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OpenEIS: Users Guide

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February 2015

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1 Introduction

OpenEIS (open energy information system) is an open-source software tool for analyzing building energy and operational data to identify 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 energy managers.

In response, OpenEIS was designed to provide standard methods for authoring, sharing, testing, using, and improving algorithms for operational building energy efficiency. The OpenEIS strategy is aimed at getting the market to validate and implement state-of-the-art analytical and diagnostic algorithms. This, in turn, should create market demand for control system manufacturers and integrators serving small and medium commercial customers, as well as for commercial tool offerings.

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 performance or consumption 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. OpenEIS provides this functionality 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 data sets suitable for direct 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.

1.1 Organization of the User Guide

OpenEIS user's guide consists of 10 sections: (1) Installation of the OpenEIS, (2) OpenEIS startup and configuration, (3) Creation of 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, and (8) Select analysis applications, (9) Run analysis applications and (10) Collect and visualize results.

2 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 from:
Link to site: https://github.com/VOLTTRON/openeis/releases

Step 2. Locate the file you have downloaded, and double click on it to start the installation (Figure 1), then click “OK”.

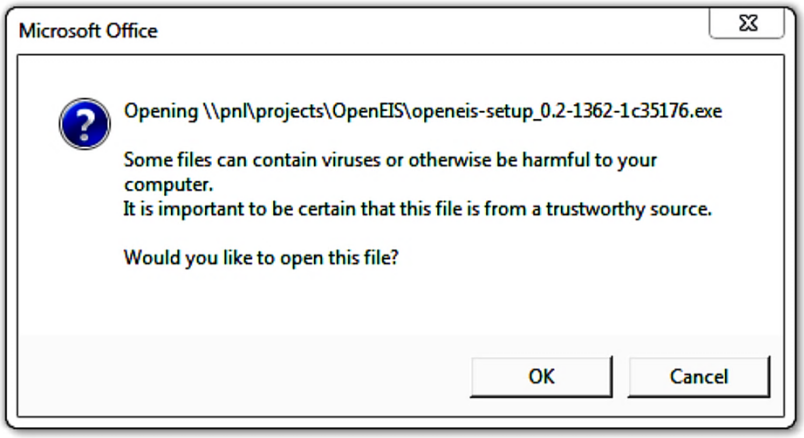

Figure 1: OpenEIS installation on Windows - start the installation process

Step 3. Select the location for installation (the default will be: C:\OpenEIS-0.2) (Figure 2) and click “Next”.

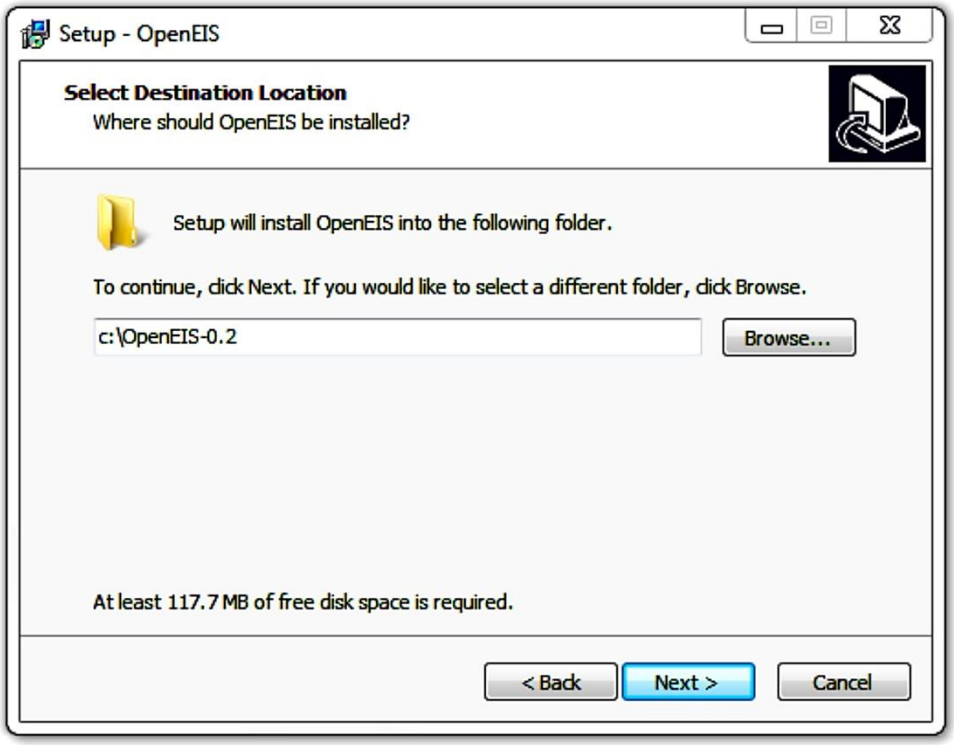

Figure 2: OpenEIS installation on Windows - choose an installation location

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

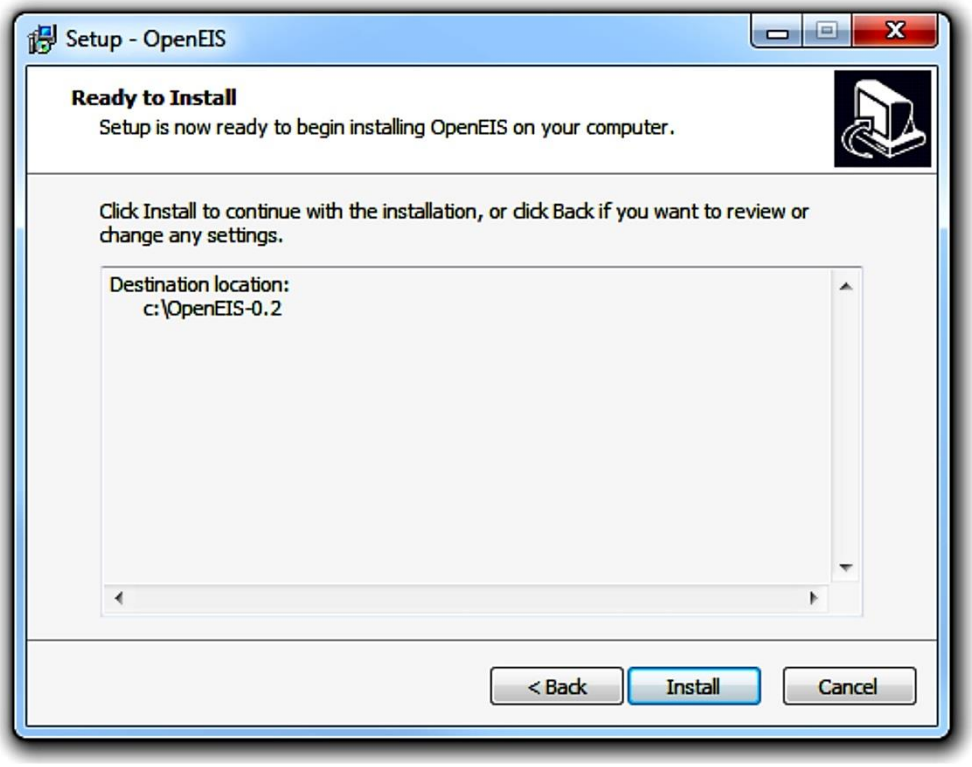

Figure 3: OpenEIS installation on Windows - ready to install

Step 5. Check “Launch application” and click “Finish” button on the last dialog. This will complete 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. The OpenEIS can be downloaded as zip file from: https://github.com/VOLTTRON/openeis (Figure 5)

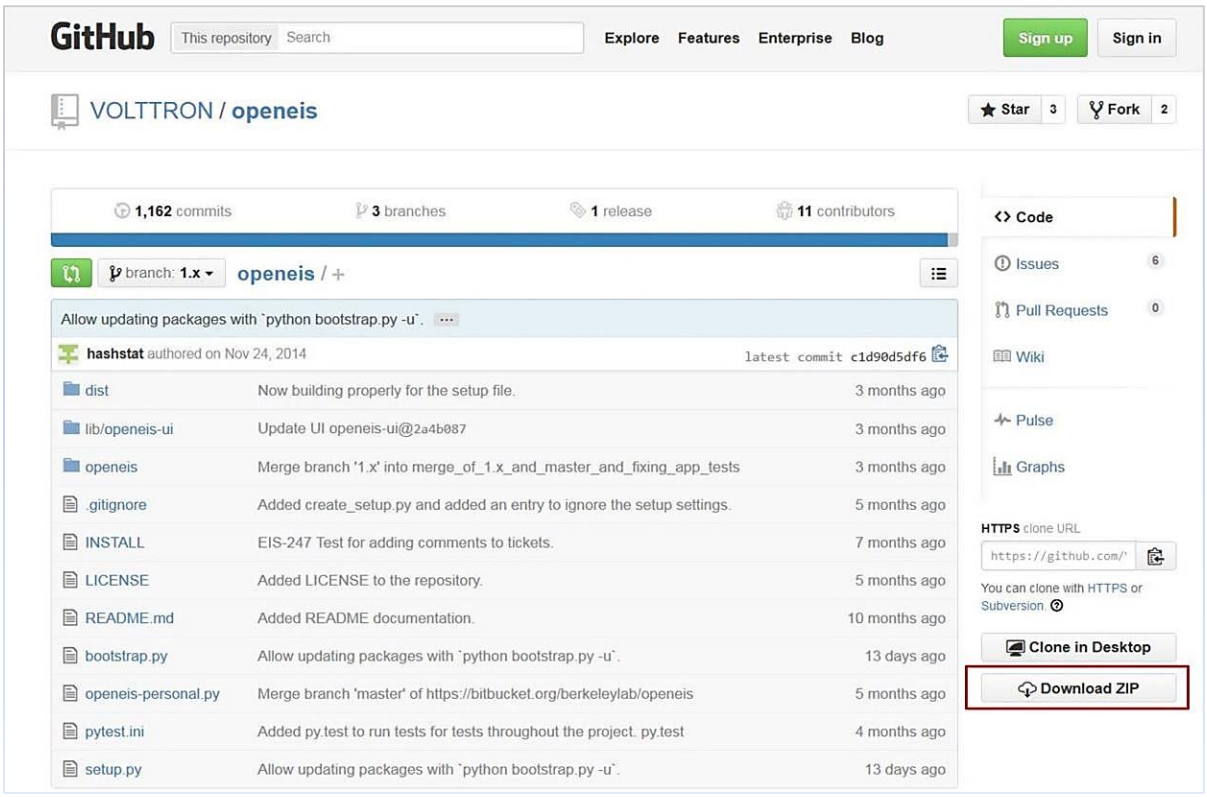

Figure 5: OpenEIS installation on Mac or Linux - OpenEIS download page

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**

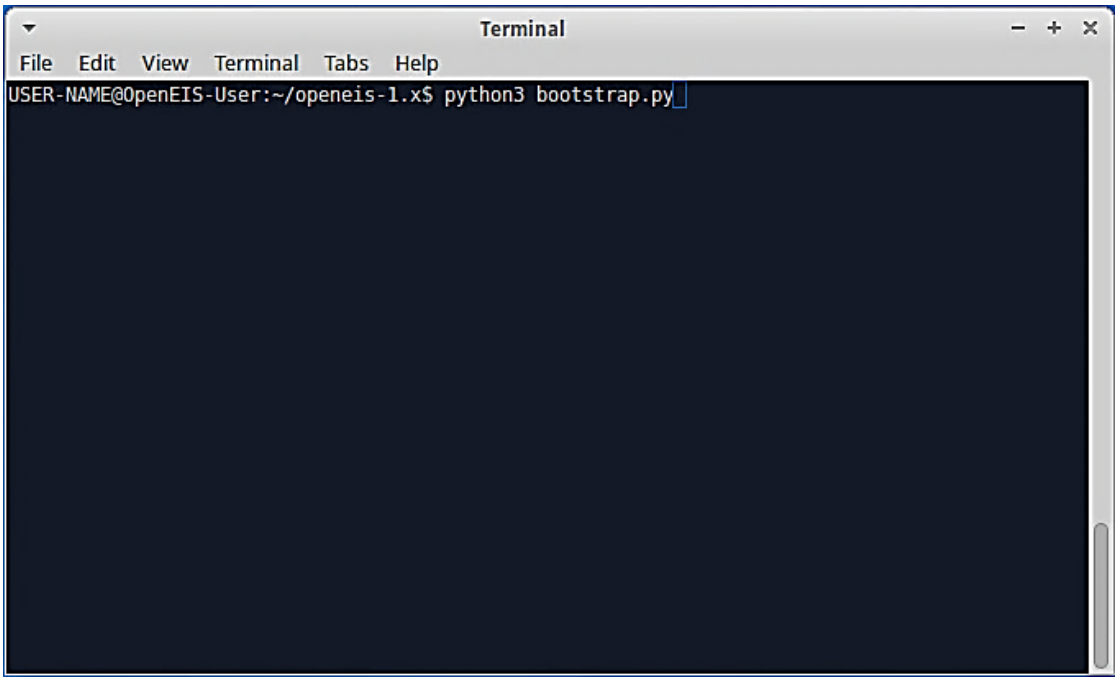

Figure 6: OpenEIS installation on Mac or Linux - building project and dependencies

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.

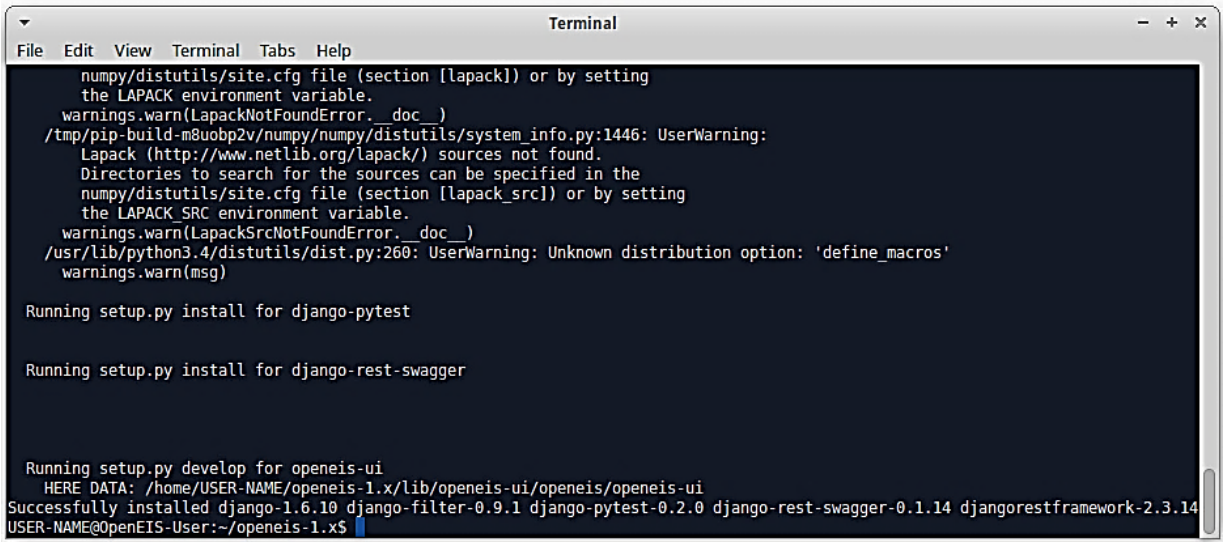

Figure 7: OpenEIS installation on Mac or Linux - bootstrap process is complete

3 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 Winodws:

Step 1. Run OpenEIS (C:\OpenEIS-0.2\start-openeis.bat) and the OpenEIS user interface is dispayed in a web browser. Use the URL, http://localhost:54620/, to run OpenEIS on other web browsers if necessary.

Step 2. The OpenEIS login page is displayed (Figure 8).

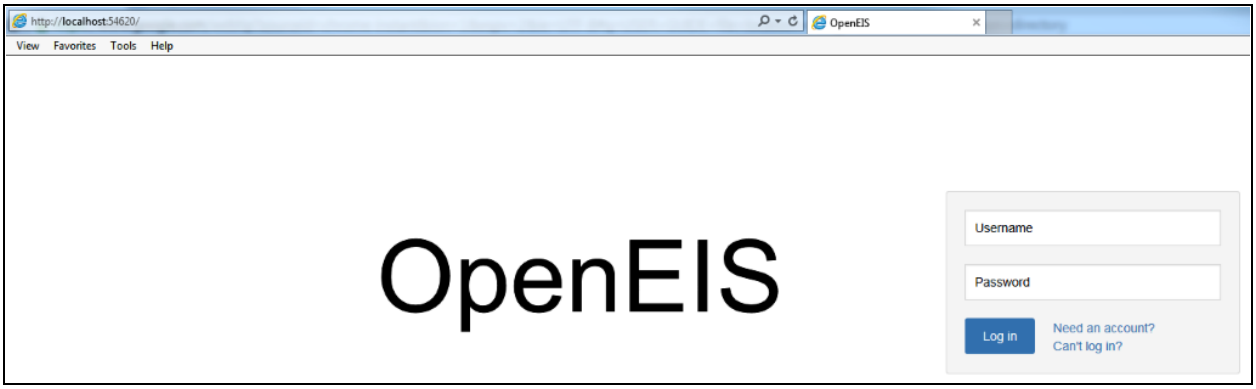

Figure 8: Running the OpenEIS - user interface

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.

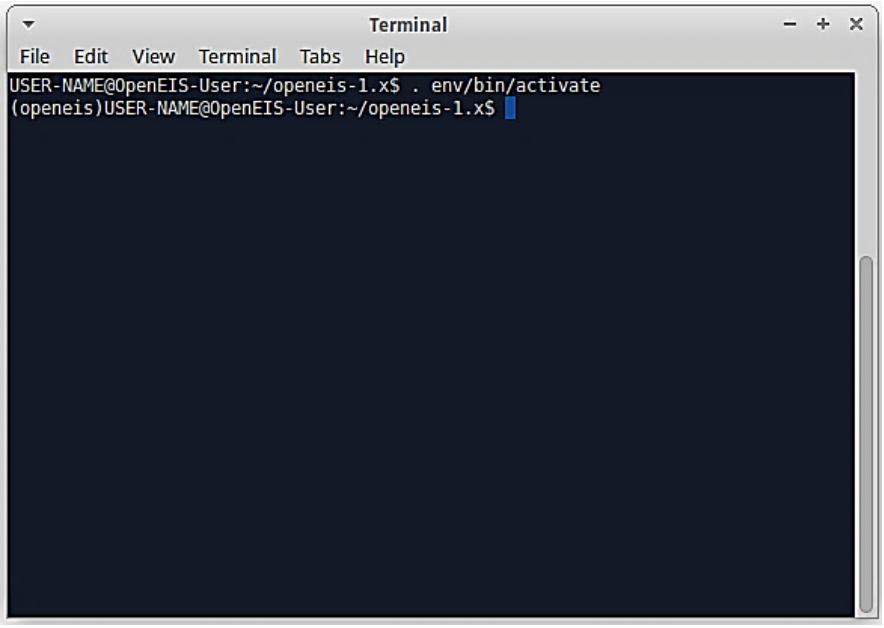

Figure 9: Running the OpenEIS - startup on Linux or Mac

Step 3. After activating the OpenEIS we can create a user account and initialize our database. 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 set 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.

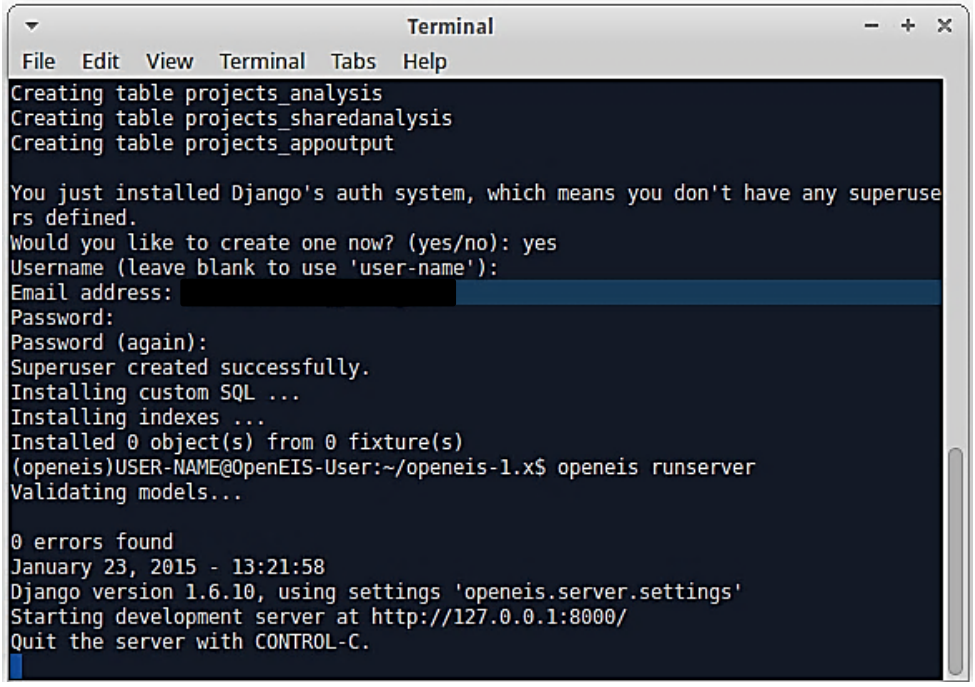

Figure 10: Running the OpenEIS - running server on Linux or Mac

Step 5. Open a web browser and enter the following URL: http://localhost:8000

One can now proceed to create a new project (Section 0). Section 3.3, Create OpenEIS Account, can be skipped because the user account was already created (Section 3.2 step 3).

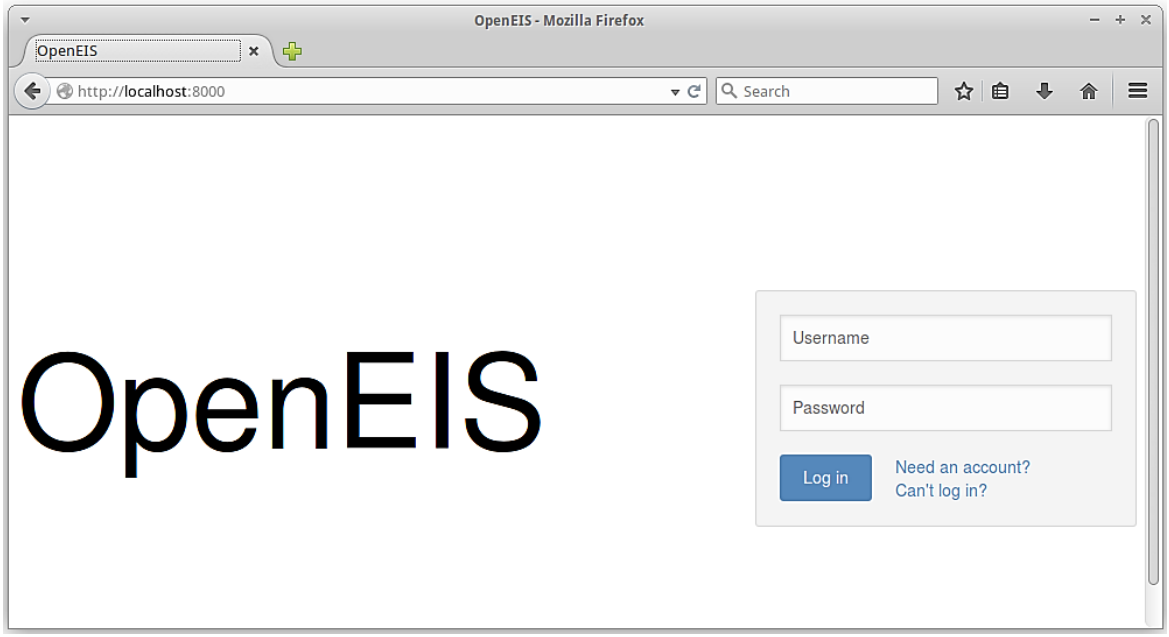

Figure 11: Running the OpenEIS - user interface

3.3 Create OpenEIS Account

Log into the OpenEIS or create an account using the following the steps:

Step 1. Upon launching the OpenEIS the log-in dialog is displayed in the web browser (Figure 12). Select “Need an account” next to the “Log in” button.

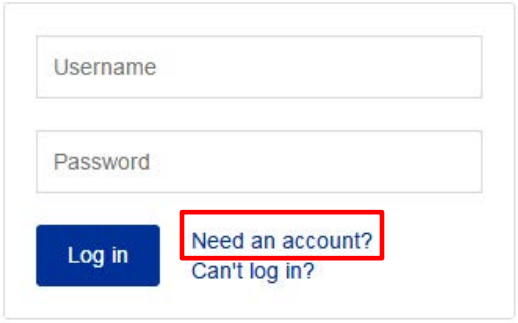

Figure 12: Running the OpenEIS - creating an account

Step 2. Fill out the “Get an account” form and press “Sign-up” (Figure 13). The user is automatically logged into the OpenEIS after completing the form.

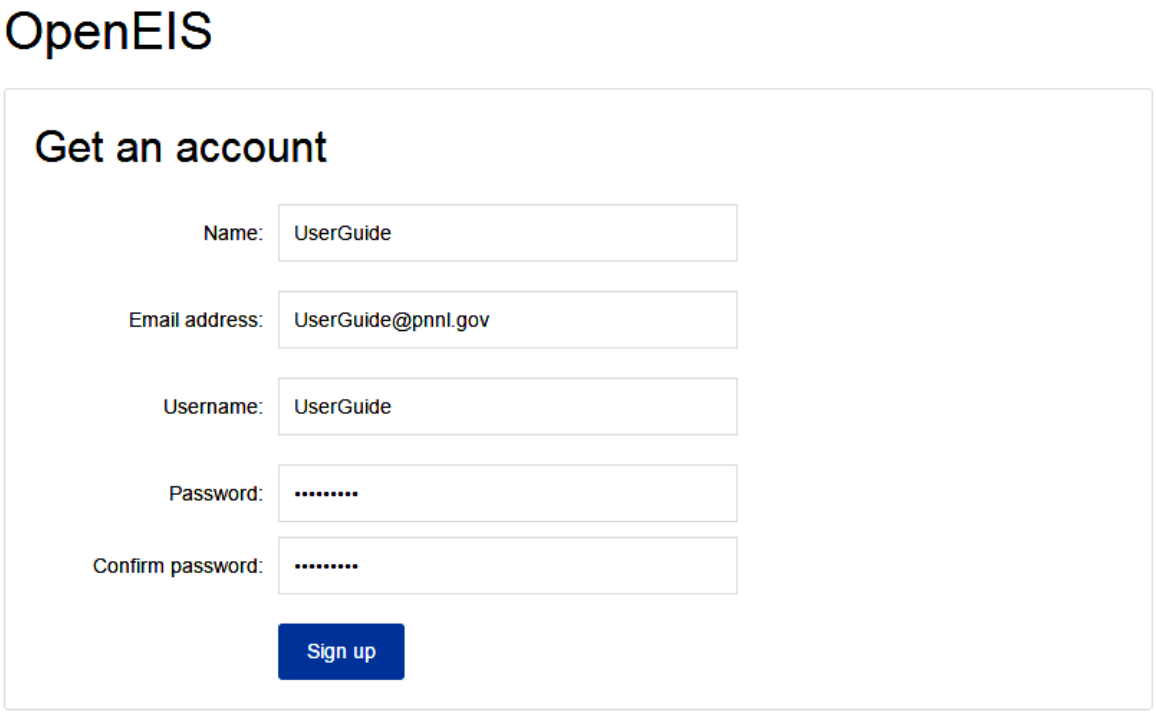

Figure 13: Running the OpenEIS - creating an account (continued)

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.

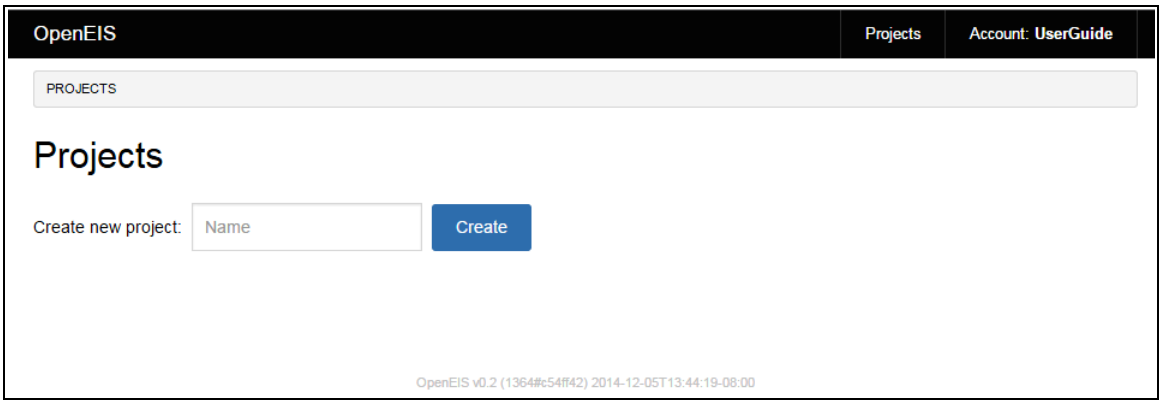

Figure 14: Running the OpenEIS - creating an account (continued)

4 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).

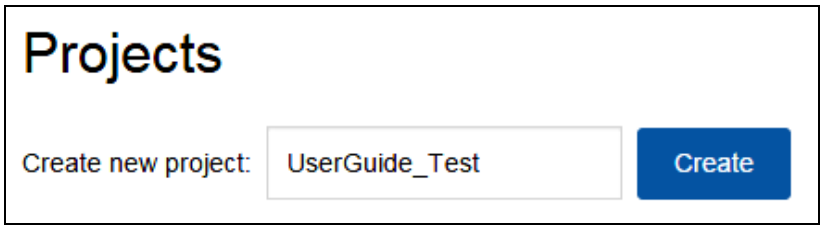

Figure 15: Create a new project - name the project

Step 2. The buttons next to project name allow the user to rename (“Rename”), delete (“Delete”), and copy (“Clone”) the project (Figure 16).

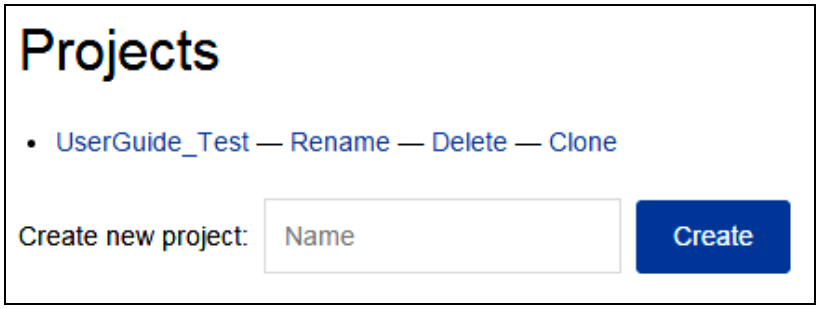

Figure 16: Create a new project - project actions

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

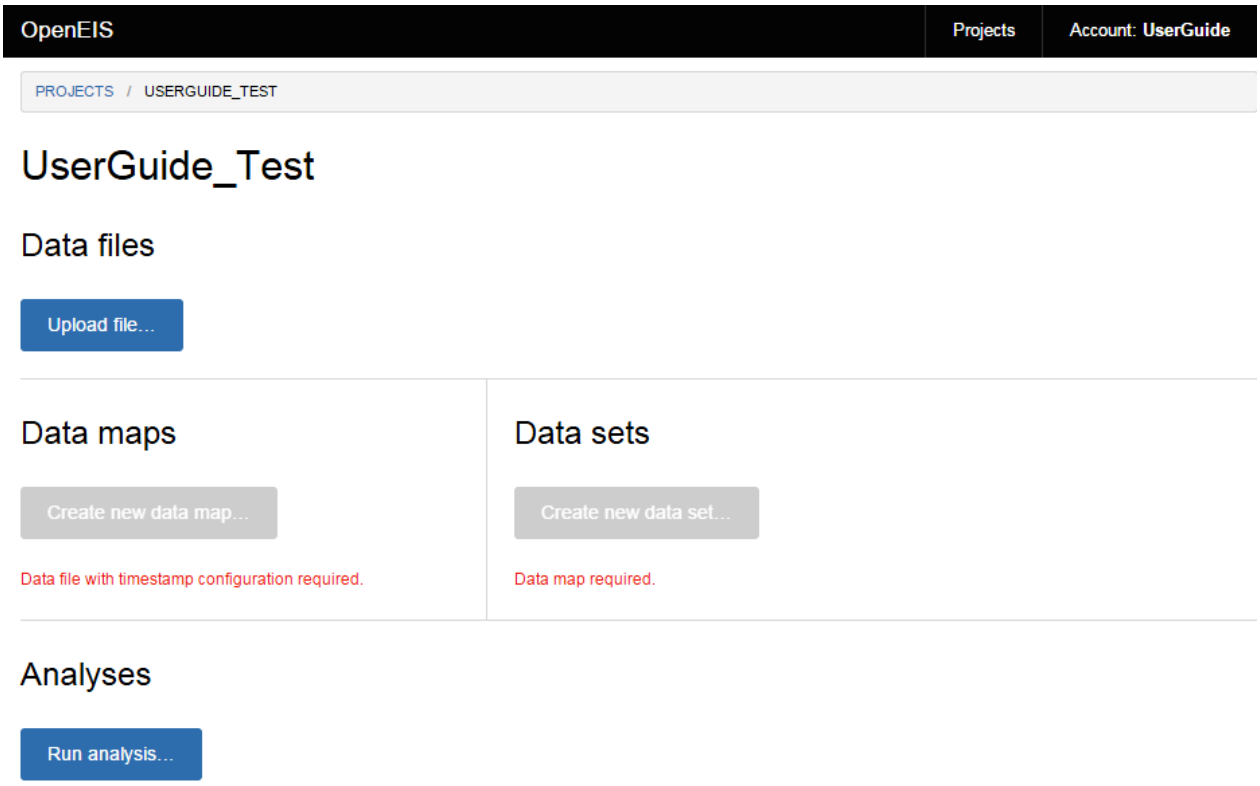

Figure 17: Create a new project - main project page

5 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. The user guide is based on two raw data files that are downloaded when the OpenEIS is installed: "UserGuide_Temperature_Dataset.csv" and "UserGuide_Signal_Dataset.csv".

5.1 Upload Raw Data File with 24-hr based Timestamp

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

Step 1. Click "Choose File" button to upload the raw data file, "UserGuide_Temperature_Dataset.csv (Figure 18). The file is located in the folder where the OpenEIS is installed. Click on "Open".

Figure 18: Upload raw data file – choose file

Step 2. Click "Upload" button. A pop-up window, "Configure timestamp", appears (Figure 19). The timestamp is 24-hour based.

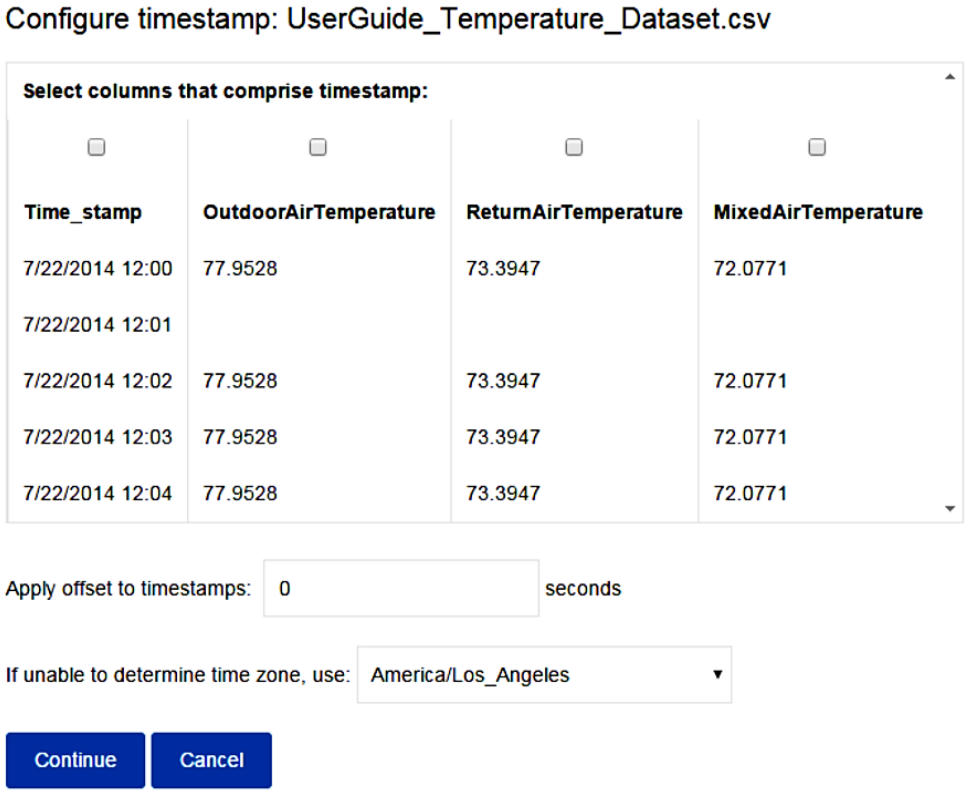

Figure 19: Upload raw data - timestamp selection

Step 3. Enter 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.

Step 4. Manually select the time zone according to the local time of the data obtained (Figure 19). Otherwise, UTC (Coordinated Universal Time) is selected as a default and the timestamps will be automatically converted to UTC.

Step 5. Select the time column checkbox and click the “Continue” button (Figure 20). If there is more than one time column, select all that apply.

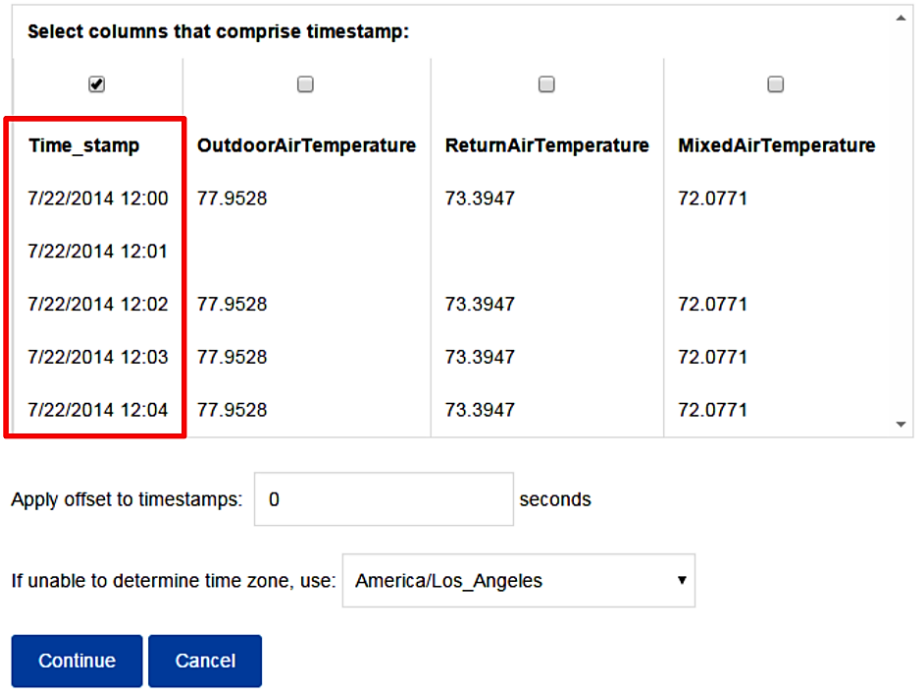

Figure 20: Upload raw data - timestamp selection (continued)

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.

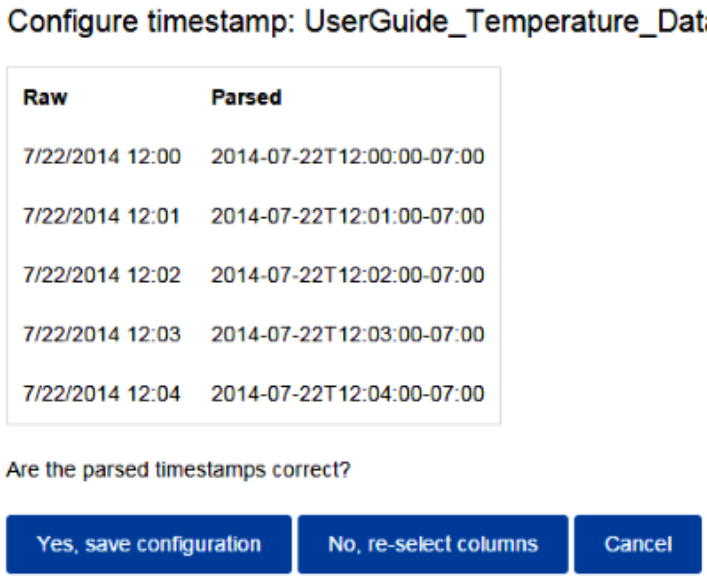

Figure 21: Upload raw data -timestamp selection (continued)

Step 7. Data file is successfully uploaded (Figure 22).

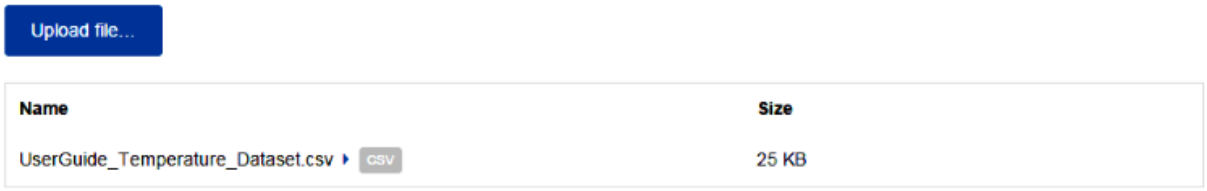

Figure 22: Upload raw data - data file input complete

Step 8. The triangular button next to the input data file provides additional options to reconfigure the timestamp (“Configure timestamp”), download data file (“Download”), rename data file name (“Rename”), and delete data file (“Delete”).

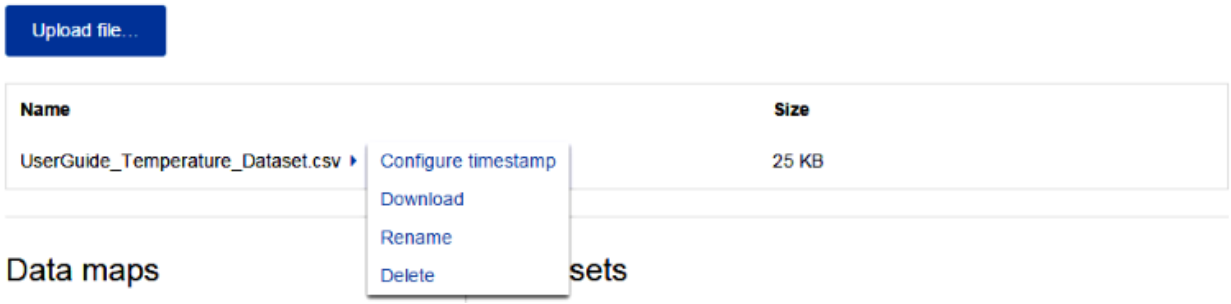

Figure 23: Upload raw data - data file additional options

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, “UserGuide_Signal_Dataset.csv. The file is located in the folder where the OpenEIS is installed. Click on “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 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.

Step 4. Manually select the time zone according to the local time of the data obtained (Figure 24). Otherwise, UTC (Coordinated Universal Time) is selected as a 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).

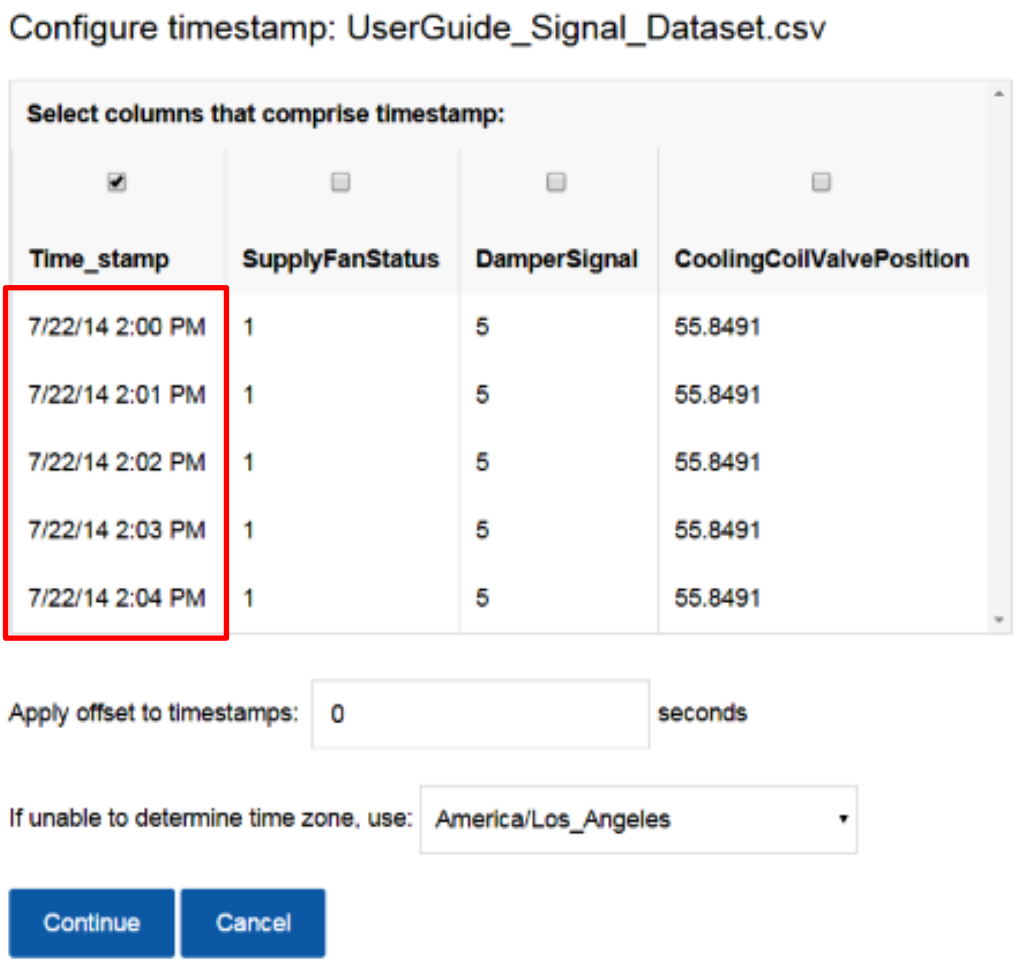

Figure 24: Timestamp configuration

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.

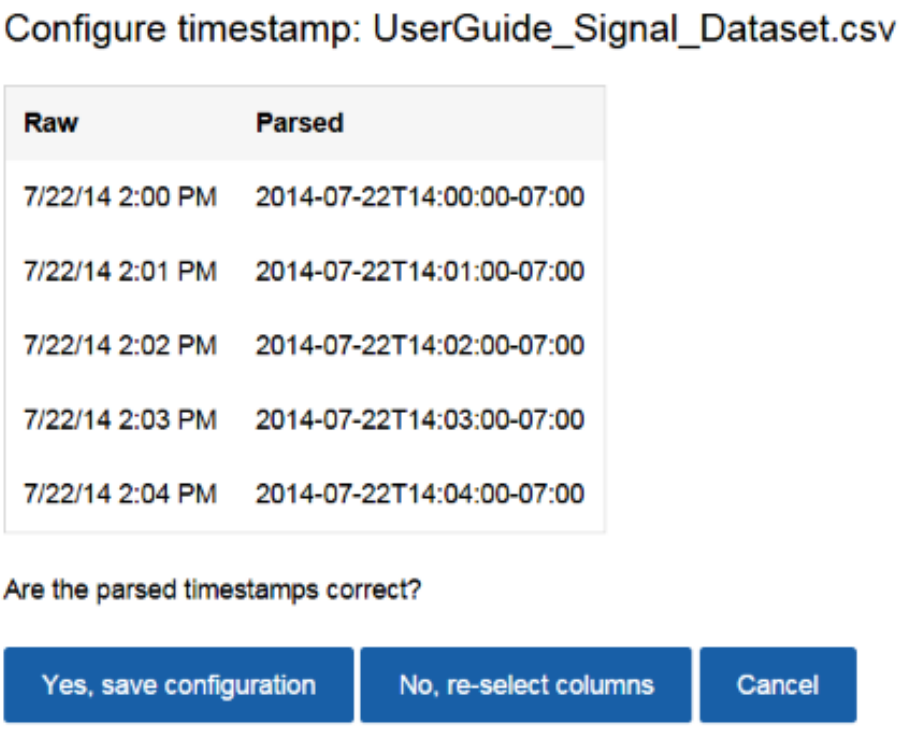

Figure 25: Timestamp configuration - raw timestamp and parsed timestamp

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

Figure 26: Create the second file

5.3 Support file formats in the OpenEIS

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

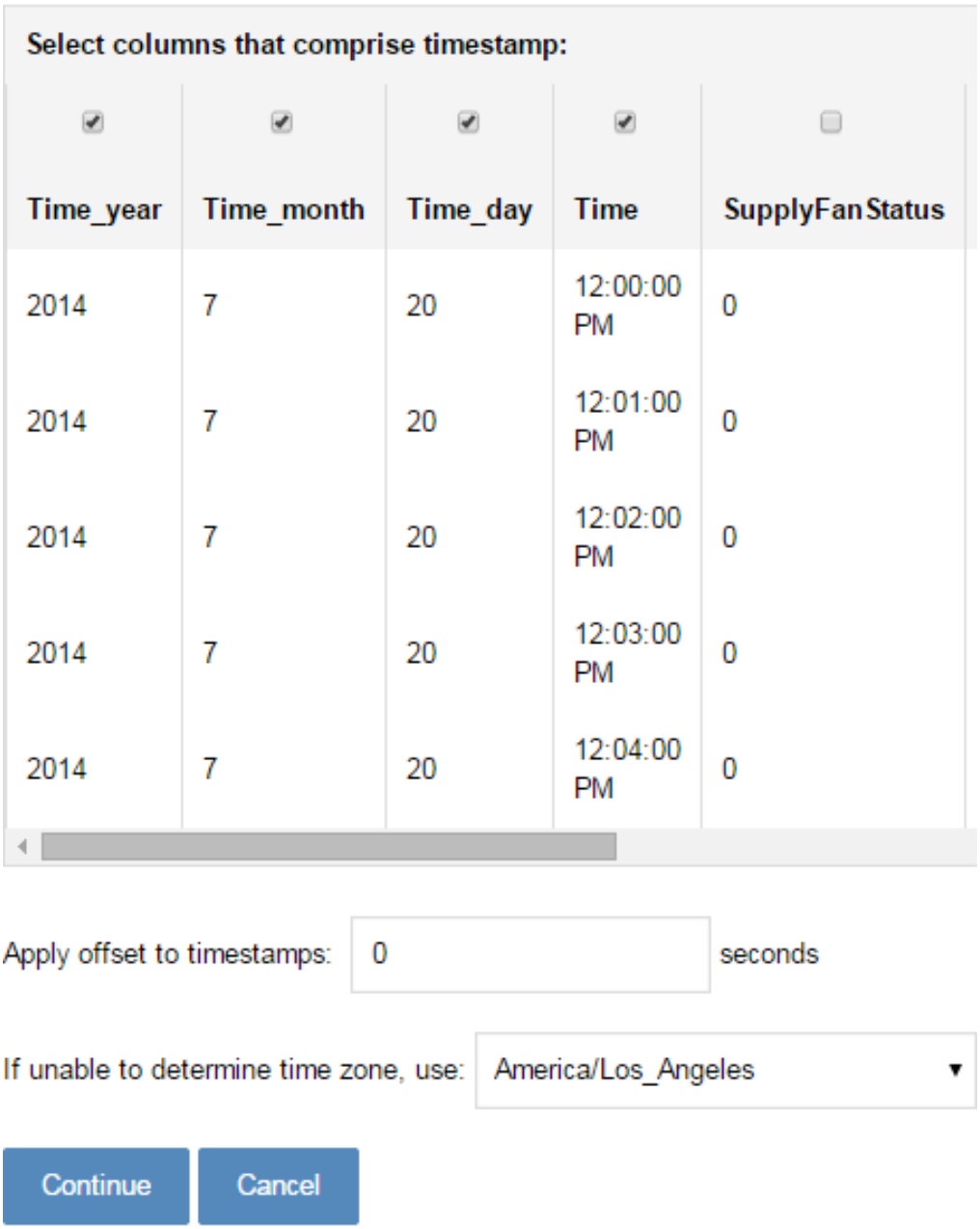

Figure 27: Different timestamp formats

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 Create a New Data Map

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

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

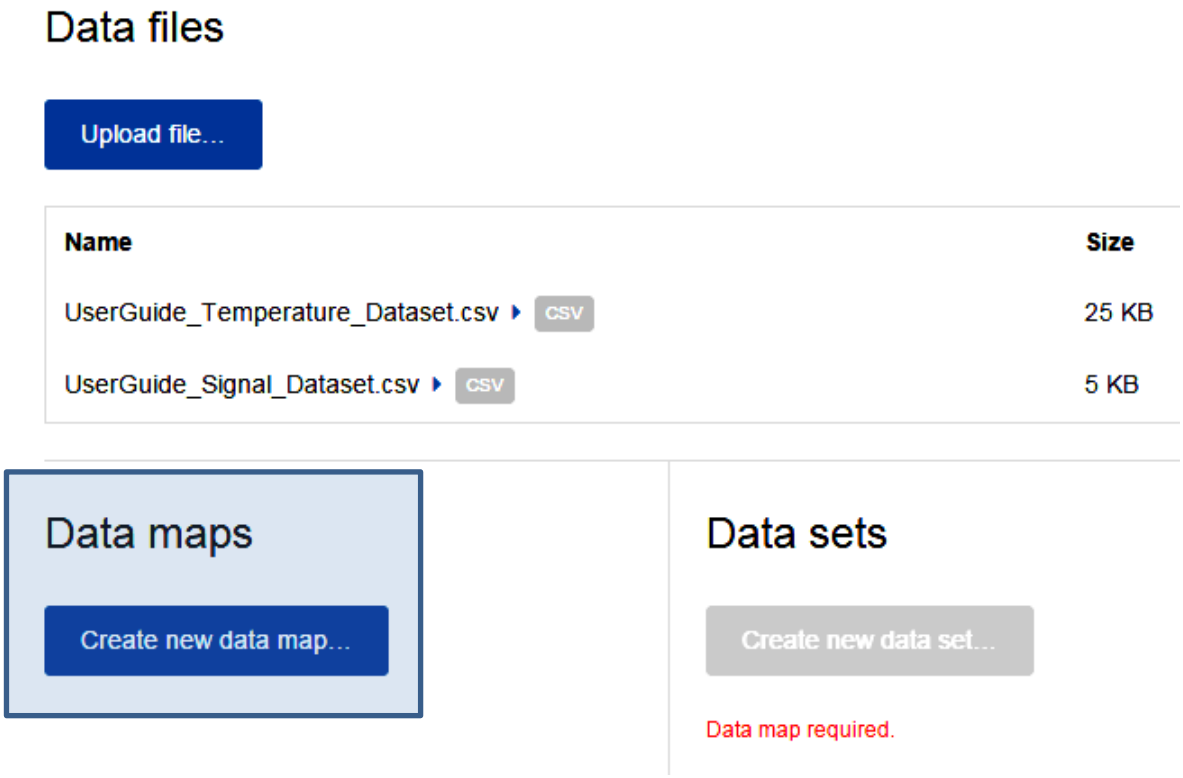

Figure 30: Create a new data map

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

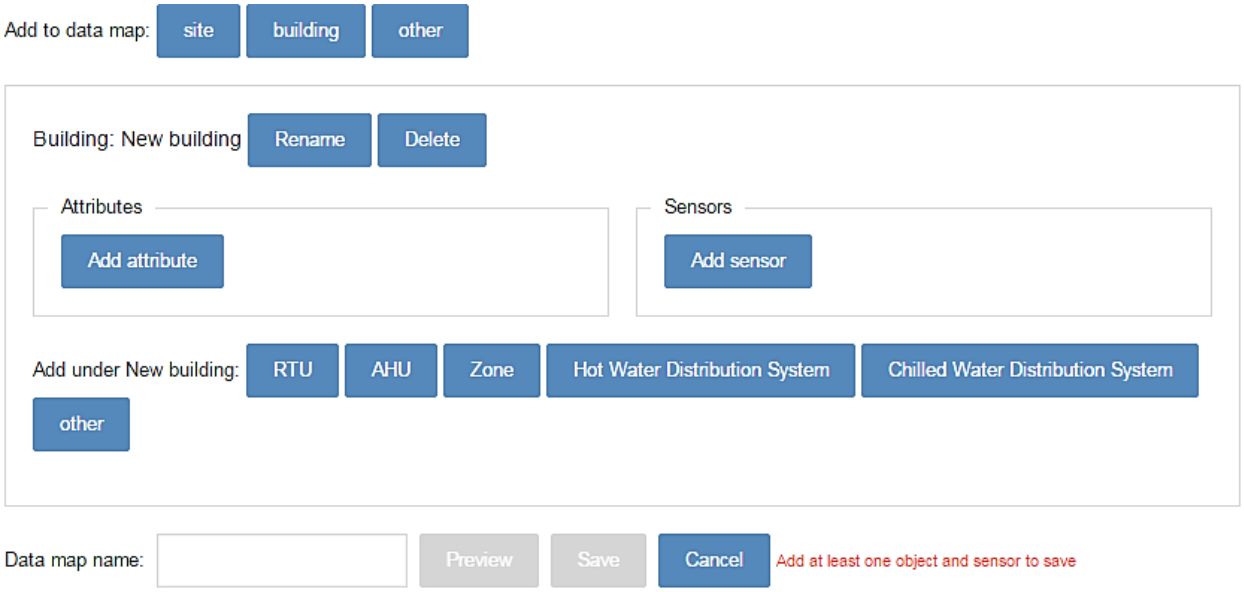

Figure 31: Create a new data map - "New data map" page

Step 3. Click "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 "Rename" button to change the building name. The default name for building is "New building" (Figure 32).

Figure 32: Create a new data map - changing the building name

Step 2. Enter the new name of building in the "Name" text box and click "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).

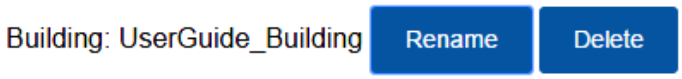

Figure 34: Create a new data map - changing the building name (continued)

6.2 Set Building Attributes

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

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

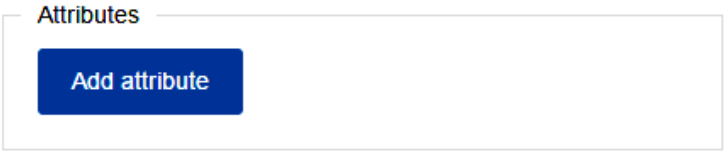

Figure 35: Setting time zone attribute for a data map

Step 2. Select "time zone" in the "New attribute" drop-down menu, as shown in Figure 36.

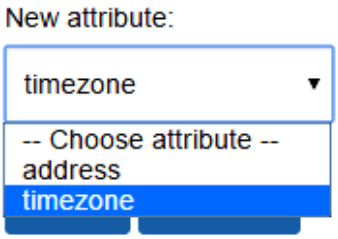

Figure 36: Setting time zone attribute for a data map (continued)

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

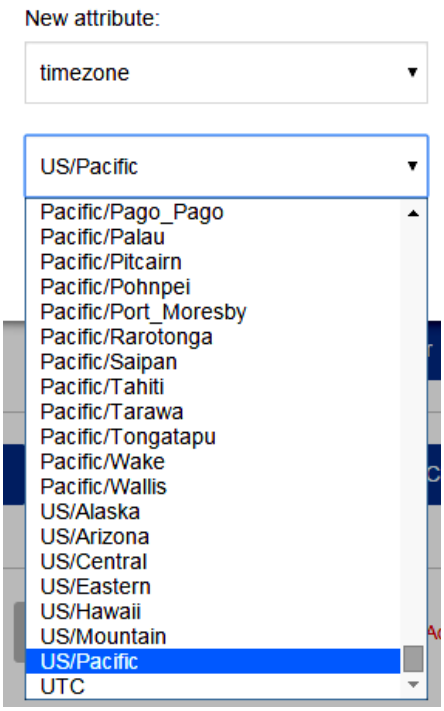

Figure 37: Setting time zone attribute for a data map (continued)

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

Figure 38: Setting time zone attribute for a data map (continued)

6.3 Add Building Sensors

This section explains the procedure to associate a user's data with a sensor at the building level (e.g., building power meter). Note: The sample data files, "UserGuide_Temperature_Dataset.csv" and "UserGuide_Signal_Dataset.csv", do not have sensor information. For a sample data file with sensor information, visit The LBNL OpenEIS website.

Step 1. Click "Add sensor" button from "Add" under "New building" menu displayed on the right side of Figure 30.

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 unit from the drop-down menu under “Value unit.”

Step 6. Click the “Add” button to complete the mapping for this point.

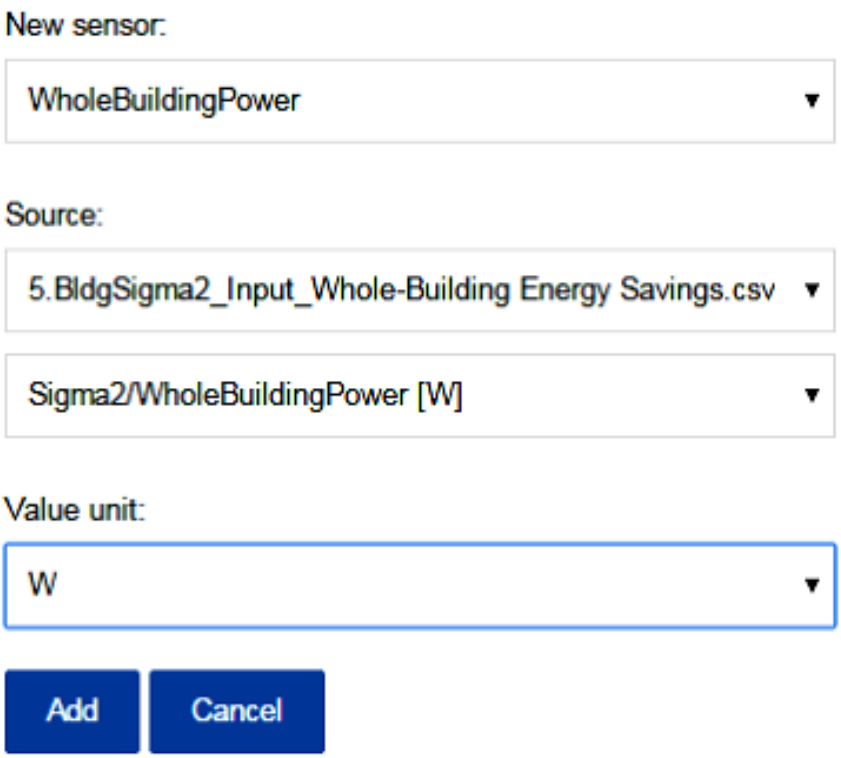

Figure 39: Sensors related to overall building mapping

6.4 Add Building Equipment

This section explains the procedure to associate a user’s data with building equipment. Building systems typically consist of heating, ventilation and air conditioning equipment.

Building equipment can be broadly categorized as conditioned air delivery equipment and chilled water or hot water distribution equipment. Conditioned air delivery systems consist of devices such as air handling units (**AHUs**), packaged roof top air conditioners or heat pumps (**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 buildings cooling and heating needs. These systems include devices such as chillers, boilers, cooling towers, fans, and pumps.

The following steps describe the process for mapping AHU data, imported in Section 0, to common OpenEIS names:

Step 1. Click “AHU” button from “Add” under “New building” menu (Figure 40).

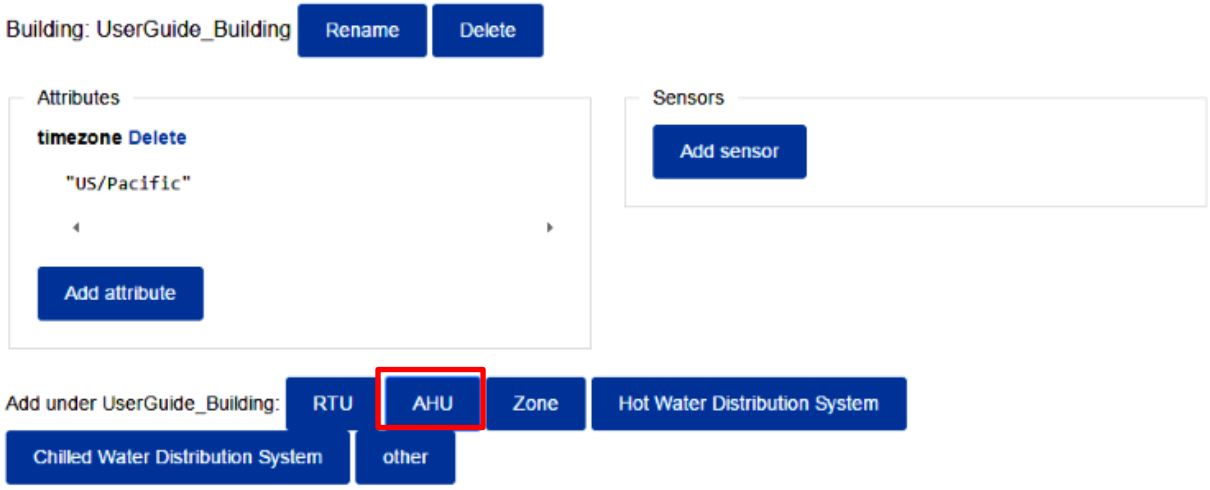

Figure 40: AHU selection

Step 2. A pop-up window appears to allow the user to enter a name for the AHU (Figure 41). Enter “AHU8” and click the “OK” button.

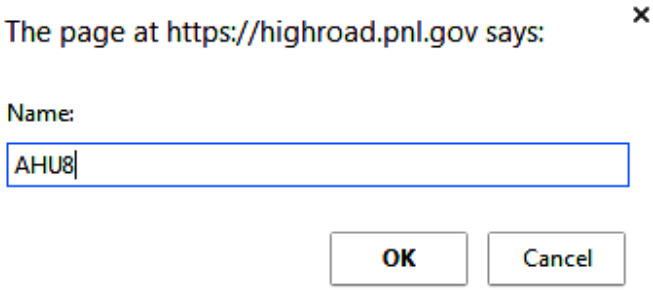

Figure 41: Enter AHU name

Step 3. Click “Add sensor” button (Figure 42).

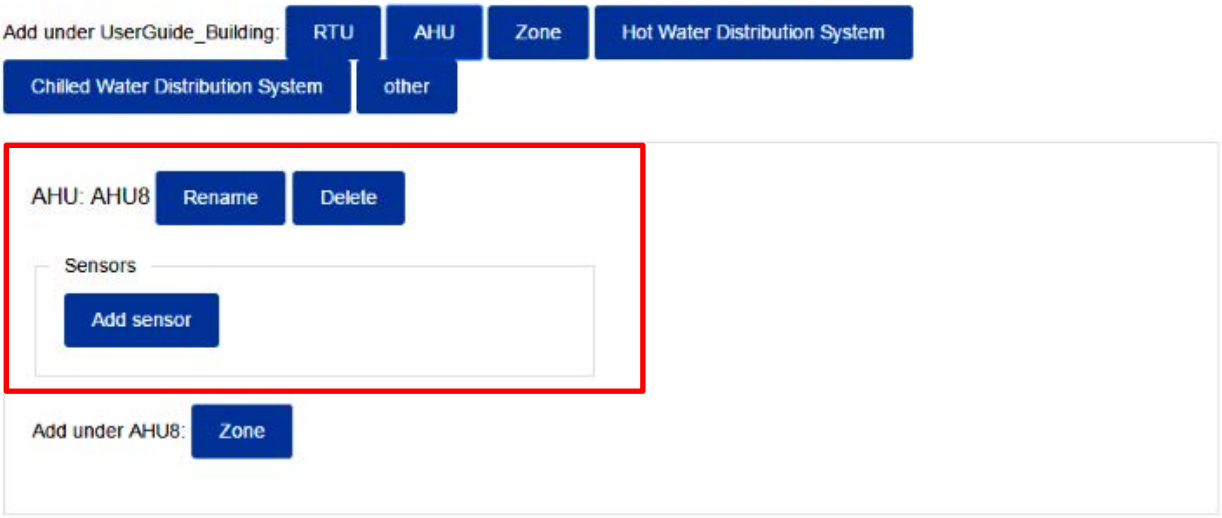

Figure 42: AHU sensor selection menu

Step 4. Select a standard name from the drop-down menu under “New sensor”. The sensor list changes according to the selected equipment, that is, each piece of equipment (i.e., AHU, RTU, hot water distribution system, and chilled water distribution system) has a different set of available sensors (Figure 43).

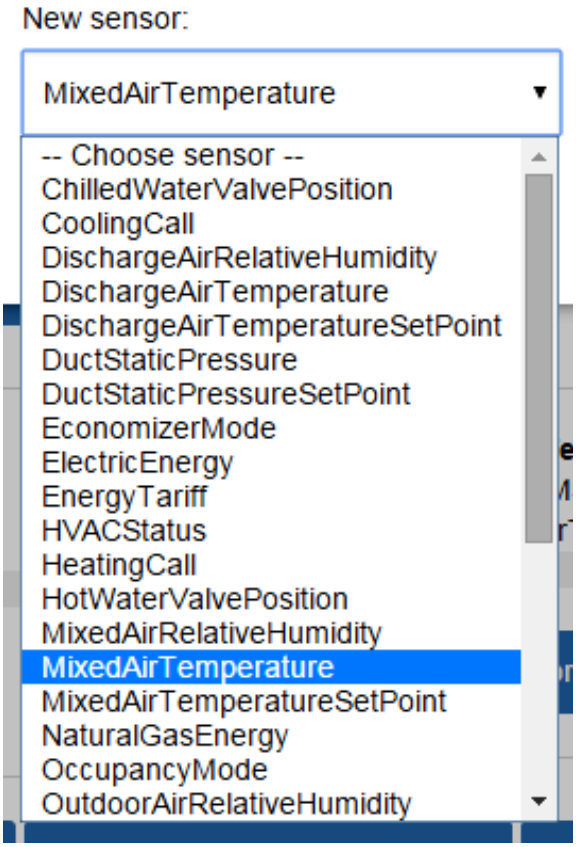

Figure 43: Select “MixedAirTemperature” in OpenEIS

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

Step 6. 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.

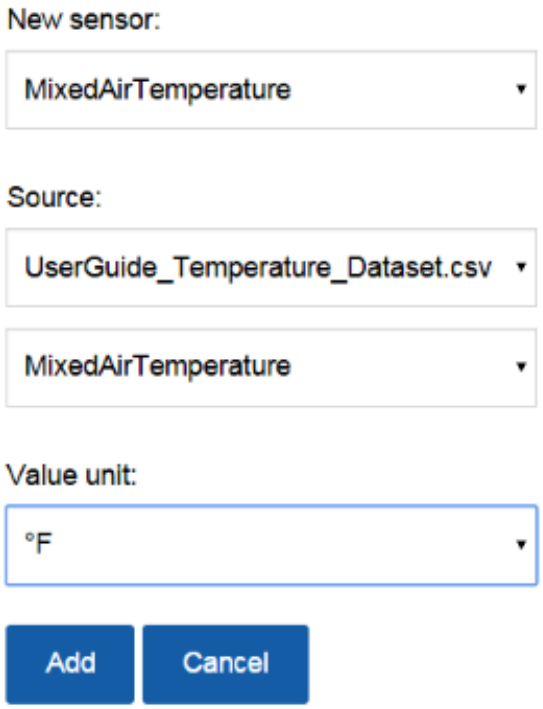

Figure 44: “MixedAirTemperature” mapping between (1) user’s import data file and (2) OpenEIS

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

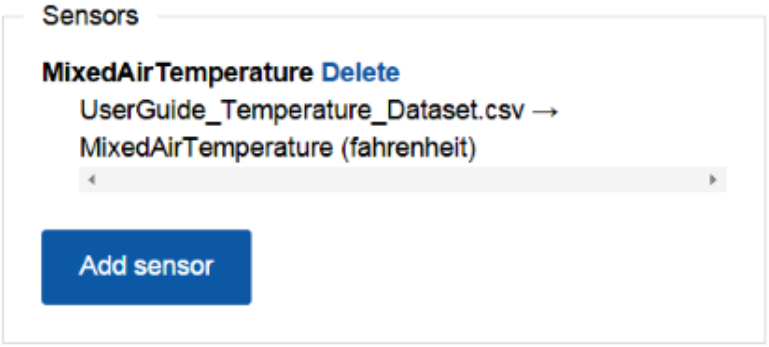

Figure 45: “MixedAirTemperature” mapping summary between user’s import data file and OpenEIS

Step 10. Repeat Steps 1 through Step 9 (of this Section: 4) until all equipment related sensors are added. Each element name from 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 [Percent] in “OpenEIS” → SupplyFanStatus in UserGuide_Signal_Dataset.csv
- OutdoorDamperSignal [Percent] in “OpenEIS” → DamperSignal in UserGuide_Signal_Dataset.csv

6.5 Adding 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. The following steps describe the process for mapping data as an RTU. Note: The sample data files, “UserGuide_Temperature_Dataset.csv” and “UserGuide_Signal_Dataset.csv”, do not have zone information.

Step 1. Click “Zone” button (Figure 46).

Step 2. Click “Add sensor” button.

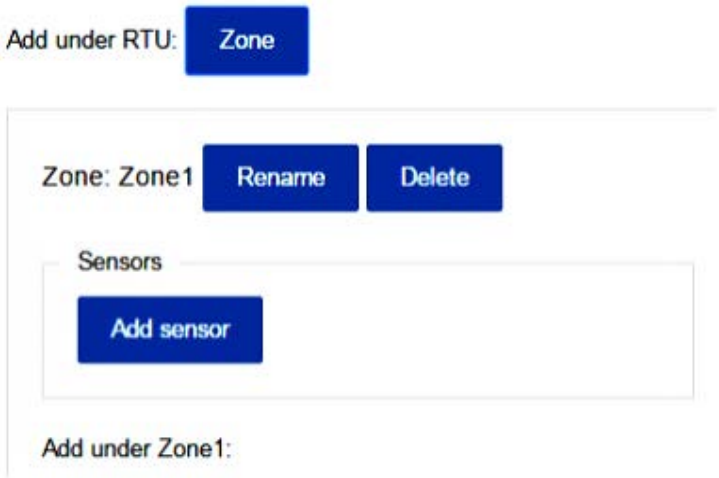

Figure 46: Zone selection

Step 3. Select a standard name from the drop-down menu under “New sensor” (Figure 47).

Step 4. Select the raw data file from the first drop-down menu under “Source”.

Step 5. Select the name of the column header in the raw data file to map to the standard OpenEIS name chosen in step 3.

Step 6. Select the unit from the drop-down menu under “Value unit”.

Step 7. Click the “Add” button to complete the mapping for this point.

Step 8. Repeat Steps 1 through Step 7 until all equipment related zones are added.

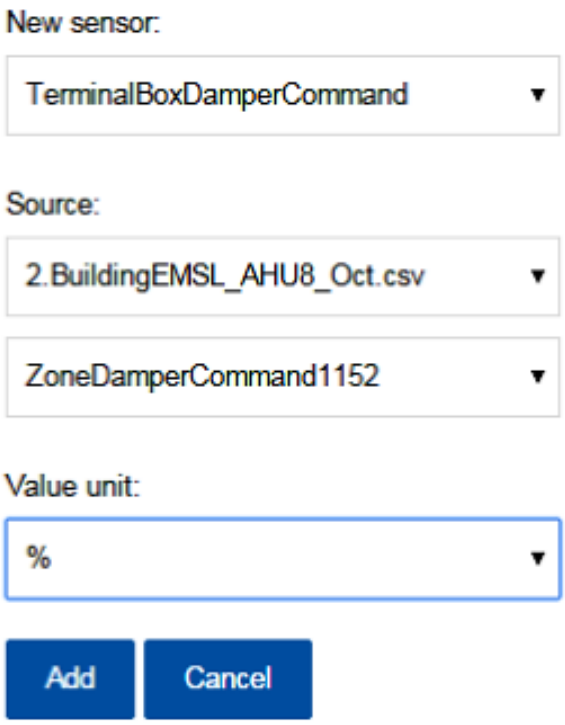

Figure 47: “TerminalBoxDamperCommand” mapping summary between user’s import data file and OpenEIS

6.6 Save a New Data Map Name

Step 1. Enter the data map name on the text box and click “Save” button to save the data map onto 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.

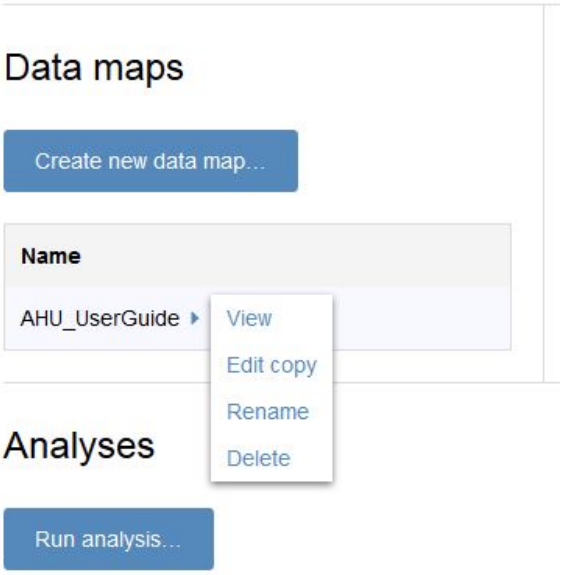

Figure 49: “AHU_UserGuide” data map available actions

The “Edit copy” action will allow one to add or delete sensors from the chosen data map. For our example, the “Edit copy” action is chosen for the “AHU_UserGuide” data map. The data map was edited to contain only the temperature sensor data (the other sensors were deleted) and the new data map was named “AHU_UserGuide_Temperatures” (Figure 50).

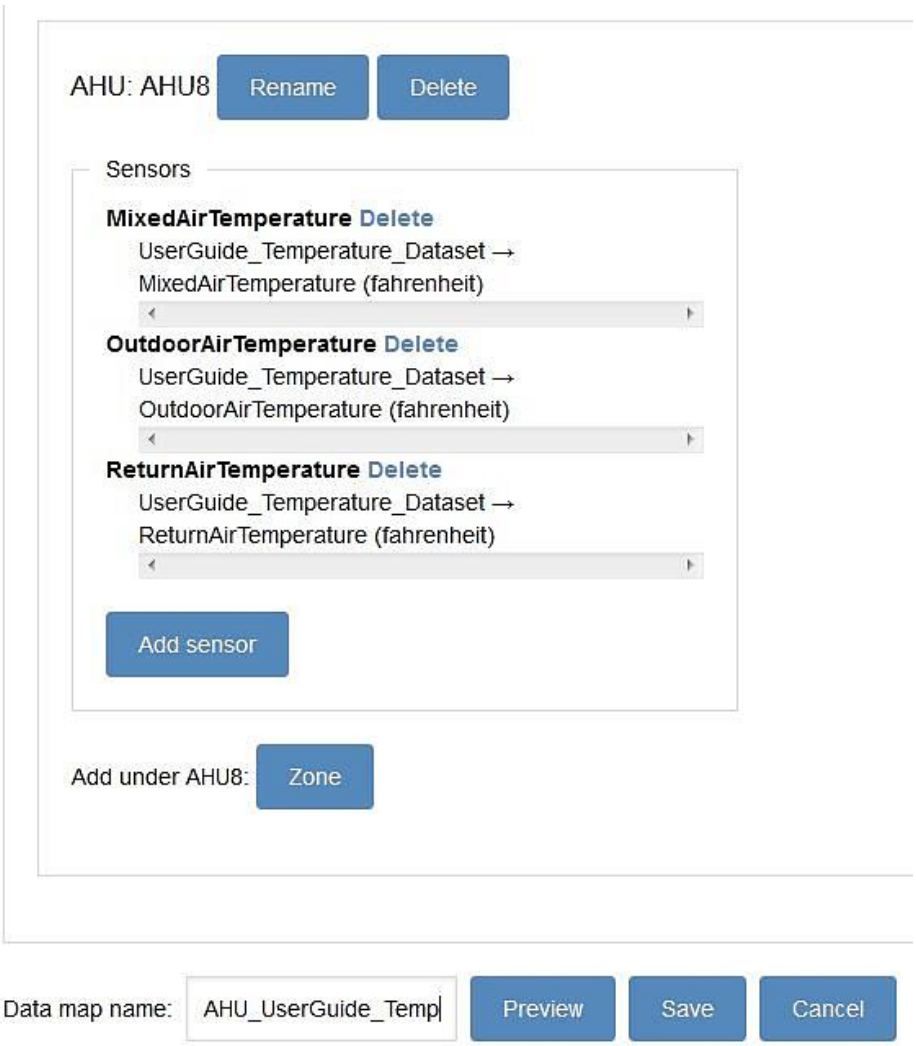

Figure 50: "Edit copy" action for a data map

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. 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 project name provides the options to view ("View"), edit ("Edit copy"), rename ("Rename") and delete ("Delete) the data map.

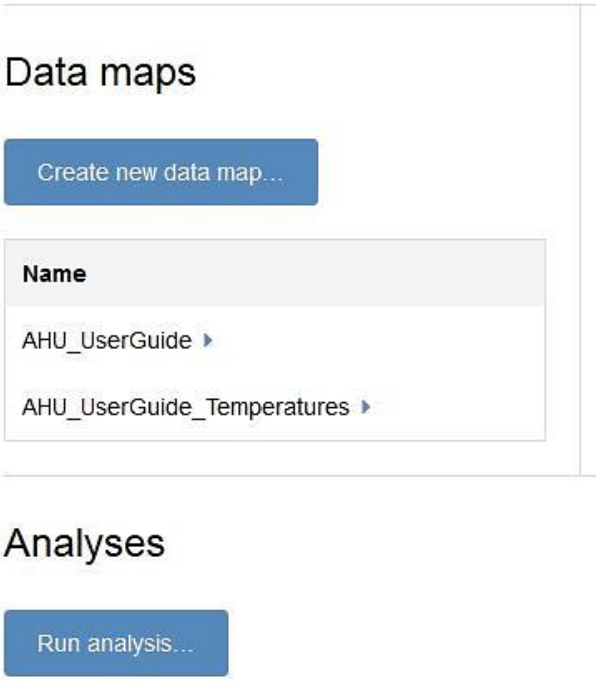

Figure 51: “Edit copy” action on a data map – saving the new data map

7 Create a New Data Set

This section explains the procedure to create a new data set from raw data files that have already been uploaded into the OpenEIS (Section 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 detail the process to create a data set:

Step 1. Click “Create new set” button under “Data sets” (Figure 52).

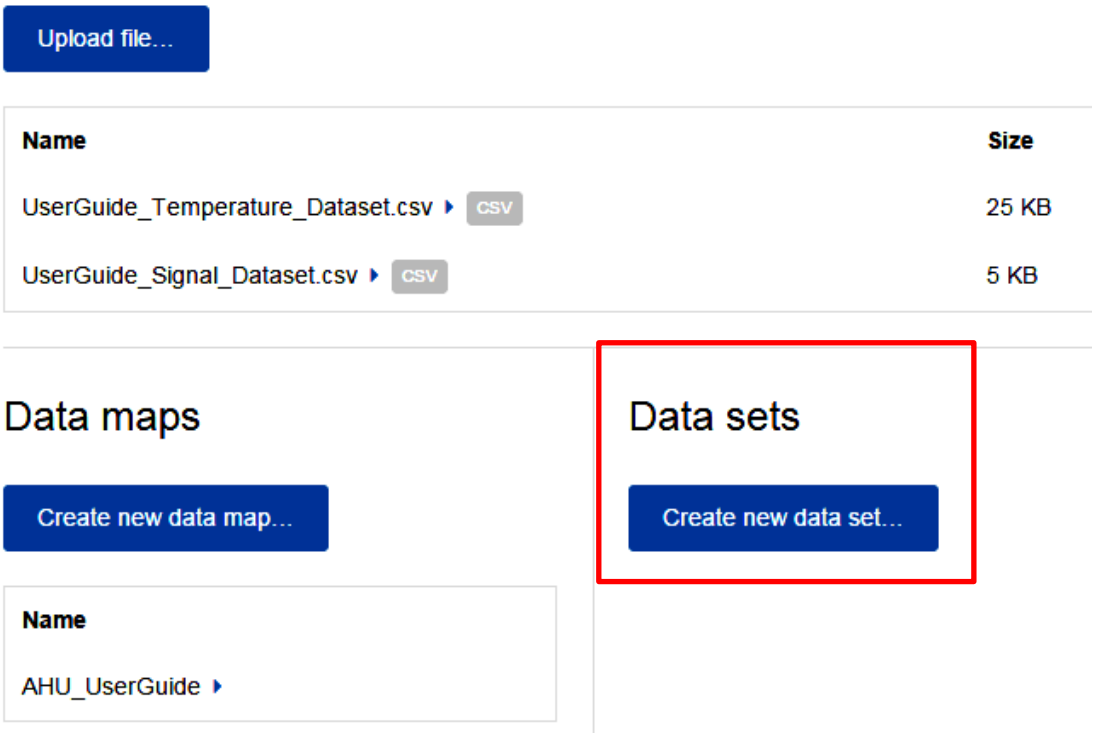

Figure 52: “Create a new data set”

Step 2. Select the new data map created in Section 0 from drop-down menu (Figure 53).

Step 3. Click “Create” button.

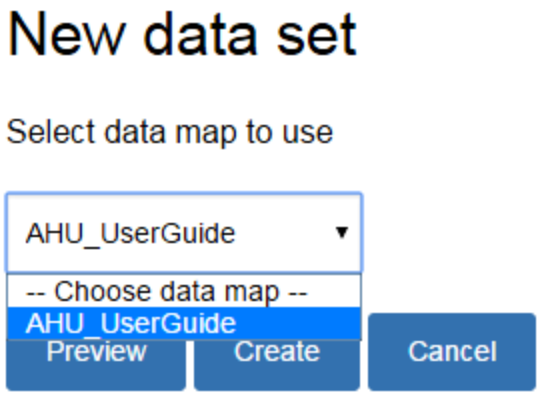

Figure 53: Data map selection

Step 4. Click the drop-down menu and select the file uploaded in Section 5. Multiple files can be selected based on the number of corresponding files associated with the chosen data map (Figure 54). For example, the data map chosen consists of:

- MixedAirTemperature → MixedAirTemperature [Fahrenheit] in “OpenEIS”
- ReturnAirTemperature → ReturnAirTemperature [Fahrenheit] in “OpenEIS”
- CoolingCoilValvePosition → CoolingCall [Percent] in “OpenEIS”
- SupplyFanStatus → SupplyFanStatus [Percent] in “OpenEIS”
- DamperSignal → OutdoorDamperSignal [Percent] in “OpenEIS”

where data for MixedAirTemperature, ReturnAirTemperature, and OutdoorAirTemperature sensors are in UserGuide_Temperature_Dataset.csv and data for CoolingCall, SupplyFanStatus, and OutdoorDamperSIgnal are in UserGuide_Signal_Dataset.csv. This example illustrates how a single data map is used to create a data set from multiple input data files.

Step 5. Click the “Create” button after selecting the appropriate data file from each drop-down menu (Figure 54).

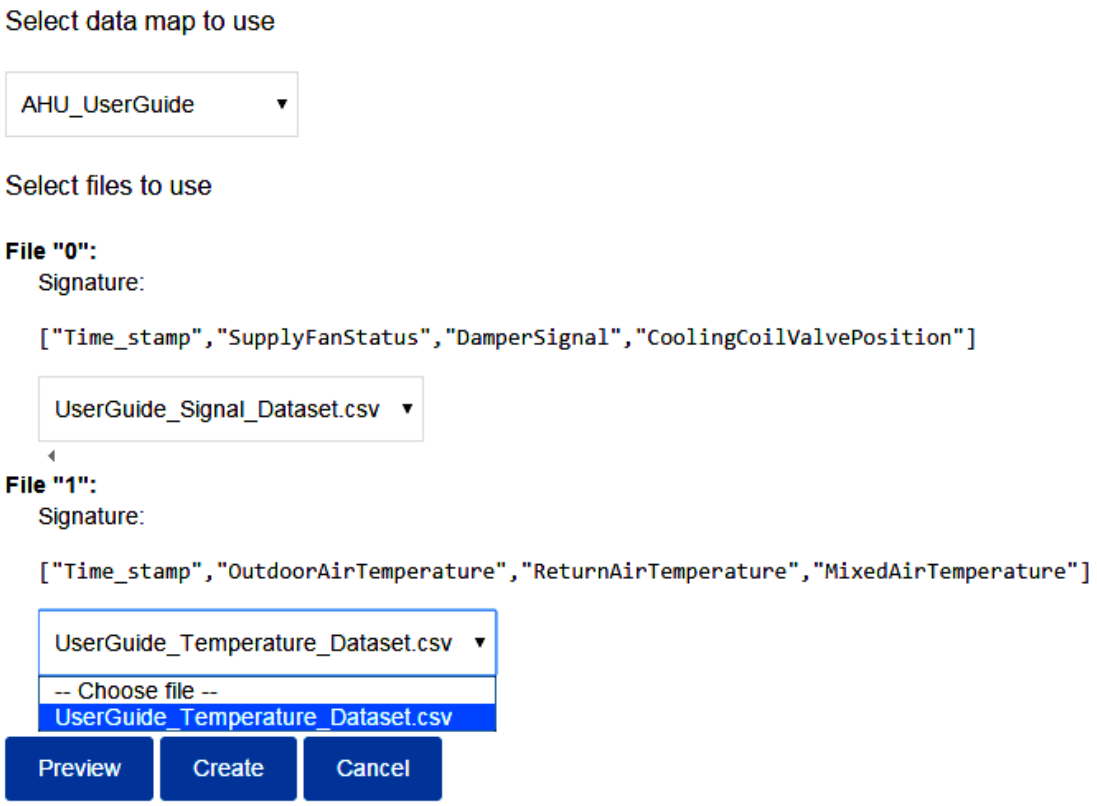

Figure 54: Data set mapping between (1) user's import data file and (2) OpenEIS

Step 6. Confirm the data set summary: data set name ("AHU_UserGuide"), process status ("complete"), and error ("None") (Figure 55).

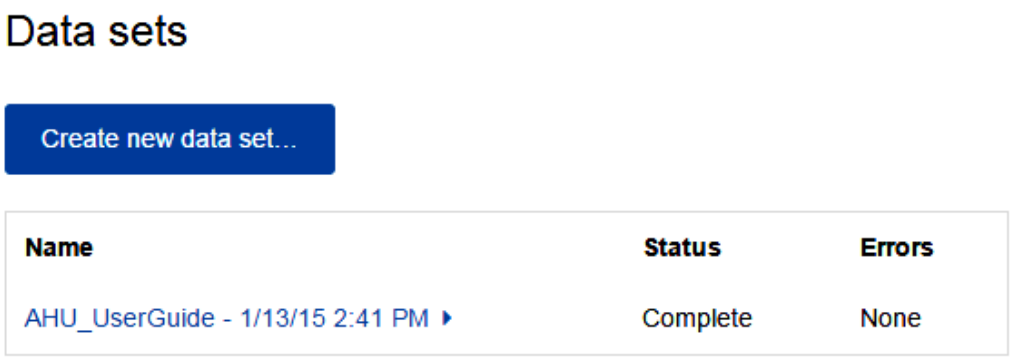

Figure 55: Data set output

Step 7. The triangle button next to file name provides the options to view data (“View”), manipulate data (“Manipulate”), download data set (“Download”), rename data set name (“Rename”), and delete (“Delete”) data (Figure 56).

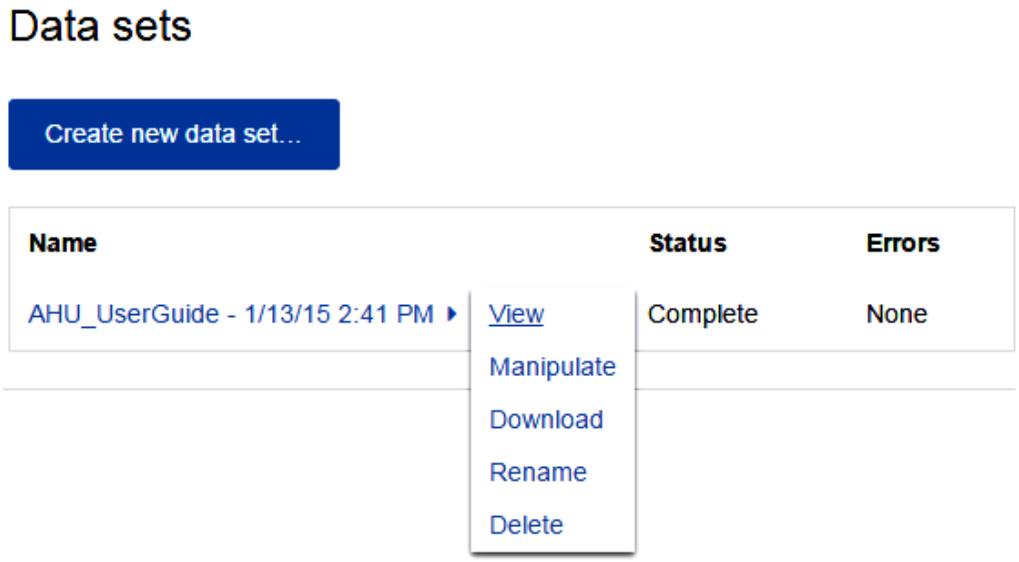

Figure 56: Data set option

Step 8. Click “View” button to confirm a new data set (Figure 56). Two data files with differing timestamps are merged into a single new data set.

time	UserGuide_Building/AHU8/CoolingCall	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	true	72.8552

Figure 57: New data set views

8 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 data set (Section 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: The OpenEIS provides “Fill” filters that can fill in the missing data. The “Fill” filter provides users the ability to fill in missing values by repeating the last known value or interpolating between the two know 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”.
- Repeated 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 “Repeated 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, etc.

- 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: The 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).

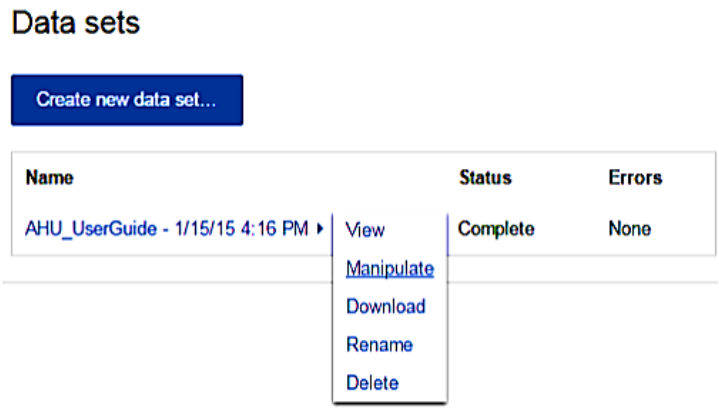

Figure 58: Select “Manipulate” in data set options

Step 2. “Manipulate the data set” page is displayed (Figure 59).

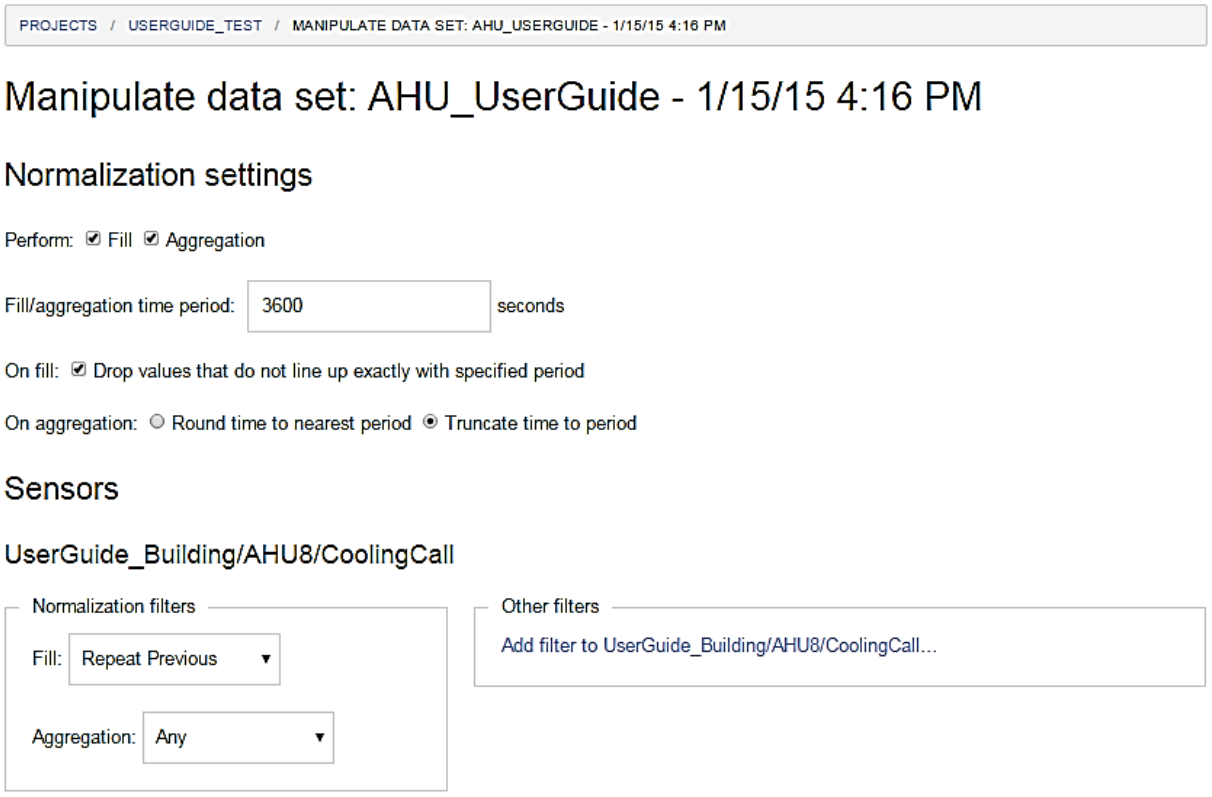

Figure 59: “Manipulate data set” page

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

Step 4. Enter duration to configure a time period in the “Fill/aggregation time period” text box. See Figure 60 for example of specified time period, 60 seconds.

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

Figure 60: Normalization settings for “Fill” filter

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

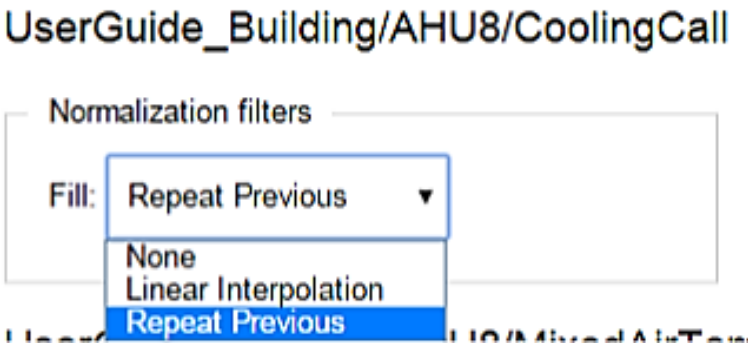

Figure 61: Select “Repeat previous” option in “Fill” filter for “CoolingCall”

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

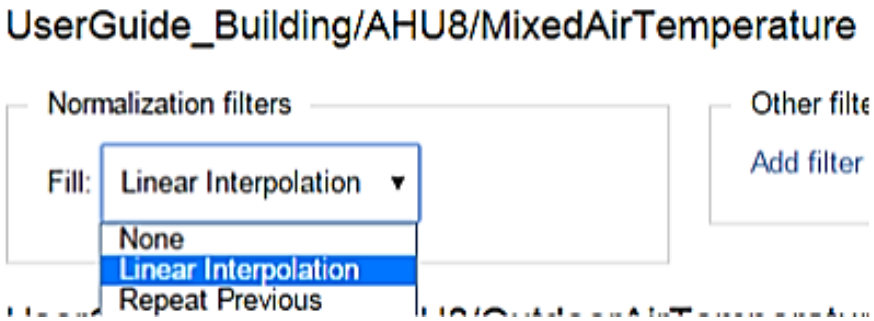

Figure 62: Select “Linear interpolation” option in “Fill” filter for “MixedAirTemperature”

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

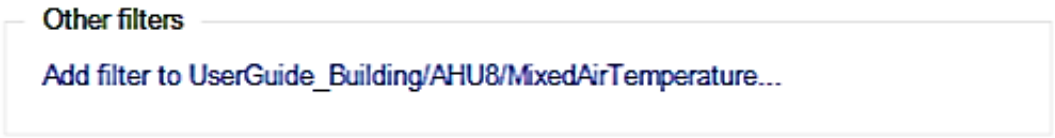

Figure 63: Add “Other filters” for “MixedAirTemperature”

Step 9. Select “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).

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

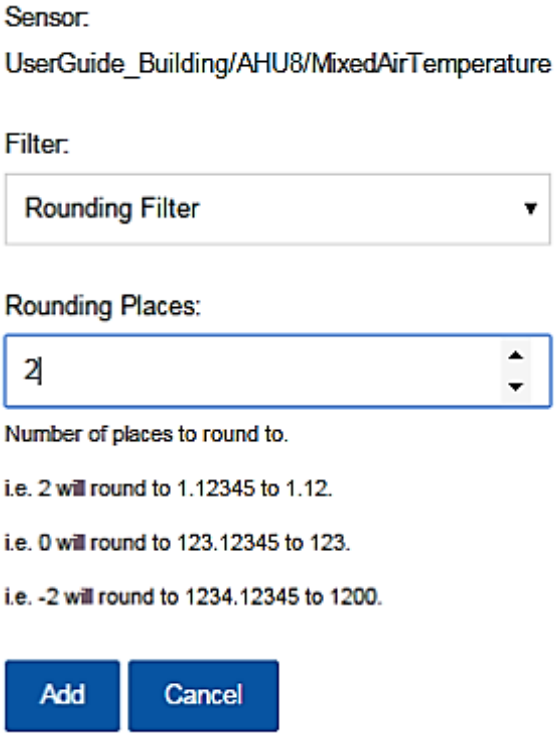

Figure 64: Configuring the “Rounding filter” for “MixedAirTemperature” sensor

Step 11. Confirm the “Rounding filter” summary. If the information is incorrect, click on “Delete” and repeat Step 8 to 10.

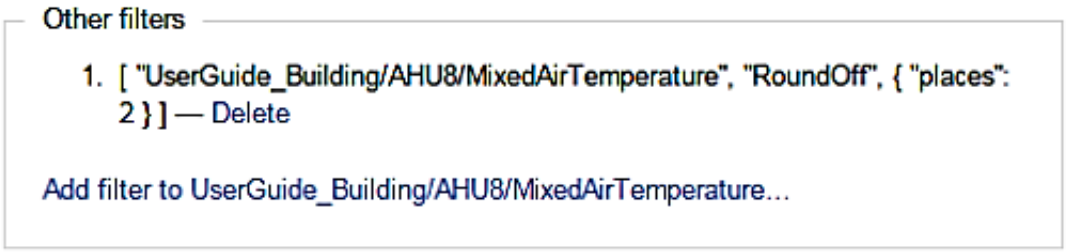

Figure 65: “Rounding filter” summary for “MixedAirTemperature”

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

- UserGuide_Building/AHU8/OutdoorAirTemperature →
  Fill: Linear interpolation and Other filters: RoundOff with “places”:2
- UserGuide_Building/AHU8/OutdoorDamperSignal →
  Fill: Linear interpolation and Other filters: RoundOff with “places”:2
- UserGuide_Building/AHU8/ReturnAirTemperature →
  Fill: Linear interpolation and Other filters: RoundOff 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).

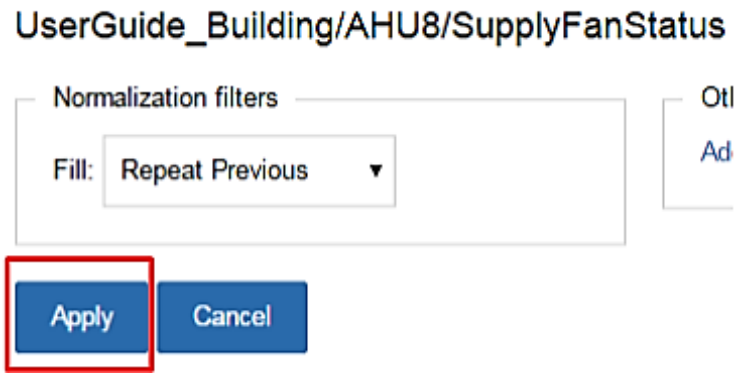

Figure 66: Perform “Fill” filter

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

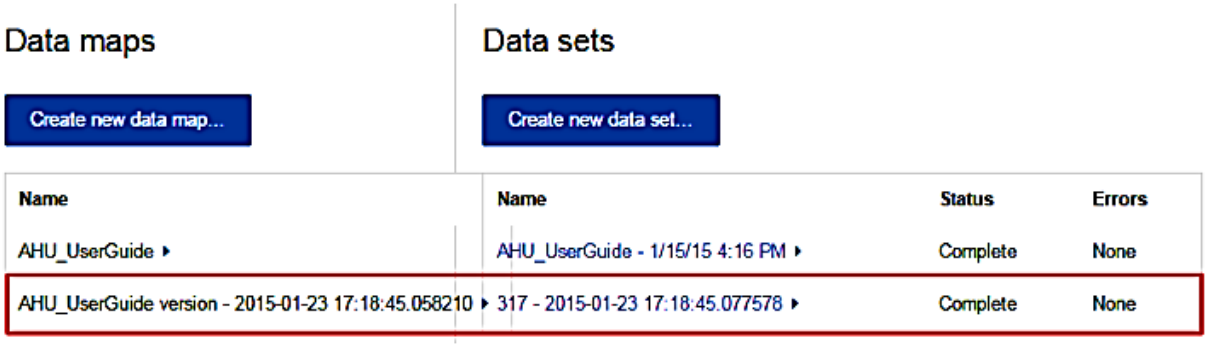

Figure 67: New data map and data set after completing “Fill” filter

Step 3. Rename the data map and data set so it 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.

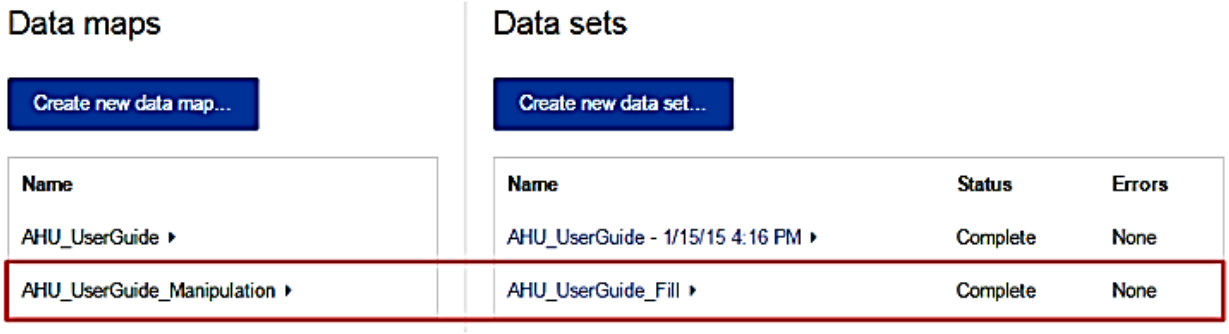

Figure 68: Change data map and data set name

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	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).

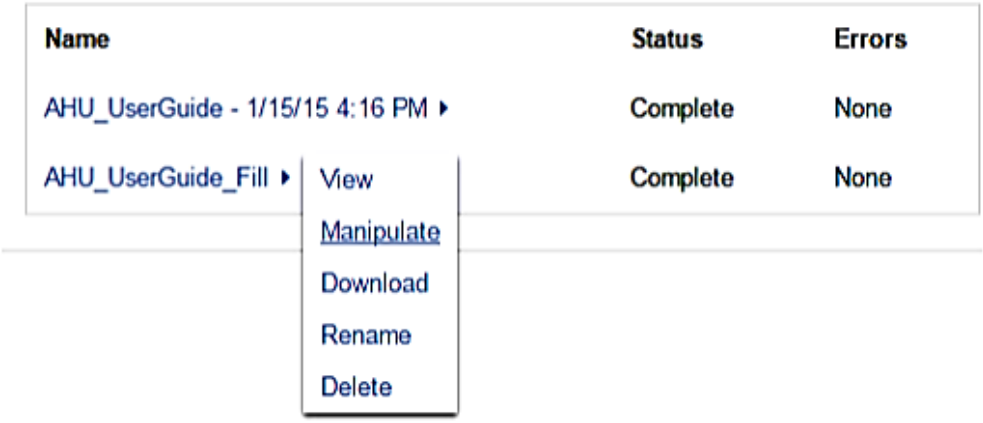

Figure 70: Select “Manipulate” in “AHU_UserGuide_Fill” menu options

Step 2. The “Manipulate data set” page is displayed (Figure 59).

Step 3. Under “Normalization settings”, deselect the “Fill” checkbox (Figure 71). Now, only “Aggregation checkbox is selected.

Step 4. Enter duration to configure a time period for “”Aggregation” filter. Figure 71 shows an example with a specified time interval of 360 seconds.

Step 5. Select “Truncate time to period” option under “On aggregation” to specify the aggregation data interval.

- 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.

Figure 71: Normalization settings change (aggregation time period: 3600 → 360 seconds)

Step 6. Select “All” under “Aggregation” drop-down menu for “CoolingCall” (Figure 72).

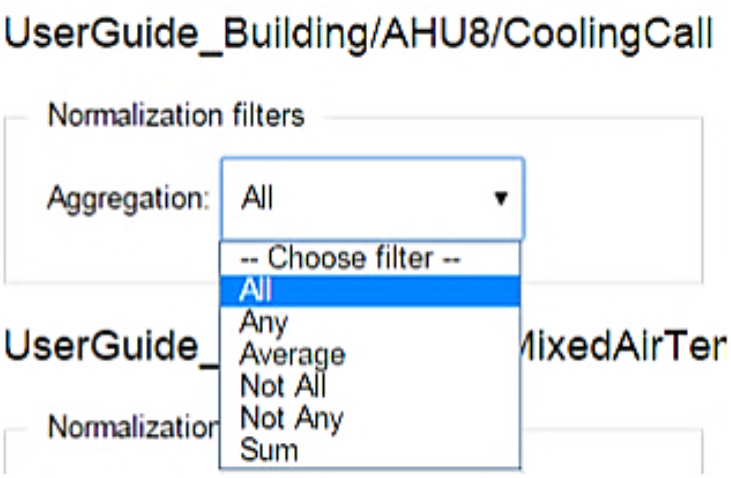

Figure 72: Select “All” function in “Aggregation” for “CoolingCall”

Step 7. Select the corresponding options under “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.

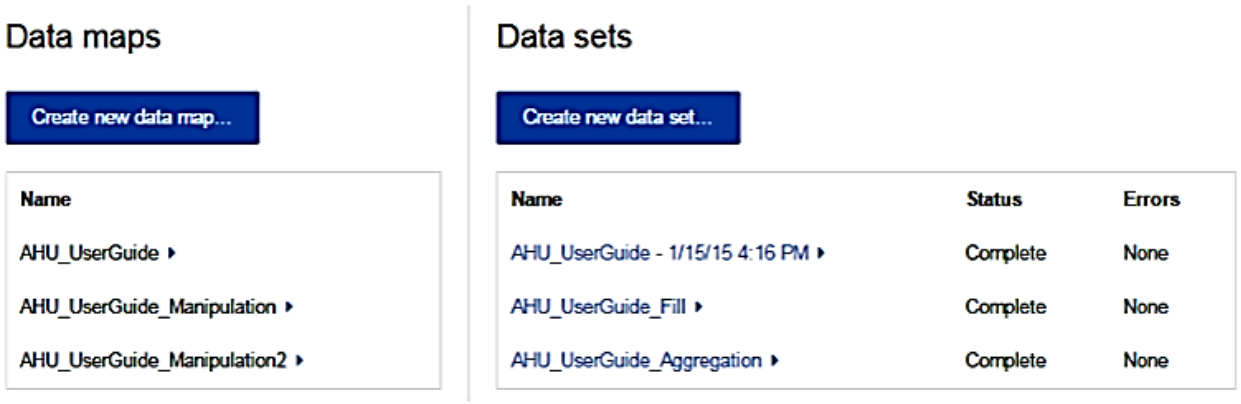

Figure 73: New data map and data set after completing "Aggregation" filter

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

time	UserGuide_Building/AHU8/CoolingCall	UserGuide_Building/AHU8/MixedAirTemperature
2014-07-22T12:00:00-07:00		72.08
2014-07-22T12:06:00-07:00		72.1
2014-07-22T12:12:00-07:00		72.12

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" first, filters. First, the "Fill" filter fills in any missing data. 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" checkbox under "Perform" (Figure 75).

Step 2. Enter duration to configure a time period for "Filter" and "Aggregation" filter. 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 unselected (Figure 75).

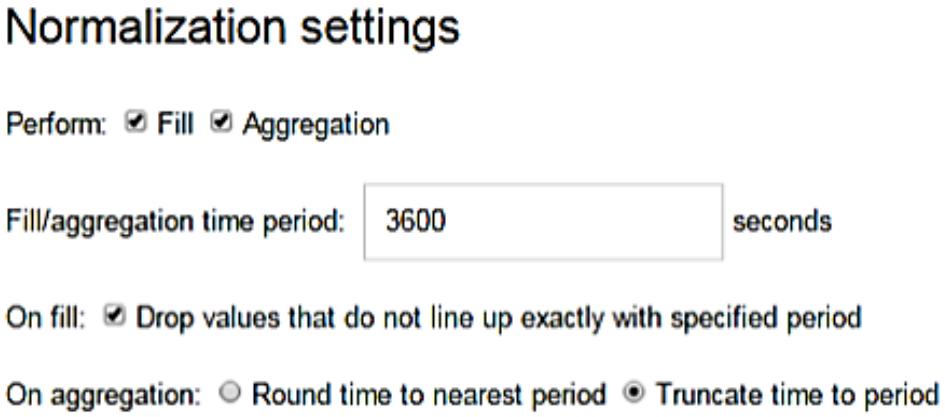

Figure 75: Normalization settings for “Fill” and “Aggregation” function

Step 5. Select “Linear Interpolation” option in “Fill” filter and “All” option for “Aggregation” filter for “Coolingcall” (Figure 76).

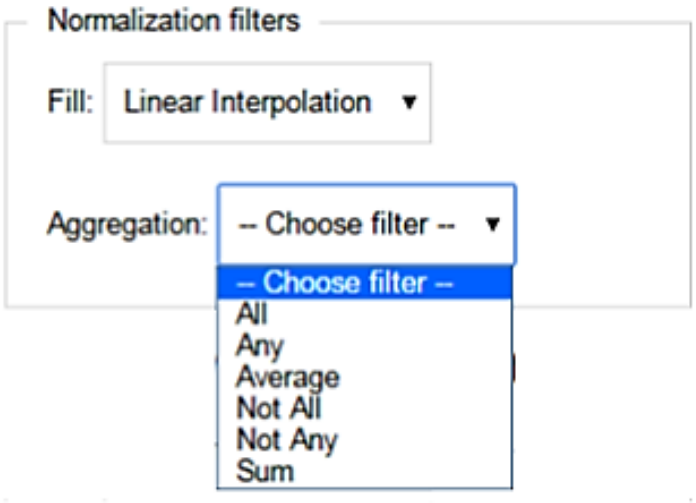

Figure 76: “Fill” and “Aggregation” function list

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".

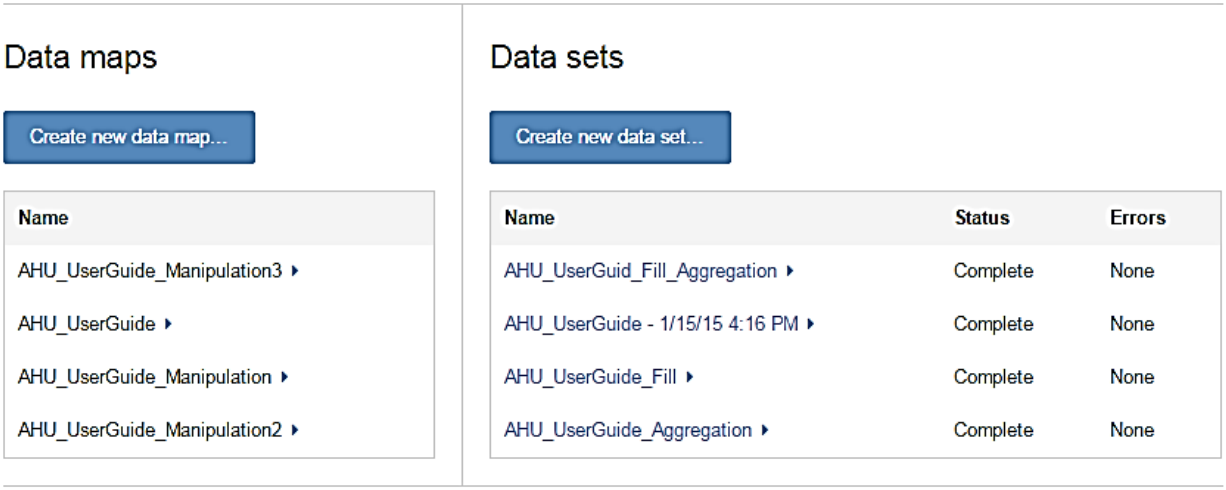

Figure 77: New data map and data set after completing "Fill" and "Aggregation" filter

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 a 360-second time intervals.

time	UserGuide_Building/AHU8/CoolingCall	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	true	72.86

Figure 78: View “AHU_UserGuide_Fill_Aggregation” data set

9 Select and Run Analysis Applications

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

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

- Auto-RCx for Air Handling HVAC Systems: detect, diagnose and automatically provide corrective actions to the problems with an AHU's operation
- Auto-RCx for Economizer HVAC Systems: detect and diagnose problems with outdoor-air ventilation and economizer operations.
- Auto-RCx for Hot-Water Distributions Systems: detect and diagnose problems with hot-water system operations.

[LBNL applications]
The LBNL OpenEIS website provides the detailed explanation of LBNL applications from the online reference documentation.

- 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 size 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
  - Heating, ventilation and air conditionint (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 “Run analysis” button under “Analyses” (Figure 79).

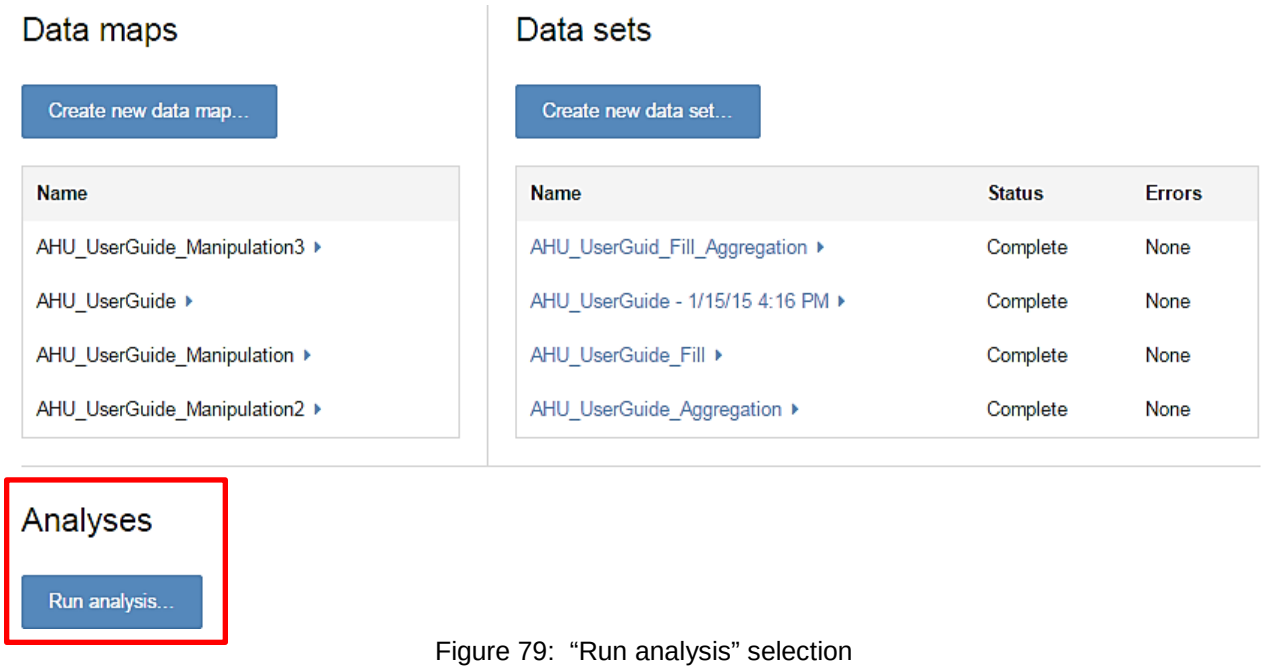

Figure 79: “Run analysis” selection

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

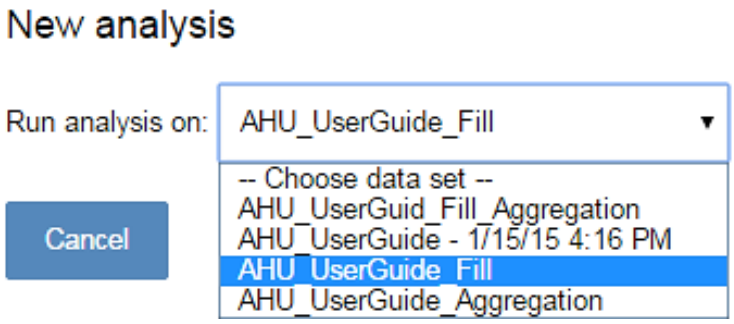

Figure 80: Data set selection

Step 3. The “New analysis” page is displayed (Figure 81).

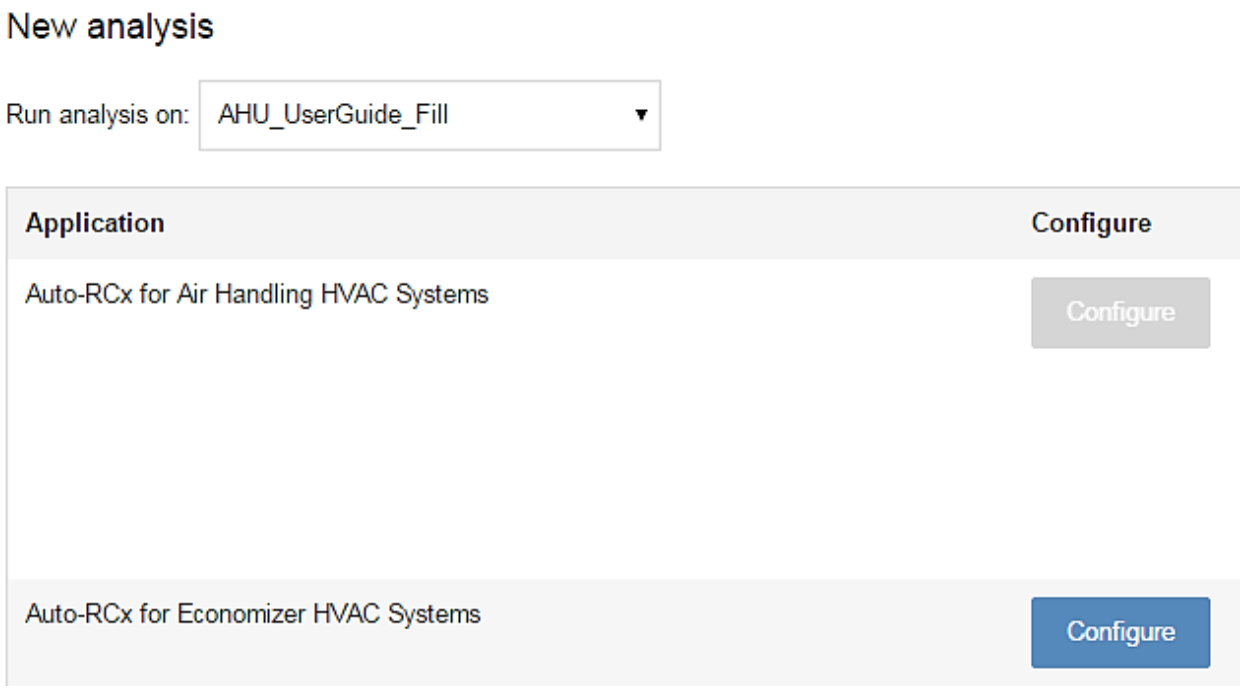

Figure 81: "New analysis" page

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 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 "Automated retro-commissioning for AHUs" displayed in red. An application with no missing inputs is displayed with a blue "Configure" button on the left.

Step 5. Click "Configure" button next to the "Automated retro-commissioning for HVAC economizer systems" application to configure the application inputs and set up parameters (Figure 82).

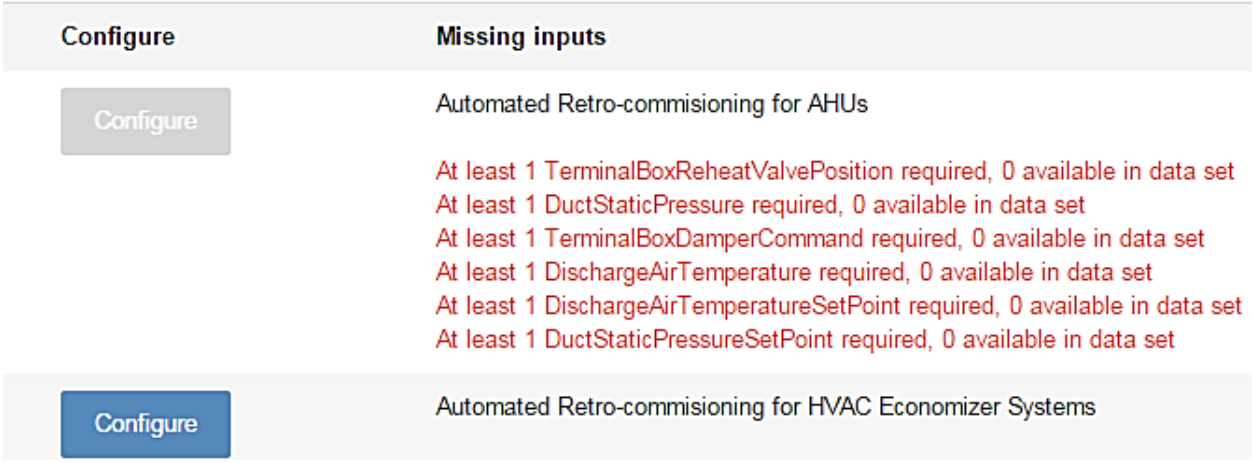

Figure 82: Missing inputs about "Automated retro-commissioning for AHUs"

Step 6. The “Automated retro-commissioning (RCx) for 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.

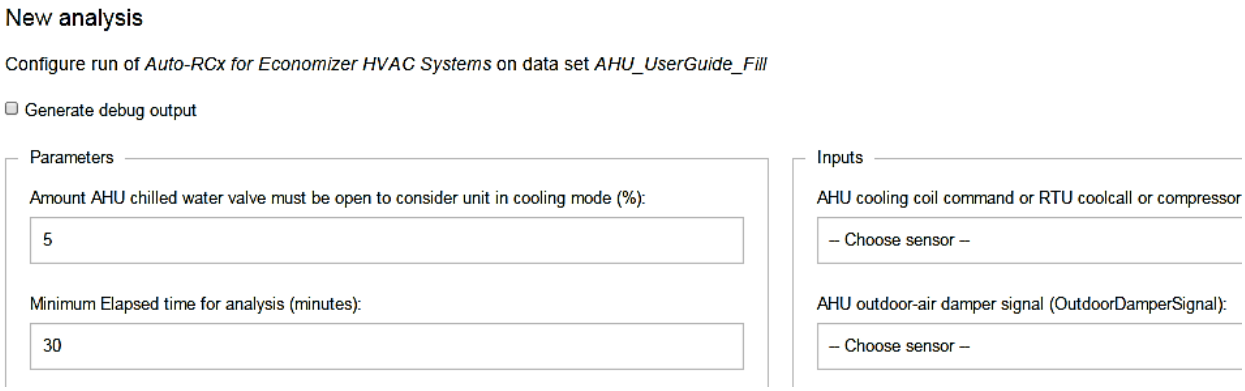

Figure 83: Auto-RCx for economizer-HVAC systems application

Step 7. The default configuration parameters for “Automated retro-commissioning for 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 “Automated retro-commissioning for HVAC economizer systems.”

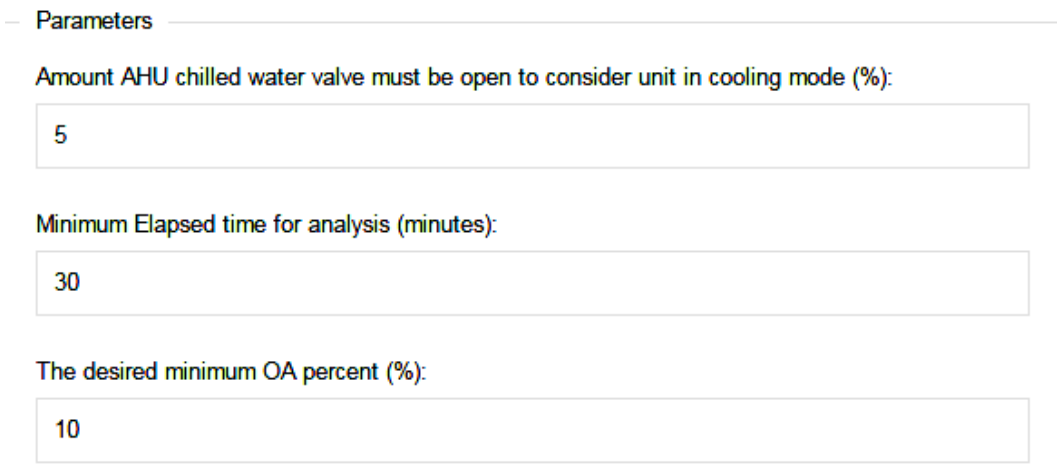

Figure 84: Application parameter configuration

Step 8. Select the inputs from each drop-down menu. Figure 85 shows the selection of "UserGuide_Building/AHU8/CoolingCall" (data set point as mapped in Section 0) for the application input "CoolingCall."

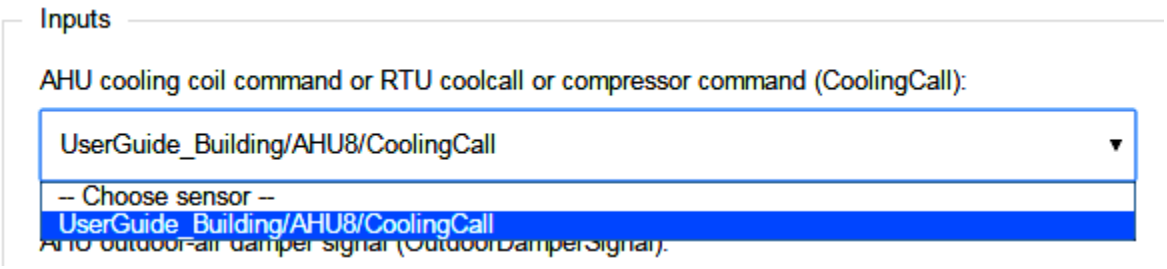

Figure 85: Application input configuration

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

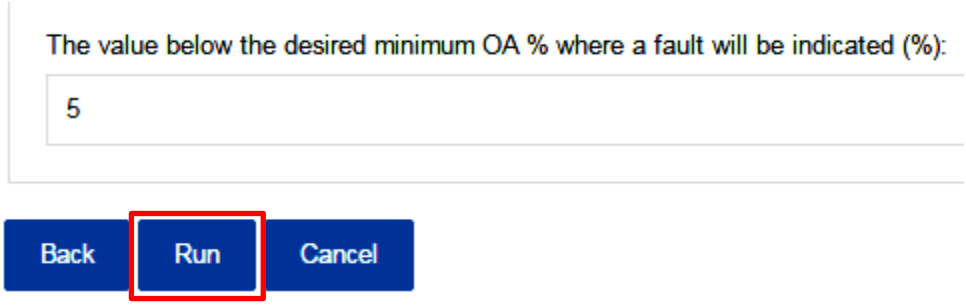

Figure 86: "Run" application

Step 10. Check the status of application processing. The status indicates whether the application processing is successful. "Complete" means the application processing completed successfully. "Name ("AHU_UserGuide_Dataset") and status ("Complete") are displayed (Figure 87).

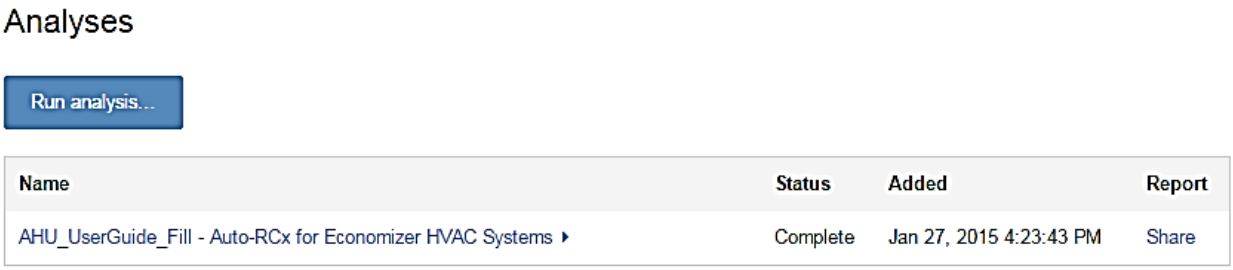

Figure 87: Application output

10 Collect and visualize Results

This section explains how to collect and visualize application results.

Step 1. The triangle button next to source Input file name allows user 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).

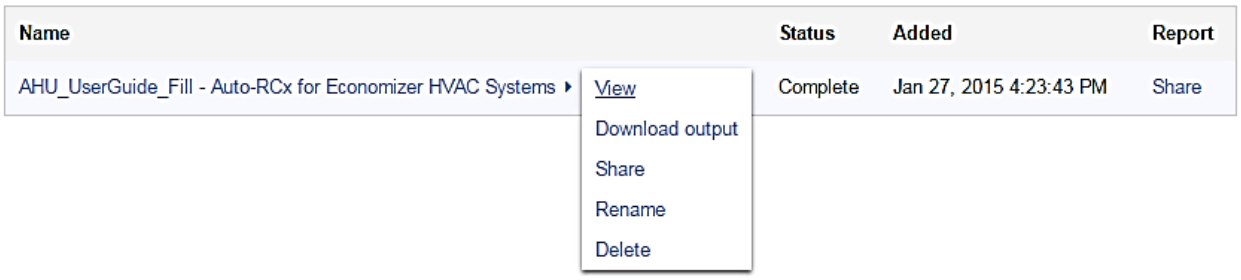

Figure 88: Application output options

Step 2. Click "View" button to see the "Automated retro-commissioning for HVAC economizer systems" results (Figure 89).

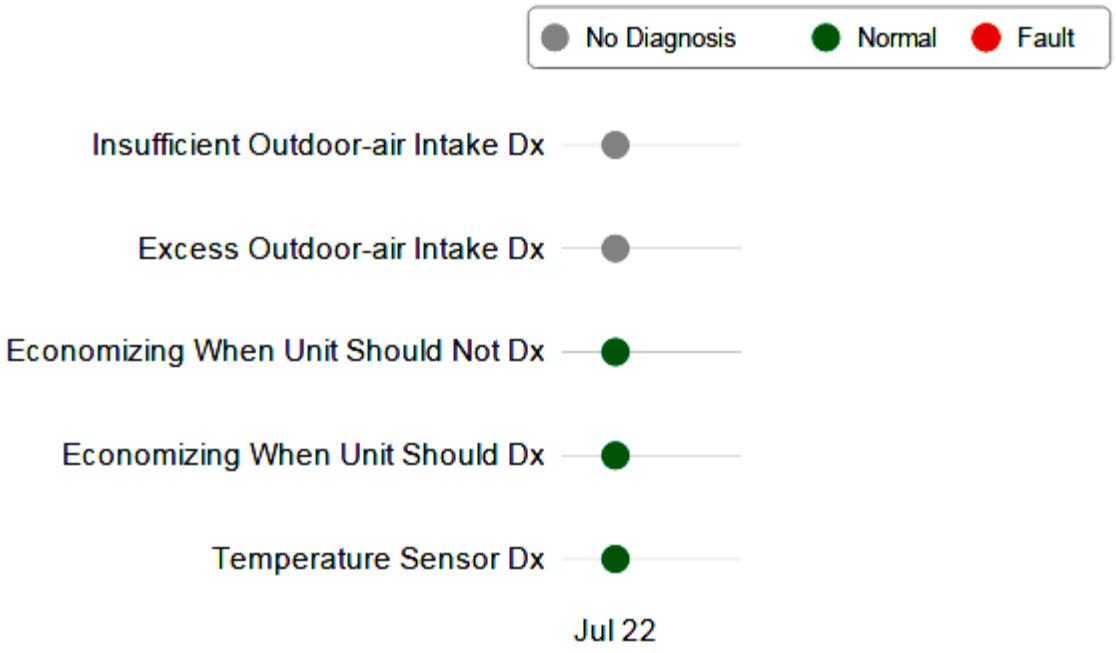

Figure 89: "Automated retro-commissioning for HVAC economizer systems" results

Step 3. For more detailed results, move the cursor over any of the circular colored icons. Figure 90 shows the daily results message for the “Automated retro-commissioning for HVAC economizer systems” diagnostic “Economizing when unit should not Dx.”

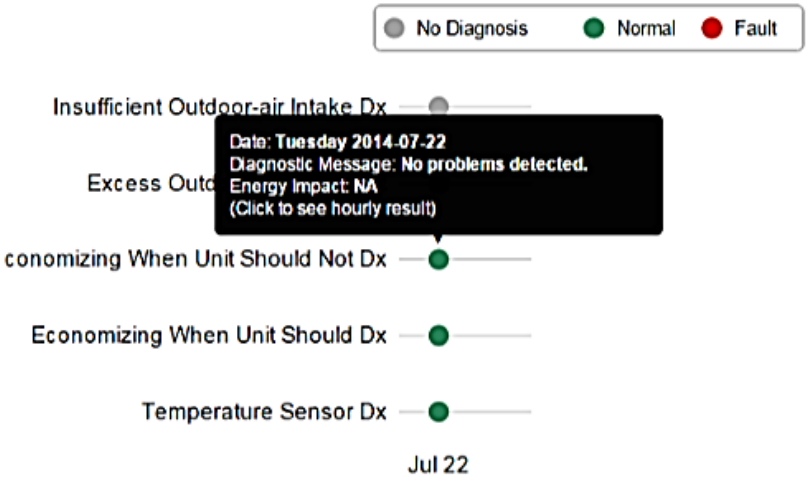

Figure 90: Daily diagnostic output

Step 4. To view hourly results for the diagnostic, click on the colored circle icon next to the feature name. See Figure 91 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.

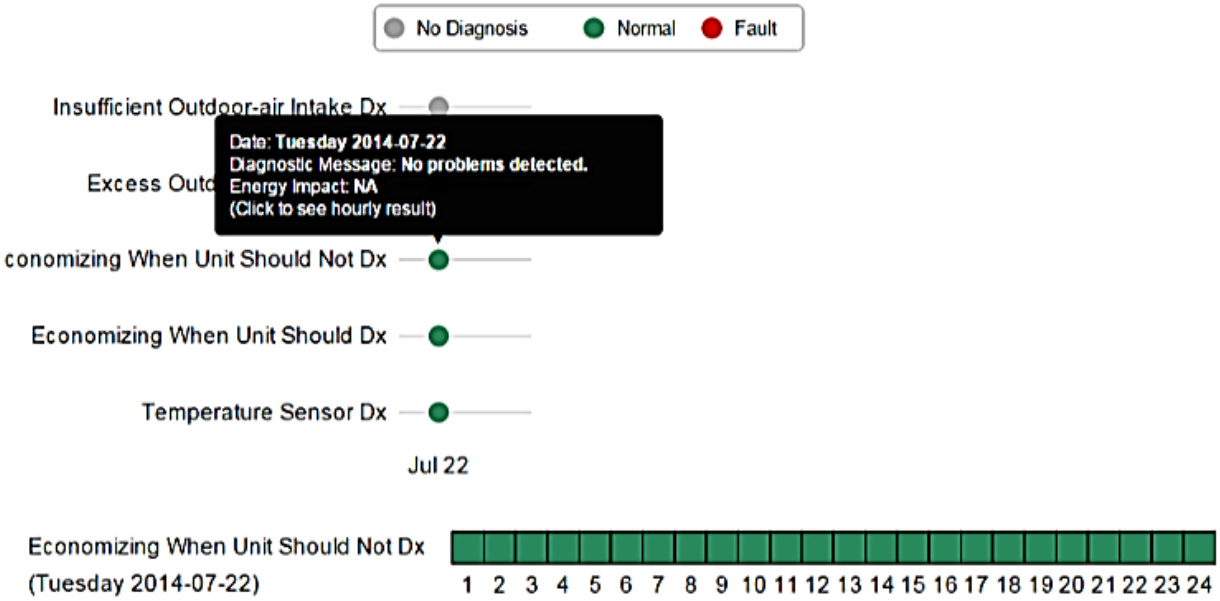

Figure 91: Hourly diagnostic output

Step 5. Click on the bar graph. The detailed hourly diagnostic message is displayed (Figure 92).

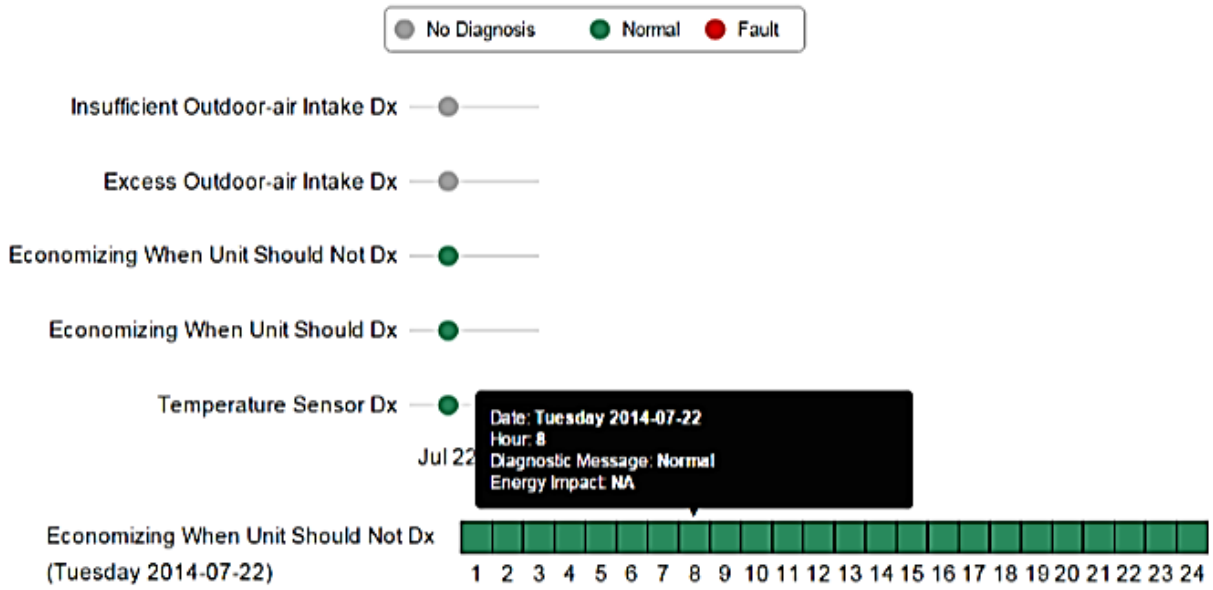

Figure 92: Hourly diagnostic output at 8:00 AM

Step 6. Click “Download output” button to download calculation output in zip file (Figure 88).

Step 7. Click “Share” button to share the application output using URL provided by the OpenEIS (Figure 93)

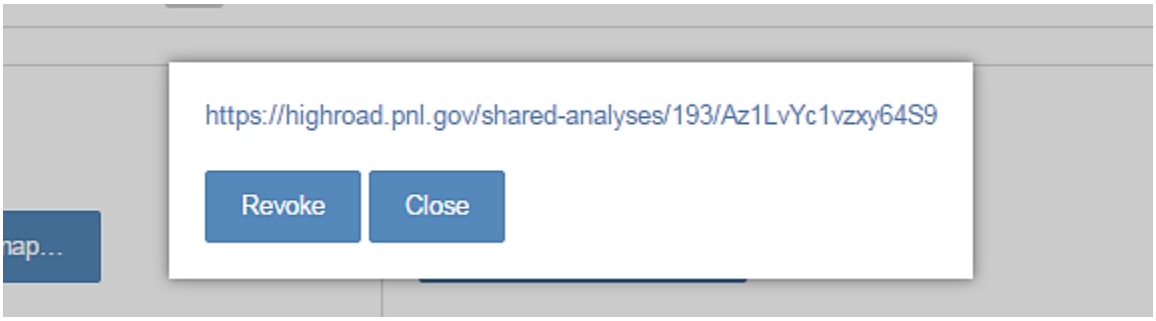

Figure 93: URL link after “Share” selection