Asset Based PI Example Kit User Guide – Utilities Management System

Version 1.2

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Published: 05/2016

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1. Introduction

The Asset Based PI Example Kits are intended as learning tools for PI AF and starting points for asset-based PI industry centric deployments. For common business objectives in your industry, each kit contains key PI AF library components such as element, analysis, and event frame templates, a representative hierarchy, information to create demo tags with demo data, and visuals - all focused around addressing one or more aspects of that business objective.

This User Guide is for the Asset Based PI Example Kit for Utilities Management System (UMS).

This example kit includes the following:

- OSIdemo_BASIC_Utilities Management System_v2016A.xml
- OSIdemo_FULL_Utilities Management System_v2016A.xml
- UOM_US Currency_v2016A.xml
- UOM_Volume_Cost_v2016A.xml
- UOM_Energy_Cost_v2016A.xml
- OSIDemo_Utilities Management System_v2016A.pdi
- Asset Based PI Example Kit User Guide – Utilities Management System_v2016A.pdf
- Intro to the Asset Based PI Example Kit for Utilities Cost Management – Slides_v2016.pdf

Additionally, there are two videos on PI Square that describe how to get started with the example kit and how PI AF is used to address the use case:

- Getting Started with an Asset Based PI Example Kit
- Intro to the Utilities Management System PI AF Example Kit

When imported into PI System Explorer, the included XML files can be used to create two different PI AF databases, described below.

The PI AF Template and Hierarchy (BASIC) database (Chapter 2) includes reference library objects (templates, enumeration sets, categories, and tables with metadata) and a simple example tree of actual elements to demonstrate hierarchy and use of templates. The intended purpose of this database is to present a starting point for customer development of their own PI AF utility monitoring model.

The Asset Based PI Demo (FULL) database (Chapter 3) Utilities Management System Asset Based PI Demo (FULL) Database includes the same library objects and simple example hierarchy as the BASIC database. However, it also includes configuration for demo tag creation and simulator analyses to generate data for a “live” demo. To demonstrate a full implementation of the FULL database, example visualization in the form of PI ProcessBook is included in the kit. The intended purpose of the FULL database is to illustrate a simple implementation of Plant utilities management and monitoring using the PI AF Server and asset-based PI tools.

The asset hierarchy included is relatively simple and is explained in further detail in Section 1.2 (Asset and Template Relationships). It is not the objective of this example to reflect hierarchy complexity that may be found in actual customer environments.

Before setting up and exploring either database, please review Section 1.3 (Common Implementation Details), as it contains important explanation of incorporated element, attribute, and hierarchy implementation details.

The Asset Based PI Example Kits have been developed as a learning tool to provide guidance to OSIsoft's customers and partners as they implement business objectives using the PI System. The Asset Based PI Example Kit for Utilities Management System is not intended to provide a complete solution for energy management and the example may be missing key requirements for a production environment. If you would like to adopt the use case for your own processes and equipment, all aspects of the kit – templates, hierarchy, analyses, and visualization – should be thoroughly reviewed and modified as needed.

1.1 Prerequisites

This document assumes the reader has a good working knowledge of PI System Explorer and PI AF, including templates, analyses, and event frames. The Getting Started with an Asset Based PI Example Kit video on PI Square provides a short walk-through on setting up the BASIC and FULL PI AF databases.

The Asset Based PI Example Kits require the following minimum PI System software versions:

- PI Data Archive 2015 or later
- PI AF Server 2015 or later
- PI Analysis Service 2015 or later
- PI ProcessBook 2015 or later

A key feature of this kit is PI future data, which is new with the 2015 PI system products, thus the basis of these requirements.

For help with the kit and PI AF, see Chapter 1.4 - How-to Guidance and Learning Resources.

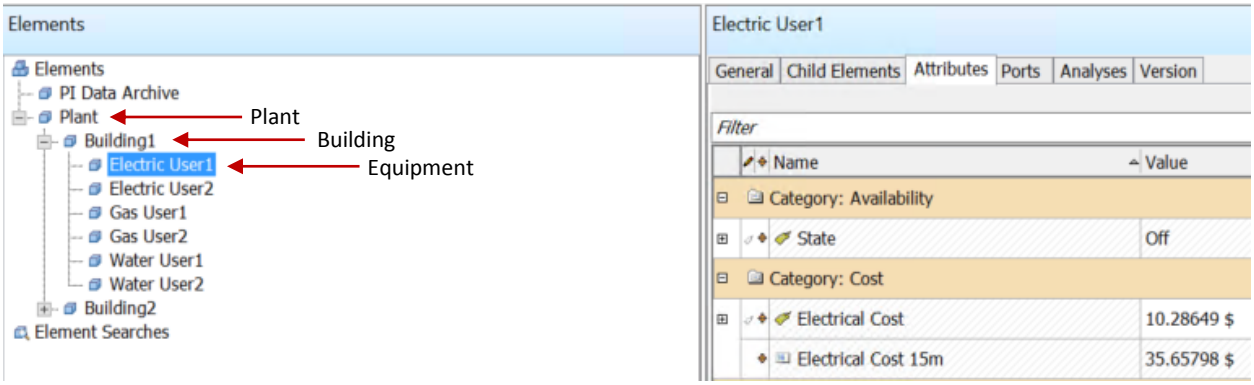
1.2 Asset and Template Relationships

1.2.1 Hierarchy and Asset Relationships

The hierarchy used in the Utilities Management System example kit is representative of what might be used in a production environment. However, it only represents one way in which the hierarchy and assets could be set up. In addition, the included "Cost" analyses are only examples, intended to demonstrate how various PI AF features can be leveraged for utilities monitoring and cost management.

When setting up this hierarchy, the following relationships between template types were chosen:

- Assets of the Plant template are parents to assets of the Building template. Assets of the Building template are parents to assets of the Equipment category templates (Electric User, Gas User, and Water User). Several calculations such as the Building Electrical Costs rollup rely on these parent-child relationships. The Generic equipment template is the base template for the Equipment category templates (Electric User, Gas User, and Water User).

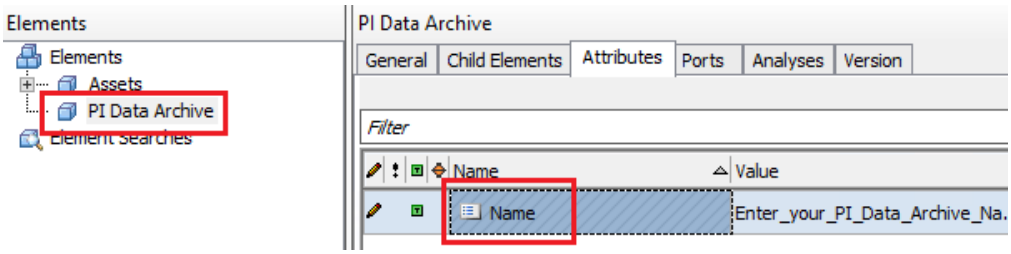


1.3 Common Implementation Details

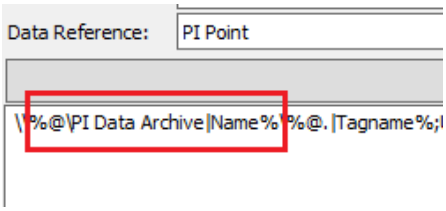
The following practices are used in the example kit.

1.3.1 Use of a *PI Data Archive* Element with a *Name* Attribute

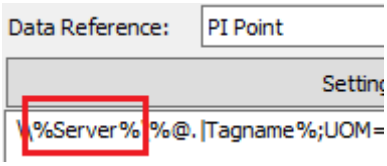
The PI AF databases include an element template and root level element named *PI Data Archive*.



The value of the *PI Data Archive*|*Name* attribute is used in tagname substitution parameters, as shown below:



Rather than the default %Server% substitution parameter below.



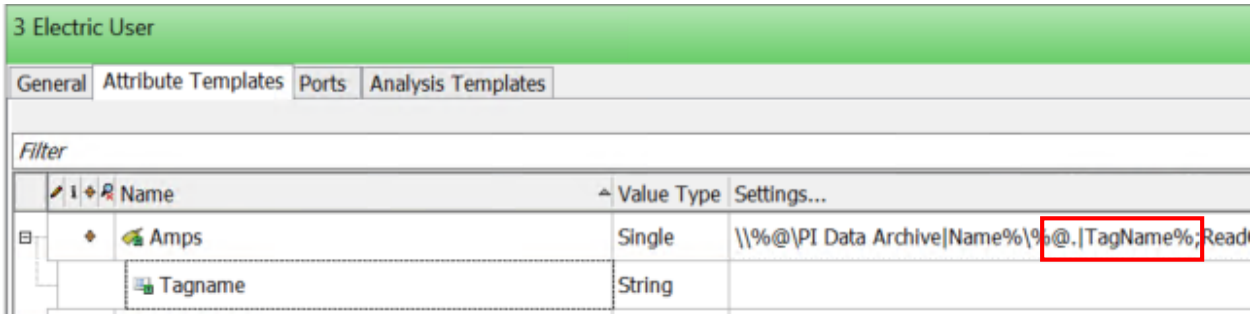
This is a good practice as it makes the templates and hierarchy readily portable between different PI AF databases. When exporting and importing a database XML into a system with a different PI Data Archive, only the value of the *Name* attribute needs to be updated. Additionally, it clearly defines the target PI Data Archive, which can be helpful when not using the default PI Data Archive.

1.3.2 Use of a *Tagname* child attribute for PI Point data reference attributes

One purpose of substitution parameters is to allow users to construct a PI tag name using the name(s) of the current attribute, current element, or nearby attributes and elements. However, this often requires a rigorous naming scheme for PI tags, which is difficult to achieve in a production environment. Often, the configuration string, and thus PI tag name, are “hard-coded” into a PI Point data reference attribute by manually editing the value, often using PI Builder.

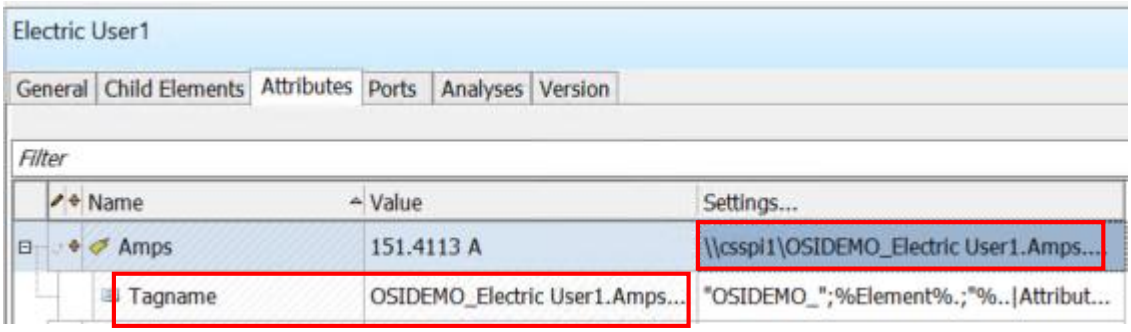
This is problematic if the attribute is based on an attribute template. If a "Reset to Template" action is performed on the element attribute, the "hard-coded" PI tag name will be lost and will need to be re-entered.

A workaround for this situation is to define a child attribute of value type String called *Tagname* for every PI Point data reference attribute template. In the attribute template, the configuration string uses a substitution parameter to get the value of the *Tagname* child attribute.



Performing a "Reset to Template" action on the PI Point data reference attribute will not lose the PI tag name. Note that a "Reset to Template" action on the *Tagname* attribute can result in the lost tag name, however, because the *Tagname* attribute has a data reference type of "<None>," a "Reset to Template" action is very rarely needed.

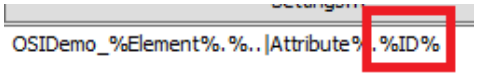
To use this structure, either use PI Builder or manually change the *Tagname* value to the appropriate PI tag name.



After manually adding or changing the *Tagname* attribute, it is recommended to do a "Create or Update PI Point" action on the parent PI Point data reference attribute. This will "lock in" the PI Point number and improve performance during queries. The "Create or Update PI Point" action can be done on the individual attribute, or a "Create or Update Data Reference" action can be completed on the element- or a parent element level.

1.3.3 Tags created within PI System Explorer should include the %ID% substitution parameter

PI Point data reference attributes can be configured to create tags on the PI Data Archive; one common scenario is when a PI Point data reference attribute is defined to be the output of an analysis. Substitution parameters are used to define the PI tag's name.



PI AF does not require that asset name and attributes be unique; it only requires that the path be unique. For example:

\Plant\Building 1\Electric User 1\|Amps

\Plant\Building 2\Electric User 1\|Amps

Without a rigorous, multi-level naming scheme, it would be easy to create a PI tag with the same name for the two amperage readings using substitution parameters. Addition of %ID% on the end of a tag naming scheme ensures unique PI tag names.

1.3.4 Analyses outputs should always be of data reference type PI Point

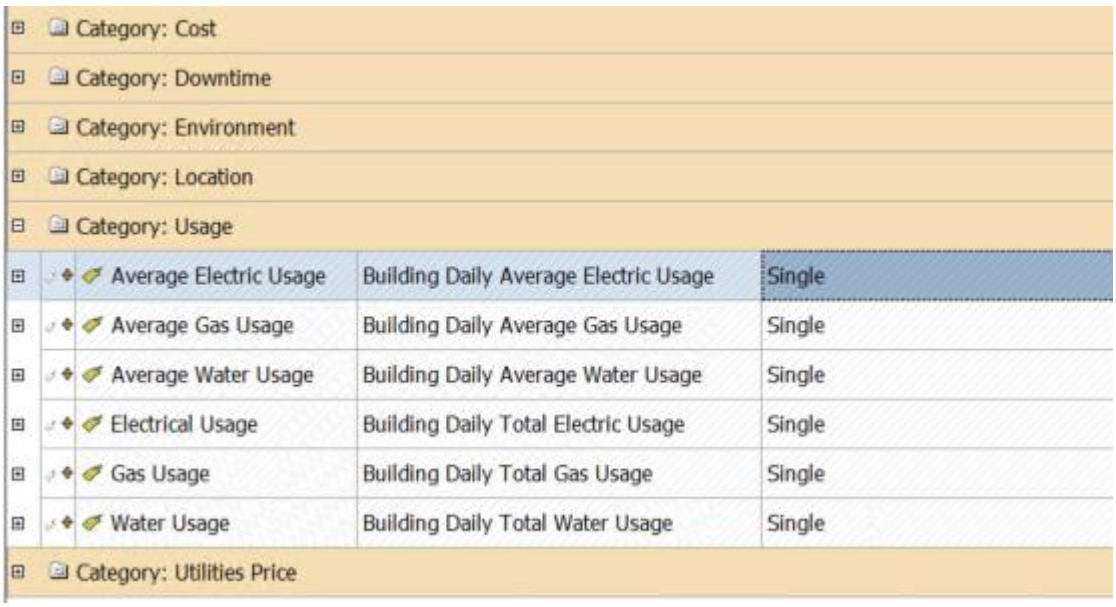
When mapping an analyses output to an attribute, the attribute should be of data reference type PI Point, as writing to a static attribute can negatively impact the performance of the PI AF Server.

Starting in PI AF Server 2015 (v2.7), you will also be able to map to a new data reference type called the Analysis data reference. This data reference should be used for analysis written to attributes that do not change frequently or do not need to be historized.

1.3.5 Categories

Many of the elements and attributes throughout the example have been labeled with one or more categories. While not required, categories are often a good way to search for groups of assets or attributes in the client tools or programmatically (in addition to other search variables such as the template type or name). For example, one could create attribute categories for *cost and usage*, and easily search for assets of the *building element* template containing that specific information.

Attribute categories are useful when you want to view attributes by a specific group, as shown below, and they can be used to identify attributes used in a rollup analysis.



1.3.6 Additional Units-of-Measure (UOMs)

Some attributes found in the PI AF databases rely on UOMs not found in the default PI AF Server install. The following UoM classes are included as part of this kit:

- US Currency
- Energy Cost
- Volume Cost

The US Currency UOM class creates UOMs for the UC dollar and cent. The Energy Cost and Volume Cost classes create UOMs for standard energy and volume units per US dollar and cent, respectively.

These UOM files should be imported (via PI System Explorer "Import from File" action) in the order indicated below, before any database imports are done. Note, UOMs are PI AF Server wide, and do not need to be imported for each PI AF database instance.

1. UOM_US_Currency_v2016A.xml
2. UOM_Energy_Cost_v2016A.xml
3. UOM_Volume_Cost_v2016A.xml

If you have UOM classes of the same name or UOMs that use the same names included in the above XMLs, importing these XML files could overwrite your current UOM definitions.

Please review your current UOM definitions before importing.

1.4 How-to Guidance and Learning Resources

While this document assumes the reader has a good working knowledge of PI System Explorer and PI AF, many resources are available for instruction and additional learning.

The online PI Live Library provides an overview and instructions for using PI Asset Framework, PI Builder, and creating Asset Analytics and Notifications.

On the YouTube OSIsoft Learning Channel, playlists on PI AF (Asset Framework), Asset Analytics, PI Event Frames, PI Notifications, PI DataLink, PI ProcessBook, and PI Coresight can walk you through the many of the processes used in the development and visualization of an AF asset model.

PI Square, OSIsoft's online community, has a space dedicated to exploring, sharing, and collaborating on solving business problems with the asset based PI System - the AF Community Library. Go here to ask questions about PI AF, download other example kits and templates, or see what others are sharing and discussing.

In general, the following were performed during the development of the example kit. These terms can be used when searching the above resources to learn how to create and visualize your own AF model or edit the template and hierarchy database:

- Using PI System Explorer

- Import and export using XML
- Create and edit templates
- Configure data references
- Build hierarchy
- Create and edit elements
- Create and edit tables
- Create categories
- Create enumeration sets
- Create event frame and event frame templates
- Create rollup, expression, and event frame generation analyses
- Manage and backfill analyses
- Create and edit elements with PI Builder (previously called PI AF Builder)
- Query elements, attributes, and event frames with PI DataLink

1.5 Overview of Utilities Management System Kit

Simulated electrical, gas, and water usage values are calculated by PI AF asset based analyses. They leverage PI AF features that typical utility monitoring would need such as Table lookups, Calculations, and Enumeration Sets. However, this Utilities monitoring DEMO is a facsimile only – not actual production equations. That is, the analyses are intended to be replaced or heavily modified if the kit is modified for production use.

The figure below provides an overview of the primary actors in the Utilities Management System kit. They include:

- **PI expression analyses (OSIDemo_RandomData)** are configured to generate random data to populate baseline parameter measurement values for electric (amps), gas (gas flow), and water (water flow) utilities monitoring.
- **PI expression analyses (Electric Usage, Gas Usage, and Water Usage)** are configured to convert the raw baseline parameters (amps, gas flow, water flow) to units (kWh, BTU, Gallons) commonly used to determine related costs for utilities.
- **PI expression analyses (Electric Cost, Gas Cost, and Water Cost)** are configured to apply simulated utility pricing ($/kWh, $/BTU, and $/Gal) in order to calculate and monitor related costs of the utilities for a facility.
- **PI rollup analyses (example, Building Gas Usage and Building Gas Cost)** are configured to calculate summary values (sum and average) for the simulated Building and the various production equipment (pumps, motors, compressors, etc.) which consume the monitored utilities.
- **PI rollup analyses (example, Gas Usage and Gas Cost)** are configured to calculate summary values (sum and average) for the simulated Plant facility which may contain one or more buildings with monitored utilities.
- **PI Event Frame analyses (example, Electric downtime and High Amperage)** are configured to track and collect key information relative to downtime events related to the various utilities.

2. Utilities Management System Asset Based PI Demo (BASIC) Database

The Utilities Management System Asset Based PI Example Template and Hierarchy (BASIC) database contains seven element templates: *PI Data Archive*, *Plant, Building, Electric User, Gas User, Water User, and Generic Equipment*. Element template category *Equipment* contains three key element templates: *Electric User, Gas User, and Water User*.

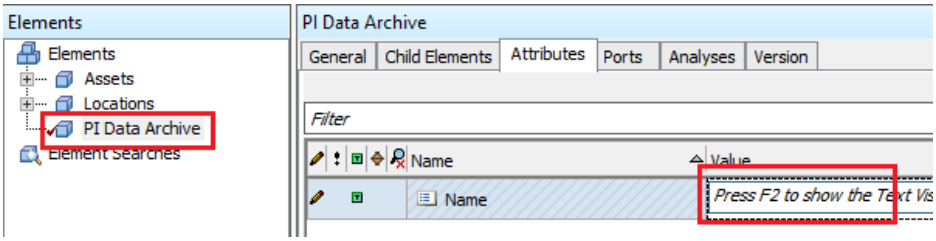
These element templates contain attributes for energy usage parameters, equipment specifications, duration of downtime, and equipment availability. It also includes various attributes used in the energy usage and utilities cost projections. These are found within the categories of usage and cost. Finally, these templates include analyses that are examples of electric, gas, and water usage within a facility/building. There are also analyses to detect equipment downtime events and duration.

The intended use of this database is to present a starting point for customer development of their own asset-based PI model in the PI AF Server. The following instructions describe how to install the database and walks through the different components that should be reviewed and modified to reflect the customer's own processes. As previously mentioned, the included hierarchy is intended as a simple example of how to use the templates. It can either be copied and edited in a second tree or directly edited.

To see how the use case would look when fully implemented, go to Chapter 3 " Utilities Management System Asset Based PI Demo (FULL) Database" to install and start up the demo version of the database.

2.1 Instructions for Use

1. Create a new, empty PI AF database called "OSIDemo Utilities Management BASIC" or similar.
2. Import the XML files in the following order using the default import settings (Allow Create, Allow Update, Automatic Check In):
    a. UOM_US_Currency_v2016A.xml
    b. UOM_Energy_Cost_v2016A.xml
    c. UOM_Volume_Cost_v2016A.xml
    d. OSIDemo_BASIC_UtilitiesManagementSystem_v2016A.xml
3. In the Elements view, enter the PI Data Archive name in the *PI Data Archive|Name* attribute. Check in this change.



4. In the library, review all element, analysis, and event frames templates for applicability and modify as necessary.

    a. The attributes included are based on the use case of the kit and common attributes of generic utilities equipment, however, different attributes and analyses may be needed in a customer's actual environment.
    b. Review attributes data sources and UOMs. Most attributes with real time data are assumed to be of data reference PI Point with existing PI tags.
    c. Review all analysis templates for the equations used and calculation triggering and frequencies.
    d. Note when an output of an analysis points to a PI Point data reference, and check the tag creations settings for the name, point source, etc. By default, PI tags created within PI AF are of the point class *base*.
5. Modify the provided hierarchy as desired by renaming, deleting, or adding assets. The existing hierarchy and elements are only included as a guide to building production elements. They may be deleted when no longer needed.
    a. Review Section 1.2 Asset and Template Relationships to understand how the templates relate to each other. Some attribute or analyses use substitution parameters that reference a parent child or element child that are of a specific element template.
6. Review attribute values for all your elements and update where needed.
    a. Many static attributes, such as *Equipment Type* or *Electric Rate* have example values in them and will need to be edited.
    b. All utilities usage related attributes should be reconciled with the actual technologies (electric, gas, and water) and type of equipment (pumps, motors, compressors, etc.) deployed in production.
    c. All Usage attributes will need to be modified (or deleted) as appropriate for the actual customer energy and utilities found within monitored facilities.
    d. For all attribute of the PI Point data reference, enter the appropriate PI tag name into the *Tagname* child attribute. (See Section 1.3.2 Use of a Tagname child attribute for PI Point data reference attributes for a full explanation.)
7. Review the Usage and Cost analyses for the Equipment category element templates (Electric User, Gas User, and Water User). The analyses employ generic calculations and may not be needed depending on the equipment deployed and utilities monitored.
8. On the Building element template, review the *Cost, Usage, and Downtime* analyses and substitute actual customer utility usage monitoring requirements.
9. The following library tables will need to be modified (or deleted) as appropriate for the actual customer monitored utilities:
    a. OSIDemo_Asset Location
    b. OSIDemo_Electric Specs
    c. OSIDemo_Gas Specs
    d. OSIDemo_Water Specs
    e. OSIDemo_Generic Specifications
10. Check in changes.
11. Start and backfill all of the *Equipment* category (Electric User, Gas User, and Water User) element analyses as needed.
12. Start & backfill the *Building* analyses as needed.
13. Start & backfill the *Plant* analyses as needed.

3. Utilities Management System Asset Based PI Demo (FULL) Database

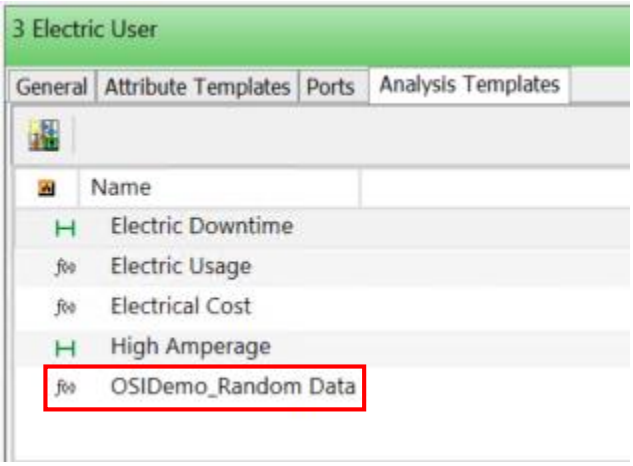
The Utilities Management System Asset Based PI Example Template and Hierarchy (FULL) database contains seven element templates: *PI Data Archive*, *Plant, Building, Electric User, Gas User, Water User, and Generic Equipment*. Element template category *Equipment* contains three key element templates: *Electric User, Gas User, and Water User*.

These element templates contain attributes for energy usage parameters, equipment specifications, duration of downtime, and equipment availability. It also includes various attributes used in the energy usage and utilities cost projections. These are found within the categories of usage and cost. Finally, these templates include analyses that are examples of electric, gas, and water usage within a facility/building. There are also analyses to detect equipment downtime events and duration.

The intended use of the Demo (FULL) database is to illustrate a simple implementation of energy management and usage monitoring using the PI AF Server and asset-based PI tools. The following instructions describe how to install the database and create and populate demo tags with demo data to create a "live" demo.

The Utilities Management System Asset Based PI Demo (FULL) database has the same contents as the Utilities Management System Asset Based PI Demo (BASIC) database except for the following differences:

- For PI Point data reference attributes that would contain data from PI tags when in a production environment:
    - The PI Analysis Service is used to generate demo data to populate these attributes. As shown below, analyses created to generate demo data for attributes are configured with a name that starts with *OSIDemo_*.



    - Tag creation is enabled and substitution parameters defined that resolve to demo tags.
    - Demo tags have a tagname that starts with *OSIDemo_*, a point source of *OSIDemo_AFAnalysis*, and are of point class *base*.
- For Event Frame Templates, *OSIDemo_* is included in the beginning of the naming pattern for event frames.

- In Library, the *OSIDemo* tables have demo data included:
    - *OSIDemo_Asset Location*
    - *OSIDemo_Electric Specs*
    - *OSIDemo_Gas Specs*
    - *OSIDemo_Water Specs*
    - *OSIDemo_Generic Specifications*

To demonstrate a full implementation of the FULL database, example visualization in the form of a PI ProcessBook named *OSIDemo_UtilitiesManagementSystem_v2016.pdi* is included in the Utilities Management System Example Kit.

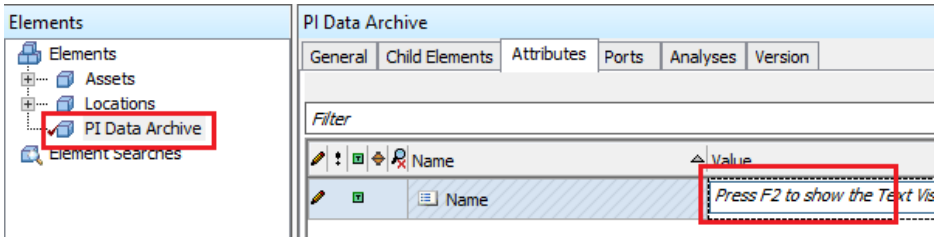
To set up a database with only the library objects and example hierarchy, ready to be modified based on a customer's own process, see Chapter 2 - Utilities Management System Asset Based PI Demo (BASIC) Database.

Note – Complete implementation of the FULL database will create 145 PI points on your PI Data Archive. These tags have a tagname that starts with *OSIDemo_* and are of point class *base.* All of the PI Points created have "PI AF UMS Kit" defined in the extended descriptor (exdesc) point attribute field. This allows searching for the tags created by specifying "PI AF UMS Kit" in the extended descriptor (exdesc) field of the PI System Management Tools (PI SMT) tag search window.

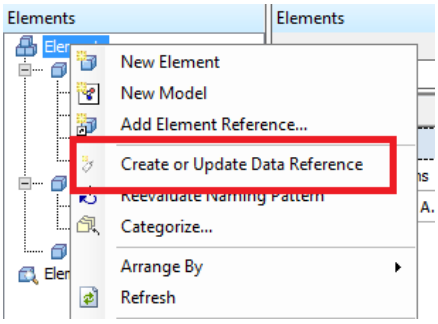
If you do not want to create demo tags on your PI Data Archive, only install the BASIC database as described in Chapter 2.1.

3.1 Instructions for Use

1) In PI System Explorer, create a new, empty PI AF database called "OSIDemo Utilities Management System FULL" or similar.
2) Import the XML files in the following order using the default import settings (Allow Create, Allow Update, Automatic Check In):
    a. UOM_US_Currency_v2016A.xml
    b. UOM_Energy_Cost_v2016A.xml
    c. UOM_Volume_Cost_v2016A.xml
    d. OSIDemo_FULL_UtilitiesManagementSystem_v2016A.xml
3) Enter the PI Data Archive server name in the *PI Data Archive|Name* attribute, and check in the change.



4) At the root element, select “Create or Update Data Reference” to generate demo PI tags for all demo elements.



If errors are thrown with the “Create or Update Data Reference” such as ***Failed to create… was not found*** then:

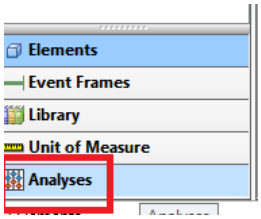
a) Find the element with the problem attribute.
b) Select the attribute(s) and right mouse click option “Reset to Template”
c) Repeat the “Create or Update Data Reference” step.

5) Check in changes.

6) On all elements based on *Electric User, Gas User, or Water User* templates (the child elements of the Building element)

a. Attribute categories *Specification, Location, and Utilities Price* attributes may be changed to customize the simulation, but modifications are not required. Example of attribute changes that might be required are the price of electric, gas, and water utilities.

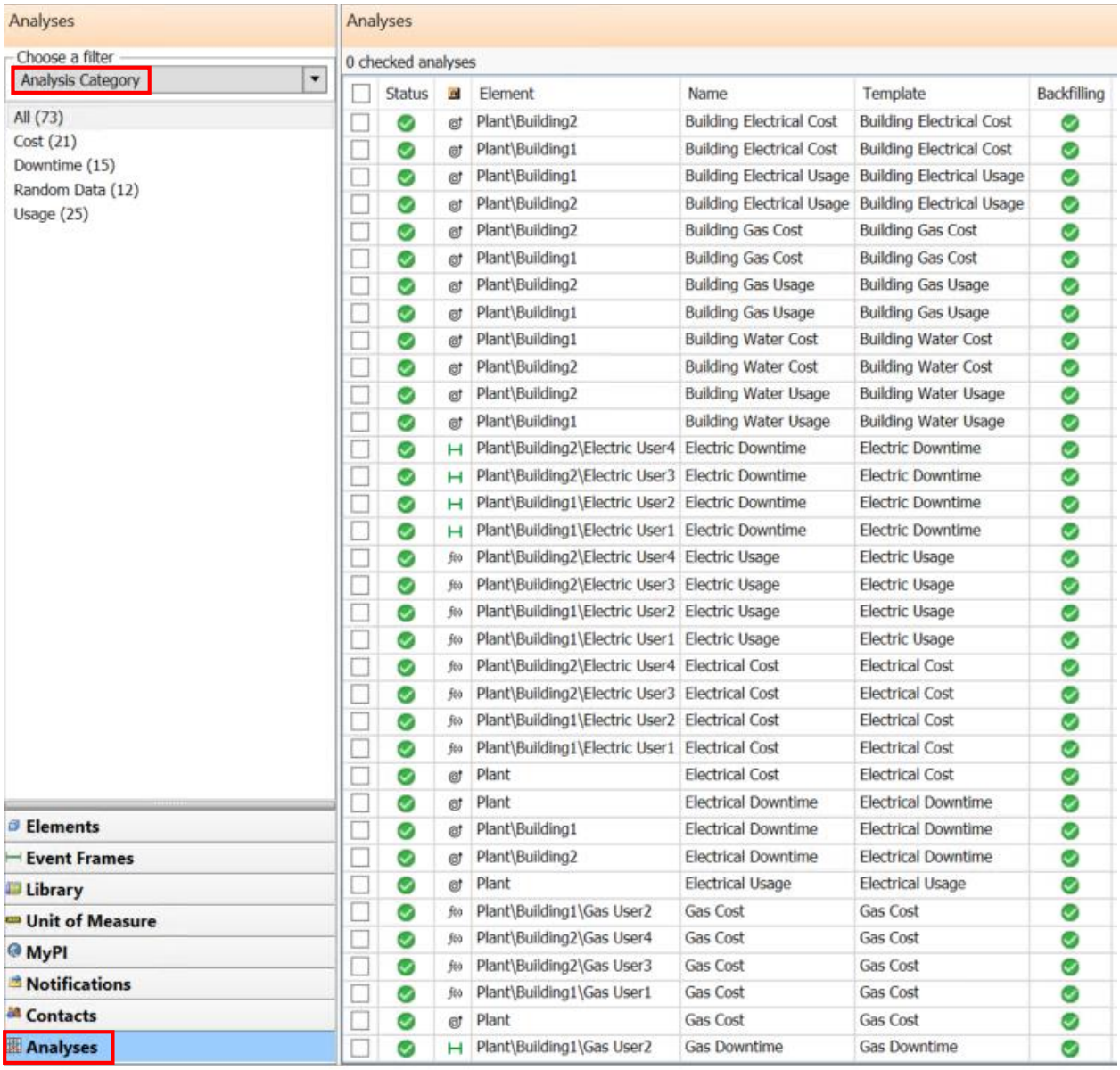
7) If not already started, start analyses, and backfill analyses, going back one to three months, in the order described below. Note that archives must already exist in the PI Data Archive going back to the date that you backfill. The Analysis plug-in can be used to manage multiple analyses.



Before proceeding to subsequent analyses, make sure backfilling has completed on all backfills.

Set the filter on the analyses plug-in to *Analysis Category* as shown below and start the analyses in the following order:

1. Start analysis category *Random Data and* backfill.
2. Start analysis category *Usage and backfill*.
3. Start analysis category *Cost and backfill*
4. Start analysis category *Downtime and backfill*.



3.2 Utilities Management System Asset Based PI Example Kit Visuals

The kit also contains one example visuals files:

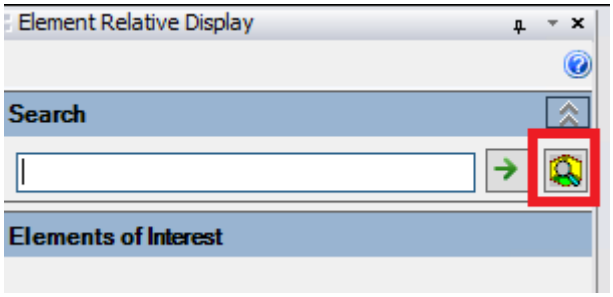
- PI ProcessBook *OSIdemo_UtilitiesManagementSystem_v2016.pdi*

3.2.1 PI ProcessBook displays

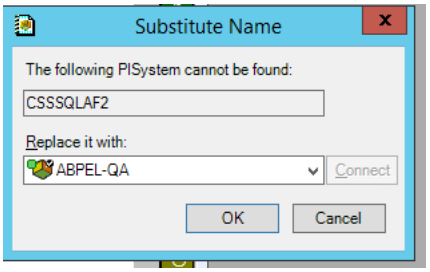
OSIdemo_UtilitiesManagementSystem_v2016A.pdi provides simple visualization of utility Usage and Cost. The PI ProcessBook display is provided as a cursory example only. Screenshots from the display can be found in the Appendix.

For the user to use the display utilizing their own AF database, the following steps are needed:

- Open the PI ProcessBook display
- If not already visible, select View > Element Relative Display from the menu
- Find *Elements of Interest* by clicking on the Search AF icon in the Elements of Interest window.

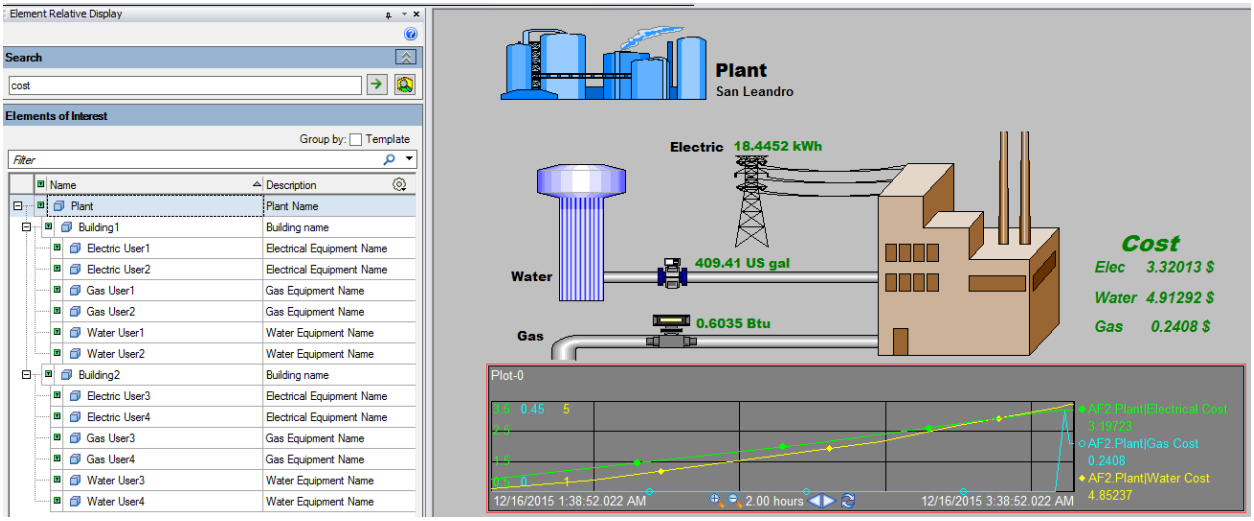


- Confirm the correct PI AF Server and PI AF database
- Search and select elements of the Building template.
- Upon startup of PI ProcessBook, a “Substitute Name” window (shown below) may appear allowing user to update referenced PISystem (PI AF Server) to correct name.



APPENDIX

PI ProcessBook display *OSIdemo_UMS_Plant_v2016A.pdi*



Version History

Version	Date	Author(s)	Description
1.0	December 16, 2015	Clarence Presha	Initial draft of guide
1.1	December 17, 2015	Clarence Presha	Post QA updates
1.2	April 21, 2016	Clarence Presha	Incorporation of minor updates, including UoM name changes.