Lehigh University Campus Metabolism Database Instructions

(Officially the "Sustainability" Database on Lehigh's PI Server)

OSIsoft
Matthew Fainor
8/10/2018

Contents

Background

This manual should provide most of the information you will need to maintain and alter the "Lehigh Campus Metabolism" database. As an important note, this project refers to itself as the "Lehigh Campus Metabolism" Project. However, Lehigh's PI Server has named the database "Sustainability." Built to track Lehigh University's electricity usage, gas usage, water usage, and waste creation data, the database aims to communicate the big picture of Lehigh's efficiency and sustainability footprint while allowing individuals to drill down through multiple layers of information to look as generally or specifically as their interests and needs guide them.

As of August 2018, the "Lehigh Campus Metabolism" database includes:

- Real-time electricity usage data from Lehigh's Shark Submeters
- Monthly electricity usage data from PPL billing statements
- Monthly gas usage data from UGI billing statements
- Monthly gas usage data calculated from on-campus steam meters, which track both individual buildings and groups of buildings
- Monthly water usage data from Bethlehem Municipal Water billing statements
- Quarterly water usage data from Bethlehem Municipal Water billing statements
- Monthly waste tracking data, assembled by the Office of Sustainability from a variety of departments across campus

For more information on the data streams coming into Lehigh University's PI Server, refer to the "Data Flow" section of this manual.

Although this document may not be the most elegant guide, I hope it will prove to be a concise and effective manual to reference as the database grows and evolves.

Lehigh University Campus Metabolism

A Student and Staff Empowerment Tool

The Lehigh Campus Metabolism Database currently houses Lehigh University's electricity usage, gas usage, water usage, and waste creation data. With the goal of becoming a tool for student and staff empowerment, the database provides more than just a platform for research and education. It provides a platform with which students and staff may engage more deeply with the data around them and the choices generating that data.

Summed up, the database:

- Tracks Utilities and Waste Data
- Maps Student Impact
- Empowers Efficiency and Sustainability

Imagine the following scenarios:

- Students provided with their monthly water and energy usage in tangible terms dig into their building's usage history, engage with educational programs and content to understand why values are the way they are, and become more mindful of their impact on the environment.
- Staff empowered with greater tracking of resources study historical trends, see where on campus and when in time usage lies outside acceptable ranges, perhaps indicating either a maintenance or behavioral issue, and make decisions with greater understanding to increase efficiency.
- Faculty studying the intersection of energy systems and the environment, green energy investment versus impact, etc., have access to information once kept on private office computers, empowering more in-depth research, and leading faculty, staff, and departments to more effectively collaborate with external organizations, increasing investment, grants, and student/faculty opportunities.

These scenarios represent likely real use cases for the Lehigh University Campus Metabolism Database.

As buildings become smarter and smarter, the integration of advanced technology into maintaining, monitoring, and controlling building systems will become more prominent. Having a current, reliable, and updated baseline system in place in which to integrate these systems will prove valuable as monitoring becomes more robust. As Lehigh looks to advance, a reflection on its mission statement: "To advance learning through the integration of teaching, research, and service to others," and our roles and responsibilities in that advancement.

Important Terms and Definitions

1) PI Server – Real-time data system encompassing a PI Asset Framework (AF) database, a PI Data Archive, and PI Vision Displays

2) PI AF Database – A human-friendly reference structure organizing the database's elements and information. You use this Asset Framework (organized as a tree structure) to navigate to information.

3) PI Data Archive – Storage location for all data uploaded to the Server and all calculations completed on the Server.

4) PI Vision Displays – PI Vision is the software utilized to create the dashboards for the entirety of the Server's information. This includes creating pages, graphs, values, etc.

5) PI System Explorer (PSE) – Software that allows a user to see the structure of the AF Server, as well as configure notifications, elements, attributes, and calculations.

6) PI Point/Tag – Stores real-time, graphable data that has a point source. Every calculation has a unique PI Point/Tag. For example, the PI Tag for Chandler-Ullman's water meter usage is: Chandler-Ullman.Water Meter 1.Water Usage

7) AF Assets/Elements – Defines an item (object) in Asset Framework (AF) (i. e. a digital representation of a physical data source)

8) Attributes – Describes an asset/element

     For example, every building has many attributes, including:

     Carbon Emissions Created from Burning Natural Gas

     Electricity Use Intensity

     Water Use per Capita

     Address

     Purpose

     Total Building Gas Usage

     All these attributes inform us about and describe the asset (the building)

9) Template – Exists as part of the PI AF database. Templates define the assets, calculations, categories, and parameters for all the elements assigned to the template.

     For example, every water meter is assigned to the "Bethlehem Municipal Water Meter" Template. This template provides the configuration for all the attributes and calculations on all the water meters so every water meter has the same configuration/information. Additionally, templates enable every element assigned to them to be edited at once instead of each element having to be edited individually.

Important Contacts

All information as of August 2018

PI System Administrator
Alex Pacheco
Library and Technology Services
alp514@lehigh.edu
610-758-6735
Point of Contact for all PI System permissions, issues, and questions

Project Sponsors
Dr. Rudy Shankar
Director, Energy Systems Engineering Institute
Rudy.Shankar@lehigh.edu
610-758-3529

Delicia Nahman
Sustainability Officer, Office of Sustainability
den210@lehigh.edu

Facilities Services
Doug Spengel
Associate Director, Utilities and Energy Management
dbs288@lehigh.edu
610-758-3974

Don Pasda
Director, Building and Utility Systems
djp207@lehigh.edu
610-758-5198

Gary Falasca
Director, Custodial, Grounds Maintenance, and Athletic Buildings
gf02@lehigh.edu
610-758-3972

Steve Schiegel
Energy Conservation Engineer
ss0n@lehigh.edu
610-758-5196

Weather Station Data
Bruce Hargreaves
Retired EES Professor
Owner, Manager, and Analyzer of Weather Stations & Data
brh0@lehigh.edu
Point of contact for all weather station data questions, initiation of data transition to the PI System

George Yasko
STEPS Operations/Technical/Program Support Manager
gby0@lehigh.edu
610-758-4840
Future owner and manager of weather station data

Daniel Brashler
Senior Computing Consultant, College of Arts & Sciences
dab406@lehigh.edu
Point of contact for any technical questions regarding weather station data transition

Notes on Weather Stations

The integration of the weather stations into the PI System will not come as part of the initial database. However, I have written up the various option plans Dr. Bruce Hargreaves and members of LTS and EES (particularly Dan Brashler and George Yasko) can take in order to integrate the weather station data:

Weather Station Data Transition Plans

Background:

Weather Stations:

- Lehigh University Weather Stations
  - Asa Packer Campus STEPS 1 — Davis Instruments Vantage Pro2
  - Asa Packer Campus STEPS 2 — Davis Instruments Vantage Pro2
  - Asa Packer Campus STEPS (additional) — Supplementary Vantage Pro Sensors:
    - Soil Moisture
    - Soil Temperature
    - Leaf Wetness

  - Goodman Campus Weather Station — Campbell Scientific Data Logger
  - Mountaintop Campus Weather Station — Davis Instruments Vantage Pro2
- Pocono Weather Stations
  - Lake Lacawac Weather Station — Campbell Scientific Data Logger
  - Lake Weather Station — Campbell Scientific Data Logger
  - Lacawac Sanctuary U. V. Station — Campbell Scientific Data Logger
- Lehigh Gap Nature Center Weather Stations
  - East Ridge Microclimate Station — Unknown
  - West Ridge Microclimate Station — Unknown
  - LGNC Microclimate Station — Unknown
  - LNE Old Bridge Microclimate Station — Unknown

The weather stations with Campbell Scientific Data Loggers log their data to the Lehigh network directly, and the weather stations with Davis Instruments Vantage Pro Sensors log their data to the Lehigh network through Envoy 8x Receivers (1 for all the STEPS sensors and 1 for the Mountaintop Campus Weather Station).

Plans:

Currently Dr. Bruce Hargreaves maintains the weather stations. Additionally Dr. Hargreaves manages all the weather station data from a remote desktop login to the computer actively collecting the data on campus. He processes the data and completes his analyses from this remote desktop by exporting a monthly CSV file for each weather station from the Davis software and adding it to an Excel template file. The weather stations currently log their data to separate Microsoft DataAccess files generated when the data sends to the computer.

In order to integrate the data into the PI System to empower Lehigh students and staff through the Lehigh University Campus Metabolism Database, the data collected should not have to generate

DataAccess files. The weather stations can switch from generating Microsoft DataAccess files to logging data to Microsoft SQL Database tables. By switching, the data can upload to the PI Server utilizing the PI Interface for RDMS via ODBC or utilizing the native interfaces for the equipment.

Option One: PI Interface for Davis Instruments Vantage Pro/Pro Plus
Utilizing the PI Interface for Davis Instruments Vantage Pro/Pro Plus to upload data

Advantages:

- Direct data import from the weather stations into the PI System
- The native interfaces will be able to handle the data resolution and the robustness of the imports
- Holds up better overtime, in terms of the quality of data and the quality of imports

Disadvantages:

- Not all the weather stations would be importing data into the PI System on the same interface

The first part of Option Plan One consists of installing the PI Interface for Davis Instruments Vantage Pro/Pro Plus onto the interface node currently collecting the weather station data. Utilizing a native interface for the devices may prove to be beneficial over utilizing the PI Interface for RDBMS via ODBC (Relational Database Management System that supports Open Database Connectivity drivers) depending on the resolution of the created SQL table. If the SQL table does not have robust mechanisms to import and maintain the data every fifteen minutes, it would be more beneficial to utilize the native interface in order to maintain data quality and the frequency of import.

The second part of Option Plan One consists of making a decision between:

1) Utilizing a native interface for the Campbell Scientific Data Loggers (PI Interface for Campbell Scientific LoggerNet) right away,
2) Setting up a Miscrosoft SQL database to collect the data coming from the Campbell Scientific Data Loggers now and later configuring the PI Interface for Campbell Scientific LoggerNet to collect the data,
3) Setting up a Microsoft SQL database to collect the data coming from the Campbell Scientific Data Loggers as a permanent solution

*Requirements for PI Interface for Davis Instruments Vantage Pro/Pro Plus:
All information verifiable in the PI Interface for Davis Instruments Vantage Pro/Pro Plus User Guide

- Compatible Devices:
  - Vantage Pro
  - Vantage Pro Plus
  - Vantage Pro2
  - Vantage Pro2 Plus
- Compatible Platforms:

- o Windows NT 4.0 SP6a
- o Windows 2000 SP4
- o Windows XP SP2
- o Windows 2003 SP1
- The Interface requires one of the following combinations of hardware from Davis Instruments:
  - o Remote data measurement sensors (e.g., outside temperature and wind)
  - o Davis Instruments Vantage Pro/Plus Weather Station Console (for retrieving data from the remote sensors)
  - o Davis Instruments Data Logger (for enabling communications between the weather console and the computer on which this Interface runs)

  OR

  - o Remote data measurement sensors (e.g., outside temperature and wind)
  - o Davis Instruments Weather Envoy (for retrieving data from the remote sensors)
  - o Davis Instruments Data Logger (for enabling communications between the Weather Envoy and the computer on which this Interface runs)

PI Interface for Davis Instruments Vantage Pro/Pro Plus Overall:

- The Data Logger (a hardware connection tool which comes with the Davis Instruments WeatherLink software kit) must be utilized
  - o Note: Dr. Hargreaves stated he uses Envoy8x Receivers to send and collect the data. Check whether that process also utilizes the data logger.
- Even if the Davis Instruments Weather Envoy is in use, the Data Logger is still required. The Weather Envoy retrieves data from the sensors and sends it via the Data Logger to the computer.
- The VantagePro.dll, which is available free of charge from the Davis Instrument web site, is required. The computer retrieves data from the weather station using the API (Application Programming Interface) provided in the VantagePro.dll, so it must be installed on the interface computer.
- Each copy of the interface connects via one serial port to one weather station (or Weather Envoy).

*Requirements for PI Interface for Campbell Scientific LoggerNet
All information verifiable in the PI Interface for Campbell Scientific LoggerNet User Guide

- Compatible Platforms:
  - o Windows Vista (32-bit & 64-bit)
  - o Windows 2008 (32-bit & 64-bit)
  - o Windows 2008 R2 (64-bit)
  - o Windows 7 (32-bit & 64-bit)
  - o Windows 8.1 (64-bit)
  - o Windows 10 (64-bit)
- Required Software:
  - o LoggerNet SDK controls (version 4.0 or higher, CSI# 16756)
  - o Scientific's LoggerNet or LoggerNet Admin Datalogger Support Software

**PI Interface for Campbell Scientific LoggerNet Overall:**

- The PI Interface for Campbell Scientific LoggerNet System transfers data from the Campbell Scientific's LoggerNet Server system to the PI Data Archive. The interface interacts with the Campbell Scientific's LoggerNet Software Development Kit (SDK) (CSI# 16756) which is included in the interface setup kit.

Data Flow:

1) Utilizing both native Interface options
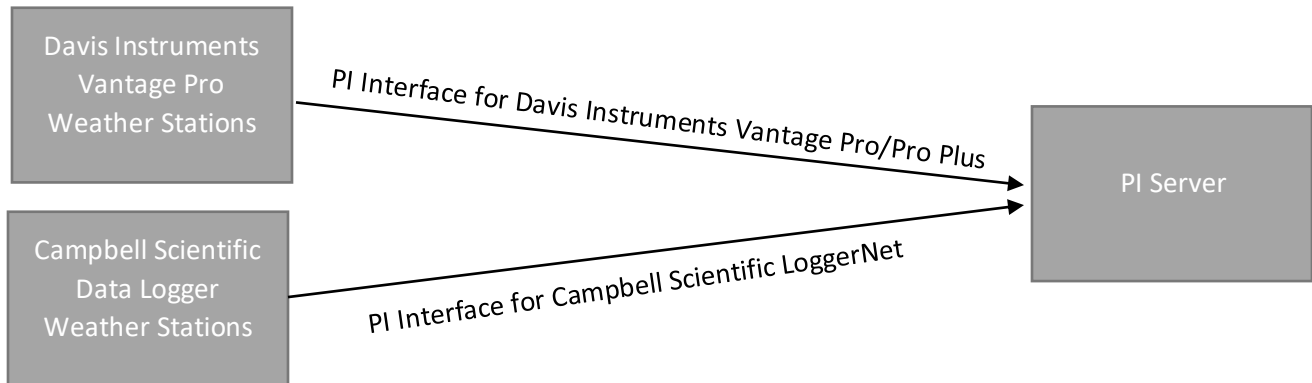
2) Utilizing the native Interface for Davis Instruments and a SQL Database for Campbell Scientific
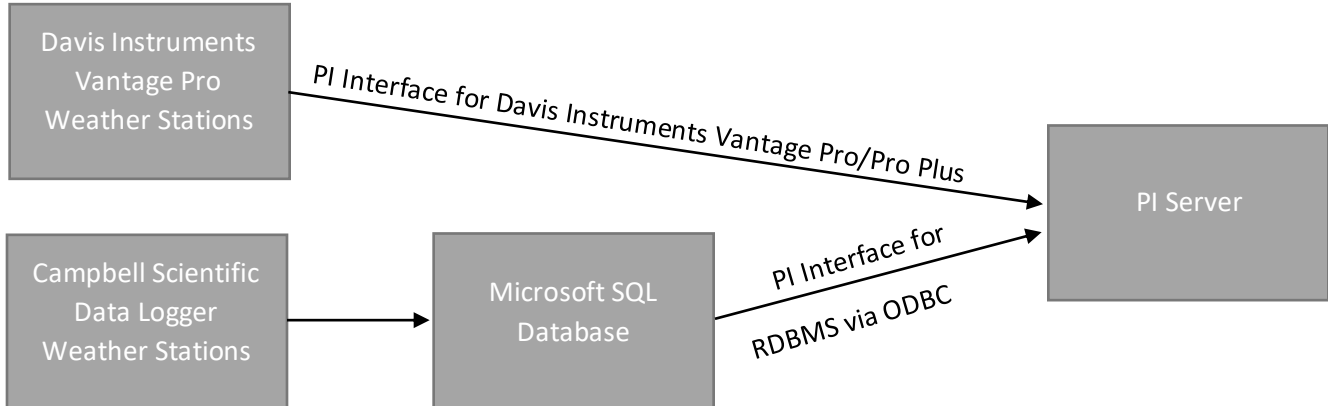
Option Two: PI Interface for RDBMS via ODBC Short-Term

Option Plan Two consists of two parts:

1) Setup the PI Interface for RDBMS via ODBC right away in order to import data from the Microsoft SQL Database into the PI System
2) Later down the line configure the PI Interface for Davis Instruments Vantage Pro/Pro Plus to import data directly from the weather stations into the PI System, and keep the weather stations with Campbell Scientific Data Loggers in the Microsoft SQL Database
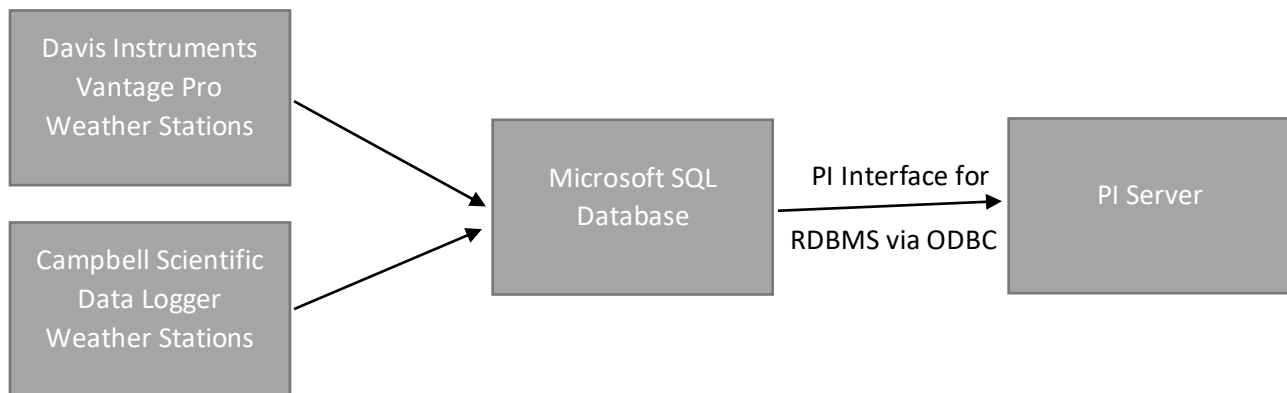
OR

1) Setup the PI Interface for RDBMS via ODBC right away in order to import data from the Microsoft SQL Database into the PI System
2) Later down the line configure both the PI Interface for Davis Instruments Vantage Pro/Pro Plus and the PI Interface for Compbell Scientific LoggerNet to import data directly from the weather stations into the PI System.

*Option Plan One outlines some of the major requirements for both the native interfaces.

Data Flow:

1) PI Interface for RDBMS via ODBC

2) Native Weather Station Options

OR

Davis Instruments Vantage Pro Weather Stations

Campbell Scientific Data Logger Weather Stations

PI Interface for Davis Instruments Vantage Pro/Pro Plus

PI Interface for Campbell Scientific LoggerNet
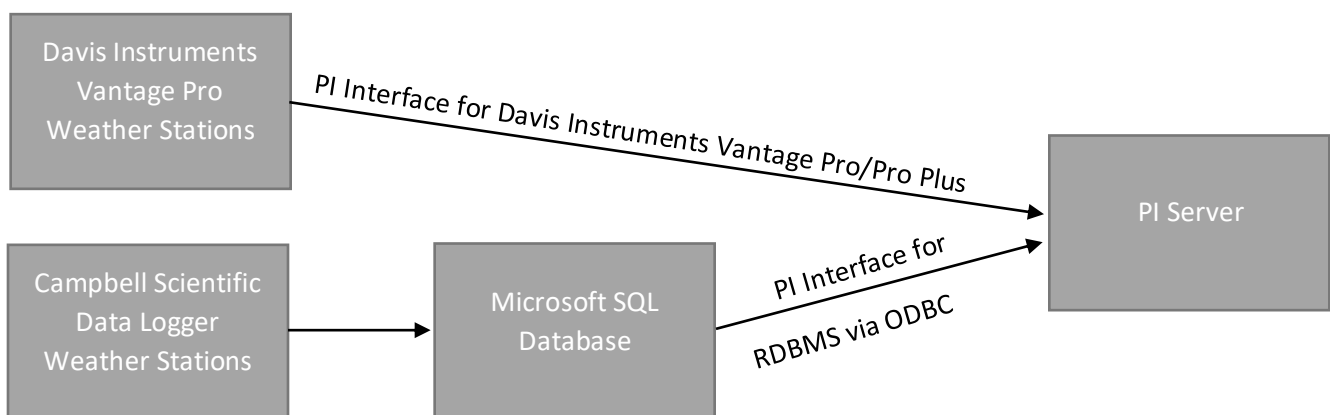
PI Server
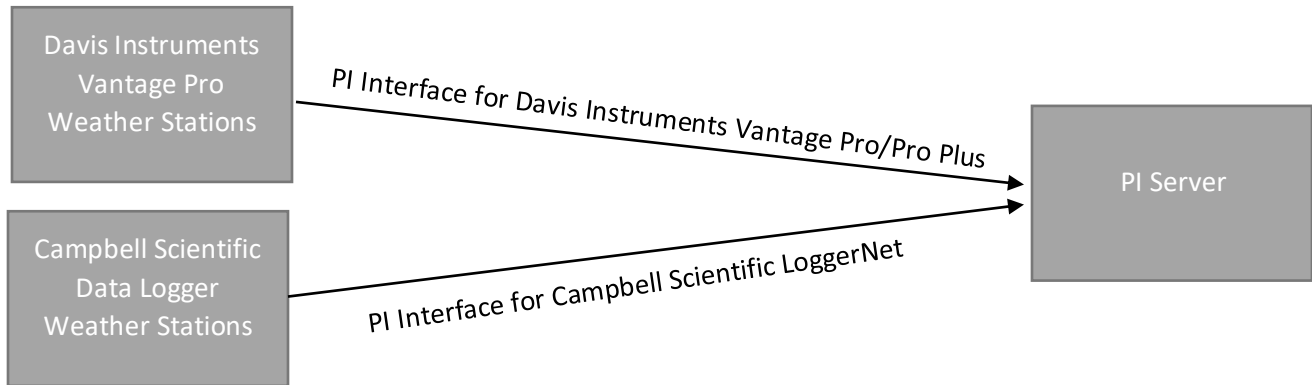
Option Three: PI Interface for RDBMS via ODBC Long-Term

Option Plan Three: Setup the PI Interface for RDBMS via ODBC in order to import data from the Microsoft SQL Database into the PI System
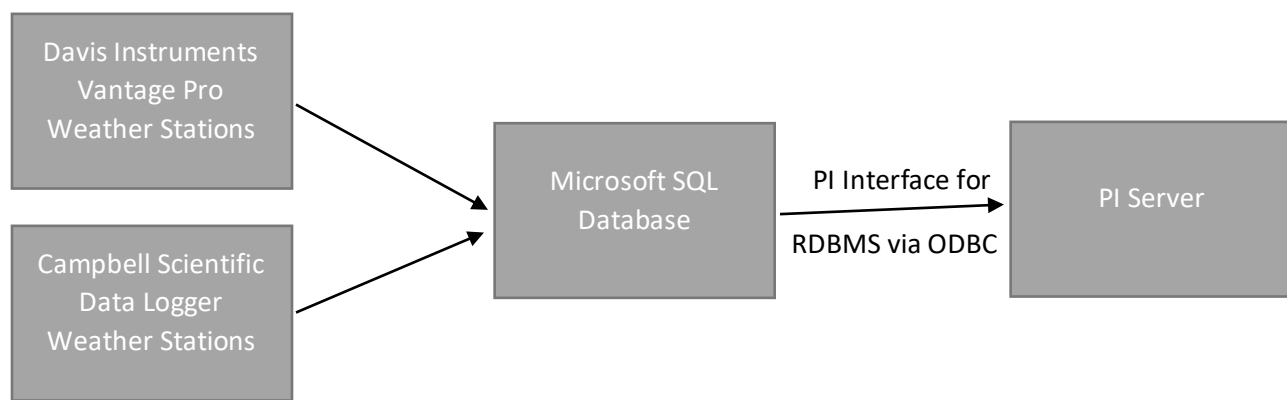
Advantages:

- All the weather stations would be importing data into the PI System on the same interface, creating a simpler data flow
- Less work for initial set up than Option Plan One

Disadvantages:

- Data needs to travel through multiple programs: From weather station, through Weather Envoy8x Receiver, into the SQL Database, through the PI Interface for RDBMS via ODBS, into the PI System's Data Archive
- Depending on the resolution of the SQL Database and the robustness of its import mechanisms, it

Data Flow:

Davis Instruments Vantage Pro Weather Stations			

| | Microsoft SQL Database | PI Interface for RDBMS via ODBC | PI Server |

| Campbell Scientific Data Logger Weather Stations | | | |

Units of Measurement Added to the UOM Library

1) Class: People   Measurement: People
2) Class: Elephants   Measurement: Elephants
3) Class: Accumulation   Measurement: Inches per Hour (in/hr)
4) Class: Water Use per Capita   Measurement: US kilogallon/person (US kgal/person)
5) Class: Water Use per Capita   Measurement: US gallon/person (US gal/person)
6) Class: Pressure   Measurement: Millibar (millibars)
7) Class: Emission Creation per Capita   Measurement: Pound per Person (lb/person)
8) Class: Energy   Measurement: kilo British thermal unit
9) Class: Energy Use Intensity   Measurement: kilo British thermal unit/gross square footage (kBtu/ft2)

Unique Assets

Shared Steam Meters

A shared steam meter is any steam asset that reports a joint steam percent usage for two or more buildings. Currently only two shared steam meters exist:

Steam Meter 9 reports a joint steam usage for Dravo House, Drinker House, and Richards House

Steam Meter 14 reports a joint steam usage for Building H – Imbt Laboratories, Building J – Mailing & Printing, and Building F – Jordan Hall

Shared Steam Meters exist on their own templates: "Steam Meter – Shared Meter – Asa Packer CH&R" (for those buildings attached to the Asa Packer Campus Central Heating and Refrigeration Facility) and "Steam Meter – Shared Meter – Mountaintop CH&R" (for those buildings attached to the Mountaintop Campus Central Heating and Refrigeration Facility).

Below is a screenshot of the analysis page from Steam Meter 9 on Dravo House showcasing the expressions involved in calculating the individual buildings' gas usages. Since gas is primarily utilized for building heating, the shared usage has been corrected for each building by proportionally linking gas usage to the building's square footage.

Monthly and Quarterly Reporting Water Meters

In order to correct for the discrepancies in water billing statements (some meters report monthly and some meters report quarterly), buildings exist on one of four templates:

1) **"Building"** – If the building has no water assets associated with it or if Facilities Services does not allocate it any water usage, then the building becomes assigned to the "Building" template.
2) **"BuildingDerived1 – Monthly Water"** - For buildings and facilities receiving water usage data on a monthly basis.
3) **"BuildingDerived2 – Quarterly Water"** – For buildings and facilities receiving water usage data on a quarterly basis.
4) **"BuildingDerived3 – Monthly and Quarterly Water"** – For buildings and facilities which have more than one water meter/asset where at least one water meter receives water usage monthly and at least one water meter receives water usage quarterly.

Currently only one facility resides on the "BuildingDerived3 – Monthly and Quarterly Water" Template. Warren Square F has two water assets: Water Meter 70 reports water usage quarterly and Water Meter 139 reports water usage monthly.

Shark Electricity Submeters

Most of the buildings on Lehigh University's campus fall under a single PPL account. Since most of the buildings fall under one account, Facilities Services receives billing and usage information for the entire account and not for each individual building. In order to monitor the usage of each building and allocate the bill to each building's account, Facilities Services has installed Shark Electricity submeters, which collect real time electricity flow, power, and usage data.

Notes:

- 121 Shark Submeters report data to the Shark system software
- Facilities manually reads the meters not directly connected to the system:
    - Chandler Ullman (However, Chandler Ullman will be receiving a brand new Shark submeter which will hopefully be connected when its renovation is completed in 2019)
    - Building B – Warehouse on Mountaintop Campus
    - Gatehouse on Mountaintop Campus
    - Ben Franklin Tech Ventures
    - Field Shop on Goodman Campus

Adding Elements

Adding New Buildings

All Instructions refer to operations in PI System Explorer. If you do not have PI System Explorer installed on your computer, discuss installation protocol with your PI System Administrator.

1) Open PI System Explorer, and connect to the "Sustainability" Database
2) In the Library section of the "Lehigh Campus Metabolism" PI AF database, click on Tables, and open the "Building Background Information" Table
   a. Scroll to the bottom of the table and add all the new building information to the table
      i. Purpose Categories: Academic, Admin, Athletics, Dining, Housing, Library, Non Lehigh, Parking, Retail, Student Life, Tenant, Vacant
      ii. Occupancy (True Capacity): Occupancy data for housing facilities--can be obtained from Residential Services.
      iii. Tenant: The name of the current Fraternity or Sorority Organization or Administrative Office currently residing in the building. Most buildings will have "Lehigh University" as the tenant, since most buildings do not house a specific office.
   b. Make the "Facility Name" the same as what you will be making your new building element name. In the new element, the table lookup will link background information from the "Building Background Information" Table to the building element, but it will not be able to match the metadata to the building element if the "Facility Name" is not exactly the same as the name of the element you will be creating shortly.

      Element Name: Coppee Hall   Facility Name (in table): Coppee Hall

3) Find the appropriate location for the building in the PI AF structure (Example: Underneath Lehigh University\Asa Packer Campus\Academic)
4) Right click on the Facility type to which it belongs (Academic, Administrative, etc.), select new, select new child element (this will position the element underneath the facility type in the location to which you would like it to belong)
5) If the building has no water assets, select the element template "Building" and hit OK
6) If the building has water assets reporting data monthly, select the element template "BuildingDerived1 – Monthly Water" and hit OK
7) If the building has water assets reporting data quarterly, select the element template "BuildingDerived2 – Quarterly Water" and hit OK
8) If the building has at least one water asset reporting data monthly and at least one water asset reporting data quarterly, select the element template "BuildingDerived3 – Monthly and Quarterly Water" and hit OK
9) Rename the building asset the same name as what you entered for its "Facility Name" in the "Building Background Information" Table and configure the building asset to your needs
10) Under the "General" tab for your new water asset, assign the appropriate asset categories:
    a. Facility category (Academic, Administrative, etc.)

b. Water Reporting Status (N/A, Monthly Water, Quarterly Water, both)
c. If the building does not share any steam or gas meters with any other building, assign the category "No Shared Gas Data"
d. If the building does share steam or gas meters with any other buildings, assign the category "Shared Gas Data"
e. If the building is not a Central Heating & Refrigeration facility, assign the category "Not CH&R"
f. If the building is a Central Heating & Refrigeration facility, assign the category "CH&R"

Adding New Building Assets (Water, Electricity, Gas, Steam Meters)

All Instructions refer to operations in PI System Explorer. If you do not have PI System Explorer installed on your computer, discuss installation protocol with your PI System Administrator.

1) **Adding a New Water Asset**
   a. **Monthly Reporting Water Data**
      i. Open PI System Explorer, and connect to the "Sustainability" Database
      ii. Find the building to which the new water asset belongs in the PI AF structure
      iii. Right click on the building, select new, select new child element (this will position the element underneath the building to which you would like it to belong)
      iv. Select the element template "Bethlehem Municipal Water Meter" and hit OK
      v. Under the "General" tab for your new water asset, assign the asset the category: "Monthly Water"
      vi. Rename and Configure the asset to your needs
         1. Naming Convention: Water Meter #
         2. Note: All asset numbers are unique and do not repeat through the system (e.g. there is only one "Water Meter 1" and only one "PPL Meter 1")
      vii. Create and link the new PI Tags for the raw data:
         1. Water Usage
            a. Naming Convention: %..Element%.W#.%Attribute% (Building Name.W#.Water Usage)
   b. **Quarterly Reporting Water Data**
      i. Open PI System Explorer, and connect to the "Sustainability" Database
      ii. Find the building to which the new water asset belongs in the PI AF structure
      iii. Right click on the building, select new, select new child element (this will put the element underneath the building to which you would like it to belong)
      iv. Select the element template "Bethlehem Municipal Water Meter" and hit OK
      v. Under the "General" tab for your new water asset, assign the asset the category: "Quarterly Water"
      vi. Rename and Configure the asset to your needs
         1. Naming Convention: Water Meter #
         2. Note: All asset numbers are unique and do not repeat through the system (e.g. there is only one "Water Meter 1" and only one "PPL Meter 1")
      vii. Create and link the new PI Tags for the raw data:
         1. Water Usage
            a. Naming Convention: %..Element%.W#.%Attribute% (Building Name.W#.Water Usage)

2) Adding a New PPL Electricity Asset
   a. Open PI System Explorer, and connect to the "Sustainability" Database
   b. Find the building to which the new PPL asset belongs in the PI AF structure
   c. Right click on the building, select new, select new child element (this will position the element underneath the building to which you would like it to belong)
   d. Select the element template "PPL Meter" and hit OK
   e. Rename and Configure the asset to your needs
      i. Naming Convention: PPL Electricity Meter #
      ii. Note: All asset numbers are unique and do not repeat through the system (e.g. there is only one "Water Meter 1" and only one "PPL Meter 1")
   f. Create and link the new PI Tags for the raw data:
      i. PPL Usage
         1. Naming Convention: %..Element%.PPL#.%Attribute% (Building Name.PPL#.PPL Usage)

3) Adding a New Lehigh University Shark Electricity Submeter
   a. Open PI System Explorer, and connect to the "Sustainability" Database
   b. Find the building to which the new Shark Electricity Submeter asset belongs in the PI AF structure
   c. Right click on the building, select new, select new child element (this will position the element underneath the building to which you would like it to belong)
   d. Select the element template "Lehigh Shark Submeter" and hit OK
   e. Rename and Configure the asset to your needs
      i. Naming Convention: Lehigh Shark Submeter #
      ii. Note: All asset numbers are unique and do not repeat through the system (e.g. there is only one "Water Meter 1" and only one "PPL Meter 1")
   f. Create and link the new PI Tags for the raw data:
      i. Full Lehigh Shark Meter data is stored in a separate PI AF database entitled "Lehigh." Since we only need a few pieces of information compared to all the data the meter collects, we only need to link a few PI Tags from the "Lehigh" database to the "Lehigh Campus Metabolism" database. You can do this by pasting the relevant tags onto the corresponding asset attributes in the "Lehigh Campus Metabolism" database. Additionally, the building names in the "Lehigh" database may differ from the building names in the "Lehigh Campus Metabolism" database. Building numbers will always correspond.
      ii. Daily Energy
         1. Naming Convention: BuildingName_Daily Energy in kWh
      iii. Daily Power
         1. Naming Convention: BuildingName_Daily Power in kW
      iv. Monthly Average Watts
         1. Naming Convention: BuildingName_Monthly Power in kW
   g. In the Library section of the database, navigate to the tables. Open the "Percentage of Shared Electricity Data (Shark Submeters)" Table.

    i.   Input the Shark Electricity Meter Name into column one and its ratio into column two.

    ii.   The ratio is the percentage of the electricity the building utilizes. If the building shares a Shark submeter with another building, it utilizes less than one hundred percent of the measured electricity (a ratio of 0.4 means the building utilizes 40% of the measured electricity). If the building does not share a Shark submeter with another building, enter "1" (100 percent) as the ratio.

4) Adding a New Gas Asset

    a.   Open PI System Explorer, and connect to the "Sustainability" Database

    b.   Find the building to which the new Gas asset belongs in the PI AF structure

    c.   Right click on the building, select new, select new child element (this will position the element underneath the building to which you would like it to belong)

    d.   Select the element template "Gas Meter" and hit OK

    e.   Rename and Configure the asset to your needs

        i.   Naming Convention: Gas Meter #

        ii.   Note: All asset numbers are unique and do not repeat through the system (e.g. there is only one "Water Meter 1" and only one "PPL Meter 1")

    f.   Create and link the new PI Tags for the raw data:

        i.   Gas Usage

            1.   Naming Convention: %..Element%.G#.%Attribute% (Building Name.G#.Gas Usage)

5) Adding a New Steam Asset

    a.   Non-Shared Steam Meter

        i.   Open PI System Explorer, and connect to the "Sustainability" Database

        ii.   A Non-Shared Steam Meter is any steam meter reading/collecting usage data for one building only.

        iii.   Find the building to which the new Steam asset belongs in the PI AF structure

        iv.   Right click on the building, select new, select new child element (this will position the element underneath the building to which you would like it to belong)

        v.   If the steam asset is linked to the Asa Packer Campus Central Heating and Refrigeration facility, select the element template "Steam Meter – Asa Packer CH&R" and hit OK

        vi.   If the steam asset is linked to the Mountaintop Campus Central Heating and Refrigeration facility, select the element template "Steam Meter – Mountaintop CH&R" and hit OK

        vii.   Rename and Configure the asset to your needs

            1.   Naming Convention: Steam Meter #

        2. Note: All asset numbers are unique and do not repeat through the system (e.g. there is only one "Water Meter 1" and only one "PPL Meter 1")

    viii. Create and link the new PI Tags for the raw data:

        1. Steam Usage

            a. Naming Convention: %..Element%.S#.%Attribute% (Building Name.S#.Steam Usage)

b. Shared Steam Meter

    i. Open PI System Explorer, and connect to the "Sustainability" Database

    ii. A shared steam meter is any steam asset reporting a joint steam percent usage for two or more buildings. This steam percentage will need to be split according to each building's usage.

    iii. Currently only two shared steam meters exist:

        1. **Steam Meter 9** reports a joint steam usage for Dravo House, Drinker House, and Richards House

        2. **Steam Meter 14** reports a joint steam usage for Building H – Imbt Laboratories, Building J – Mailing & Printing, and Building F – Jordan Hall

    iv. Find the first building to which the new Steam asset belongs in the PI AF structure

    v. Right click on the building, select new, select new child element (this will position the element underneath the building to which you would like it to belong)

    vi. If the steam asset is linked to the Asa Packer Campus Central Heating and Refrigeration facility, select the element template "Steam Meter – Shared Meter – Asa Packer CH&R" and hit OK

    vii. If the steam asset is linked to the Mountaintop Campus Central Heating and Refrigeration facility, select the element template "Steam Meter – Shared Meter – Mountaintop CH&R" and hit OK

    viii. Rename and Configure the asset to your needs

        1. Naming Convention: Steam Meter #

        2. Note: All asset numbers are unique and do not repeat through the system (e.g. there is only one "Water Meter 1" and only one "PPL Meter 1")

        3. Note: The steam asset will receive the same name underneath every building for which it collects data (example: Dravo, Drinker, and Richards share a steam meter. They all have the asset "Steam Meter 9" as a child element).

    ix. Create and link the new PI Tags for the raw data:

        1. Shared Steam Usage

            a. Model your naming off the steam asset example for Dravo, Drinker, and Richards Houses: Dravo.Drinker.Richards.S9.Steam Usage

    x. Under the "Analysis" tab, configure the Individual Gas Usage Calculation

Name	Expression	Va	Va	Output Attribute	
Explanation	//correcting the gas usage from one meter for a set of three buildings. Since gas is utilized for buildin			Map	⊗
DravoSquare_Footage	'\Lehigh University\Asa Packer Campus\Housing\Residential Housing\Dravo House|Gross Square Footage'			Map	⊗
DrinkerSquare_Footage	'\Lehigh University\Asa Packer Campus\Housing\Residential Housing\Drinker House|Gross Square Footage'			Map	⊗
RichardsSquare_Footage	'\Lehigh University\Asa Packer Campus\Housing\Residential Housing\Richards House|Gross Square Footage'			Map	⊗
TotalSquare_Footage	Dravo_Square_Footage+Drinker_Square_Footage+Richards_Square_Footage			Map	⊗
DravoPercentage	Dravo_Square_Footage/Total_Square_Footage			Map	⊗
DrinkerPercentage	Drinker_Square_Footage/Total_Square_Footage			Map	⊗
RichardsPercentage	Richards_Square_Footage/Total_Square_Footage			Map	⊗
DravoGas_Adjustment	'Shared Gas Usage'*Dravo_Percentage			Individual Gas Usage	⊗
DrinkerGas_Adjustment	'Shared Gas Usage'*Drinker_Percentage			Map	⊗
RichardsGas_Adjustment	'Shared Gas Usage'*Richards_Percentage			Map	⊗

Scheduling: ● Event-Triggered ○ Periodic   [Advanced...]
Trigger on [Any Input ▼]

(Individual Gas Calculation window for Dravo House)

1. Calculation: Individual Gas Usage
2. Description: Correcting the combined steam meter to approximate the gas usage for each individual building
3. Analysis Type: Expression
4. Since gas is utilized primarily for building heating, the usage is proportionally linked to the buildings' square footage
5. Copy the analysis above, replacing the building names (Dravo House, Drinker House, Richards House) with your own building names. Make sure your paths in the first three expressions lead to the correct place. If the building is underneath Asa Packer Campus and Academic, the string would be: "\Lehigh University\Asa Packer Campus\Academic\Building Name|Gross Square Footage"
6. Map the appropriate Adjustment calculation to "Individual Gas Usage" for each building.
    ii. Repeat this process for each building the steam asset meters

Adding New Waste Weight Streams

1) Open PI System Explorer, and connect to the "Sustainability" Database
2) Find the waste stream category (compost, recycling, reuse-donation, or waste) to which the new waste stream belongs located underneath "Waste Streams."
3) Right click on the waste stream category, select new, select new child element (this will position the element underneath the waste stream category to which you would like it to belong)
4) Select the element template "Waste Stream Components" and hit OK
5) Under the "General" tab for your new waste stream, assign the waste stream the category to which it belongs (compost, recycling, reuse-donation, or waste)
6) Rename and configure the asset to your needs
7) Naming Convention: None
8) Create and link the new PI Tags for the raw data:
9) Weight
10) Naming Convention: WT %Element% (WT "Waste Stream Name") – WT stands for Waste Tracking

Adding New Weather Stations

1) Open PI System Explorer, and connect to the "Sustainability" Database
2) If the weather station has the same base data as "Asa Packer Campus Weather Station A," create the weather station on the "Weather Stations" Template and add the additional attributes not present on the template directly to the weather station asset.
3) If the weather station does not have the same base data as "Asa Packer Campus Weather Station A," do not create the weather station on a template and start from scratch.

Deleting/Removing Elements

When a building is torn down, the meters/usage allocations attached to it may no longer be relevant or may be moved to a different facility. In this case, you will want to remove the building from the PI AF database structure. If the element is not deleted, the last recorded usage information will be included in the database's calculations and skew the total usage for Facility Type, Campus, and Lehigh University. Maybe a building no longer needs its steam meter or has upgraded to a Shark Electricity Submeter from its PPL Meter. In either case, you will want to remove the asset no longer wanted from the PI AF database so its last meter reading is not continually included in the roll-up calculations. However, in all cases you will want to keep the PI Tag associated with the building to maintain the historical data.

You will likely not have permission to delete elements in the Sustainability database. Contact your PI System administrator with the elements you would like to have deleted.

If you do have administrative permissions to delete elements:

1) Right click on the building (or water asset, gas asset, etc.)
2) Click Delete (this will delete the building and all its child elements from the PI AF database, but it will not delete its PI Tags from the PI Data Archive)
3) Verify the delete by clicking yes when prompted whether you really want to delete the element or not
4) If a system is in place to retire PI Tags, contact the PI System Administrator to "retire" the PI Tags from the building (or asset) so they can be separated easily from the rest of the PI Tags collecting data.

Important Notes on Altering Elements

Altering Central Heating and Refrigeration Elements

Central Heating and Refrigeration buildings must always be categorized "CH&R." Proper categorization ensures proper calculations occur.

Central Heating and Refrigeration Facilities:

Asa Packer Campus: Central Heating & Refrigeration
Mountaintop Campus: Building D – Central Heating & Refrigeration

Other than the first note, treat Central Heating and Refrigeration Facilities as you would treat any other Facility.

Altering Shared Steam Meters

A shared steam meter is any steam asset reporting a joint steam percent usage for two or more buildings. Currently only two shared steam meters exist:

Steam Meter 9 reports a joint steam usage for Dravo House, Drinker House, and Richards House

Steam Meter 14 reports a joint steam usage for Building H – Imbt Laboratories, Building J – Mailing & Printing, and Building F – Jordan Hall

If an element with a shared steam meter no longer has its steam usage metered jointly, create a new, non-shared steam meter element for the building (refer to "Adding a New Steam Asset" section of this manual). Although, this action creates a disconnect between the building's historical steam data on the shared steam meter, this action streamlines the calculation process and places the individual steam meter on a template with every other individual steam meter (as a side note, changing the meter will not disrupt the gas usage totalizations on the building itself, only on the steam meter). Additionally, the individual steam meter is more accurate than the shared steam meter, since usage on the shared steam meter was estimated as proportional to the heated square footage of the building.

Updating Information

Updating Tenant Information (Fraternity & Sorority and Administrative Offices)

Every building has an attribute called "Tenant." This attribute houses the current organization residing in the building. For most of the buildings on campus, the Tenant attribute reads "Lehigh University," but for Fraternity & Sorority Houses and Administrative Offices, the Tenant attribute will display the name of the organization or office housed in the building.

For example, "Gamma Phi Beta" is the current tenant for House 100 listed under the building's Tenant attribute. Similarly, 203 East Packer Avenue's current tenant is "Zoellner Administration.

It is more than likely this information will change as Fraternities & Sororities and Offices move and are added to campus. Below are the instructions for updating a building's tenant:

1) In the library section of the PI AF database, open Tables, and open the "Building Background Information" table.
2) In the tenant column, update the organization residing in the building and check-in your changes.
3) Go to the building being updated and check to make sure the Tenant attribute has been updated.

Water Meter Changes Reporting Time - Quarterly Water Meter Now Receives Billing Monthly (or vice versa)

If you encounter a situation where a water meter, historically reporting data quarterly, now reports data monthly, or vice versa, you will need to change the template of the building to reflect that change. In this way, the calculations will be able to compute the correct water usage.

1) Right click on the building in question
2) Scroll over "Convert"
3) Click on "Change Template"
4) If the building was on the template "BuildingDerived2 – Quarterly Water" and now receives water data monthly, change the template to "BuildingDerived1 – Monthly Water" and click OK
5) If the building was on the template "BuildingDerived1 – Monthly Water" and now receives water data monthly, change the template to "BuildingDerived2 – Quarterly Water" and click OK

6) If the building was on the template "BuildingDerived3 – Monthly and Quarterly Water" but no longer receives data for both, change the template to the appropriate reporting time.

Data Flow into the PI Server

Data Flow
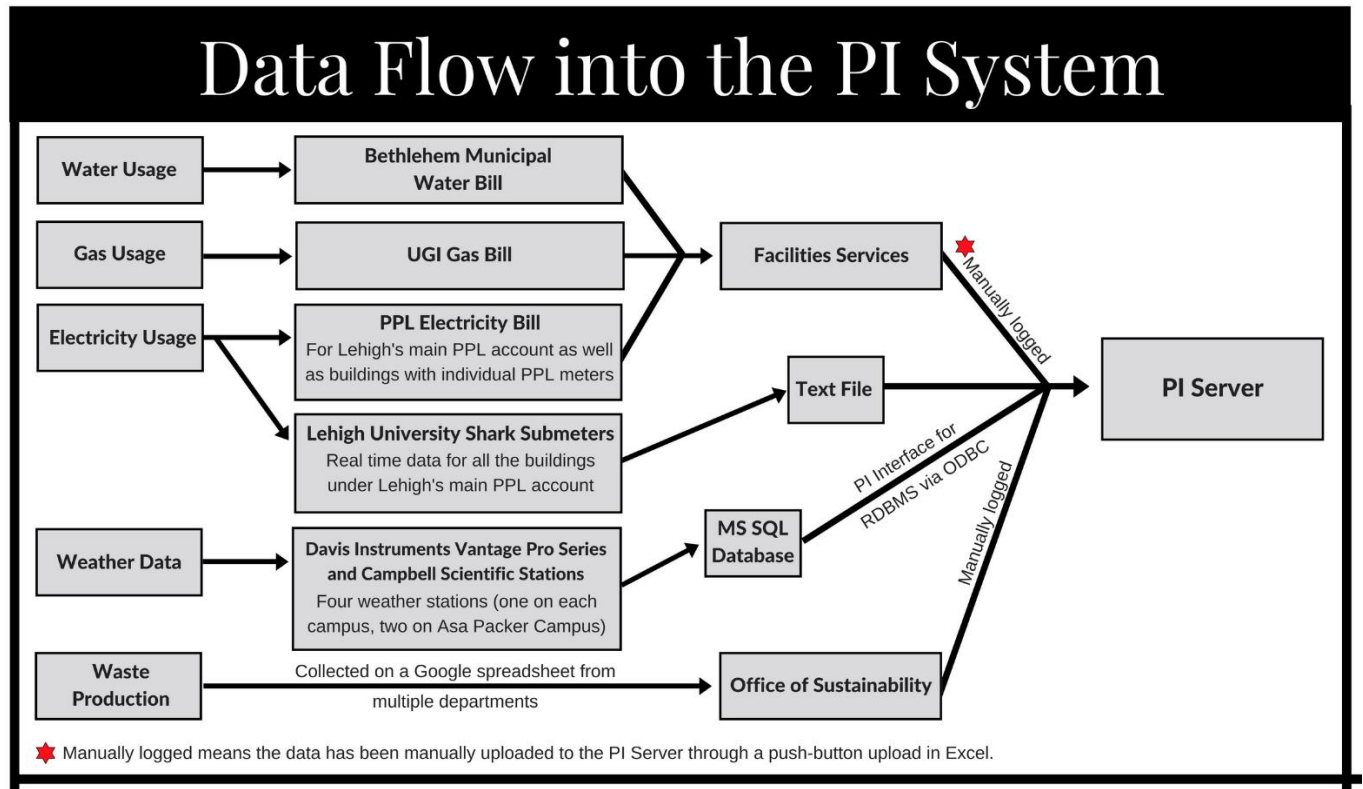
Manually Uploading Data

Manually Uploaded data:

11) PPL Electricity Usage Usage (Monthly)
12) Bethlehem Municipal Water Usage (some meters monthly, some meters quarterly)
13) UGI Natural Gas Usage (Monthly)
14) Waste Tracking Data (Monthly)
15) Undergraduate Students (Yearly)
16) Graduate Students (Yearly)

**All manually uploaded data is timestamped the last day of the month at midnight
(5/31/2017 12:00:00 AM OR 5/31/2017 00:00:00)**

Write "No Data" instead of a value when there is no data to enter

Instructions for Manually Uploading/Logging Data

Manually uploading data utilizes PI Datalink. There exists two different Excel macro-enabled workbooks with integrated push buttons for manual data uploading:

1) PI Data Upload Sheet for Facilities Services   All Utility Usage Data
2) PI Data Upload Sheet for Office of Sustainability   All Waste Stream Data & Student Pop.

Steps for Utilizing Workbooks:

1) The Workbooks are linked to a VBA code, which controls the upload of information to the PI Server. Because of this linkage, all the information (timestamp, PI Tag, Value, Results, Root Path) needs to stay in the specific cell locations outlined in the VBA code. If these locations have been or need to be altered, look at "Steps for Modifying Workbooks" to accommodate the changes.
2) When pushed, the button uploads all the data in the Excel spreadsheet to the PI Data Archive.
3) The workbook outlines systematic instructions for prepping and uploading data.

How to Connect to PI Server through PI Datalink (Excel add-in)

1) Make sure you have PI Datalink downloaded onto your computer and installed on Excel. The PI DataLink tab should appear in the main Excel toolbar. To check if PI DataLink has been installed on your computer and to add it to the toolbar in Excel:
   a. Go to File
   b. Click Options
   c. Click Add-ins
   d. At the bottom of the screen is a drop-down menu to the right of the word "Manage:" Click on the drop-down menu, select "COM Add-ins," and hit the "Go…" button.
   e. Put a check mark in PI DataLink and hit OK. This will add PI DataLink to the Excel toolbar. If you do not see PI DataLink in this list of available add-ins, the software has not been installed on your computer.
2) If PI DataLink has not been installed contact your PI System Administrator in Library and Technology Services to gain permission to install the software and write access to the database
3) If PI DataLink has been installed and appears in your Excel toolbar, proceed.
4) Click the PI DataLink tab
5) Click Settings
6) Click Connection Manager…
7) Highlight PI-Data
   a. This is the asset server—where the database and the reference structure lives
   b. Click "Connect", and make sure you connect to the asset server (a green circle will appear on the top left of the icon)
   c. Click "Set as Default" (a check-mark icon will appear on the top right of the asset server icon).
8) Highlight pi-data.ad.lehigh.edu
   a. This is the data archive—where the historical data and information is stored
   b. Click "Connect", and make sure you connect to the asset server (a green circle will appear on the top left of the icon)

    c. Click "Set as Default" (a check-mark icon will appear on the top right of the asset server icon).

Steps for Modifying Workbooks:

When an asset needing manual data upload is added to the system, you will need to modify the Excel Workbook in order to begin uploading data to the system.

Adding Assets:

1) Take the newly created PI Tag of the asset being added and place it in whatever location you would like in the list of PI Tags (this may be at the end, this may be in the middle to maintain the alphabetical order of facility names, etc.)
2) Because you have added an asset, you have also added a row in the Input Values Table
3) Open the Visual Basic (VBA) editor in Excel by hitting the "Developer" tab on the tool bar and clicking the "Visual Basic" icon. (If you do not see the "Developer" tab on your tool bar, follow the following steps):
    a. Click File
    b. Click Options
    c. Click Customize Ribbon
    d. On the right-hand side of the screen, toggle the "Customize the Ribbon" drop down menu
    e. Select Main Tabs
    f. Underneath the drop down menu, put a checkmark in the "Developer" box
    g. Hit OK
    h. You should now see the "Developer" tab on the tool bar
4) Double click on the appropriate module:
    a. Module1   PPL Electricity Code
    b. Module2   Gas Code
    c. Module3   Monthly Water Code
    d. Module4   Quarterly Water Code
    e. PutVal_code   Waste Creation Code
    f. Module1   Student Population
5) Find the line of code (line 31):

numoftags = 30   'we have 30 tags, from cell F5 to F34

**30 is just an example number

6) Rewrite the line to read:

numoftags = 31   'we have 31 tags, from cell F5 to F35

**add the number of tags you have added to your spreadsheet to the original number and update the cell range

7) You are ready to upload more data. DO NOT hit the green triangle run button in the VBA editor. If you do this and have no values in the Excel workbook, the macro will upload zeros for the entire set of PI Tags at the given time stamp.

Deleting Assets:

1) Follow the same steps as adding an asset. Instead of adding the number of assets added to the workbook to the original number in line 31 of the code, you will be subtracting the number of assets added to the workbook from that original number.

I Have Made a Mistake Uploading Data. What Now?

Looks as if you may have run into some issues manually uploading data through the macro-enabled excel workbooks. Here is what to do when mistakes occur:

Find your mistake:

1) You pressed the upload button without first inputting the values
    a. If there are no values in the value column, the excel spreadsheet automatically uploads zero as the value for all the PI Tags. We do not want this to happen because could skew calculations.
    b. Contact the PI System Administrator, indicating which points at which time stamps you wish to delete.
    c. Proceed to utilize the spreadsheet normally with slightly more caution.
2) You uploaded new values without changing the timestamp to the correct date
    a. The spreadsheet works by uploading values to the specified timestamp. If values already exist at the specified timestamp, the spreadsheet will overwrite them and replace them with the new specified values. If you did not change the time stamp, you have overwritten the existing values with new, incorrect data for that timestamp.
    b. Do not change the timestamp. Re-upload the correct values for the timestamp to replace the incorrect values you just uploaded.
    c. After successfully, re-uploading the original timestamp data, proceed to utilize the spreadsheet normally with slightly more caution.
3) You changed the timestamp but did not insert the correct values you wished to upload
    a. Do not change the timestamp. Just insert the correct values into the value column and upload the data. The new data will overwrite and replace the incorrect data you just uploaded, correcting the mistake.
4) You uploaded the correct values to the correct timestamp but forgot to replace blanks with "No Data"
    a. Replace all blanks with "No Data"
    b. Hit the upload button
    c. The new data will replace the data you just uploaded at the specified timestamp.

PI Vision

For general use information and editing questions, refer to the "PI Vision 2017 R2 User Guide"

Downloading Data

Downloading data from each of the dashboards proves to be a simple process:

1) Select the dashboard at which you would like to look (Lehigh University Information, Building Information, etc.)
2) At the bottom of the screen, select the time range at which you would like to look.
3) In the top right hand corner of the page is a drop-down arrow icon. Click the arrow, and you can export data from the PI Vision platform onto your computer as an .xml or a .csv file.

When you export data as a .csv file, all the data for every attribute on the page during the time period selected will download onto an Excel Workbook. From that point, sort and take the specific information you would like.

Analyzing Site Visitors and Downloaders

1) Analyzing site visitors:

   There are some simple reports built into the PI Vision Admin page regarding usage. Some additional information can be queried from the SQL backend, including how many different users have viewed a certain display and the last time they viewed it. The PI Administrator will know the SQL table linked to the Lehigh University Campus Metabolism PI Vision displays

2) Analyzing Dashboard Downloads:

   To know the download analytics, you may be able to sort through the information collected on the Internet Information Systems (IIS) logs. To obtain access to these logs, contact Library and Technology Services.

   Every action on Lehigh's online server is logged by IIS. The downloading of information would have a unique code in the logs indicating PI Vision data download. However, as of the moment, that code is unknown to me. Additionally, having to manual sort through the logs for specific codes may not be the most efficient way to determine download numbers. Future work will need to be completed to determine the most efficient way to analyze dashboard downloads.