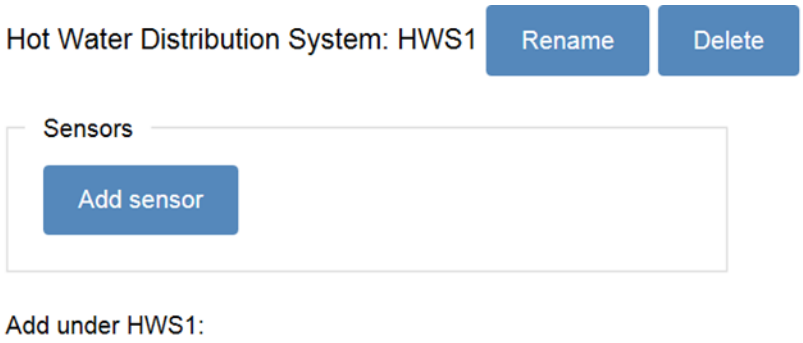


Figure 106. New Data Map Page – Add Sensors for HWS1

Step 6. Follow Steps 4-9 under Section 6.4 to add the following sensors:

- BoilerStatus [status] in ‘OpenEIS’ → BoilerStatus_2 in UserGuide_AHU.csv
- PumpVFDCommand [%] in ‘OpenEIS’ → HotWaterPumpVFDCommand in UserGuide_AHU.csv
- LoopDifferentialPressure [atm] in ‘OpenEIS’ → HotWaterLoopDp in UserGuide_AHU.csv

- LoopDifferentialPressureSetPoint [atm] in ‘OpenEIS’ → HotWaterLoopDpSetPoint in UserGuide_AHU.csv
- SupplyWaterTemperature [Fahrenheit] in ‘OpenEIS’ → HotWaterSupplyTemperature in UserGuide_AHU.csv
- SupplyWaterTemperatureSetPoint [Fahrenheit] in ‘OpenEIS’ → HotWaterSupplyTemperatureSetPoint in UserGuide_AHU.csv
- ReturnWaterTemperature [Fahrenheit] in ‘OpenEIS’ → HotWaterReturnTemperature in UserGuide_AHU.csv
- NaturalGasEnergy [kBtu] in ‘OpenEIS’ → Boiler Gas [kBtu/hr] in UserGuide_WholeBuilding.csv

Step 7. At the bottom of the page, name the data map ‘AHU_UserGuide_HWS’ and click ‘Save’.

Step 8. Follow the steps in Section 7.0 to create a new data set using the data map ‘AHU_UserGuide_HWS’. Name this new data set ‘AHU_UserGuide_HWS’.

Step 9. Follow the steps in Section 8.2 to manipulate the data set’ AHU_UserGuide_HWS’ and apply fill filters for all parameters. Name the new dataset ‘AHU_UserGuide_HWS’.

Step 10. Select ‘Run analysis…’ and choose the dataset ‘AHU_UserGuide_HWS from the drop down menu. The analysis page (Figure 107) now shows no missing inputs for ‘AIRCx for Hot-Water Distributions Systems’ and the corresponding ‘Configure’ button is not greyed out.

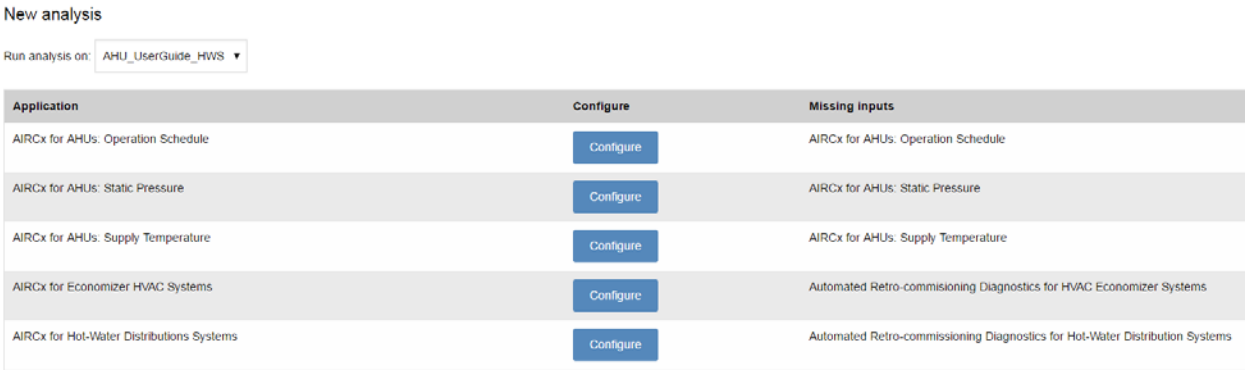


Figure 107. No Missing Inputs for AIRCx for Hot-Water Distributions Systems

Step 11. Click the ‘Configure’ button next to the ‘AIRCx for Hot-Water Distributions Systems’ application to configure the application inputs and set up parameters.

Step 12. The ‘AIRCx for Hot-Water Distributions Systems’ application configuration page is displayed (Figure 108). The application configuration page is divided into two parts: a set of parameters for the application and a set of inputs from the new data set.

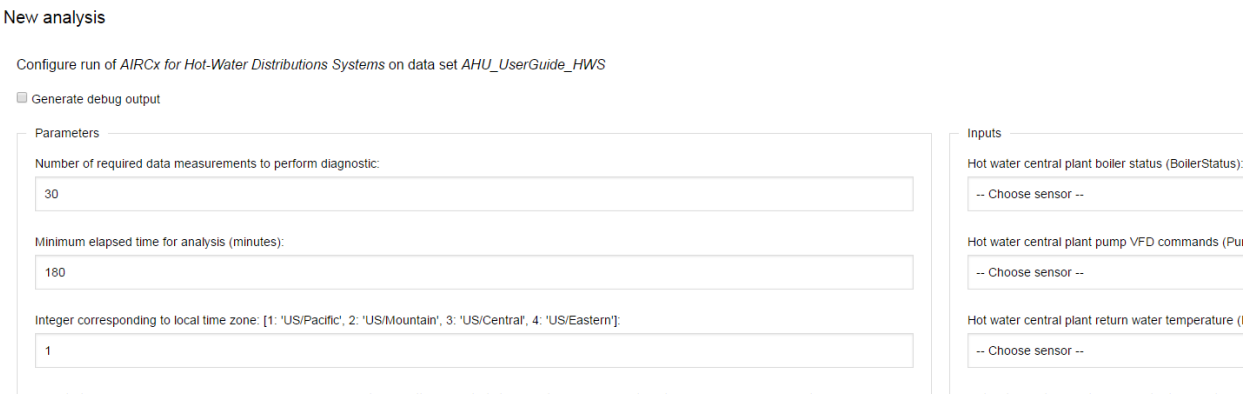


Figure 108. AIRCx for Hot-Water Distributions Systems Application

Step 13. The default configuration parameters for 'AIRCx for Hot-Water Distributions Systems' will automatically propagate into their respective input boxes, but a user can modify these default settings. A description of the parameters associated with this analysis are given in Table 4.

Table 4. AIRCx for Hot-Water Distributions Systems - Parameters

Parameter	Description
Number of required data measurements to perform diagnostic	Minimum number of data measurements to return a conclusive diagnostic check.
Minimum elapsed time for analysis (minutes)	The minimum time frame that the data should cover for successful analysis.
Sensitivity	This value provides a means for determining parameter sensitivity. A high sensitivity will identify more faults but may also lead to false positives. Values can be 0 (low sensitivity), 1 (normal sensitivity), 2 (high sensitivity) or 3 (custom).
Hot-water supply temperature low limit (°F)	Minimum hot-water supply temperature: hot-water supply temperature is outside of configured operation range.
Hot-water supply temperature high limit (°F)	Maximum hot-water supply temperature: hot-water supply temperature is outside of configured operation range.
Hot-water return temperature low limit (°F)	Minimum hot-water return temperature: hot-water return temperature is outside of configured operation range.
Hot-water return temperature high limit (°F)	Maximum hot-water return temperature: hot-water return temperature is outside of configured operation range.
'HW loop Low Delta-T Dx' - desired difference between the hot water supply and return temperatures (°F)	Desired temperature difference between the hot-water supply and return temperature (delta-T).

Parameter	Description
'HW loop Low Delta-T Dx' - threshold for detection of low delta-T for hot water distribution systems	If the temperature difference (delta-T) between the hot-water supply and return temperature is lower than the desired delta-T by this value a fault is identified.
'HW loop Supply Temperature Reset Dx' - the required difference between the minimum and the maximum hot-water supply temperature set point for detection of a hot-water supply temperature set point reset (°F)	If the difference between the minimum and maximum hot-water supply temperature set point (over a pre-determined period, usually 24 hours) is less than this value, a fault is generated.
'HW loop High Supply Temperature Dx' - threshold for the average hot water supply temperature (°F) **	If the average hot water supply temperature exceeds this value, then the hot water supply temperature is too high and the hot water supply temperature set point should be reduced (retuning opportunity).
'HW loop High Supply Temperature Dx' - threshold for the average pump(s) speed command (%) **	If the average speed command for the hot-water distribution system pump(s) exceeds this value, then the hot water supply temperature is too high and the hot water supply temperature set point should be reduced (retuning opportunity).
Hot-water loop differential pressure low limit (psi)	Minimum hot-water loop differential pressure: hot-water loop differential pressure is outside of configured operation range.
Hot-water loop differential pressure high limit (psi)	Maximum hot-water loop differential pressure: hot-water loop differential pressure is outside of configured operation range.
'HW loop Differential Pressure Reset Dx' - the required difference between the minimum and the maximum hot-water loop differential pressure set point for detection of a hot-water loop differential pressure set point reset (psi)	If the difference between the minimum and maximum hot-water loop differential pressure set point (over a pre-determined period, usually 24 hours) is less than this value, a fault is generated.
'HW loop High Differential Pressure Dx' - Pump threshold to determine if the loop differential pressure is too high (%)	If the average speed command for the hot-water distribution system pump(s) is higher than this value, the loop differential pressure is too high and the loop differential pressure set point should be reduced (retuning opportunity).
'HW Differential Pressure Control Loop Dx' and 'HW Supply Temperature Control Loop Dx' - the allowable percent deviation from the set point for the hot-water supply temperature and loop differential pressure	If the percent deviation from set point is greater than this value, a fault is generated.

** The diagnostic check associated with these thresholds is done simultaneously and both must evaluate to a fault condition for conclusive detection of faulty operations.

Step 14. Select the inputs from each drop-down menu. The necessary inputs are displayed with a drop-down menu (similar to Figure 100), while the rest are optional.

Step 15. After all parameters and inputs are selected, click the 'Run' button to run the application (similar to Figure 86).

Step 16. Check the status of the application processing. The status indicates whether the application processing is successful. ‘Complete’ means the application processing completed successfully (similar to Figure 87). If the application does not complete its run, select ‘Download output’ to download and view the error log.

Step 17. Click on the triangle next to the application name under analyses and select ‘View’ from the drop down menu. The output of the application is displayed (Figure 109). To view hourly results for the diagnostic, click on the colored circle icon next to the feature name (similar to Figure 93).

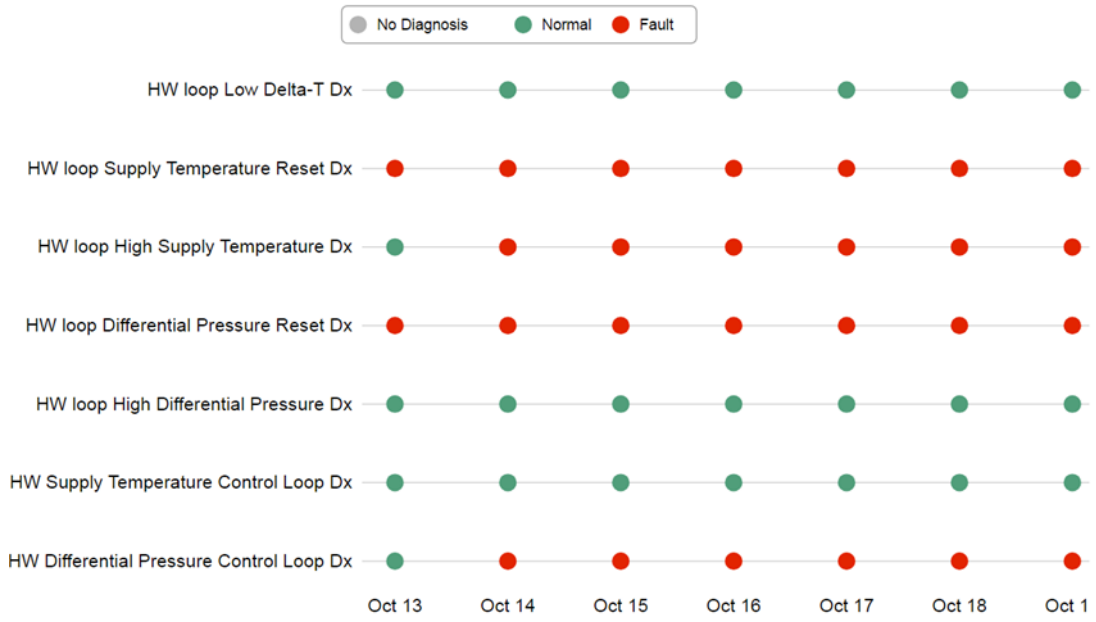


Figure 109. AIRCx for Hot-Water Distributions Systems - Output

11.5 AIRCx for Economizer HVAC Systems

Follow the steps described below to detect, diagnose, and automatically provide diagnostic outputs to problems with outdoor-air ventilation and economizer operations.

Step 1. In the project home page, click ‘Run analysis…’

Step 2. The browser will prompt you for a dataset to run the analysis on. Choose ‘AHU_UserGuide’

Step 3. The ‘New analysis’ page is displayed (Figure 81). If the required data inputs for an application are not available in the selected data set, the OpenEIS will indicate that the application cannot be used. The ‘Configure’ button for the application will be greyed out and the missing inputs will be shown in red text. An application with no missing inputs is displayed with a blue ‘Configure’ button on the left.

Step 4. Click the ‘Configure’ button next to the ‘AIRCx for Economizer HVAC Systems’ application to configure the application inputs and set up parameters.

Step 5. The ‘AIRCx for Economizer HVAC Systems’ application configuration page is displayed (Figure 110). The application configuration page is divided into two parts: a set of parameters for the application and a set of inputs from the new data set.

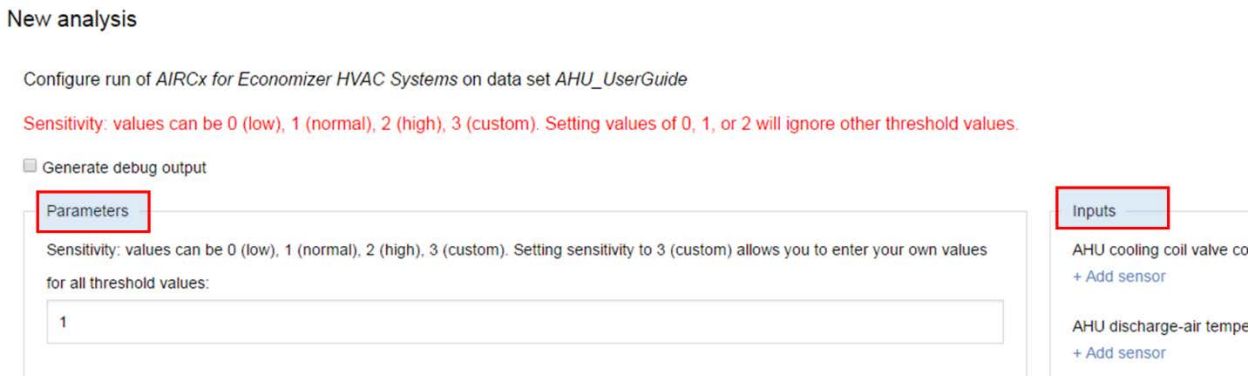


Figure 110. AIRCx for Economizer HVAC Systems Application

Step 6. The default configuration parameters for ‘AIRCx for Economizer HVAC Systems’ will automatically propagate into their respective input boxes, but a user can modify these default settings. The only parameter that does not have a default value is ‘Sensitivity’, which requires the user to set it. Figure 111 shows the configuration menu for ‘AIRCx for Economizer HVAC Systems’. A description of the parameters associated with this analysis are given in Table 5.

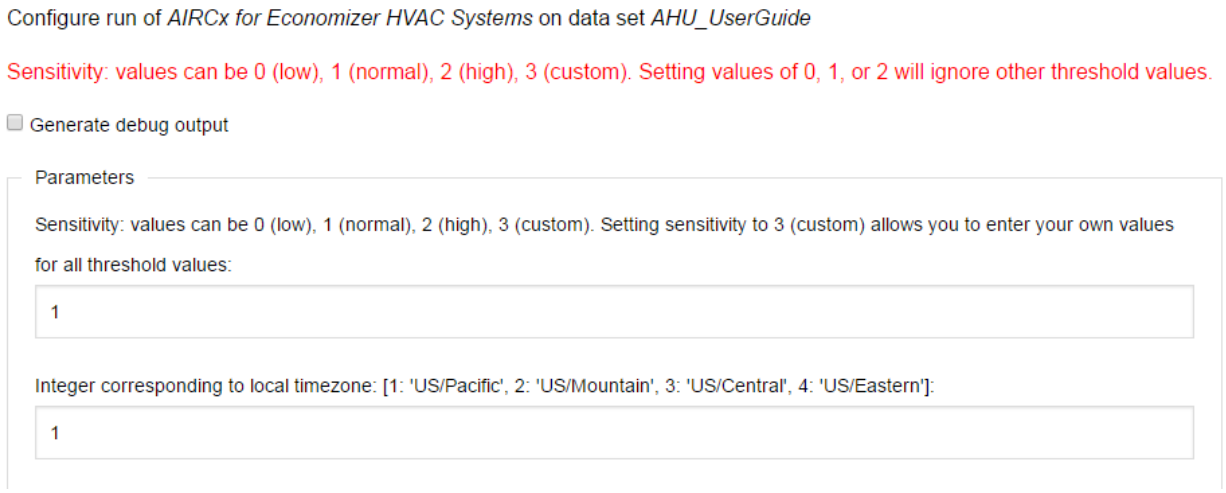


Figure 111. AIRCx for Economizer HVAC Systems - Input Configuration

Table 5. AIRCx for Economizer HVAC Systems - Parameters

Parameter	Description
Sensitivity	This value provides a means for determining parameter sensitivity. A high sensitivity will identify more faults but may also lead to false positives. Values can be 0 (low sensitivity), 1 (normal sensitivity), 2 (high sensitivity) or 3 (custom).

Parameter	Description
Integer corresponding to local time zone	1: US/Pacific 2: US/Mountain 3: US/Central 4: US/Eastern
Minimum elapsed time for analysis (minutes)	The minimum time frame that the data should cover for successful analysis.
Minimum number of data measurements	Number of required data measurements to perform diagnostic.
Device type - RTU or AHU (default=AHU)	The device type the diagnostic data is being trended from. Roof top units (RTUs) use a vapor compression cycle and air-handling units (AHUs) use a chilled water coil to temper air.
Economizer type - differential dry bulb (DDB) or High limit set point (HL)	DDB - economizing configured to disable when the outdoor-air temperature is greater than the return-air temperature. HL - economizing configured to disable when the outdoor-air temperature is greater than a set point value (the high limit value).
High limit (HL) temperature set point for HL type economizer (°F)	The outdoor temperature above which the unit is configured to stop economizing. If the unit utilizes a DDB type economizer this parameter is ignored.
Economizer control temperature dead-band (°F)	DDB economizer: The diagnostic will consider conditions favorable for economizing when the outdoor-air temperature is lower than then return-air temperature by this value. HL economizer: The diagnostic will consider conditions favorable for economizing when the outdoor-air temperature is lower than then HL temperature by this value.
AHU/RTU rated Energy Efficiency Ratio (EER)	Rated Energy Efficiency Ratio for the AHU/RTU.
Rated CFM of supply fan at 100% supply fan speed (CFM)	Rated CFM of supply fan at 100% speed provided from AHU/RTU specifications.
Required difference between outdoor-air and return-air temperatures for an accurate diagnostic (°F)	If the outdoor-air and return-air temperatures are too close the diagnostics cannot produce reliable results. This value helps eliminate data where conditions are not favorable for the diagnostic process (recommended minimum value 5°F).
Minimum AHU chilled water valve position for determining if the AHU is in a cooling mode (%)	Amount AHU chilled water valve must be open to consider unit in cooling mode. If device is an RTU the compressor status command is used and this parameter is ignored.
'Temperature Sensor Dx' - Threshold for detecting temperature sensor problems (°F)	Threshold for the amount the mixed-air temperature must exceed both the outside- and return-air temperatures or fall below both the outside- and return-air temperatures for detection of temperature sensor inconsistencies.

Parameter	Description
Mixed-air temperature sensor low limit (°F)	Minimum expected reading for the mixed-air temperature sensor. If the average mixed-air temperature is below this value a fault is generated.
Mixed-air temperature sensor high limit (°F)	Maximum expected reading for the mixed-air temperature sensor. If the average mixed-air temperature exceeds this value a fault is generated.
Return-air temperature sensor low limit (°F)	Minimum expected reading for the return-air temperature sensor. If the average return-air temperature is below this value a fault is generated.
Return-air temperature sensor high limit (°F)	Maximum expected reading for the return-air temperature sensor. If the average return-air temperature exceeds this value a fault is generated.
Outdoor-air temperature sensor low limit (°F)	Minimum expected reading for the outdoor-air temperature sensor. If the average outdoor-air temperature is below this value a fault is generated.
Outdoor-air temperature sensor high limit (°F)	Maximum expected reading for the outdoor-air temperature sensor. If the average outdoor-air temperature exceeds this value a fault is generated.
'Temperature Sensor Dx' - Threshold value for temperature difference between outdoor-air temperature and mixed-air temperature reading when the outdoor-air damper is near 100% open (°F)	If average difference between outdoor-air and mixed-air temperatures exceeds this value when the outdoor-air damper is near 100% open, a fault is generated.
'Economizing When Unit Should Dx' - Threshold for the outdoor-air damper position when conditions are favorable for economizing - value above which the damper is considered open for economizing (%)	If the average outdoor-air damper position is less than this value when conditions are favorable for economizing and the AHU/RTU is cooling, then a fault is generated.
'Economizing When Unit Should Dx' - Value below 100% in which the outdoor-air fraction as a percent is considered insufficient for economizing (%)	When economizing the outdoor-air fraction (percent) should be near 100%. If the calculated outdoor-air fraction is below 100% by this value, a fault is generated.
Minimum outdoor-air damper set point (%)	Minimum position for outdoor-air damper, when not economizing (%).
'Economizing When Unit Should Not Dx' - Threshold value above the minimum outdoor-air damper set point at which a fault will be identified - when conditions are not favorable for economizing or the AHU/RTU is not cooling (%)	If the average outdoor-air damper position exceeds the outdoor-air damper position minimum set point by this value while in ventilation mode (not cooling) or when conditions are not favorable for economizing a fault will be generated.
The desired minimum outdoor-air fraction as a percent (%)	The desired minimum outdoor-air fraction as a percent when the AHU/RTU is not economizing.
'Excess Outdoor-air Intake Dx' - Threshold value above the desired minimum outdoor-air fraction as a percent where a fault will be indicated, when AHU/RTU is not economizing (%)	If the average outdoor-air fraction as a percent is higher than the desired minimum outdoor-air fraction when the AHU/RTU is not economizing then a fault will be generated.
'Insufficient Outdoor-air Intake Dx' - Threshold value below the minimum outdoor-air damper set point at which a fault will identified (%)	If the average outdoor-air damper position is lower than the minimum outdoor-air damper position by this value, a fault is generated.

Parameter	Description
'Insufficient Outdoor-air Intake Dx' - The value below the desired minimum outdoor-air fraction (percent) where a fault will be identified (%)	If the average outdoor-air fraction (percent) is lower than the desired minimum outdoor-air fraction by this value insufficient outdoor air is being provided for ventilation, and a fault will be generated.

Step 7. Select the inputs from each drop-down menu. Click the 'Add sensor' under the input 'CoolingCall' and select the 'UserGuide_Building/AHU8/CoolingCall' (Figure 112). Repeat this for all relevant input sensors.

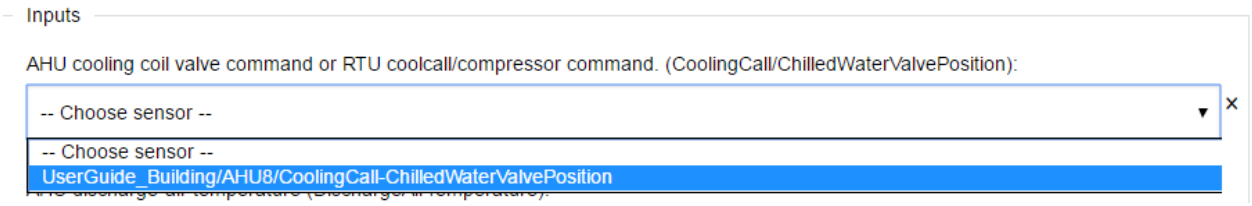


Figure 112. 'Add Sensor' for 'CoolingCall'

Step 8. The necessary inputs are displayed with a drop-down menu (Figure 113), while the rest are optional.

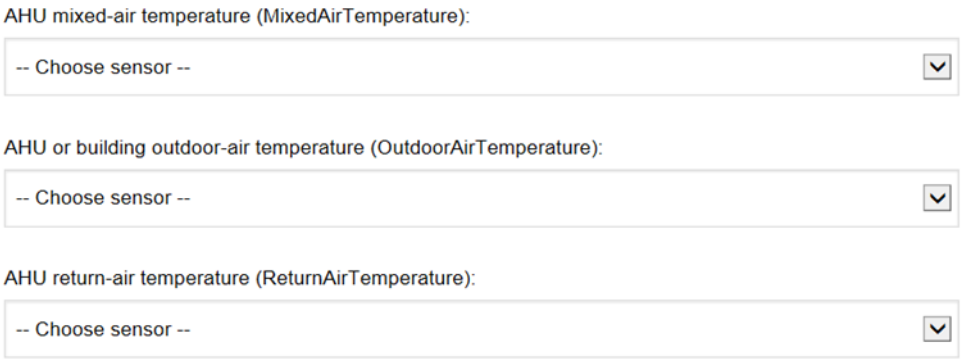


Figure 113. AIRCx for Economizer HVAC Systems Application Necessary Inputs

Step 9. After all parameters and inputs are selected, click the 'Run' button to run the application (Figure 114).

Figure 114. 'Run' Application

Step 10. Check the status of the application processing. The status indicates whether the application processing is successful. ‘Complete’ means the application processing completed successfully (Figure 87). If the application does not complete its run, select ‘Download output’ to download and view the error log.

Step 11. Click on the triangles next to the application name under analyses and select ‘View’ from the drop down menu. The output of the application is displayed and has two tabs: ‘data’ and ‘analysis’. The data tab displays graphs of all the sensors that were selected as inputs for the applications (Figure 115).

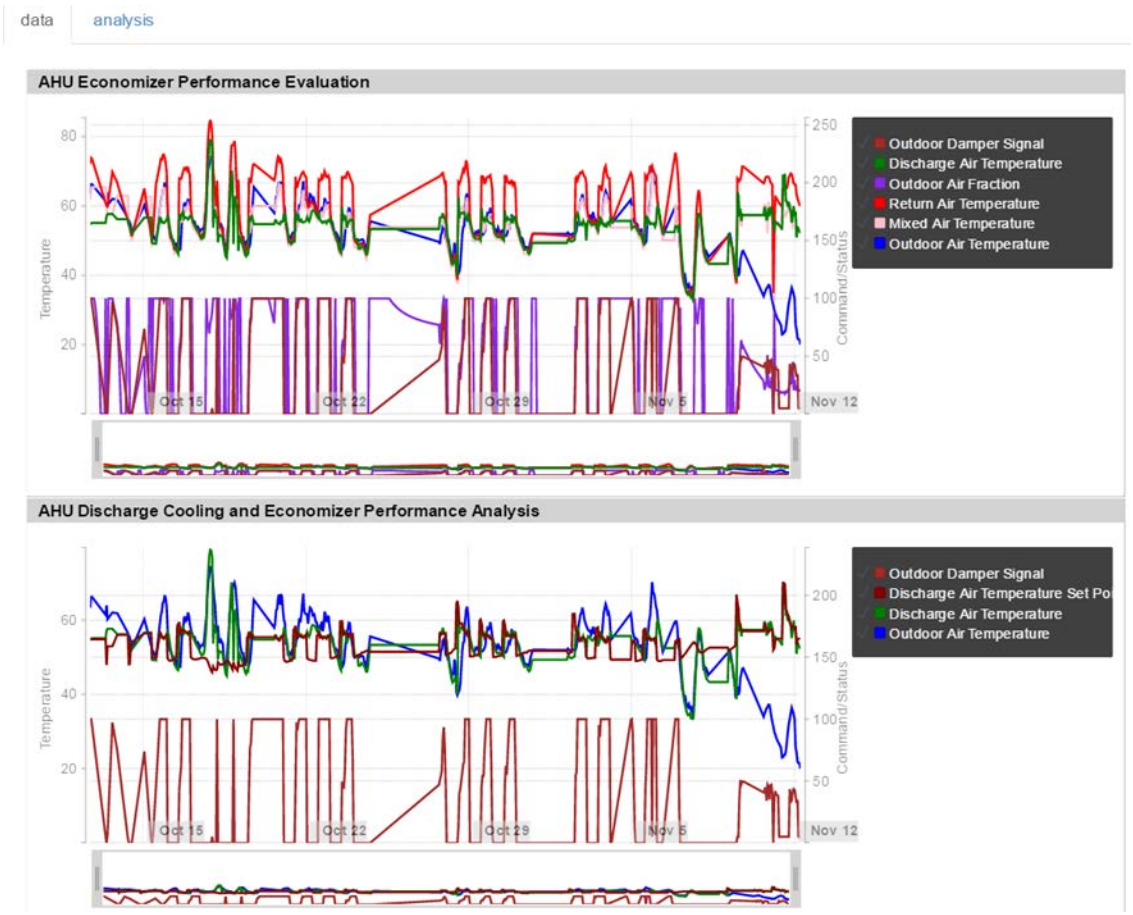


Figure 115. AIRCx for Economizer HVAC Systems – Output: Data Tab

Step 12. Click the ‘analysis’ tab to view the diagnostic results. For more detailed results, move the cursor over any of the circular colored icons. Figure 116 shows the daily results message for the ‘Automated retro-commissioning for HVAC economizer systems’ diagnostic ‘Economizing when unit should not Dx’.

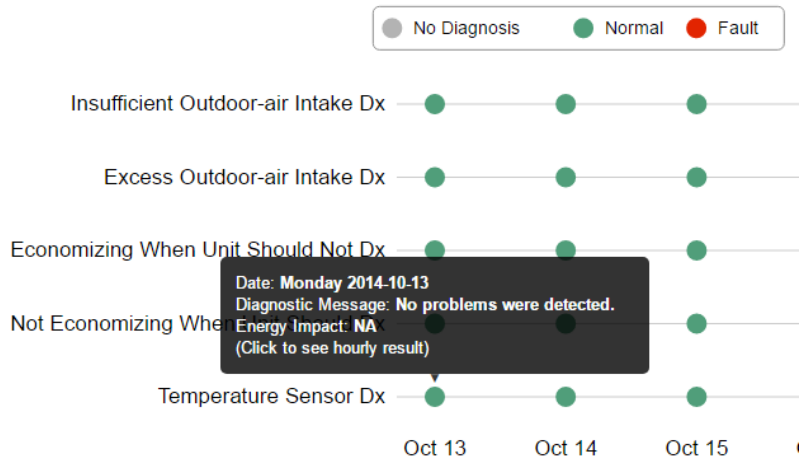


Figure 116. AIRCx for Economizer HVAC Systems - Daily Diagnostic Output

Step 13. To view hourly results for the diagnostic, click on the colored circle icon next to the feature name. See Figure 93 for an example screenshot of 'Automated retro-commissioning for HVAC economizer systems' hourly results. The hourly diagnostic bar graph is displayed to help analyze trends and patterns.

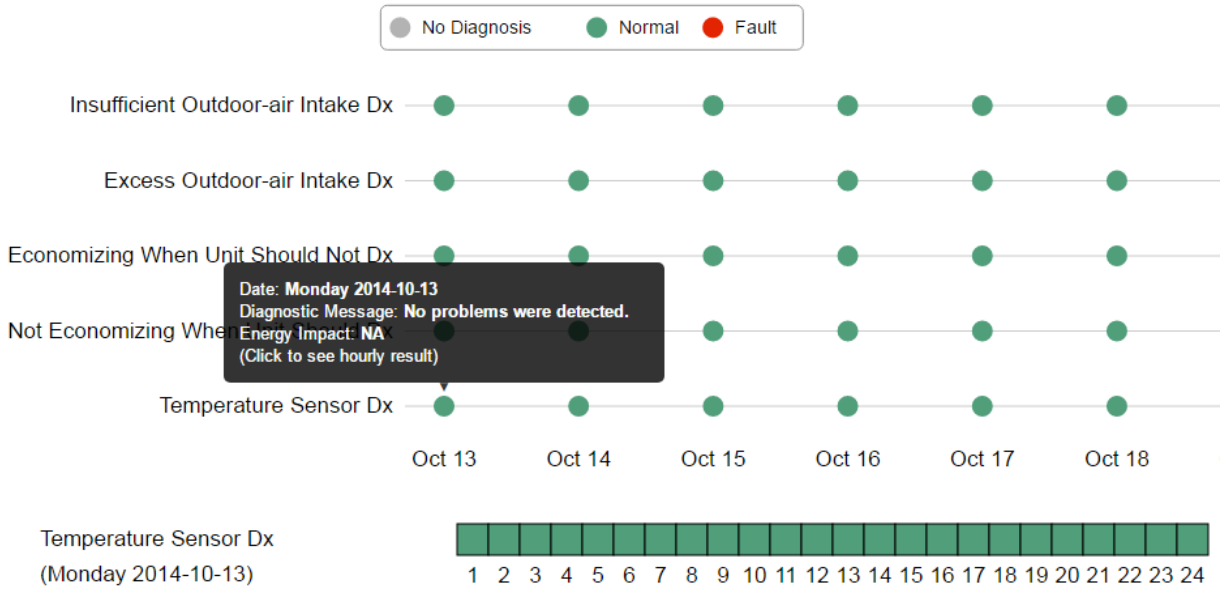


Figure 117. AIRCx for Economizer HVAC Systems - Hourly Diagnostic Output

Step 14. Click on the bar graph. The detailed hourly diagnostic message is displayed (Figure 94).

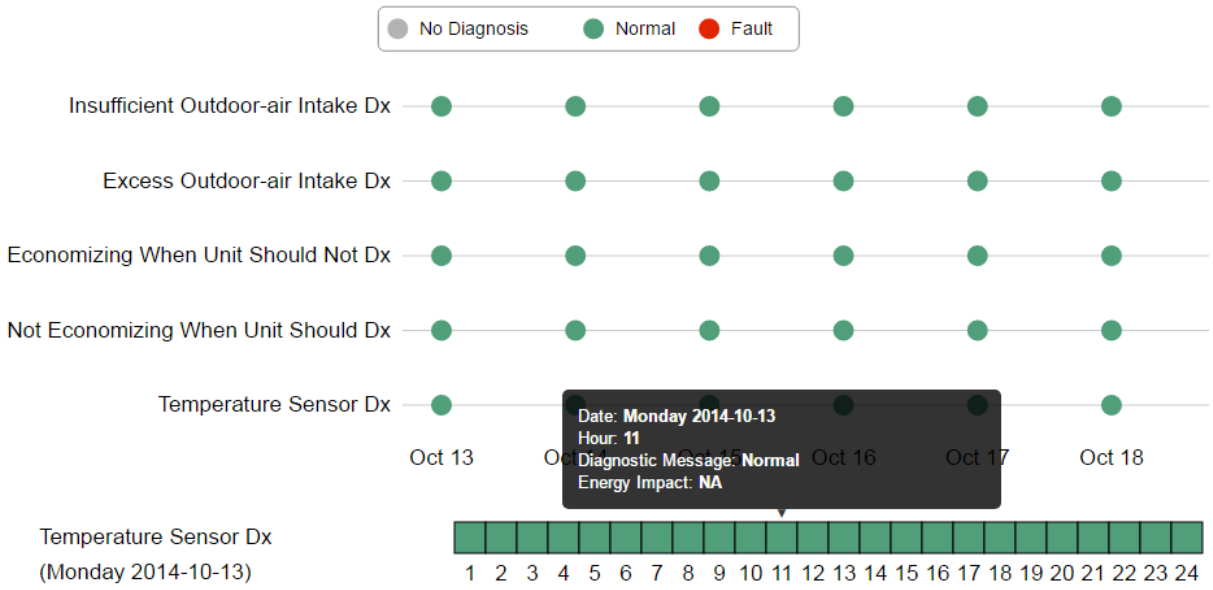


Figure 118. AIRCx for Economizer HVAC Systems - Hourly Diagnostic Output at 11 A.M.

11.6 Compressor Cycling Diagnostic

A problem associated with RTUs is short cycling, an operational mode during which an RTU goes through ON and OFF cycles too frequently. This application quantifies the number of times an RTU is ON cycling or OFF cycling in a given time period.

Follow the steps described below to run the ‘‘Compressor Cycling’ application. For this application, use the data file ‘UserGuide_setpoint.csv’ included in the installation package. Use instructions in Sections 6.0 and 7.0 to map the following points under a new RTU named ‘RTU1’ (Figure 119).

- ZoneAirTemperature [Fahrenheit] in ‘OpenEIS’ → SpaceTemp in UserGuide_setpoint.csv
- ZoneAirTemperatureSetPoint [Fahrenheit] in ‘OpenEIS’ → ActVlgStpt in UserGuide_setpoint.csv
- SupplyFanStatus [status] in ‘OpenEIS’ → SupplyAirTemp in UserGuide_setpoint.csv

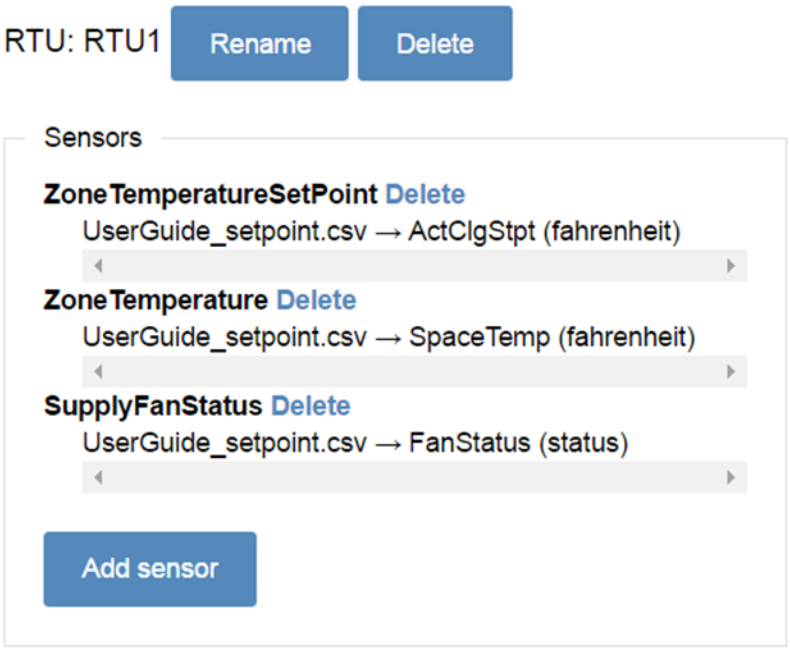


Figure 119. Data Mapping for Dataset 'Setpoint_RTU'

After mapping this data, create its corresponding dataset and name it 'Setpoint_RTU'.

Step 1. In the project home page, click 'Run analysis…'

Step 2. The browser will prompt you for a dataset to run the analysis on. Choose 'SetpointMap_RTU'

Step 3. The 'New analysis' page is displayed (Figure 81). If the required data inputs for an application are not available in the selected data set, the OpenEIS will indicate that the application cannot be used. The 'Configure' button for the application will be greyed out and the missing inputs will be shown in red text. An application with no missing inputs is displayed with a blue 'Configure' button on the left.

Step 4. Click the 'Configure' button next to the 'Compressor Cycling' application to configure the application inputs and set up parameters. A description of the parameters associated with this analysis are given in Table 6.

Table 6. Compressor Cycling Application - Parameters

Parameter	Description
Minimum number of observations for analysis	The number of required data measurements to detect a temperature setpoint change.
Sensitivity	This value provides a means for determining parameter sensitivity. A high sensitivity will identify more faults but may also lead to false positives. Values can be 0 (low sensitivity), 1 (normal sensitivity), 2 (high sensitivity) or 3 (custom).

Step 5. The ‘Compressor Cycling’ application configuration page is displayed (Figure 120). Change the default parameters values if required. Select the input sensors from the drop down menus, and click ‘Run’.

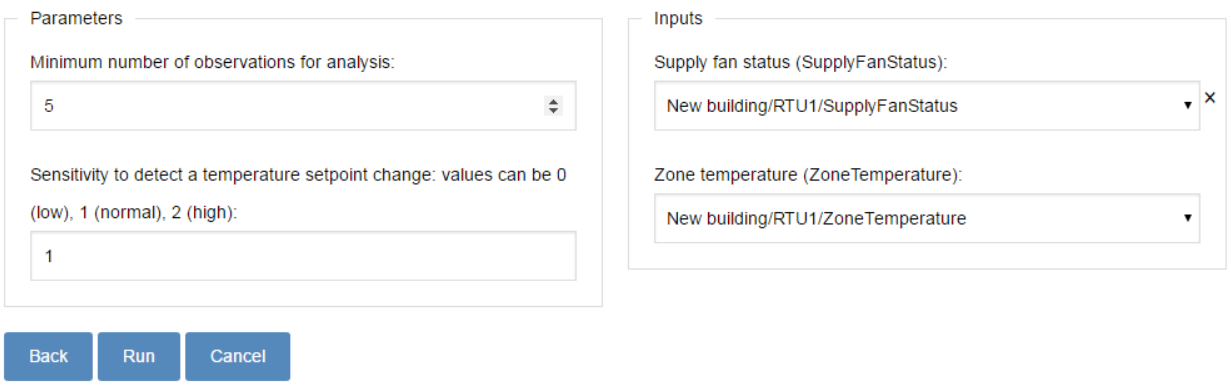


Figure 120. Compressor Cycling Application Configuration

Step 6. Check the status of the application processing. The status indicates whether the application processing is successful. ‘Complete’ means the application processing completed successfully (Figure 87). If the application does not complete its run, select ‘Download output’ to download and view the error log.

Step 7. Click on the triangles next to the application name under analyses and select ‘View’ from the drop down menu. The output of the application (Figure 121) is a time series graph of the zone temperature set-point, zone temperature sensor measurements and fan status (if selected as input). The modifications described in Steps 3 and 4 of Section 10.0 can be applied to this output as well.

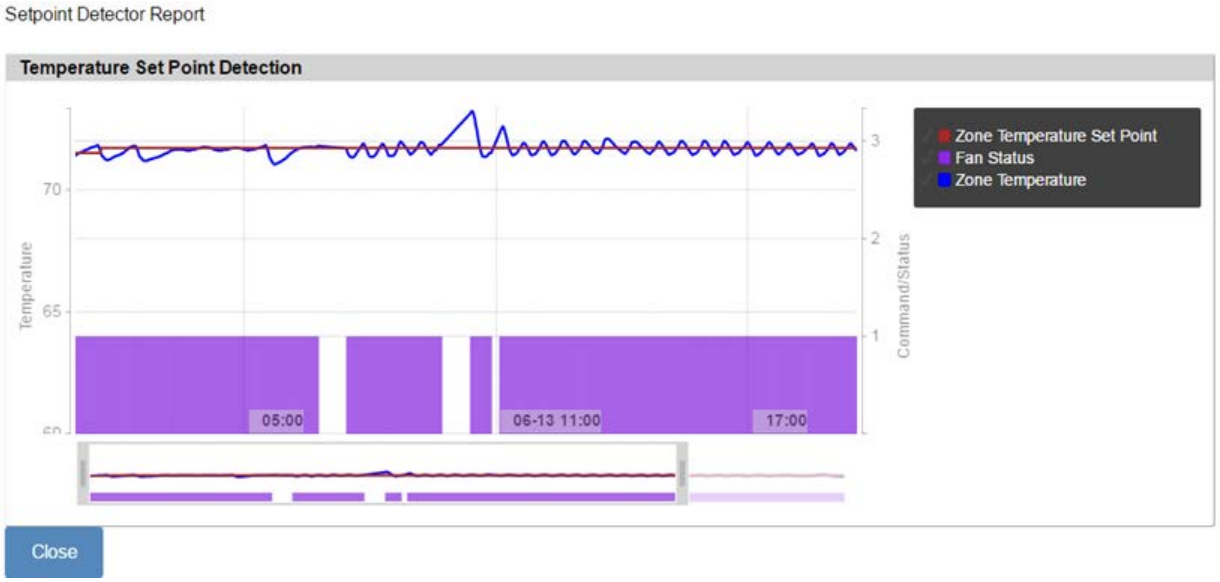


Figure 121. ‘Temperature Setpoint Detector’ Application – Output

11.7 Daily Summary

Follow the steps described below to run the 'Daily Summary' application for a summary of daily energy usage. Metrics included in the application are load variability, load minimum and maximum, peak load benchmark, daily load ratio, and daily load range.

Step 1. In the project home page, click 'Run analysis…'

Step 2. The browser will prompt you for a dataset to run the analysis on. Choose 'AHU_UserGuide'

Step 3. The 'New analysis' page is displayed (Figure 81). If the required data inputs for an application are not available in the selected data set, the OpenEIS will indicate that the application cannot be used. The 'Configure' button for the application will be greyed out and the missing inputs will be shown in red text. An application with no missing inputs is displayed with a blue 'Configure' button on the left.

Step 4. Click the 'Configure' button next to the 'Daily Summary' application to configure the application inputs and set up parameters.

Step 5. The 'Daily Summary' application configuration page is displayed (Figure 83). The application has two parameters and one input. Enter '1000' (or the actual area) for 'Square footage' parameter', select the input sensor (UserGuid_Building/WholeBuilding) from the drop down menu, and click 'Run'.

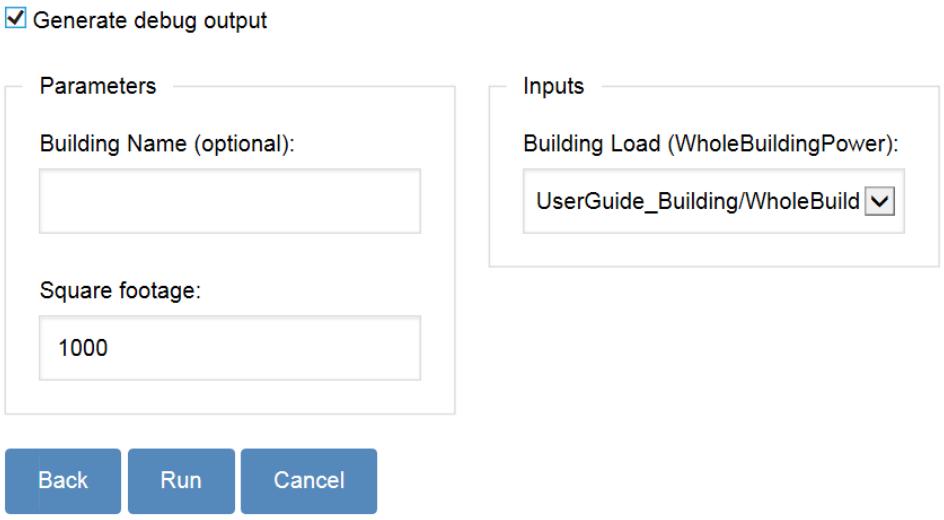


Figure 122. Daily Summary Application Configuration

Step 6. Check the status of the application processing. The status indicates whether the application processing is successful. 'Complete' means the application processing completed successfully. If the application does not complete its run, select 'Download output' to download and view the error log. Click on the triangle next to the completed daily summary and select 'View'.

Step 7. A sample output of the 'Daily Summary' application is show in Figure 122.

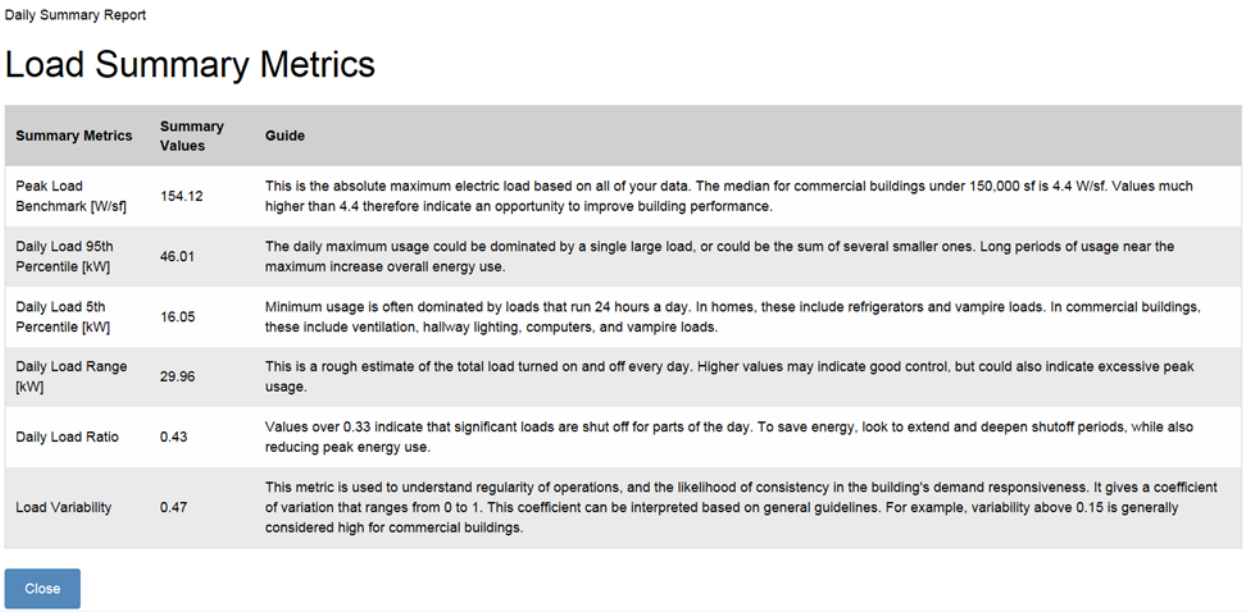


Figure 123. Daily Summary Application – Output

11.8 Visualization for AHU HVAC Systems

Follow the steps described below to run the 'Visualization for AHU HVAC Systems' application to display time-series graphs for data associated with the AHUs in the building.

Step 1. In the project home page, click 'Run analysis…'

Step 2. The browser will prompt you for a dataset to run the analysis on. Choose 'AHU_UserGuide'

Step 3. The 'New analysis' page is displayed (Figure 81). If the required data inputs for an application are not available in the selected data set, the OpenEIS will indicate that the application cannot be used. The 'Configure' button for the application will be greyed out and the missing inputs will be shown in red text. An application with no missing inputs is displayed with a blue 'Configure' button on the left.

Step 4. Click the 'Configure' button next to the 'Visualization for AHU HVAC Systems' application to configure the application inputs and set up parameters.

Step 5. The 'Visualization for AHU HVAC Systems' application configuration page is displayed (Figure 83). The application has no parameters. Mandatory inputs are provided with a drop-down menu by default; for optional sensors, click '+Add sensor' to activate the drop-down menu. Select the appropriate input sensors from the drop down menus, and click 'Run'.

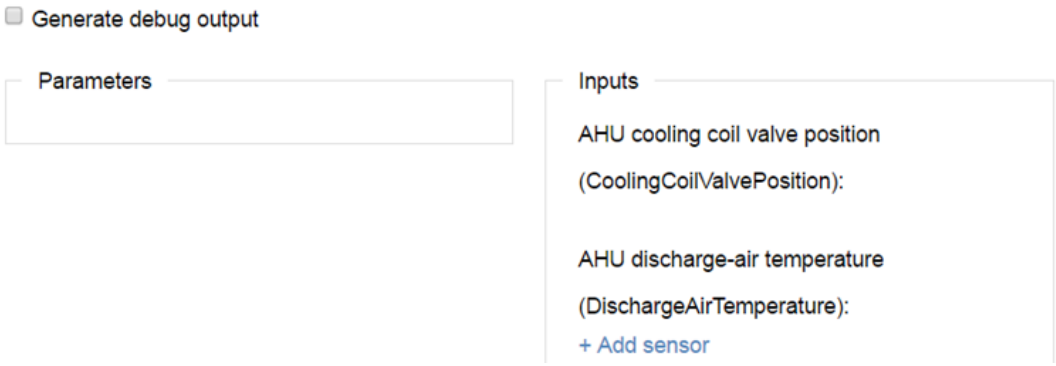


Figure 124. Visualization for AHU HVAC Systems Application

Step 6. Check the status of the application processing. The status indicates whether the application processing is successful. 'Complete' means the application processing completed successfully. If the application does not complete its run, select 'Download output' to download and view the error log.

Step 7. Click on the triangle next to the completed Visualization for AHU HVAC Systems application and select 'View'.

Step 8. The 'Visualization for AHU HVAC Systems' results (Figure 89) are displayed. If a graph is empty, it indicates that the corresponding input sensor was not provided for the analyses.

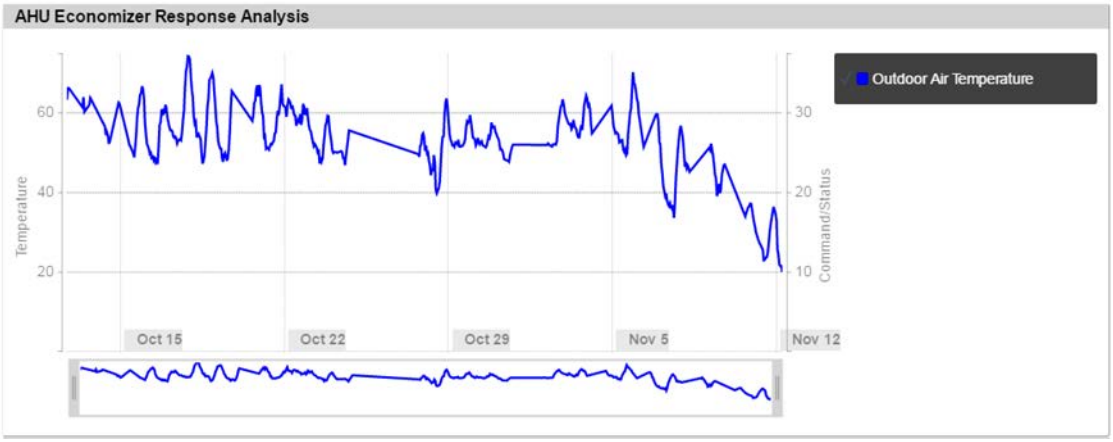


Figure 125. 'Visualization for AHU HVAC Systems' Results

Step 9. The graphs can be modified by the user according to their need. The specific parameters can be selected/deselected from the legend. A tick against a legend entry indicates that the corresponding graph is included. Clicking on it would deselect the entry; the corresponding graph would disappear and the legend entry would be greyed out. An example screenshot is shown in Figure 94 where 'Outdoor Air Temperature' is deselected as compared to where it is selected in Figure 93.

Step 10. The time frame for displaying results can be adjusted using the window below the graph as highlighted in yellow in Figure 95. Click on the vertical edges of the window and drag sideways

for adjusting displayed time frame. The window can also be moved as a whole for further adjustment.

11.9 Energy Signature and Weather Sensitivity

Follow the steps described below to run the 'Energy Signature and Weather Sensitivity' analysis. Energy signatures are used to monitor and maintain the performance of temperature-dependent loads such as whole-building electric or gas use, or heating and cooling systems or components. Weather sensitivity is a single summary statistic that contextualizes the shape of the energy signature.

Step 1. In the project home page, click 'Run analysis…'

Step 2. The browser will prompt you for a dataset to run the analysis on. Choose 'AHU_UserGuide'

Step 3. The 'New analysis' page is displayed (Figure 81). If the required data inputs for an application are not available in the selected data set, the OpenEIS will indicate that the application cannot be used. The 'Configure' button for the application will be greyed out and the missing inputs will be shown in red text. An application with no missing inputs is displayed with a blue 'Configure' button on the left.

Step 4. Click the 'Configure' button next to the 'Energy Signature and Weather Sensitivity' application to configure the application inputs and set up parameters.

Step 5. The 'Energy Signature and Weather Sensitivity' application configuration page is displayed (Figure 126). The application has one parameter and two inputs. Select the input sensors from the drop down menus, and click 'Run'.

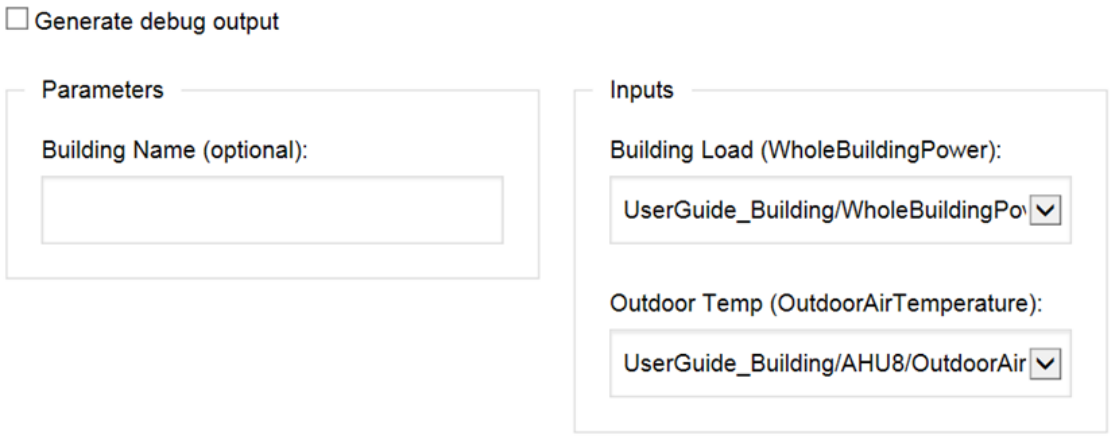


Figure 126. Energy Signature and Weather Sensitivity Application

Step 6. Check the status of the application processing. The status indicates whether the application processing is successful. 'Complete' means the application processing completed successfully. If the application does not complete its run, select 'Download output' to download and view the error log. Click on the triangles next to the application name under analyses and select 'View' from the drop down menu (Figure 83).

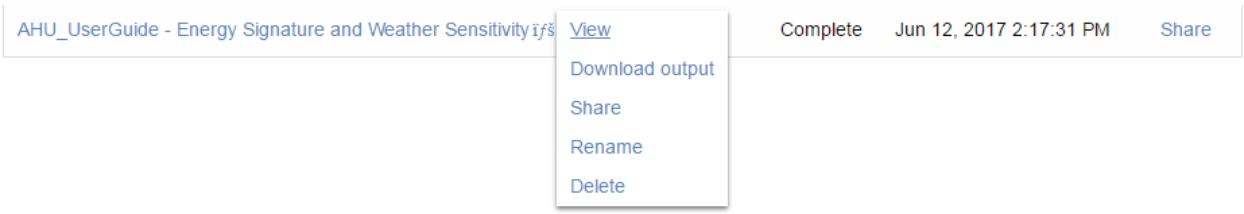


Figure 127. Energy Signature and Weather Sensitivity Application

Step 7. A sample output of the 'Daily Summary' application is shown in Figure 128.

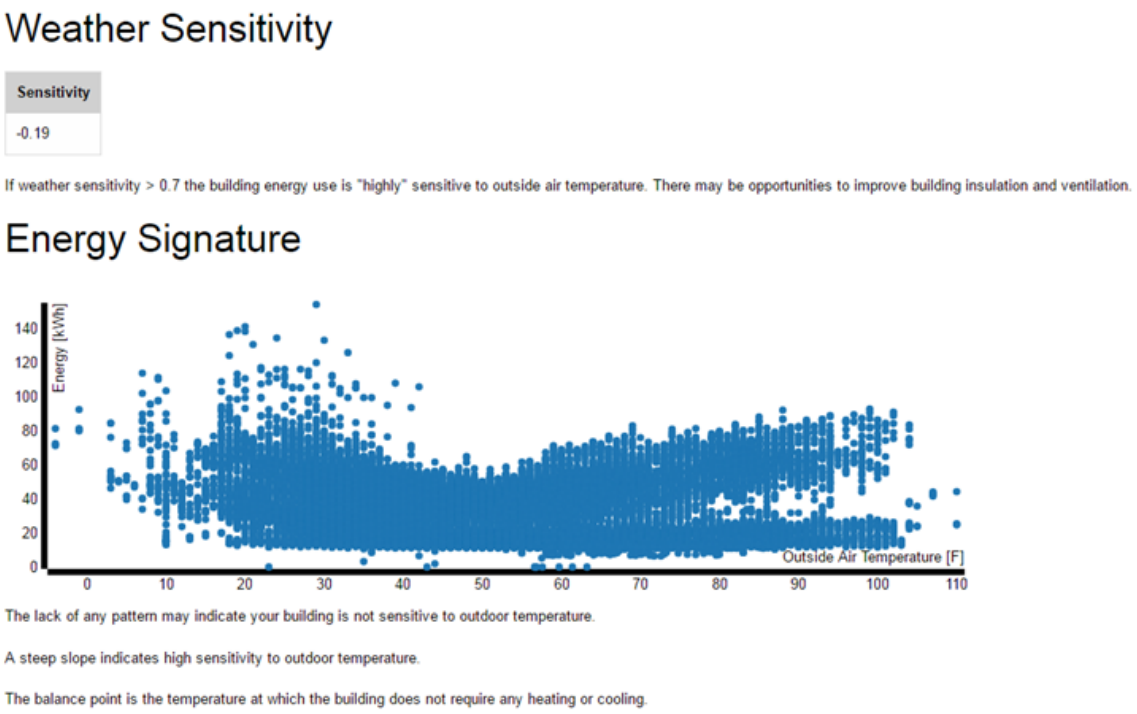


Figure 128. Energy Signature and Weather Sensitivity - Output

11.10 Example Driver Application - Electricity Map

Follow the steps described below to run the 'Example Driver Application - Electricity Map' application. Electricity maps are a means of visualizing and presenting a time series profile of Whole Building Electricity calculations. The maps color-code the size of the load so that hot spots and patterns are easily identified.

Step 1. In the project home page, click 'Run analysis…'

Step 2. The browser will prompt you for a dataset to run the analysis on. Choose 'AHU_UserGuide'

Step 3. The 'New analysis' page is displayed (Figure 81). If the required data inputs for an application are not available in the selected data set, the OpenEIS will indicate that the application cannot be used. The 'Configure' button for the application will be greyed out and the missing inputs will

be shown in red text. An application with no missing inputs is displayed with a blue ‘Configure’ button on the left.

Step 4. Click the ‘Configure’ button next to the ‘Example Driver Application - Electricity Map’ application to configure the application inputs and set up parameters.

Step 5. The ‘Example Driver Application - Electricity Map’ application configuration page is displayed (Figure 129). The application has one parameter and one input. Select the input sensor from the drop down menu, and click ‘Run’.

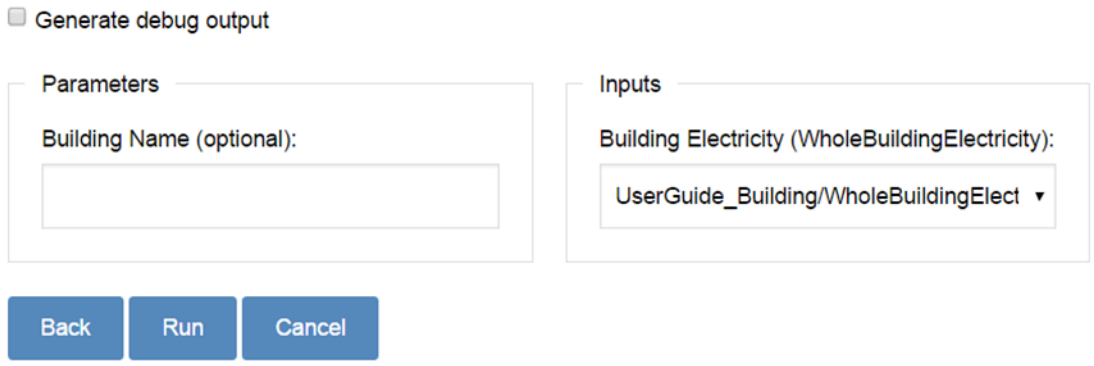


Figure 129. Example Driver Application - Electricity Map Application

Step 6. Check the status of the application processing. The status indicates whether the application processing is successful. ‘Complete’ means the application processing completed successfully. If the application does not complete its run, select ‘Download output’ to download and view the error log. Click on the triangles next to the application name under analyses and select ‘View’ from the drop down menu.

Step 7. The building energy electricity map is displayed. The left side of the graph shows the corresponding date and the top side shows the corresponding hour for every graph entry (Figure 130).

Figure 130. Electricity Map Output

Step 8. Scroll to the bottom of the graph to see details on the color scheme and what they represent (Figure 131).

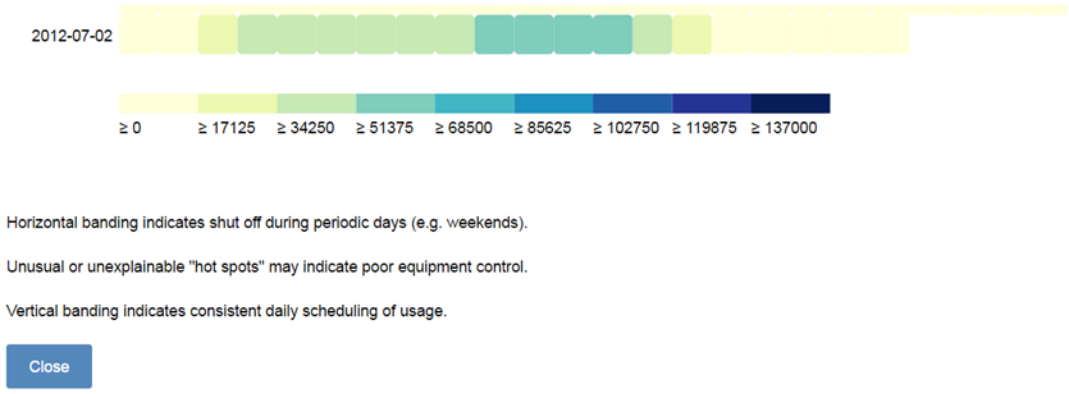


Figure 131. Color Scheme Details - Electricity Map Output

11.11 Heat Map

Follow the steps described below to run the 'Heat Map' application. Heat maps are a means of visualizing and presenting the information that is contained in a time series load profile. The maps color-code the size of the load so that hot spots and patterns are easily identified.

Step 1. In the project home page, click 'Run analysis…'

Step 2. The browser will prompt you for a dataset to run the analysis on. Choose 'AHU_UserGuide' as data set.

Step 3. The 'New analysis' page is displayed. If the required data inputs for an application are not available in the selected data set, the OpenEIS will indicate that the application cannot be used. The 'Configure' button for the application will be greyed out and the missing inputs will be shown in red text. An application with no missing inputs is displayed with a blue 'Configure' button on the left.

Step 4. Click the 'Configure' button next to the 'Heat Map' application to configure the application inputs and set up parameters.

Step 5. The 'Heat Map' application configuration page is displayed (Figure 132). The application has one parameter and one input. Select the input sensor from the drop down menu, and click 'Run'.

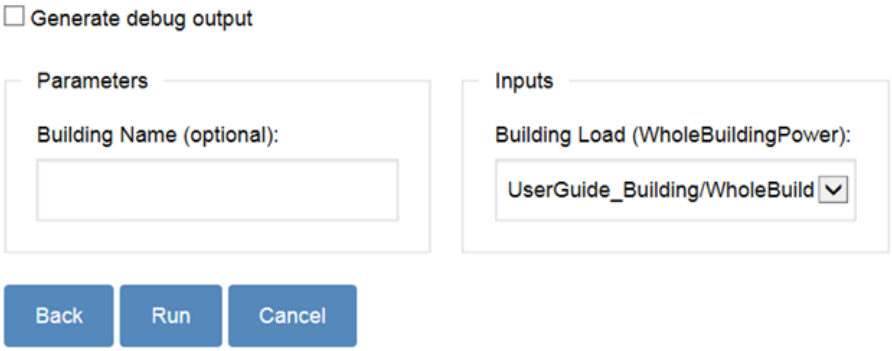


Figure 132. Heat Map Application - Configuration

Step 6. Check the status of the application processing. The status indicates whether the application processing is successful. 'Complete' means the application processing completed successfully. If the application does not complete its run, select 'Download output' to download and view the error log. Click on the triangles next to the application name under analyses and select 'View' from the drop down menu.

11.12 Hot Water Plant Data Visualization

Follow the steps described below to run the 'Hot Water Plant Data Visualization' application. This application displays time-series graphs for data associated with the hot water system.

Step 1. In the project home page, click 'Run analysis…'

Step 2. The browser will prompt you for a dataset to run the analysis on. Choose the dataset 'AHU_UserGuide_HWS' created in Section 11.3.

Step 3. The 'New analysis' page is displayed. If the required data inputs for an application are not available in the selected data set, the OpenEIS will indicate that the application cannot be used. The 'Configure' button for the application will be greyed out and the missing inputs will be shown in red text. An application with no missing inputs is displayed with a blue 'Configure' button on the left.

Step 4. Click the 'Configure' button next to the 'Hot Water Plant Data Visualization' application to configure the application inputs and set up parameters.

Step 5. The 'Hot Water Plant Data Visualization' application configuration page is displayed (Figure 133). The application has no parameters. Select the input sensors from the drop down menus, and click 'Run'.

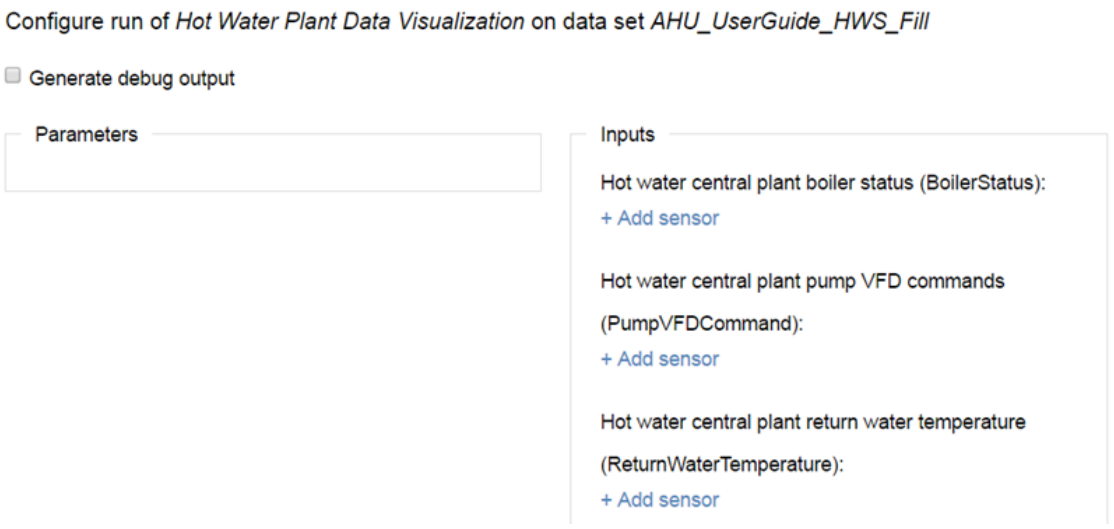


Figure 133. Hot Water Plant Data Visualization Application

Step 6. Check the status of the application processing. The status indicates whether the application processing is successful. 'Complete' means the application processing completed successfully. If the application does not complete its run, select 'Download output' to download and view the error log. Click on the triangles next to the application name under analyses and select 'View' from the drop down menu.

Step 7. The output displays time series graphs on the data from all sensors defined as inputs for the application (Figure 134).

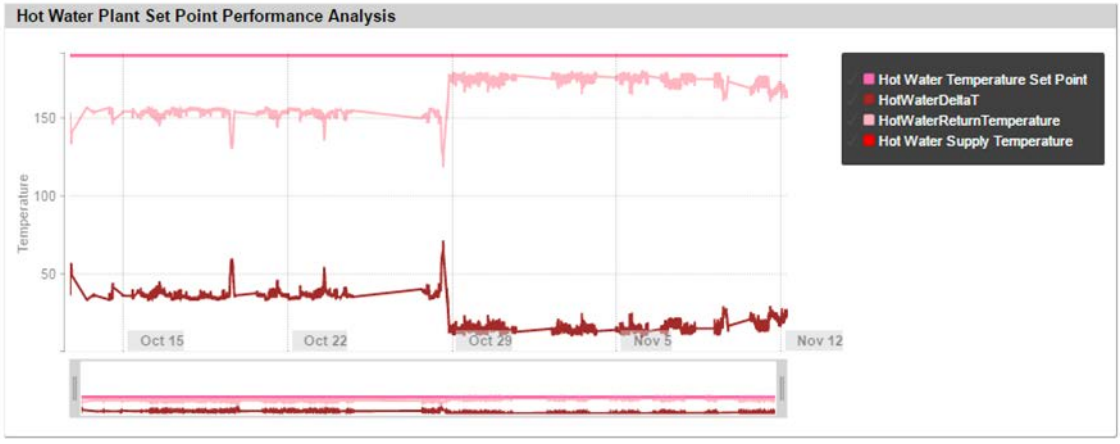


Figure 134. Hot Water Plant Data Visualization Application Output

11.13 Load Duration Curves

Follow the steps described below to run the 'Load Duration Curves' application. Load duration curves are used to understand the number of hours or percentage of time during which the building load is at or below a certain value.

Step 1. In the project home page, click 'Run analysis…'

Step 2. The browser will prompt you for a dataset to run the analysis on. Choose ‘AHU_UserGuide’ as the data set.

Step 3. The ‘New analysis’ page is displayed (Figure 81). If the required data inputs for an application are not available in the selected data set, the OpenEIS will indicate that the application cannot be used. The ‘Configure’ button for the application will be greyed out and the missing inputs will be shown in red text. An application with no missing inputs is displayed with a blue ‘Configure’ button on the left.

Step 4. Click the ‘Configure’ button next to the ‘Load Duration Curves’ application to configure the application inputs and set up parameters.

Step 5. The ‘Load Duration Curves’ application configuration page is displayed (Figure 135). Select the input sensor from the drop down menu, and click ‘Run’.

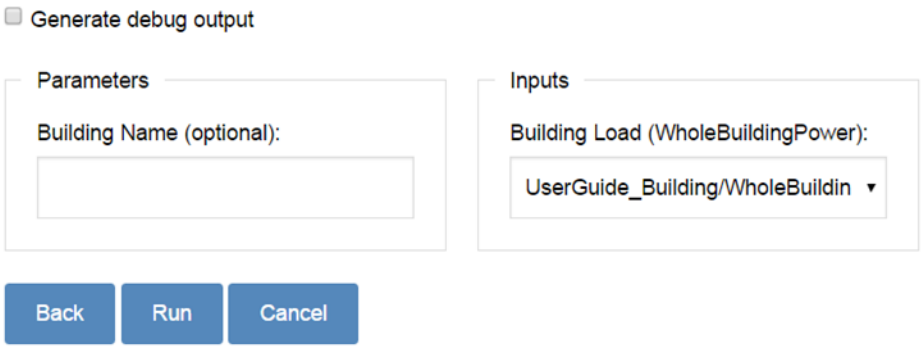


Figure 135. ‘Load Duration Curves’ Application

Step 6. Check the status of the application processing. The status indicates whether the application processing is successful. ‘Complete’ means the application processing completed successfully. If the application does not complete its run, select ‘Download output’ to download and view the error log. Click on the triangles next to the application name under analyses and select ‘View’ from the drop down menu.

Step 7. The load-duration curve is displayed (Figure 136). From this information, the user can understand for how much percentage of time the loads are at a particular range of interest. The highest loads ideally should occur for a small fraction of the time. If the building is near its peak load for a significant portion of the time, the HVAC equipment could be undersized, or there could be systems that run more than necessary. If the load is near peak for only a short duration of time, there may be an opportunity to reduce peak demand charges.

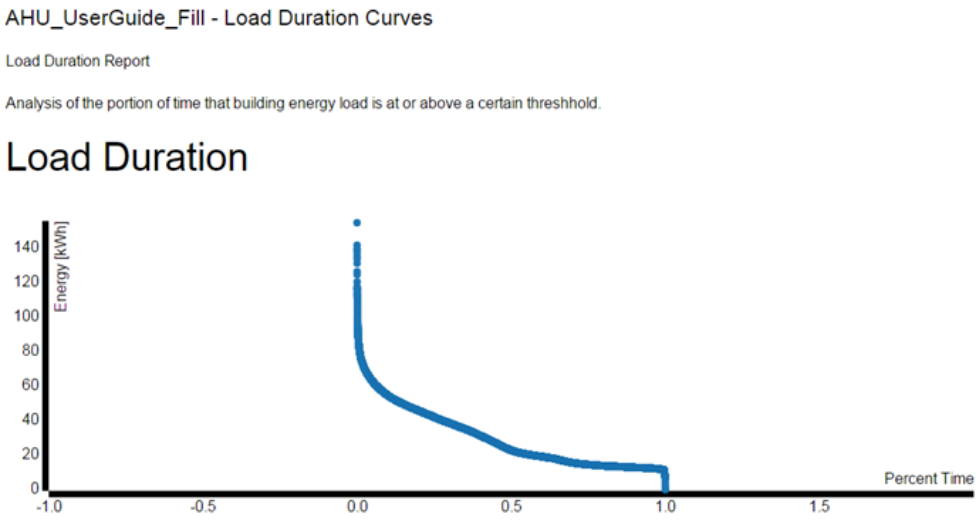


Figure 136. 'Load Duration Curves' Application Output

11.14 Schedule Detector

Follow the steps described below to run the 'Schedule Detector' application.

Step 1. In the project home page, click 'Run analysis…'

Step 2. The browser will prompt you for a dataset to run the analysis on. Choose 'AHU_UserGuide' as the data set.

Step 3. The 'New analysis' page is displayed. If the required data inputs for an application are not available in the selected data set, the OpenEIS will indicate that the application cannot be used. The 'Configure' button for the application will be greyed out and the missing inputs will be shown in red text. An application with no missing inputs is displayed with a blue 'Configure' button on the left.

Step 4. Click the 'Configure' button next to the 'Schedule Detector' application to configure the application inputs and set up parameters. A description of the parameters associated with this analysis are given in Table 7.

Table 7. Schedule Detector Applications - Parameters

Parameter	Description
Sample rate for occupancy schedule detection	This value provides a means for determining a time interval to represent the occupancy schedule.

Step 5. The 'Schedule Detector' application configuration page is displayed (Figure 137). The application has no default values for its parameters. Enter values for all the parameters and select the input sensors from the drop down menus, and click 'Run'.

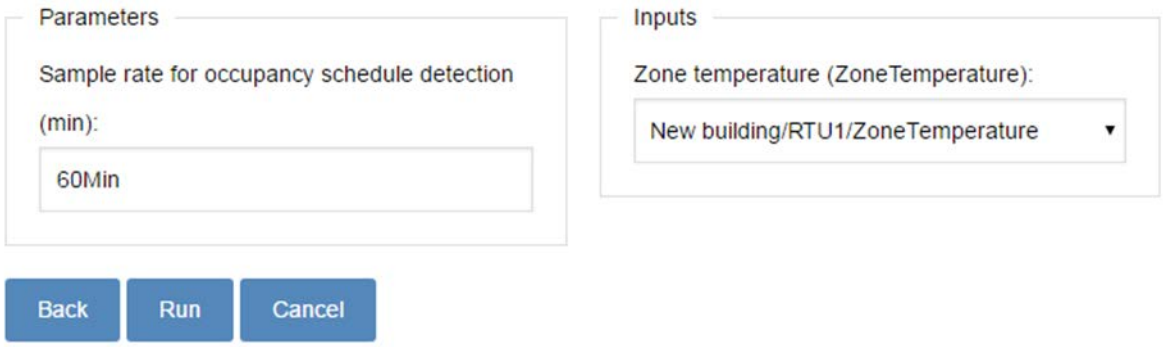


Figure 137. 'Schedule Detector' Application Configuration

Step 6. Check the status of application processing. The status indicates whether the application processing is successful. 'Complete' means the application processing completed successfully. If the application does not complete its run, select 'Download output' to download and view the error log. Click on the triangles next to the application name under analyses and select 'View' from the drop down menu.

Step 7. The output of the application displays the HVAC status and the zone temperature as time-series graphs (Figure 138).

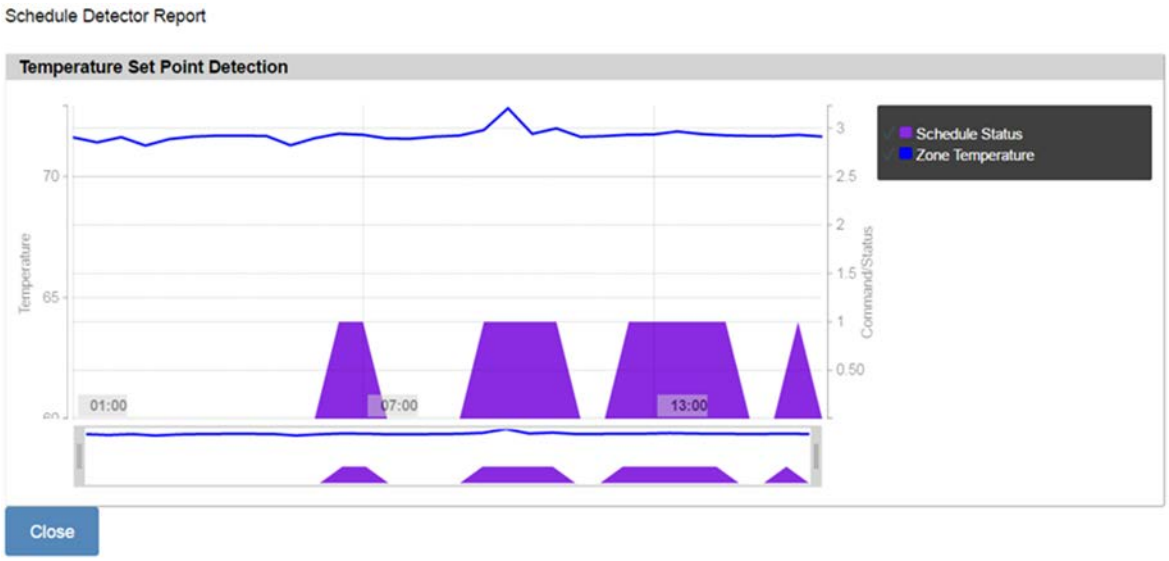


Figure 138. 'Schedule Detector' Application Output

11.15 Sensor Suitcase: HVAC

Follow the steps described below to run the 'Sensor Suitcase: HVAC' application. This application is used to identify problems in the operation and performance of packaged HVAC RTUs in small commercial buildings. The diagnostic suite targets problems that are common to this class of buildings, specifically overheating and overcooling, overly narrow separation between heating and cooling setpoints, absence of nighttime HVAC setbacks, RTU short-cycling, and non-use of the RTU economizer

when outdoor conditions allow for ‘free cooling’. For this application, use the data file ‘Sensor_suitcase_HVAC.csv’ included in the installation package and map the data given in the file with the corresponding OpenEIS parameter.

Step 1. In the project home page, click ‘Run analysis…’

Step 2. The browser will prompt you for a dataset to run the analysis on. Choose ‘AHU_UserGuide’ as the data set.

Step 3. The ‘New analysis’ page is displayed (Figure 81). If the required data inputs for an application are not available in the selected data set, the OpenEIS will indicate that the application cannot be used. The ‘Configure’ button for the application will be greyed out and the missing inputs will be shown in red text. An application with no missing inputs is displayed with a blue ‘Configure’ button on the left.

Step 4. Click the ‘Configure’ button next to the ‘Sensor Suitcase: HVAC’ application to configure the application inputs and set up parameters.

Step 5. The ‘Sensor Suitcase: HVAC’ application configuration page is displayed (Figure 139). The application has no default values for its parameters. Enter values for all the parameters and select the input sensors from the drop down menus, and click ‘Run’.

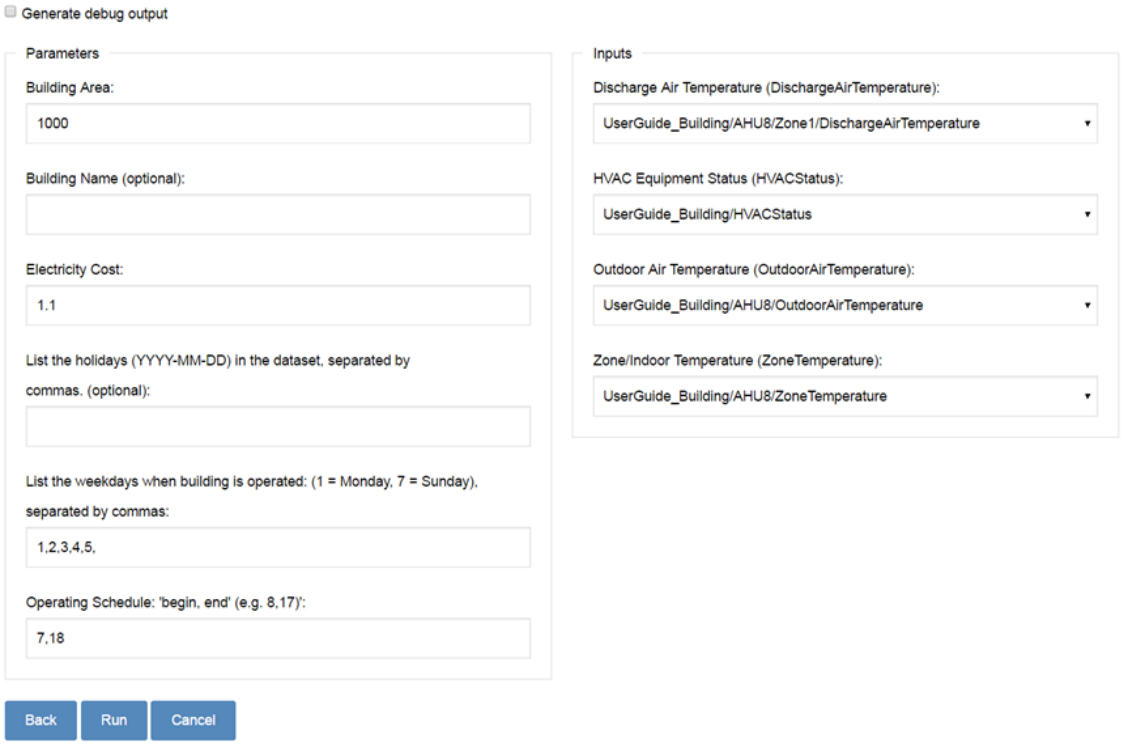


Figure 139. ‘Sensor Suitcase: HVAC’ Application Configuration

Step 6. Check the status of application processing. The status indicates whether the application processing is successful. ‘Complete’ means the application processing completed successfully. If

the application does not complete its run, select ‘Download output’ to download and view the error log. Click on the triangles next to the application name under analyses and select ‘View’ from the drop down menu.

Step 7. The output of this application displays any problem detected with the HVAC system and recommendations on how these problems can be fixed (Figure 140). An estimate of cost savings if these recommendations are followed is also given (assumes correct energy cost parameters are provided). This provides the user with the faults in their system as well as the ability to make economically-wise decisions for correcting the faults (i.e., is it economical or not to correct the problem?).

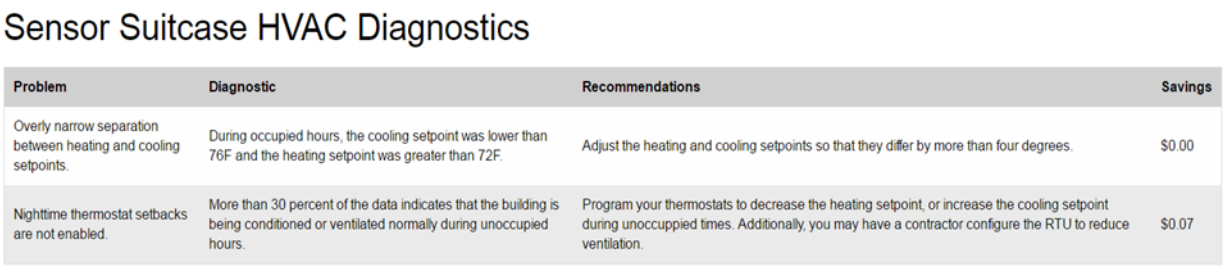


Figure 140. ‘Sensor Suitcase: HVAC’ – Output

11.16 Sensor Suitcase: Lighting

Follow the steps described below to run the ‘Sensor Suitcase: Lighting’ application. This application is used to identify problems in the operation and performance of lighting systems in small commercial buildings. This diagnostic suite targets problems that are common to this class of buildings, specifically, excessive lighting during the day-time and after-hours periods.

Step 1. In the project home page, click ‘Run analysis…’

Step 2. The browser will prompt you for a dataset to run the analysis on. Choose ‘AHU_UserGuide’ as the data set.

Step 3. The ‘New analysis’ page is displayed. If the required data inputs for an application are not available in the selected data set, the OpenEIS will indicate that the application cannot be used. The ‘Configure’ button for the application will be greyed out and the missing inputs will be shown in red text. An application with no missing inputs is displayed with a blue ‘Configure’ button on the left.

Step 4. Click ‘Configure’ button next to the ‘Sensor Suitcase: Lighting’ application to configure the application inputs and set up parameters.

Step 5. The ‘Sensor Suitcase: Lighting’ application configuration page is displayed (Figure 141). The application has no default values for its parameters. Enter values for all the parameters and select the input sensors from the drop down menus, and click ‘Run’.

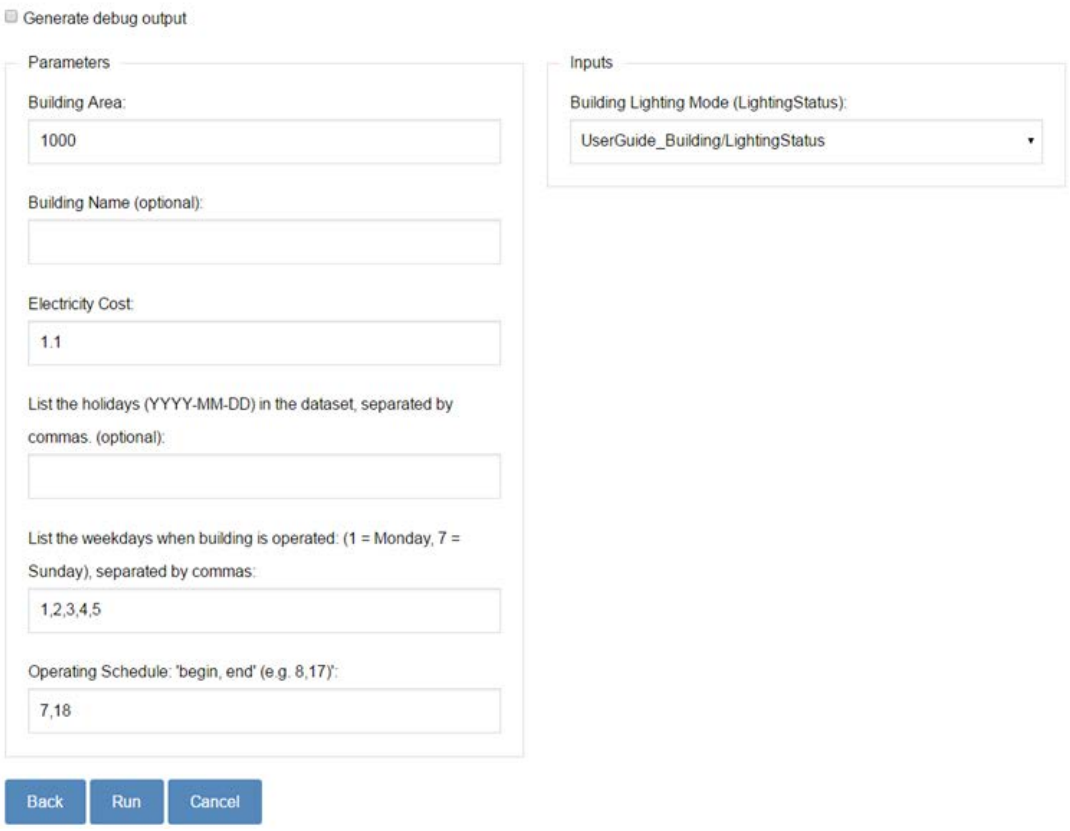


Figure 141. 'Sensor Suitcase: Lighting' Application

Step 6. Check the status of the application processing. The status indicates whether the application processing is successful. 'Complete' means the application processing completed successfully. If the application does not complete its run, select 'Download output' to download and view the error log. Click on the triangles next to the application name under analyses and select 'View' from the drop down menu.

Step 7. The output of this application lists the problem, a detailed diagnostic, recommendations on how to correct them, and the cost savings that could be achieved from this correction (Figure 142).

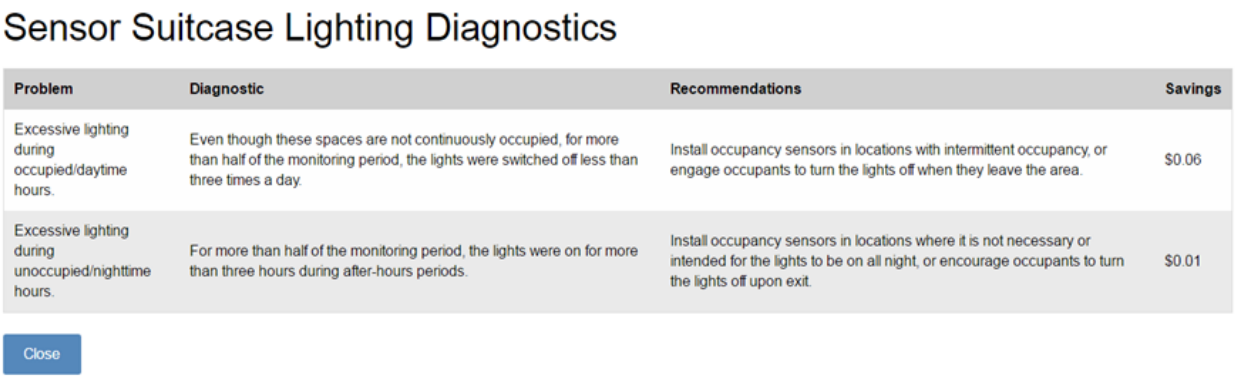


Figure 142. 'Sensor Suitcase: Lighting' Application – Output

11.17 Temperature Setpoint Detector

Follow the steps described below to run the 'Temperature Setpoint Detector' application.

Step 1. In the project home page, click 'Run analysis…'

Step 2. The browser will prompt you for a dataset to run the analysis on. Choose 'SetpointMap_RTU'.

Step 3. The 'New analysis' page is displayed (Figure 81). If the required data inputs for an application are not available in the selected data set, the OpenEIS will indicate that the application cannot be used. The 'Configure' button for the application will be greyed out and the missing inputs will be shown in red text. An application with no missing inputs is displayed with a blue 'Configure' button on the left. A description of the parameters associated with this analysis are given in Table 8.

Table 8. Temperature Setpoint Detector Application - Parameters

Parameter	Description
Minimum number of observations for analysis	The number of required data measurements to detect a temperature setpoint change.
Sensitivity	This value provides a means for determining parameter sensitivity. A high sensitivity will identify more faults but may also lead to false positives. Values can be 0 (low sensitivity), 1 (normal sensitivity), 2 (high sensitivity) or 3 (custom).

Step 4. Click the 'Configure' button next to the 'Temperature Setpoint Detector' application to configure the application inputs and set up parameters.

Step 5. The 'Temperature Setpoint Detector' application configuration page is displayed (Figure 143). The application has no default values for its parameters. Enter values for all the parameters and select the input sensors from the drop down menus, and click 'Run'.

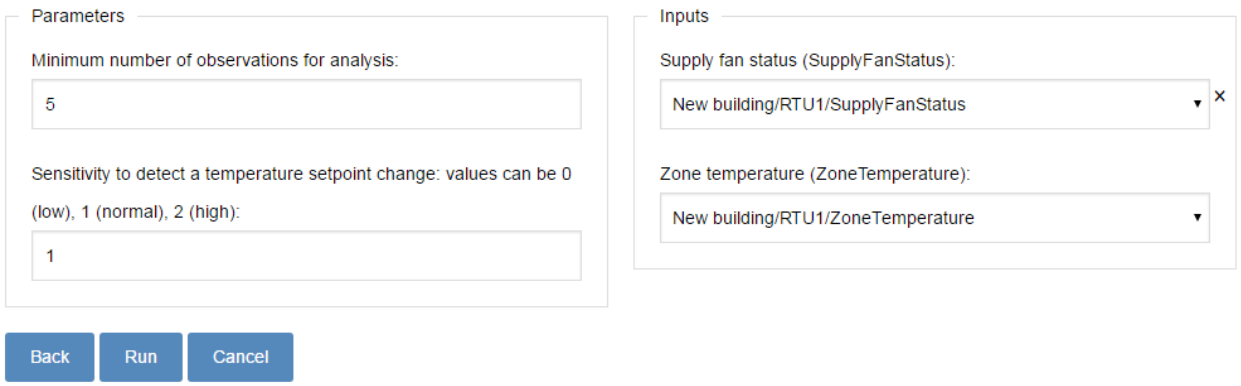


Figure 143. 'Temperature Setpoint Detector' Application Configuration

Step 6. Check the status of the application processing. The status indicates whether the application processing is successful. ‘Complete’ means the application processing completed successfully. If the application does not complete its run, select ‘Download output’ to download and view the error log.

Step 7. Click on the triangles next to the application name under analyses and select ‘View’ from the drop down menu. The output of the application (Figure 144) is a time series graph of the zone temperature set-point, zone temperature sensor measurements, and fan status (if selected as input). The modifications described in Steps 3 and 4 of Section 10.0 can be applied to this output as well.

Figure 144. ‘Temperature Setpoint Detector’ Application – Output

11.18 Time Series Load Profiling

Follow the steps described below to run the ‘Whole-Building Energy Savings’ application. Time series load profiling is used to understand the relationship between energy use and the time of day, for different types of days (weekdays, weekends, holidays, etc.). Abnormalities or changes in load profiles can indicate inefficiencies due to scheduling errors, unexpected or irregular equipment operation, high use during unoccupied hours, or untimely peaks.

Step 1. In the project home page, click ‘Run analysis…’

Step 2. The browser will prompt you for a dataset to run the analysis on. Choose ‘AHU_UserGuide’.

Step 3. The ‘New analysis’ page is displayed (Figure 81). If the required data inputs for an application are not available in the selected data set, the OpenEIS will indicate that the application cannot be used. The ‘Configure’ button for the application will be greyed out and the missing inputs will be shown in red text. An application with no missing inputs is displayed with a blue ‘Configure’ button on the left.

Step 4. Click the ‘Configure’ button next to the ‘Time Series Load Profiling’ application to configure the application inputs and set up parameters. The ‘Time Series Load Profiling’ application configuration page is displayed (Figure 145).

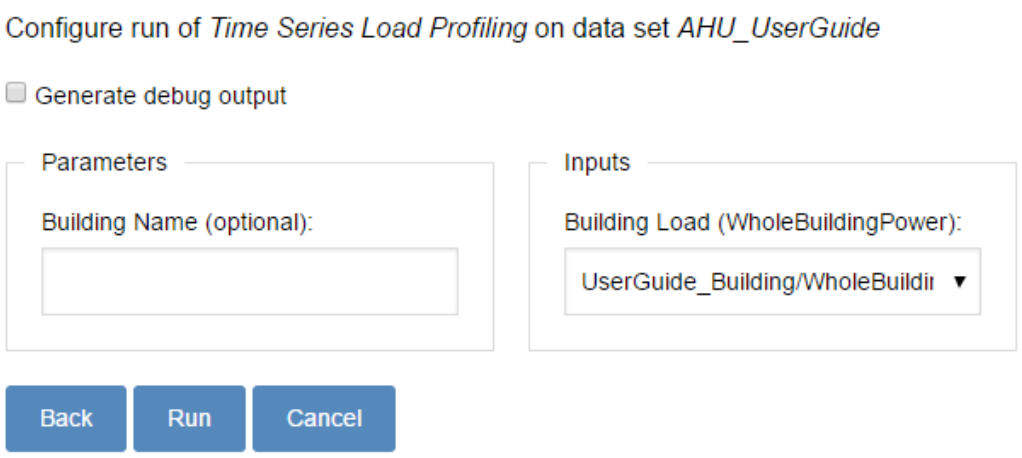


Figure 145. ‘Time Series Load Profiling’ Application Configuration Page

Step 5. The application has no default values for its parameters. Enter values for all the parameters, select the input sensors from the drop down menus, and click ‘Run’.

Step 6. Check the status of the application processing. The status indicates whether the application processing is successful. ‘Complete’ means the application processing completed successfully. If the application does not complete its run, select ‘Download output’ to download and view the error log. Click on the triangles next to the application name under analyses and select ‘View’ from the drop down menu.

Step 7. The output of the application displays a day type profiles for Holiday, Sunday, Saturday, or Weekday (Figure 146).

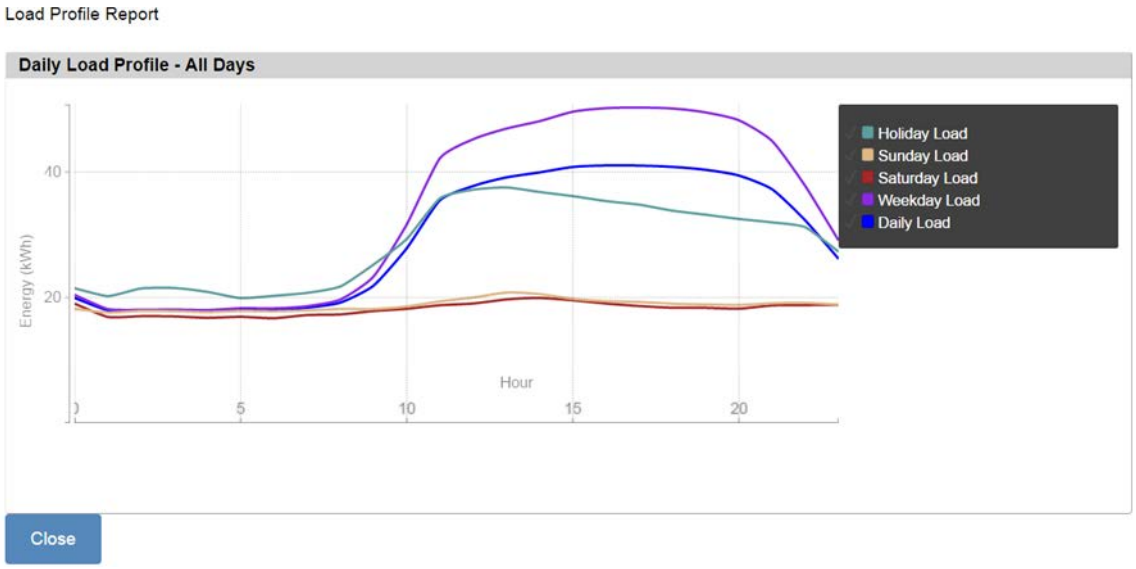


Figure 146. 'Time Series Load Profiling' Application - Output

11.19 Whole-Building Energy Savings

Follow the steps described below to run the 'Whole-Building Energy Savings' application. Whole-building energy savings is used to quantify the energy savings associated with an improvement in building operations or equipment. Energy savings is calculated as the difference between the metered energy use after improvements were made, and the baseline projection of energy use.

Step 1. In the project home page, click 'Run analysis…'

Step 2. The browser will prompt you for a dataset to run the analysis on. Choose 'AHU_UserGuide' as the data set.

Step 3. The 'New analysis' page is displayed (Figure 81). If the required data inputs for an application are not available in the selected data set, the OpenEIS will indicate that the application cannot be used. The 'Configure' button for the application will be greyed out and the missing inputs will be shown in red text. An application with no missing inputs is displayed with a blue 'Configure' button on the left.

Step 4. Click the 'Configure' button next to the 'Whole-Building Energy Savings' application to configure the application inputs and set up parameters.

Step 5. The 'Whole-Building Energy Savings' application configuration page is displayed (Figure 147). The application has no default values for its parameters. Enter values for all the parameters, select the input sensors 'UserGuide_Building/WholeBuildingPower' and 'UserGuide_Building/OutdoorAirTemperature' from the drop down menus, and click 'Run'.

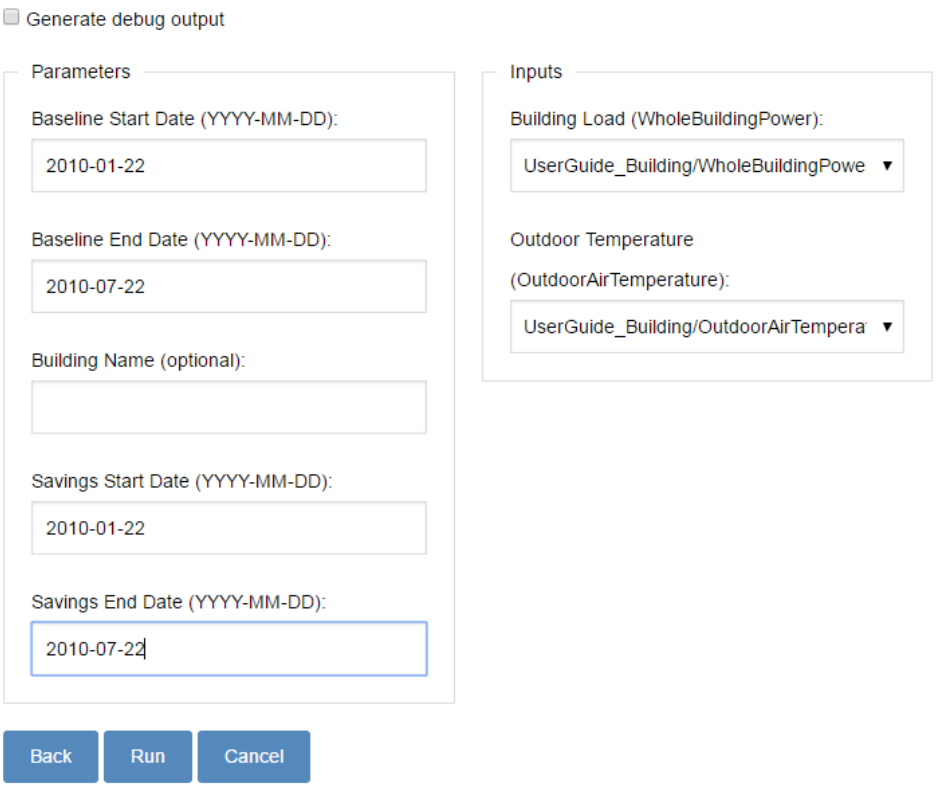


Figure 147. 'Whole-Building Energy Savings' Configuration Page

Step 6. Check the status of the application processing. The status indicates whether the application processing is successful. 'Complete' means the application processing completed successfully. If the application does not complete its run, select 'Download output' to download and view the error log.

Step 7. Click on the triangles next to the application name under analyses and select 'View' from the drop down menu (Figure 148).

Step 8. The output of this application displays a time-series graph of the building energy savings for the timeline defined as parameters for the application. A flat slope of the cumulative sum time series indicates that use has remained the same. A positive slope indicates energy savings, while a negative slope indicates that more energy is being used after the supposed "improvement" date.

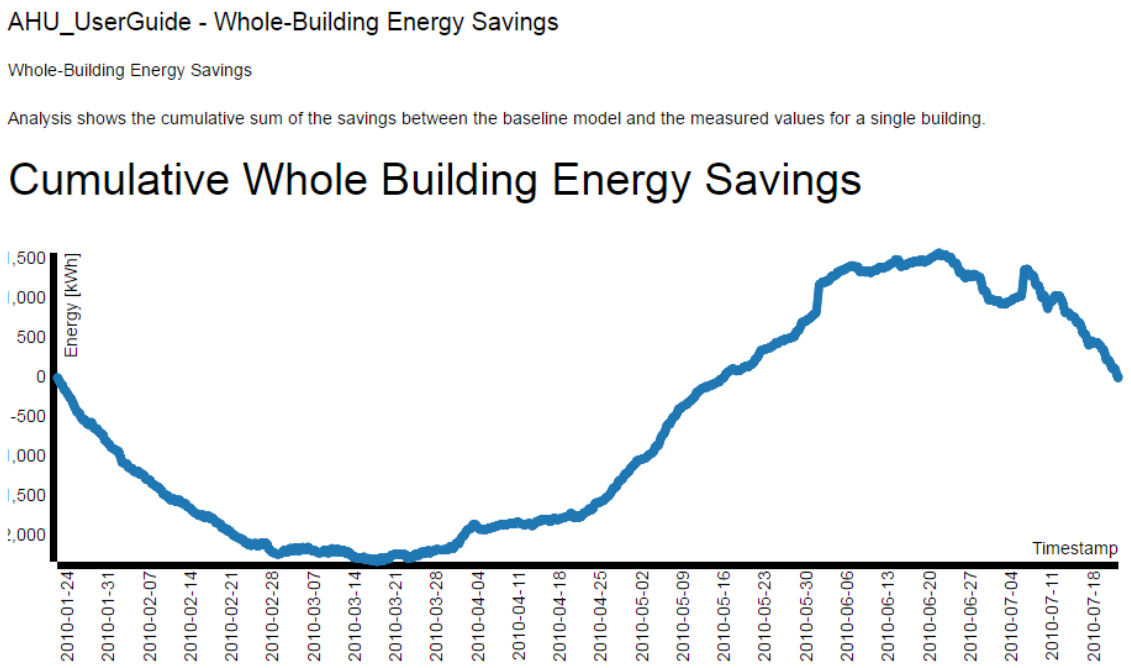


Figure 148. 'Whole-Building Energy Savings' Application – View Output

11.20 Zone Data Visualization

Follow the steps described below to run the 'Zone Data Visualization' application.

Step 1. In the project home page, click 'Run analysis…'

Step 2. The browser will prompt you for a dataset to run the analysis on. Choose 'AHU_UserGuide' or 'AHU_UserGuide_HWS_Fill' as the data set.

Step 3. The 'New analysis' page is displayed. If the required data inputs for an application are not available in the selected data set, the OpenEIS will indicate that the application cannot be used. The 'Configure' button for the application will be greyed out and the missing inputs will be shown in red text. An application with no missing inputs is displayed with a blue 'Configure' button on the left.

Step 4. Click the 'Configure' button next to the 'Zone Data Visualization' application to configure the application inputs and set up parameters.

Step 5. The 'Zone Data Visualization' application configuration page is displayed (Figure 149). The application has no parameters. Mandatory inputs are provided with a drop-down menu by default; for optional sensors, click '+Add sensor' to activate the drop-down menu. Select the appropriate input sensors from the drop down menus, and click 'Run'.

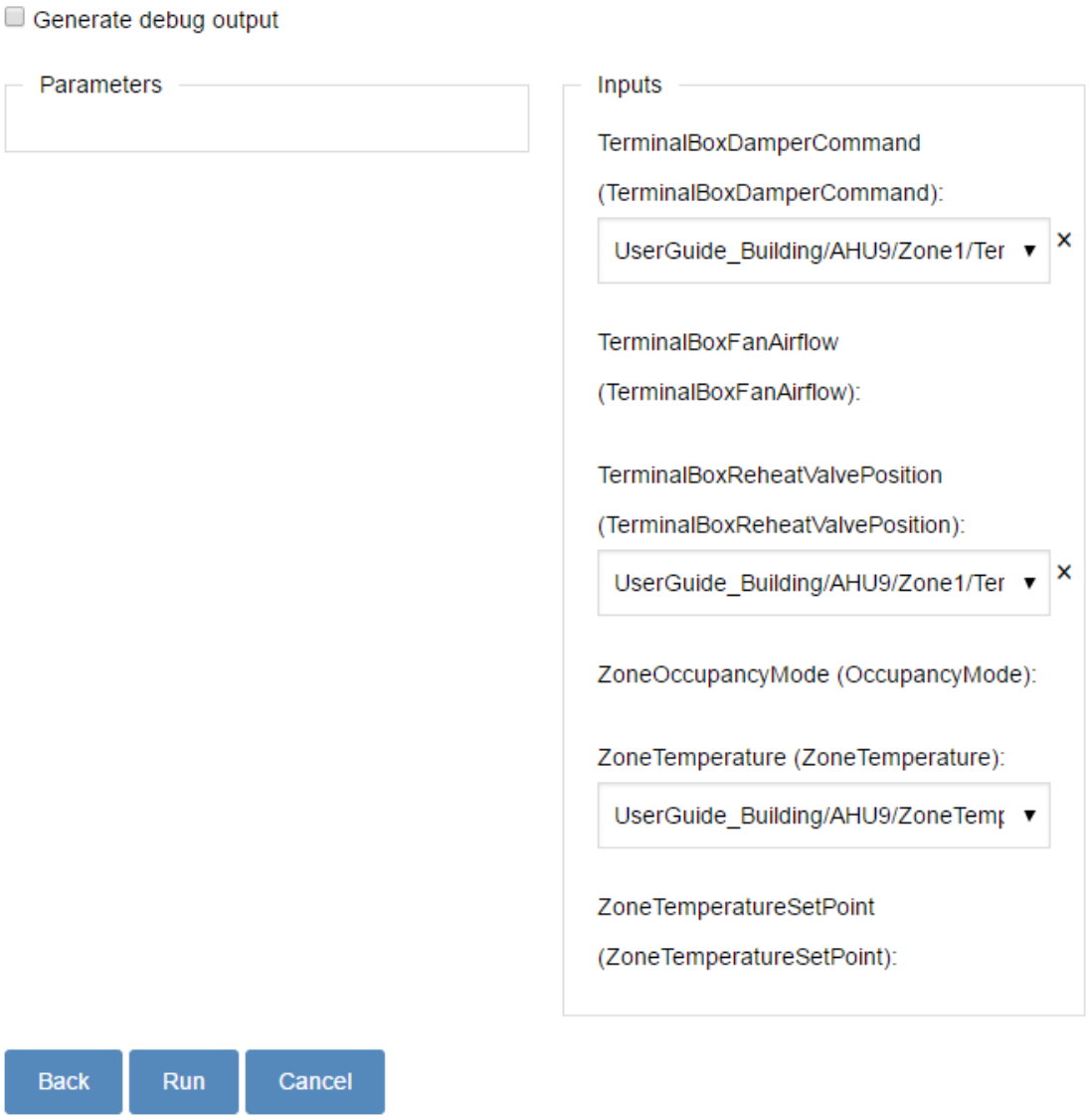


Figure 149. 'Zone Data Visualization' Application Configuration Page

Step 6. Check the status of the application processing. The status indicates whether the application processing is successful. 'Complete' means the application processing completed successfully. If the application does not complete its run, select 'Download output' to download and view the error log. Click on the triangles next to the application name under analyses and select 'View' from the drop down menu.

Step 7. The output of this application is displayed in the form of time series graphs of the sensors selected as inputs to the application (Figure 150).

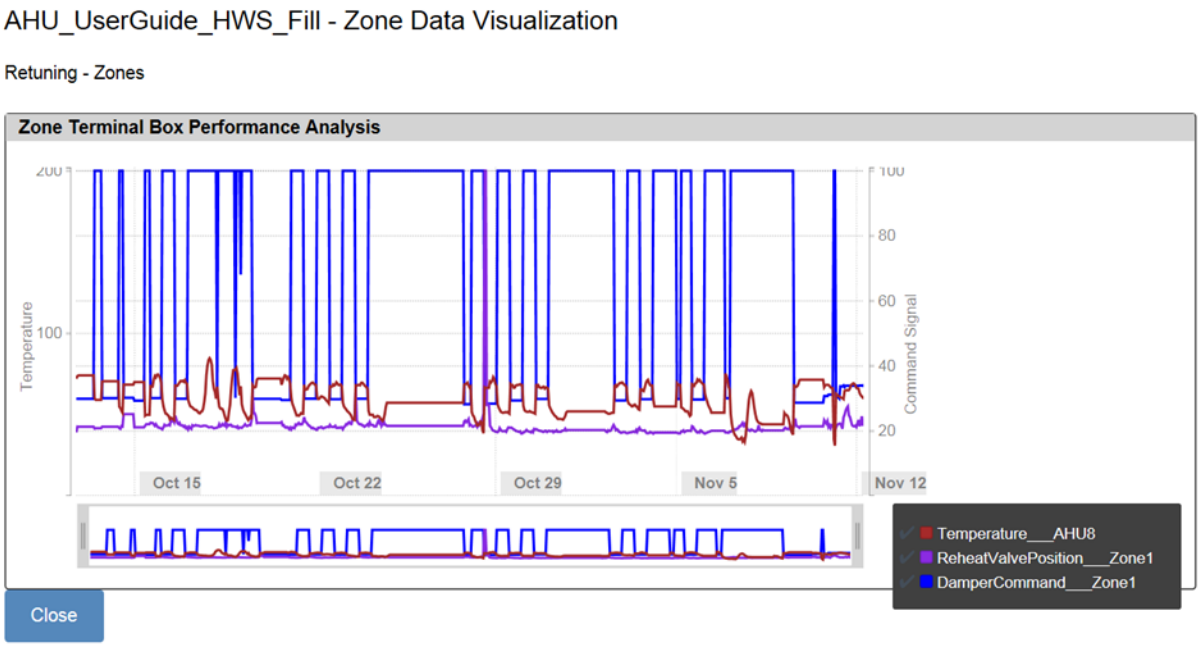


Figure 150. 'Zone Data Visualization' Application – View Output

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