



# **2015 OSIsoft TechCon**

Modeling your processes using  
the PI System

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Published: May 6, 2015

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## The Context

You work at a Coal Fired Power plant. Your job responsibility requires you to understand and keep track of how your assets are performing. Specifically, you want to use your engineering expertise to:

- Build an asset model that provide context to all users of your PI System
- Create a representation of your important processes
- Apply your engineering expertise to help detect impending problems
- Proactively alert users to these impending problems
- Provide a dashboard of important information
- Help users to refine their processes based on forecasts and predictions
- Enable all users to easily find and view information

You want to use the PI System to accomplish these tasks but it seems so daunting and “large”. You don’t know where to start and you’re uncertain about the time and efforts needed. You know the following:

- Your coal fired power plant has 4 units, each with its own boiler
- Your plant has many important pieces of equipment
- Fuel cost represents the majority of your operating cost and any improvements here would go straight to your bottom line
- Likewise, the efficiency of your turbines is an important parameter to monitor for maintenance scheduling
- You are switching coal types as a cost saving move and the maintenance manager asked you to monitor mill parameters and let him know if you see any anomalies

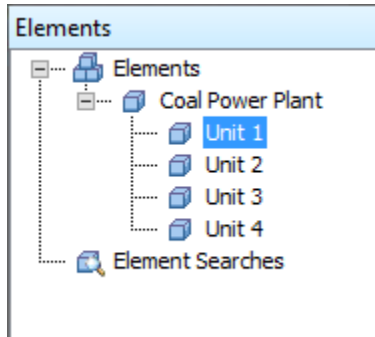
## Plan of attack

Rather than trying to build your entire (comprehensive) asset model using PI AF, you understand that it’s not necessary to do all this at once but rather can be done over time. You start by modeling your most important assets and process, and subsequently add and improve your model over time.

## Directed Activity 1 – Building a Template and PI AF Hierarchy for your Coal Mills

In this exercise, we will build a PI AF element template for coal mills for your plant using PI System Explorer. Once that is done, we would use that template as a basis to build the PI AF structure to represent all your coal mills.

1. Start PI System Explorer (32bit).
2. Create a new database.
3. Create an initial hierarchy for your coal power plant with 4 Units.



4. Go to your Library -> Element Templates section.
5. Create a new element template by right-clicking on the Element Templates pane on the right.
6. Name it "Mill", with a description of "Coal grinding mills" and a category of "Coal Handling Equipment" and "Mill".


















Mill	
General	Attribute Templates   Ports   Analysis Templates
Name:	Mill
Description:	Coal Grinding Mill
Base Template:	<None>
Categories:	Coal Handling Equipment;Mill
Default Attribute:	<None>
Naming Pattern:	
<input type="checkbox"/> Allow Extensions <a href="#">Extended Properties</a> <a href="#">Security</a>	
Find:	<a href="#">Derived Templates</a> <a href="#">Elements</a> <a href="#">Referenced Parent Templates</a> <a href="#">Derived Elements</a> <a href="#">Referenced Child Templates</a>

7. Select "OK" and answer "Yes" to create the new Category.
8. Go to the Attribute Templates tab.

9. Right-click in the right pane and create the following attributes for your template. For all the attributes listed below, configure them as PI Point Data Reference, with a Setting of:

`\\%Server%\%..\Element%.%Element%.%Attribute%`

- a. Feeder Current Draw, UOM = Amperes (A)
- b. Feeder Rate, UOM = Thousand Pounds Per Hour (klb/hr)
- c. Mill Total Primary Air Flow, UOM = Thousand Pounds Per Hour (klb/hr)
- d. Mill Feeder Bias, UOM = Percent (%)
- e. Mill Primary Air Flow, UOM = Percent (%)
- f. Mill Inlet Pressure, UOM = inches of water column (inWC)
  - i. If inWC is not in your supplied UOM library. You will need to create that.
    1. Go to your Unit of Measure tab
    2. Select Pressure
    3. Create a new UOM for Pressure
    4. Call it “inches of water column”
    5. Abbreviation = inWC
    6. Reference UOM of “pound-force per square inch”
    7. Factor = 0.03609
    8. Select “OK”
    9. Go back to the Element Template Library and select UOM = inWC for your Mill Inlet Pressure
- g. Mill Discharge Pressure, UOM = inWC
- h. Mill Differential Pressure, UOM = inWC
- i. Mill Hot Primary Air Temperature, UOM = degree F
- j. Mill Hot Primary Air Flow, UOM = Thousand Pounds Per Hour (klb/hr)
- k. Mill Cold Primary Air Flow, UOM = Thousand Pounds Per Hour (klb/hr)
- l. Mill Coal Air Temperature, UOM = degree F
- m. Check in your changes

Mill			
General Attribute Templates Ports Analysis Templates			
Filter 			
   Name	Description	Default Value 	
 Feeder Current Draw	Feeder Current Draw	0 A	
 Feeder Rate	Feeder Rate	0 klb/hr	
 Mill Coal Air Temperature	Mill Coal Air Temperature	0 °F	
 Mill Cold Primary Air Flow	Mill Cold Primary Air Flow	0 klb/hr	
 Mill Differential Pressure	Mill Differential Pressure	0 inWC	
 Mill Discharge Pressure	Mill Discharge Pressure	0 inWC	
 Mill Feeder Bias	Mill Feeder Bias	0 %	
 Mill Hot Primary Air Flow	Mill Hot Primary Air Flow	0 klb/hr	
 Mill Hot Primary Air Temperature	Mill Hot Primary Air Temperature	0 °F	
 Mill Inlet Pressure	Mill Inlet Pressure	0 inWC	
 Mill Primary Air Flow	Mill Primary Air Flow	0 %	
 Mill Total Primary Air Flow	Mill Total Primary Air Flow	0 klb/hr	

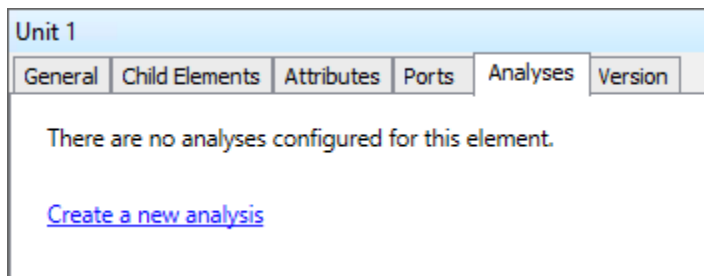
- n. Go to the elements hierarchy
  - i. Right click on Unit 1 through Unit 4 and create Mill A, Mill B, Mill C, Mill D and Mill E child elements for each unit based on the newly created element (Mill) template.
- o. Check in your changes



## Directed Activity 2 – Building Analyses for your Coal Mills to Track Coal Usage

In this exercise, we will take advantage of Asset Analytics built into PI AF to create Rollup calculations to trace coal usage.

1. Go to the Unit 1 Analyses tab
2. Create a new analysis



3. In the Analyses tab:
  - a. Select Rollup Analysis type
  - b. Name the Analysis
    - i. Feeder Rate Rollup
  - c. Filter by Attribute Name
    - i. Feeder Rate
  - d. Select the Sum Function
  - e. Configure the Rollup schedule to be Event-Triggered

Unit 1

General Child Elements Attributes Ports Analyses Version

Name: Feeder Rate Rollup

Description:

Categories:

Analysis Type: ☐ Expression ☒ Rollup ☐ Event Frame Generation

Sample Child Element: Mill A Group By: None

Rollup attributes from

☒ Child elements of Unit 1

☐ This element - Unit 1

To select attributes set criteria below

Attribute Name: Feeder Rate

Attribute Category:

Element Category:

Element Template:

Select the function(s) to write to an attribute

Function Output(s) Value

☒ Sum Map

☐ Average

☐ Minimum

☐ Maximum

☐ Count

Evaluate

Name	
✓ Feeder Rate	Mill A
Feeder Current Draw	Mill A
Mill Coal Air Temperature	Mill A
Mill Cold Primary Air Flow	Mill A
Mill Differential Pressure	Mill A
Mill Discharge Pressure	Mill A
Mill Feeder Bias	Mill A
Mill Hot Primary Air Flow	Mill A
Mill Hot Primary Air Temperature	Mill A
Mill Inlet Pressure	Mill A
Mill Primary Air Flow	Mill A
Mill Total Primary Air Flow	Mill A

Show more attributes (Showing 12 of total 12 attributes: 1 items selected)

Scheduling: ☒ Event-Triggered ☐ Periodic ☐ Run on demand

Trigger on: Any Input

Advanced...

Connected to the PI Analysis Service.

- f. Map the output to a new attribute and create a PI Point to store the output.

Attribute Properties

Name: Feeder Rate Rollup\_Sum

Description:

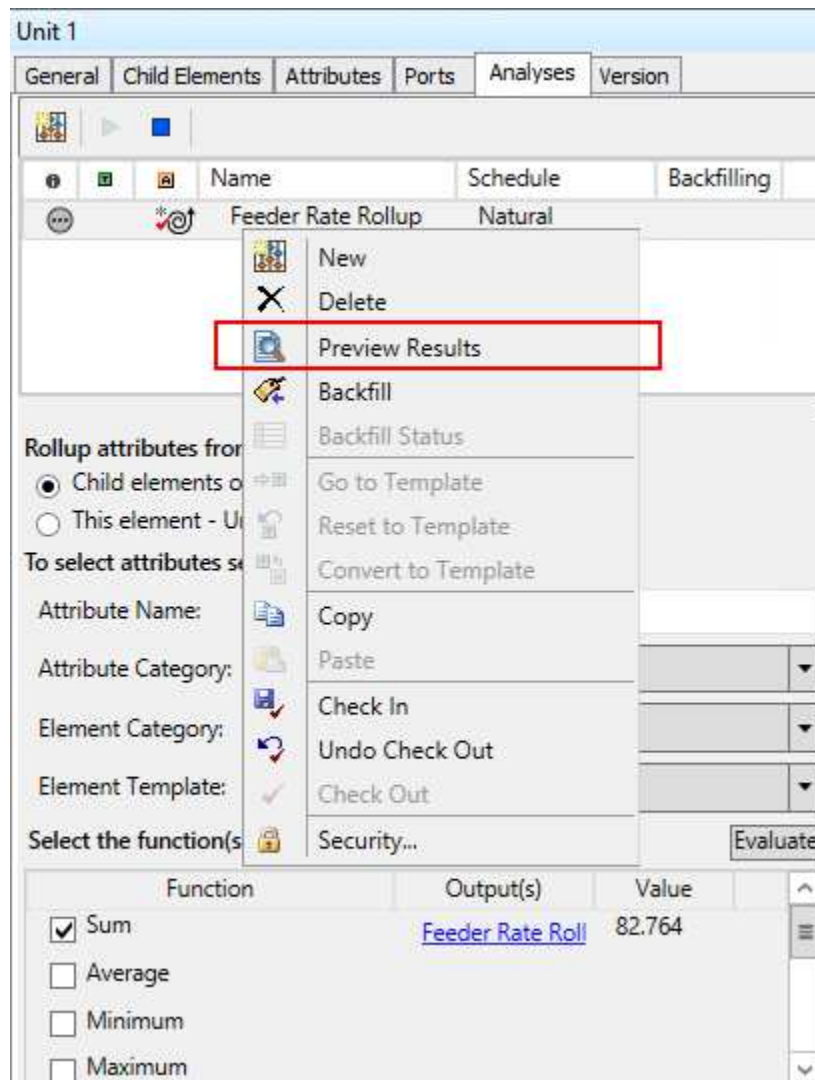
Data Server: PISRV1

Value Type: Double

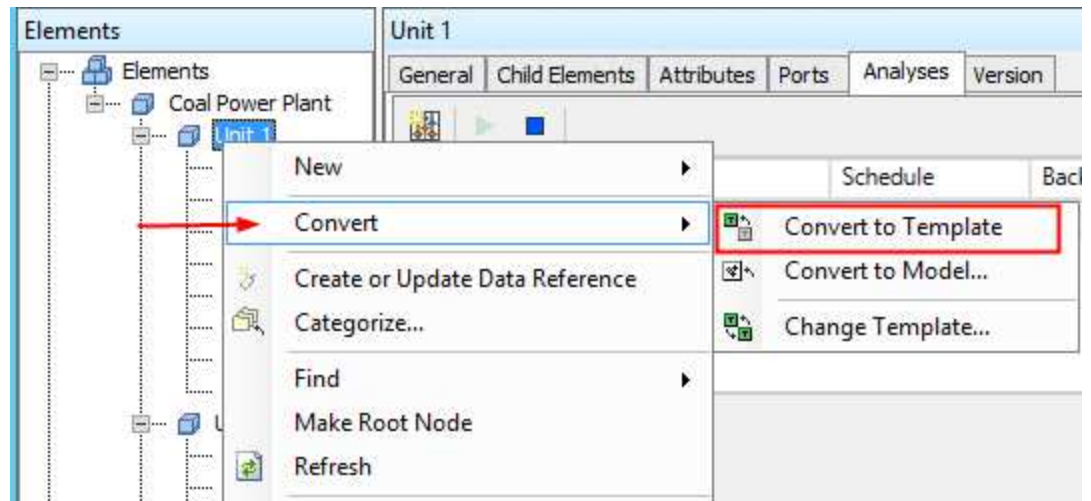
PI Point will be created.

OK Cancel

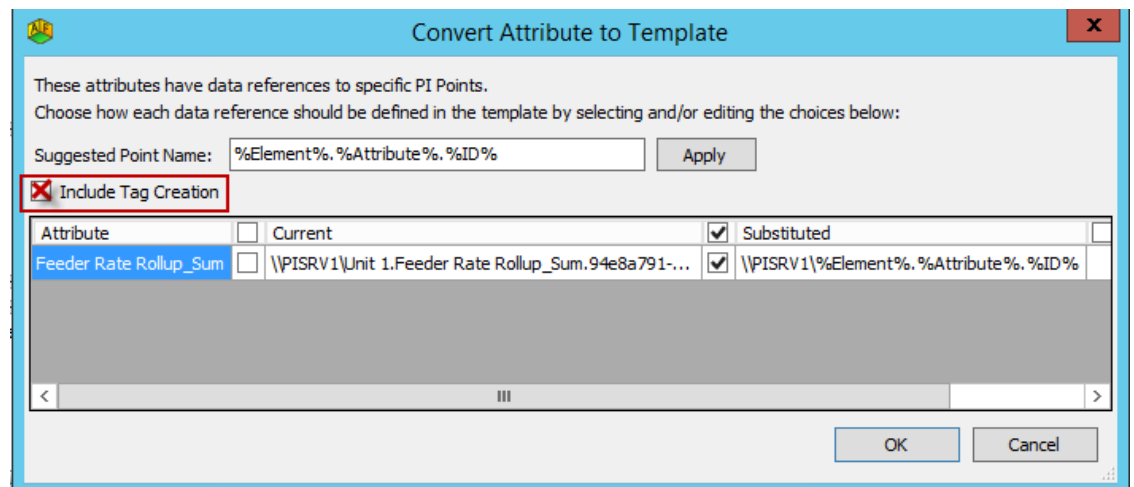
- g. Select "Evaluate" to ensure you have sensible results
- h. Right-click on the Analysis and select Preview Results to examine what the output would be using historical data.
- i. Experiment by using different Start and End Times



- i. Check in your changes
- j. Right-click on the Analysis and select Backfill to backfill the output over some historical time range.
  - i. Choose \*-30d to \* to backfill over the last 30 days
  - ii. Once backfill is done, examine the results by right-clicking on the Feeder Rate Rollup attribute and selecting Time Series Data
- k. You want to deploy this same Rollup analysis to the other 3 units in a template fashion.
  - i. Right click on Unit 1 in the hierarchy and select Convert to Template



- ii. Select "Include Tag Creation" and select "OK" in the Convert Attribute to Template dialog box. By using substitution parameter, this ensures multiple instances of the Rollup analysis do not write their respective output to the same PI Point.



- iii. Go to the Library and examine the "Unit Template" under Element Templates
- iv. Right-click on Unit 2, Unit 3 and Unit 4 in the element hierarchy, select "Change Template" and select "Unit Template".
- v. Check in your changes
- vi. Examine the asset hierarchy:
  1. Mills and Units are now from templates
  2. Each Unit has a Rollup Analysis associated with it
  3. All Rollup outputs are written to PI Points and are therefore available in client tools

## Directed Activity 3 – Marking Important Events for your Coal Mills

In this exercise, we will take advantage of Asset Analytics built into PI AF to create event frames to mark important events such as periods of high current usage for your mills.

1. Go to the Library and select Event Frame Templates
2. Create a new event frame template
  - a. Name the new event frame template
  - b. Provide an optional Description
  - c. Choose the “Coal Handling Equipment” and “Mill” categories

The screenshot shows the 'Mill Over Current Event' configuration window with the 'General' tab selected. The fields are as follows:

Field	Value
Name:	Mill Over Current Event
Description:	To Capture Mill Over Current
Base Template:	<None>
Categories:	Coal Handling Equipment;Mill
Default Attribute:	<None>
Naming Pattern:	
Find:	<a href="#">Derived Templates</a> <a href="#">Event Frames</a> <a href="#">Referenced Parent Templates</a> <a href="#">Derived Event Frames</a> <a href="#">Referenced Child Templates</a>

Additional options: ☐ Allow Extensions, [Extended Properties](#), [Security](#)

- d. Select the “Attribute Templates” tab
- e. Create attributes that you want to have in every event frame. These attributes will refer back to attributes of the referenced element. Ensure you configure the UOM properly for these attributes.

The screenshot shows the 'Mill Over Current Event' configuration window with the 'Attribute Templates' tab selected. It displays a table of attributes with a filter bar at the top.

Filter		
Name	Description	Default Value
Average Feeder Rate		0 klb/hr
Average Mill Total Primary Air Flow		0 klb/hr
Maximum Feeder Current Draw		0 A
Maximum Mill Hot Primary Air Temperature		0 °F

- i. Average Feeder Rate

1. Configure this attribute to be a PI Point Data Reference with the following settings:

The screenshot shows the 'PI Point Data Reference' dialog box. It has a title bar with a close button (X). The dialog is divided into several sections:

- Data server:** A dropdown menu showing '%Server%'.
- Tag name:** A text input field with a search icon (magnifying glass) to its right.
- Tag Creation:** A checkbox that is currently unchecked, followed by a text input field and a three-dot menu icon.
- Attribute:** A radio button is selected, followed by a dropdown menu showing '.\Elements[.]Feeder Rate'.
- Unit of Measure:** A section containing a 'Source Units' text input field.
- Value retrieval methods:** A section containing several settings:
  - By Time:** A dropdown menu showing 'Automatic'.
  - Relative time:** A text input field.
  - By Time Range:** A dropdown menu showing 'Average'.
  - Calculation basis:** A dropdown menu showing 'Time Weighted'.
  - Min percent good:** A text input field showing '80'.
- Read only:** A checkbox that is checked.
- Buttons:** 'OK' and 'Cancel' buttons at the bottom right.

2. When the event frame is created, this attribute will hold the average of the Feeder Rate for the duration of the event frame
- ii. Average Mill Total Primary Air Flow
    1. Configure this attribute to be a PI Point Data Reference with the following settings:

**PI Point Data Reference**

Data server: %Server%

Tag name:

☐ Tag Creation

☒ Attribute: .\Elements[.]Mill Total Primary Air Flow

Unit of Measure

Source Units:

Value retrieval methods

By Time: Automatic

Relative time:

By Time Range: Average

Calculation basis: Time Weighted

Min percent good: 80

☒ Read only

OK Cancel

2. When the event frame is created, this attribute will hold the average of the Mill Total Primary Air Flow for the duration of the event frame
- iii. Maximum Feeder Current Draw
  1. Configure this attribute to be a PI Point Data Reference with the following settings:

PI Point Data Reference

Data server: %Server%

☐ Tag name:

☐ Tag Creation

☒ Attribute: .\Elements[.]Feeder Current Draw

Unit of Measure

Source Units:

Value retrieval methods

By Time: Automatic

Relative time:

By Time Range: Maximum

Calculation basis: Time Weighted

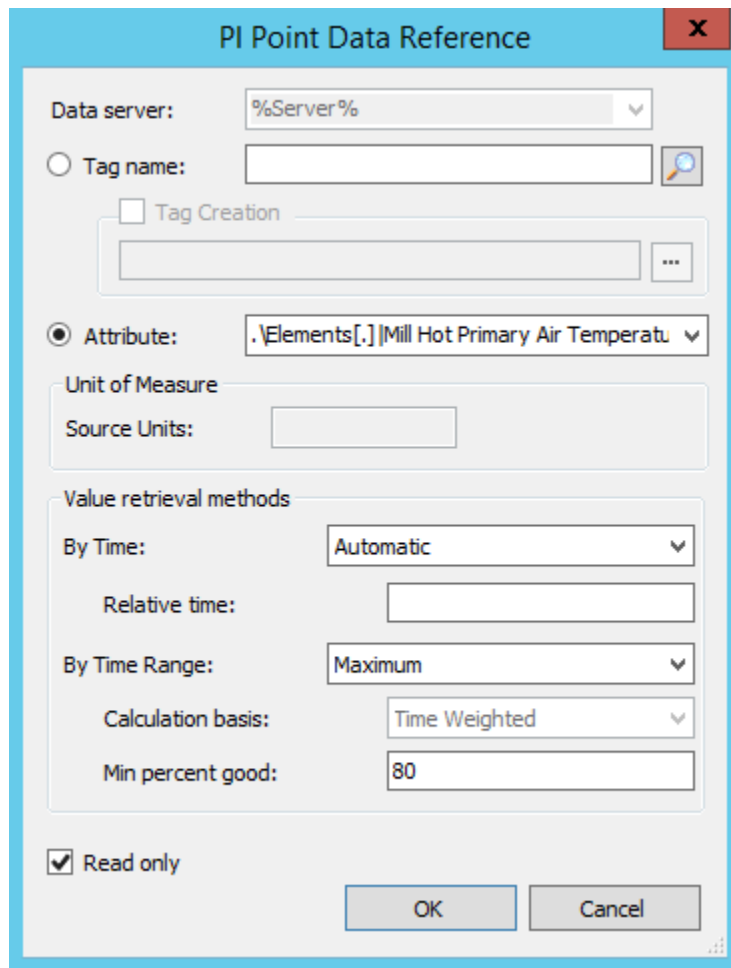
Min percent good: 80

☒ Read only

OK Cancel

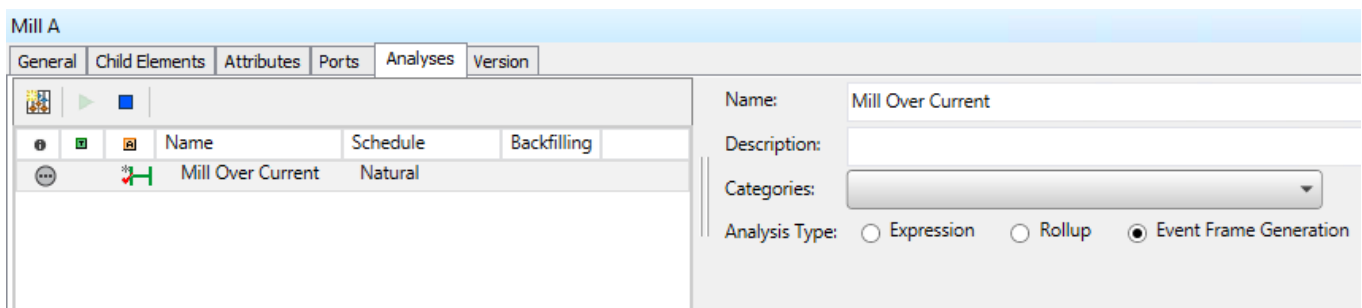
2. When the event frame is created, this attribute will hold the maximum value of the Feeder Current Draw for the duration of the event frame
- iv. Maximum Mill Hot Primary Air Temperature
  1. Configure this attribute to be a PI Point Data Reference with the following settings:





The image shows a 'PI Point Data Reference' dialog box. It has a title bar with a close button. The main area contains several sections: 'Data server' with a dropdown set to '%Server%'; 'Tag name' with an empty text box and a search icon; 'Tag Creation' with a checkbox and an empty text box; 'Attribute' with a radio button selected and a dropdown set to '.\Elements[.]Mill Hot Primary Air Temperatu'; 'Unit of Measure' with a 'Source Units' text box; 'Value retrieval methods' with 'By Time' set to 'Automatic', 'Relative time' as an empty text box, 'By Time Range' set to 'Maximum', 'Calculation basis' set to 'Time Weighted', and 'Min percent good' set to '80'; and a 'Read only' checkbox which is checked. At the bottom are 'OK' and 'Cancel' buttons.

2. When the event frame is created, this attribute will hold the maximum value of the Mill Hot Primary Air Temperature for the duration of the event frame
  - v. Check in your changes
3. Select Unit 1 -> Mill A in the element hierarchy and go to the Analyses tab
4. Create a new analysis
  - a. Select Event Frame Generation Analysis type
  - b. Name the Analysis "Mill Over Current"



The image shows a screenshot of the 'Mill A' window with the 'Analyses' tab selected. On the left is a table with columns 'Name', 'Schedule', and 'Backfilling'. It contains one entry: 'Mill Over Current' with a 'Natural' schedule. On the right are configuration fields: 'Name' set to 'Mill Over Current', an empty 'Description' field, an empty 'Categories' dropdown, and 'Analysis Type' with radio buttons for 'Expression', 'Rollup', and 'Event Frame Generation' (which is selected).

5. Select the event frame template you just built from the drop down
6. Configure the Start Trigger
  - a. 'Feeder Current Draw' > 80. This is the threshold whereby an event frame will be created. When the current draw drops back below 80, the event frame will close.
7. Select Event-Triggered Scheduling

Event Frame Template: Mill Over Current Event

↑ ↓ Evaluate

Name	Expression	Value
StartTrigger	'Feeder Current Draw' > 80	
EndTrigger	Type an expression (optional)	

[Add a new expression](#)

StartTrigger true for:  Minutes

☐ Generate child root cause event frame before parent event frame starts

Duration:  Minutes

Name:

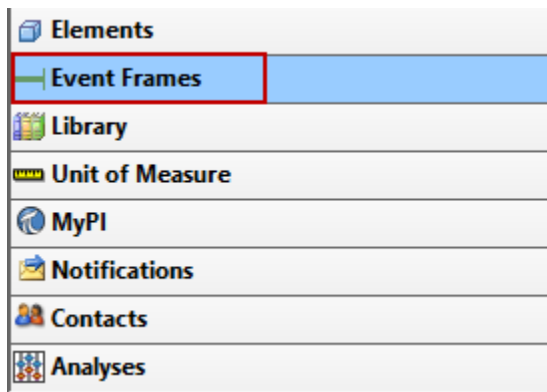
Category:

Scheduling: ☒ Event-Triggered ☐ Periodic ☐ Run on demand

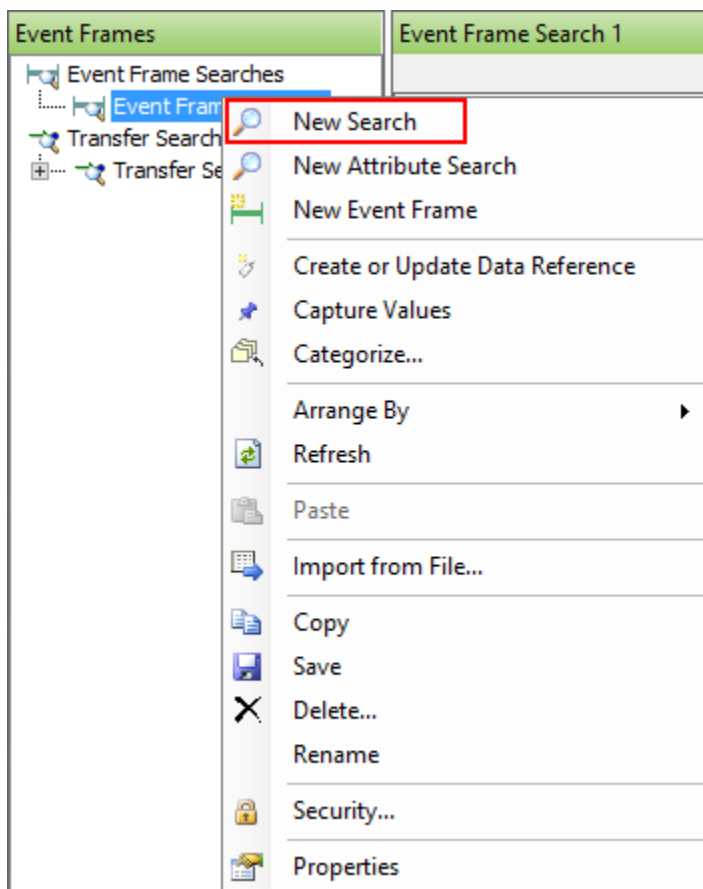
Trigger on: Any Input

Advanced...

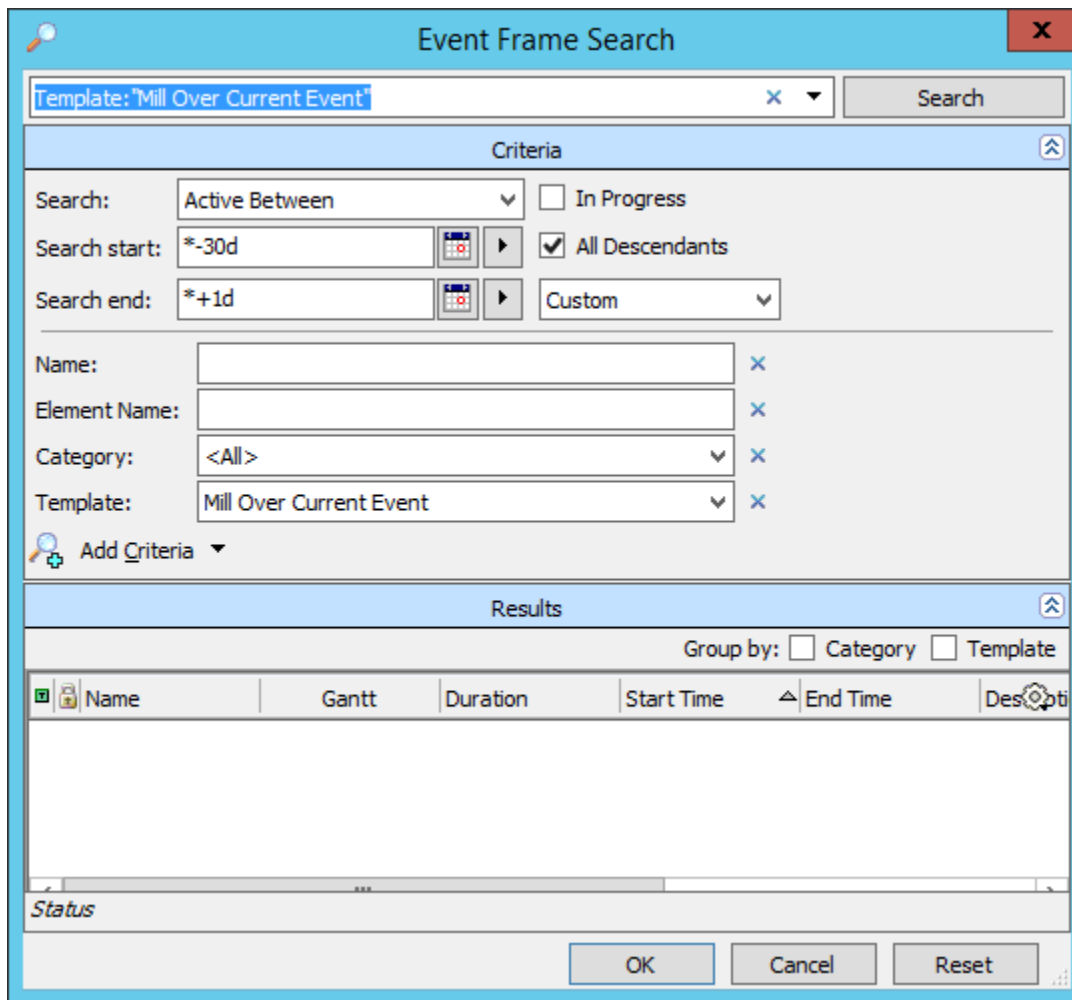
8. Select the Evaluate button to check whether the Start Trigger is currently true or false
9. Check in your changes
10. Right-click on the analysis and Preview over the last 30 days
11. Right-click on the analysis and Backfill over the last 30 days
12. Go to the Event Frames plug-in in PI System Explorer



13. Right-click under Event Frame Searches and choose New Search



- a. Search for event frames over the last 30d
- b. Select the event frames template you just created



The image shows a software dialog box titled "Event Frame Search". At the top, there is a search bar containing the text "Template: Mill Over Current Event" and a "Search" button. Below this is a section labeled "Criteria" which contains several input fields and checkboxes. The "Search:" dropdown is set to "Active Between". "Search start:" is set to "\*-30d" and "Search end:" is set to "\*+1d". There are checkboxes for "In Progress" (unchecked) and "All Descendants" (checked). Below these are fields for "Name:", "Element Name:", "Category:" (set to "<All>"), and "Template:" (set to "Mill Over Current Event"). Each of these four fields has a small "x" icon to its right. At the bottom of the "Criteria" section is an "Add Criteria" button. Below the "Criteria" section is a "Results" section. It has a "Group by:" label with checkboxes for "Category" and "Template". Below this is a table with columns: "Name", "Gantt", "Duration", "Start Time", "End Time", and "Description". The table is currently empty. At the bottom of the dialog are "OK", "Cancel", and "Reset" buttons.

Event Frame Search

Template: Mill Over Current Event

Search

Criteria

Search: Active Between ☐ In Progress

Search start: \*-30d ☒ All Descendants

Search end: \*+1d Custom

Name:

Element Name:

Category: <All>

Template: Mill Over Current Event

Add Criteria

Results

Group by: ☐ Category ☐ Template

Name	Gantt	Duration	Start Time	End Time	Description
------	-------	----------	------------	----------	-------------

Status

OK Cancel Reset

- c. Select OK and examine some of the event frames search results

## Directed Activity 4 – Building a Template and PI AF Hierarchy for your HP Turbines and IP Turbines for Efficiency Monitoring

Now that you’ve done such a great job in modeling the mills, the steam turbine is approaching an overhaul next year and you would like to determine the efficiency and track it on line. You can then use this data along with the inlet and outlet temperatures and pressures to perform any necessary in depth root cause analysis. Note that this exercise will only focus on the data required to calculate the efficiency but other data such as vibration and bearing temperatures can also be added to the model in the future.

In this exercise, we will build a PI AF element template for the HP turbines and IP turbines for your plant using PI System Explorer. Once that is done, we could use that template as a basis to build the PI AF structure to represent the turbines for all four units in your plant.

You will start with the HP turbine and follow by the IP turbine. When you configure the analyses to calculate the various properties, take the opportunity to examine the Steam Functions that are available in the functions list.

1. Start with the initial hierarchy constructed for the coal mills created in Exercise 1.
2. Go to your Library -> Element Templates section.
3. Create a new element template by right-clicking on the Element Templates pane on the right.
4. Name it “HP Turbine”, with a description of “High Pressure Steam Turbine” and a category of “HP turbine”.

The screenshot shows the 'HP Turbine' element template configuration window. The 'General' tab is selected, showing fields for Name, Description, Base Template, Categories, Default Attribute, and Naming Pattern. The 'Name' field is 'HP Turbine', 'Description' is 'High Pressure Steam Turbine', 'Base Template' is '<None>', 'Categories' is 'HP Turbine', 'Default Attribute' is '<None>', and 'Naming Pattern' is empty. There is an 'Allow Extensions' checkbox and links for 'Extended Properties' and 'Security'. At the bottom, there are links for 'Find: Derived Templates', 'Elements', 'Referenced Parent Templates', 'Derived Elements', and 'Referenced Child Templates'.

5. Select “OK” and answer “Yes” to create the new Category.
6. Go to the Attribute Templates tab.
7. Right-click in the right pane and create the following attributes for your template. For all the attributes listed below, configure them as PI Point Data Reference, with a Setting of:




























**\\%Server%\%Element%.%Attribute%**

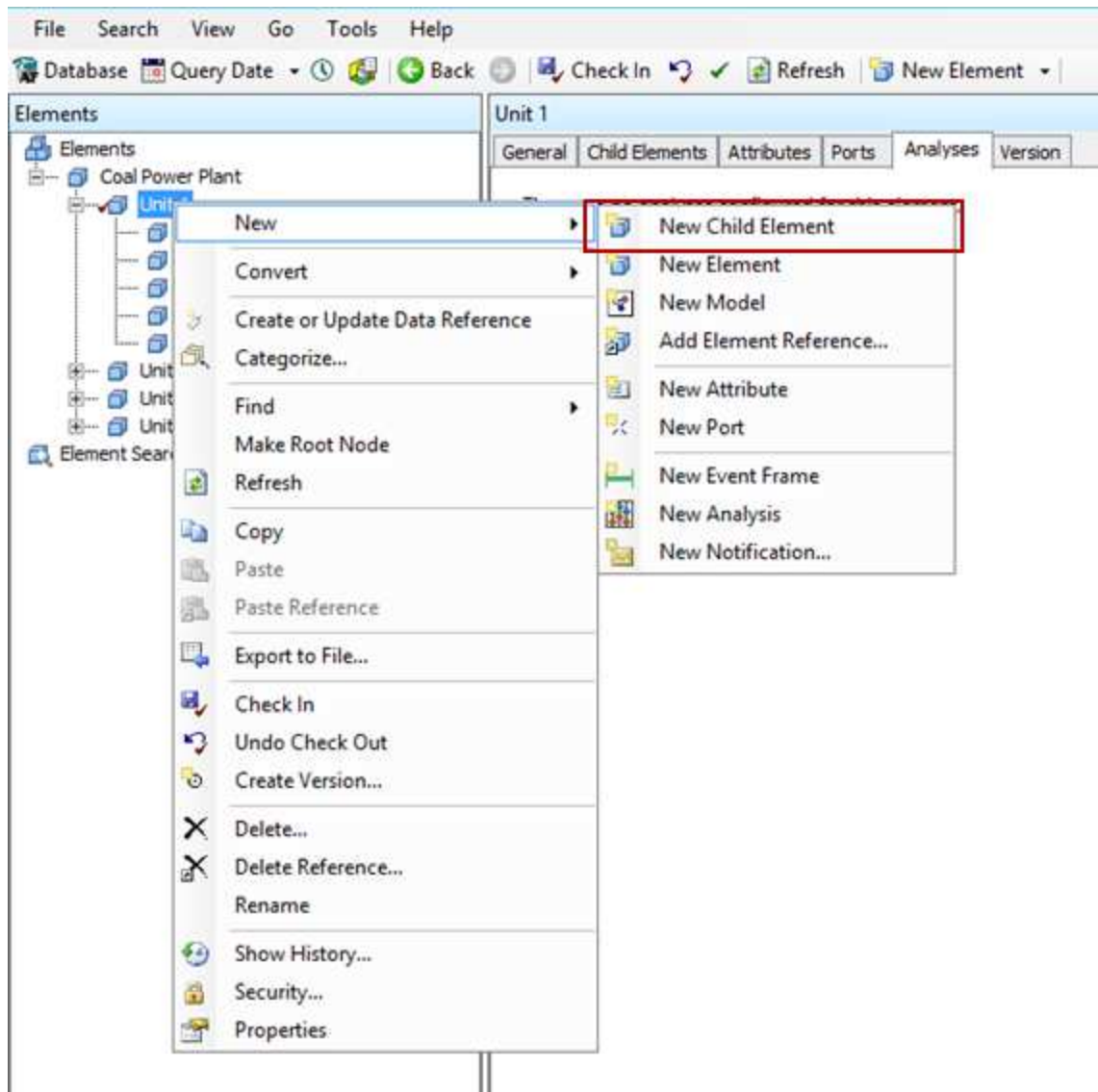
- a. AtmosphericPressure, UOM = pound-force per square inch (customary), default value = 14.7. Note that since the atmospheric pressure is measured at one place in the station, there are no individual unit pressure transmitters. Therefore the PI point data reference does not include the unit designation. The PI point data reference for this attribute only is:

\\%Server%\%Attribute%. The rest of the attributes are unit based and utilize the convention above.

- b. ColdRHEnthalpy, UOM = Btu/lb, default value = 1300
- c. ColdRHPressureAvg, UOM = pound-force per square inch (customary), default value = 500
- d. ColdRHPressureN, UOM = pound-force per square inch, default value = 500
- e. ColdRHPressureS, UOM = pound-force per square inch, default value = 500
- f. ColdRHTemperatureAvg, UOM = deg F, default value = 600
- g. ColdRHTemperatureN, UOM = deg F, default value = 600
- h. ColdRHTemperatureS, UOM = deg F, default value = 600
- i. HPTurbineEff, UOM = %, default value = 85
- j. ThrottleEnthalpy, UOM = Btu/lb, default value = 1460
- k. ThrottlePressureAvg, UOM = pound-force per square inch (customary), default value = 2000
- l. ThrottlePressureN, UOM = pound-force per square inch, default value = 2000
- m. ThrottlePressureS, UOM = pound-force per square inch, default value = 2000
- n. ThrottleTemperatureAvg, UOM = deg F, default value = 1000
- o. ThrottleTemperatureN, UOM = deg F, default value = 1000
- p. ThrottleTemperatureS, UOM = deg F, default value = 1000
- q. Create a child element under Unit 1 in the element hierarchy based on this template you just built. Name the child element "HP Turbine".
- r. Check in your changes.

NOTE: In order to save time, the HP turbine template can be imported. See step #9 below. If importing the HP turbine template, ensure a child element is created based on the HP turbine template as described in step 7q above.

HP Turbine				
General		Attribute Templates	Ports	Analysis Templates
Filter 				
			Name	Description
Template: HP Turbine				
			AtmosphericPressure	Atmospheric Pressure
			ColdRHEnthalpy	Cold RH Steam Enthalpy
			ColdRHPressureAvg	Cold RH pressure average
			ColdRHPressureN	Cold RH pressure North
			ColdRHPressureS	Cold RH pressure South
			ColdRHTemperatureAvg	Cold RH temperature average
			ColdRHTemperatureN	Cold RH temperature North
			ColdRHTemperatureS	Cold RH temperature South
			HPTurbineEff	HP turbine efficiency
			ThrottleEnthalpy	Throttle steam enthalpy
			ThrottlePressureAvg	Throttle pressure average
			ThrottlePressureN	Throttle pressure North
			ThrottlePressureS	Throttle Pressure South
			ThrottleTemperatureAvg	Throttle temperature average
			ThrottleTemperatureN	Throttle temperature North
			ThrottleTemperatureS	Throttle temperature South



8. Go back to the Library and the HP Turbine element template. Click on the Analysis Template tab near the top of the screen and create a new analysis template. Assemble the analytic calculations. These calculations use functions such as average(Avg), unit conversions(Convert) and others which may be selected from the Function choices on the right or the user may start typing the function and the automatic tool tips (Intellisense-like) will assist with the correct equation and function syntax.


NOTE: if you have imported the HP Turbine, the analyses have already been built for you. Go to the Analysis Template tab and examine the expressions.




- a. Select Expressions analysis type. Provide a name and description for your analysis.
- b. Select the Example Element to be the new HP Turbine element you just created in the previous step (step 8).
- c. Calculate variable ThrtPresAvg - the average of the north and south throttle pressures using the Avg function and then adjust for atmospheric pressure to obtain psia. The calculation is written to the output attribute ThrottlePressureAvg. The next few steps describe the other calculations in the module.
- d. Variable ThrtPresAvgkPa - Convert the throttle pressure from psia to kPa using the Convert function. We do not need to store this output so we are not writing it to an output attribute.
- e. Calculate Variable ThrottleTempAvg - the average throttle temperature and write the result to output attribute ThrottleTemperatureAvg
- f. Variable ThrtTempdegC - Convert the average throttle temperature to deg C
- g. Variable ThrtEnthalpy - Now that the throttle pressure and temperature parameters have been determined in the proper form, we can determine the throttle steam enthalpy using the Steam\_HPT function. The steam table functions currently use only SI units. Write this value to output attribute ThrottleEnthalpy.
- h. Calculate variable ColdRHTempavg - the average cold RH temperature and write it to output attribute ColdRHTemperatureAvg.
- i. Variable ColdRHTempdegC - Convert the average cold RH temperature to deg C. This does not need to be written to an output attribute.
- j. Calculate variable ColdRHPresAvg - the average cold RH pressure and adjust for atmospheric pressure. Write this value to the output attribute ColdRHPressureAvg
- k. Variable ColdRHEnthalpy - Determine the cold RH enthalpy using the average temperature and pressure in SI units and write it to output attribute ColdRHEnthalpy.
- l. Variable ThrottleEntropy - Determine the Throttle steam entropy using the average throttle pressure and temperature in SI units. This does not need to be written to an output attribute.
- m. Variable ColdRHIsentEnthalpy - Determine the cold RH isentropic enthalpy using the function Steam\_HPS and the cold RH pressure and the throttle entropy. This is the value of the lowest achievable enthalpy exiting the HP turbine as it is determined assuming no entropy increase.
- n. Calculate variable HPTEff - Using the calculated throttle enthalpy, Cold RH enthalpy and Cold RH isentropic enthalpy variables previous calculated in steps g, k, and m to calculate the HP turbine efficiency. Note that this is a ratio of the actual steam energy reduction to the maximum energy reduction across the machine multiplied by 100 to express as a percentage. Write this value to output attribute HPTurbineEff.
- o. The screen should look like the below.



HP Turbine

General | Attribute Templates | Ports | Analysis Templates

 Name Schedule

 HP Turbine Frequency=60

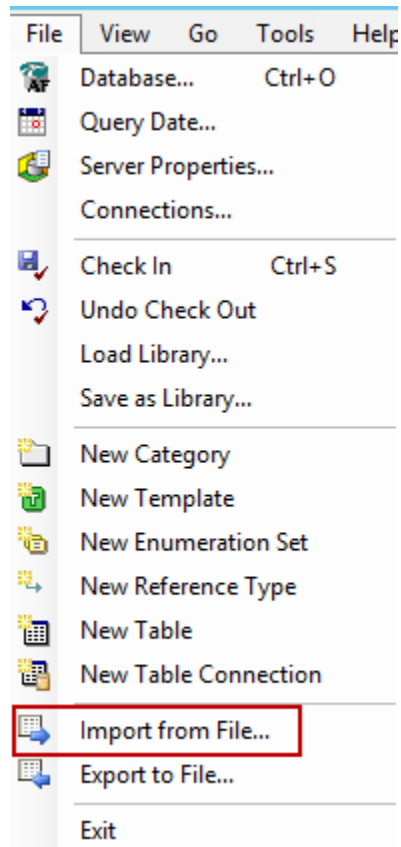
Example Element: [Coal Power Plant\Unit 1\HP Turbine](#)

  Evaluate

Name	Expression	Value	Output Attribute	
thrtpresavg	<code>Avg('ThrottlePressureS','ThrottlePressureN')+'AtmosphericPressure'</code>		<a href="#">ThrottlePressureAvg</a>	⊗
thrtpresavgkPa	<code>Convert('ThrottlePressureAvg','kPa')</code>		<a href="#">Map</a>	⊗
ThrtttmpdegC	<code>Avg('ThrottleTemperatureN','ThrottleTemperatureS')</code>		<a href="#">ThrottleTemperatureAvg</a>	⊗
ThrttempdegC	<code>Convert('ThrottleTemperatureAvg','°C')</code>		<a href="#">Map</a>	⊗
ThrtEnth	<code>Steam_HPT(thrtpresavgkPa,ThrttempdegC)</code>		<a href="#">ThrottleEnthalpy</a>	⊗
ColdRHTempAvg	<code>Avg('ColdRHTemperatureS','ColdRHTemperatureN')</code>		<a href="#">ColdRHTemperatureAvg</a>	⊗
ColdRHTmpdegC	<code>Convert('ColdRHTemperatureAvg','°C')</code>		<a href="#">Map</a>	⊗
ColdRHPresAvg	<code>Avg('ColdRHPressureN','ColdRHPressureS')+'AtmosphericPressure'</code>		<a href="#">ColdRHPressureAvg</a>	⊗
ColdRHPresKPa	<code>Convert('ColdRHPressureAvg','kPa')</code>		<a href="#">Map</a>	⊗
ColdRHEntalpy	<code>Steam_HPT(ColdRHPresKPa,ColdRHTmpdegC)</code>		<a href="#">ColdRHEntalpy</a>	⊗
ThrottleEntropy	<code>Steam_SPH(thrtpresavgkPa,ThrtEnth)</code>		<a href="#">Map</a>	⊗
ColdRHIsentH	<code>Steam_HPS(ColdRHPresKPa,ThrottleEntropy)</code>		<a href="#">Map</a>	⊗
HPTeff	<code>((ThrtEnth-ColdRHEntalpy)*100)/(ThrtEnth-ColdRHIsentH)</code>		<a href="#">HPTurbineEff</a>	⊗

[Add a new expression](#)

- p. Click on the Evaluate button to ensure the calculations work properly.
  - q. Configure your analysis to run every minute.
  - r. Check in your changes
9. As a convenience for you, the IP Turbine template has been built for you. In addition, HP Turbine and IP Turbine templates using SI units have also been built for you. You can import them from the UC2015 folder on your desktop.
  - a. In PI System Explorer, select File -> Import from File



- b. Navigate to the UC2015 folder on your desktop and import the IP Turbine, HP Turbine (SI) and IP Turbine (SI) templates.
- c. In the element hierarchy, right-click Unit 1 and create new child elements based on the IP Turbine template.
- d. Optionally you can create child elements for HP Turbine (SI) and IP Turbine (SI).

## Directed Activity 5 – Building a Template and PI AF Hierarchy for the calculation of the Net Unit Heat Rate

In this exercise, we will build a PI AF element template to calculate the Turbine Cycle Heat Rate, the Gross Unit heat Rate and the Net Unit heat Rate for the units in your plant. Heat Rate is a direct representation of the efficiency of your assets and process so it's critical to track any changes over time. The calculation uses PI tags for throttle and cold RH enthalpy created in the calculation of the HP and IP turbine efficiency calculations so they will not need to be repeated.

Note that the heat rate calculated in this module is an approximation where parameters utilized that normally would be needed to be outputs of an energy balance computer program such as Cold RH flow, are approximated. However, if these values are not available from such a program, they can be approximated and the calculations will still have value because the monitoring and trending can be performed and changes from the norm at a stable generation level near full load can be investigated. Once we calculate the various heat rates mentioned above into a template, we can use it as a basis to build the PI AF structure to calculate the parameters for all four units in your plant.

1. Go to your Library -> Element Templates section.
2. Create a new element template by right-clicking on the Element Templates pane on the right.
3. Name it "Heat Rate", with a description of "Heat Rate Calculations" and a category of "Heat Rate".

The screenshot shows the 'Heat Rate' element template configuration window. The 'General' tab is active, displaying the following fields:

- Name:** Heat Rate
- Description:** Heat rate calculations
- Base Template:** <None>
- Categories:** Heat Rate
- Default Attribute:** <None>
- Naming Pattern:** (empty field)












Below the fields, there is a checkbox for 'Allow Extensions' which is unchecked. To the right of this checkbox are three links: 'Extended Properties', 'Security', and 'Find:'. The 'Find:' section contains four links: 'Derived Templates', 'Elements', 'Referenced Parent Templates', and 'Derived Elements'. At the bottom right, there is a link for 'Referenced Child Templates'.

4. Select "OK" and answer "Yes" to create the new Category.
5. Go to the Attribute Templates tab.
6. Right-click in the right pane and create the following attributes for your template. For all the attributes listed below, configure them as PI Point Data Reference, with a Setting of:

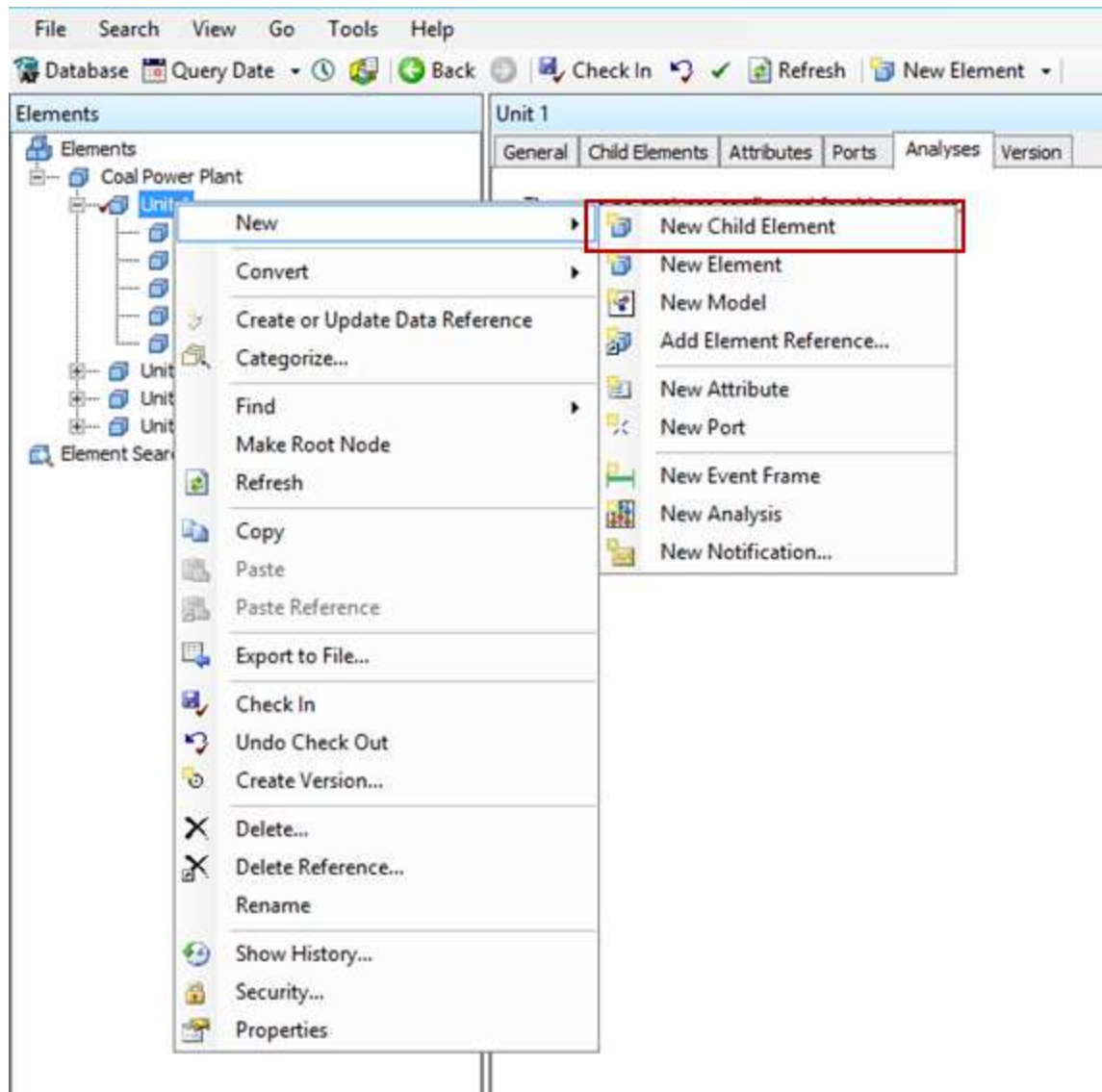
\\%Server%\%..\Element%.%Attribute%

- a. BoilerEff, UOM = %, default value = 88
- b. ColdRHEnthalpy, UOM = Btu/lb, default value = 1300

- c. FeedwtrFlow, UOM = lb/hr, default value = 2000000
- d. FeedwtrOutletEnthalpy, UOM = Btu/lb, default value = 460
- e. GrossGeneration, UOM = MW, default value = 200
- f. GrossTurbineCycleHeatRate, UOM = Btu/kWh, default value = 8500
- g. GrossUnitHeatRate, UOM = Btu/kWh, default value = 9000
- h. HotRHEnthalpy, UOM = Btu/lb, default value = 1500
- i. NetGeneration, UOM = MW, default value = 190
- j. NetUnitHeatRate, UOM = Btu/kWh, default value = 10000
- k. ThrottleEnthalpy, UOM = Btu/lb, default value = 1460
- l. Check in your changes.

Heat Rate				
<div>General</div> <div>Attribute Templates</div> <div>Ports</div> <div>Analysis Templates</div>				
Filter				
<div> <div> <div></div> <div></div> <div></div> <div></div> </div> <div>Name</div> <div>Description</div> <div>Default Value</div> </div>				
<div> <div> <div></div> <div></div> <div></div> </div> <div>Template: Heat Rate</div> </div>				
		BoilerEff	Boiler efficiency	88 %
		ColdRHEnthalpy	Cold RH enthalpy in Btu/lb	1300 Btu/lb
		FeedwtrFlow	Feedwater flow	2000000 lb/hr
		FeedwtrOutletEnthalpy	Feedwater outlet enthalpy in Btu/lb	460 Btu/lb
		GrossGeneration	Gross load	200 MW
		GrossTurbineCycleHeatRate	turbine cycle heat rate	8500 Btu/kWh
		GrossUnitHeatRate	Gross unit heat rate	9000 Btu/kWh
		HotRHEnthalpy	Hot RH enthalpy in Btu/lb	1500 Btu/lb
		NetGeneration	Net load	190 MW
		NetUnitHeatRate	Net heat rate	10000 Btu/kWh
		ThrottleEnthalpy	Throttle steam enthalpy	1460 Btu/lb

- m. Create a child element under Unit 1 in the element hierarchy based on this template you just built.



- n. Name your new child element "Heat Rate"
- o. Check in your changes
- 7. Go back to the Library and the Heat Rate element template. Click on the Analysis Template Tab and create a new analysis template.
  - a. Select Expressions analysis type. Provide a name and description for your analysis.
  - b. Select the Example Element to be the new Heat Rate element you just created in the previous step.
  - c. Calculate variable CRHFlow – This calculation is an approximation of the cold RH steam flow as 90% of the feedwater flow. This flow is not commonly measured. A more exact calculation can be performed by subtracting all the steam leak-offs for the HP Turbine control valves and any extractions to the high pressure feedwater heaters, then adding any RH attemperation flow (if applicable). The calculation depends on the specific unit configuration and design, therefore for the purposes of this exercise, it is approximated.

- d. Variable TurbineCycleHR – Determine the heat added to the boiler feedwater by multiplying the feedwater flow by the difference of the throttle steam and feedwater outlet enthalpy. Then determine the heat added in the reheater by multiplying the Cold RH flow by the difference between the Hot RH and Cold RH enthalpy. Divide the sum of the heat added to the steam in the boiler by the gross generation. Since gross generation is in MW, it must be converted to KW by multiplying it by 1000. Note that the steam enthalpies were calculated previously in the turbine efficiency calculations. The feedwater enthalpy is an approximation in this exercise.
- e. Calculate Variable GrossHeatRate - the gross heat rate is obtained by adjusting the turbine cycle heat rate for the boiler efficiency. Note that the boiler efficiency is approximated.
- f. Variable NetHeatRate – Adjust the gross heat rate for the auxiliary power consumed by the unit to obtain net heat rate. This can be easily done by multiplying the gross heat rate by the ratio of the gross to net generation.
- g. Check in your changes. The screen should look like the below.

**Heat Rate**

General | Attribute Templates | Ports | Analysis Templates

Name: Heat Rate

Description:

Categories:

Analysis Type: ☒ Expression ☐ Rollup

Example Element: [Select an example element](#)

Evaluate

Name	Expression	Value	Output Attribute
CRHFlow	'FeedwtrFlow'*0.9		<a href="#">Map</a>
TurbineCycleHR	(( 'FeedwtrFlow'*( 'ThrottleEnthalpy' - 'FeedwtrOutletEnthalpy' ))+(CRHFlow*( 'HotRHEntalpy' - 'ColdRHEntalpy' )))/('GrossGeneration'*1000)		<a href="#">GrossTurbineCycleHeatRate</a>
GrossHeatRate	TurbineCycleHR/('BoilerEff'/100)		<a href="#">GrossUnitHeatRate</a>
NetHeatRate	GrossHeatRate*'GrossGeneration'/'NetGeneration'		<a href="#">NetUnitHeatRate</a>

[Add a new expression](#)

- h. Click on the Evaluate button to ensure the calculations work properly.
  - i. Configure your analysis to run as Event-Triggered.
  - j. Check in your changes
8. As a convenience for you, the Heat Rate template in SI units has been built for you. You can import them from the UC2015 folder on your desktop.
- a. In PI System Explorer, select File -> Import from File

- b. Select the Heat Rate-SI file



## Directed Activity 6 – Project Coal Usage Based on Generation Forecasts

In this exercise, you will use the results from the calculations you have developed so far to project how much coal you will need on an hour by hour basis based on power generation forecasts. A PI Point has been pre-created which contains power generation forecasts through end of June 2015. You will create an analysis to take the highest heat rate, corresponding to lowest efficiency, over the last 1 day and project how much coal you will need at the same time 7 days into the future based on the power generation forecasts. You will do this periodically every hour.

1. Go to the element hierarchy and select the Unit template.
  - a. Go to the Attribute Templates tab and create an attribute.
  - b. Name the attribute – “Target MW Generation in 7 Days”
    - i. Configure it as a PI Point Data Reference with the following settings:

Group by: ☐ Category ☐ Template

Name: Target MW Generation in 7 Da

Description:

Properties: <None>

Categories:

Default UOM: megawatt

Value Type: Double

Default Value: 290 MW

Data Reference: PI Point

Settings...

\\%Server%\TotalMWForecast;RelativeTime=+7d

Data server: %Server%

Tag name: TotalMWForecast

Tag Creation

Attribute:

Unit of Measure

Source Units: <Default> (MW)

Value retrieval methods

By Time: Automatic

Relative time: +7d

By Time Range: End Time

Calculation basis: Time Weighted

Min percent good: 80



☒ Read only



OK Cancel

- ii. The Relative Time offset in the PI Point DR configuration will retrieve data from 7 days into the future. For the purpose of this exercise, the PI Point “TotalMWForecast” has been prepopulated with hourly MW forecast for ~3 Months into the future.
- iii. Go to the Analysis Template tab and create a new analysis

- iv. Provide a name for the new analysis
- v. Select Expression analysis type
- vi. Select an Example element and choose Unit 1
- vii. Create an analysis that would use the highest gross heat rate from Unit 1 in the last day to calculate the estimated required tonnage of Coal to support the MW forecast 7 days into the future. The type of coal that you're using has a heating value (HHV) of 8700 Btu/lb.
  1. Configure a variable to hold the HHV of the coal
  2. Configure an expression to multiply the highest gross heat rate from Unit 1 over the last day \* the 7 day MW forecast / Coal HHV / 2000. A conversion must be made for the 7 day MW forecast to KW and an overall conversion is needed to convert lb/hr to ton/hr.

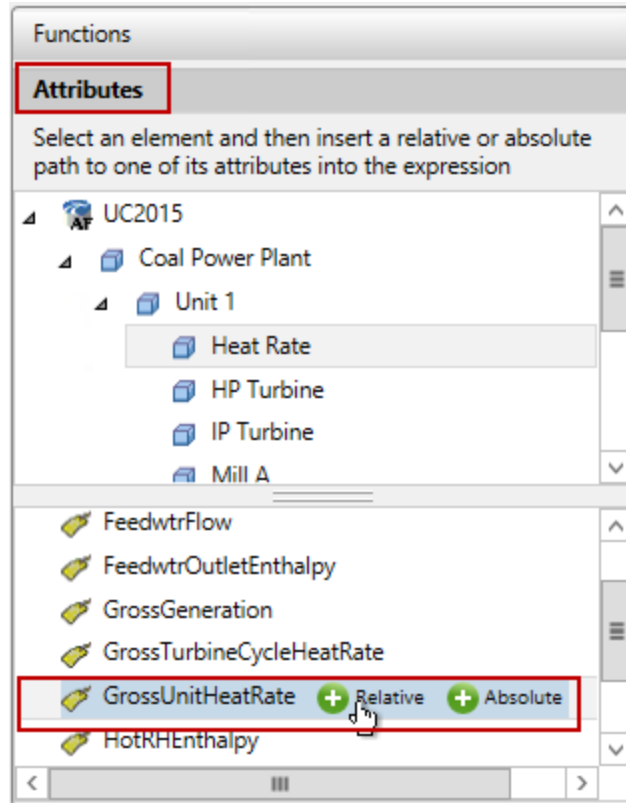
Example Element: [Coal Power Plant\Unit 1](#)



 Evaluate

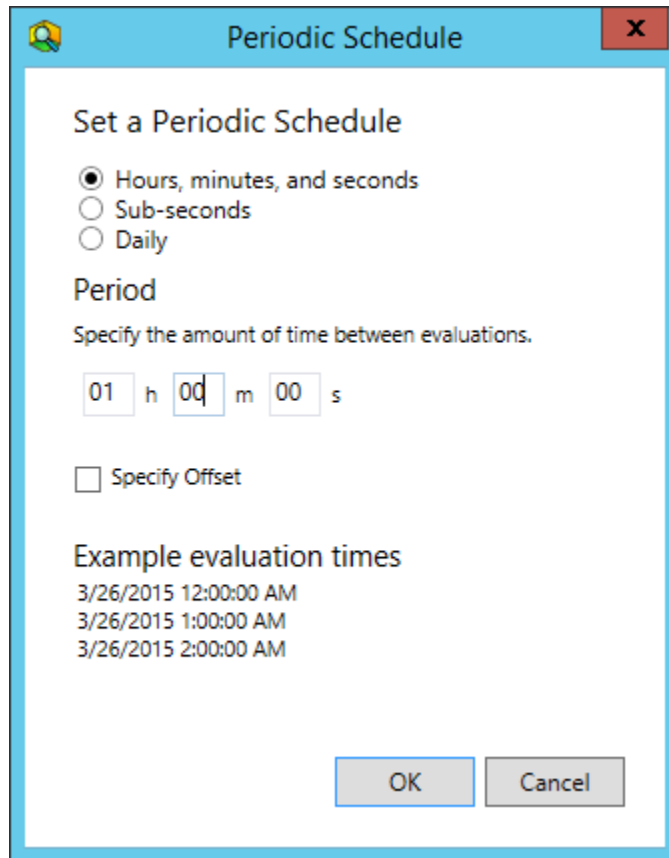
Name	Expression	Value	Output Attribute	
CoalHHV	8700	8700	<a href="#">Map</a>	
CoalReq	(TagMax('.\Heat Rate GrossUnitHeatRate', '*-1d', '*') * Convert('Target MW Generation in 7 Days', "KW")) / CoalHHV / 2000		<a href="#">Map</a>	

[Add a new expression](#)

NOTE: Use the Attributes pane, located under the Functions pane, to traverse the element hierarchy in order to select the attribute that you need.

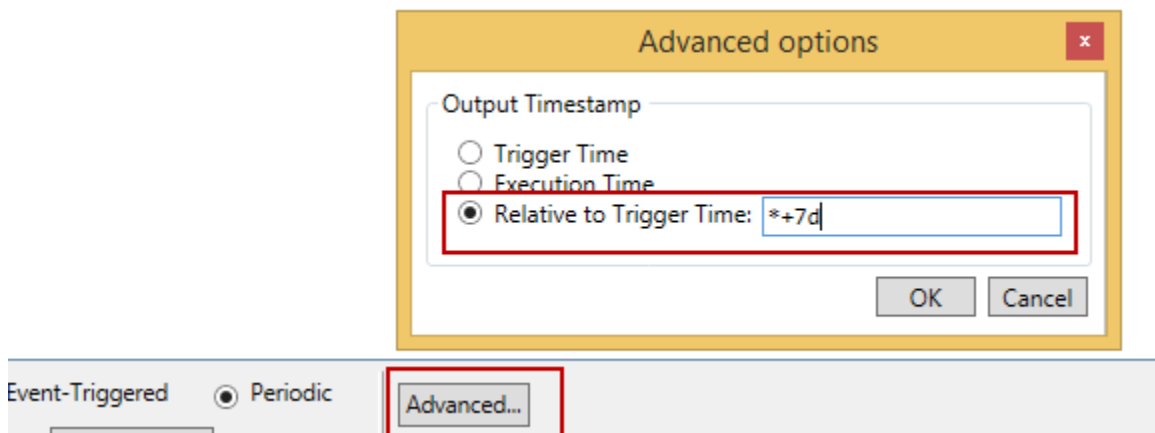


3. Configure the analysis to run Periodically every hour



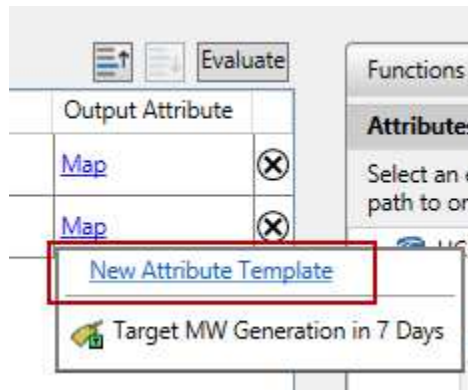
The image shows a 'Periodic Schedule' dialog box. It has a title bar with a yellow icon and a close button. The main content area is titled 'Set a Periodic Schedule'. There are three radio buttons: 'Hours, minutes, and seconds' (selected), 'Sub-seconds', and 'Daily'. Below these is a section titled 'Period' with the instruction 'Specify the amount of time between evaluations.' There are three input fields: '01' for hours, '00' for minutes, and '00' for seconds. Below these is a checkbox labeled 'Specify Offset'. At the bottom, there is a section titled 'Example evaluation times' with three lines of text: '3/26/2015 12:00:00 AM', '3/26/2015 1:00:00 AM', and '3/26/2015 2:00:00 AM'. At the bottom right are 'OK' and 'Cancel' buttons.

4. Select the Advanced button and configure the output to write the result 7 days into the future. This would enable you to have a time synchronized pair of values – the forecast MW and the calculated (estimated) coal required to satisfy the forecast based on the current condition of your Unit.



The image shows two overlapping windows. The top window is titled 'Advanced options' and has a close button. It contains a section titled 'Output Timestamp' with three radio buttons: 'Trigger Time', 'Execution Time', and 'Relative to Trigger Time' (selected). The 'Relative to Trigger Time' option has a text input field containing '\*+7d'. At the bottom right are 'OK' and 'Cancel' buttons. The bottom window is partially visible and shows a tabbed interface with 'Event-Triggered' and 'Periodic' tabs. The 'Periodic' tab is selected. Below the tabs is an 'Advanced...' button, which is highlighted with a red rectangle.

5. Map the output to a new attribute template



6. Name the new attribute and ensure you're saving the output history

 A screenshot of a dialog box titled 'Attribute Properties' with a red 'X' close button in the top right corner. Inside the dialog, there are several fields:
 

- 'Save Output History:' with radio buttons for 'Yes' (selected) and 'No'.
- 'Name:' with a text box containing 'Estimated Required Fuel'.
- 'Description:' with an empty text box.
- 'Data Server:' with a dropdown menu showing 'tnt'.
- 'Value Type:' with a dropdown menu showing 'Double'.

 At the bottom of the dialog, there is a message: 'A PI Point data reference attribute will be created.' Below this message are two buttons: 'OK' and 'Cancel'.

- a. Select the Evaluate button to ensure your calculations are sensible
- b. Check in your changes
- c. Go to Unit 1 in your element hierarchy and check the attributes tab to ensure the attributes and the PI Point are created

Note – since this analysis runs periodically every hour, it may not show a value until the analysis has executed at least once.

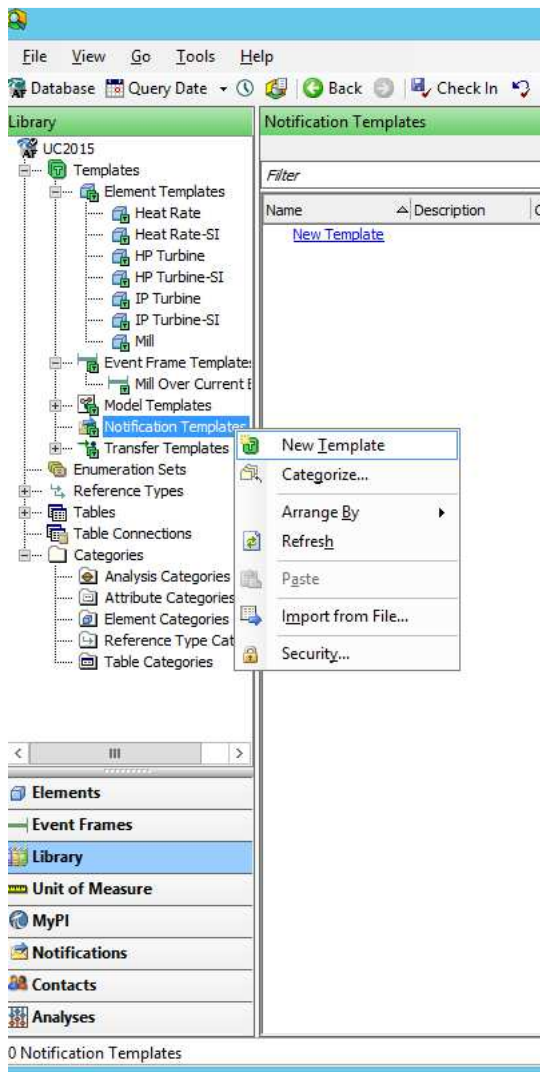
## Directed Activity 7 – Building Notifications

### Creating a Notification Template

In this section, we will build AF Notifications to inform us when our process is operating in dangerous or suboptimal conditions. We would like to be notified when our Net Unit Heat Rate exceeds 9400 Btu/kWh. If the heat rate falls back to 9350 Btu/kWh or lower, then the assets are running well. This is an example of hysteresis which we can model with a “deadband” on a simple comparison condition.

We will create notification templates so that we can easily replicate them for all similar units.

1. Go to your Library -> Notification Template section.
2. Create a new Notification Template by right clicking on the node and clicking “New Template...”.



3. On the Overview tab, give the template a name like “Heat Rate Max” and a description like “Maximum heat rate exceeded”. We have also added it to the “Heat Rate” category.

**Heat Rate Max**

Overview | Trigger | Message | Subscriptions

Name: Heat Rate Max

Description: Maximum heat rate exceeded

Status:

Categories: Heat Rate

Creation and Startup Options

☐ Automatically create a notification for each element, and start it

☐ Automatically create a notification for each element

☒ Do not create a notification automatically

Trigger

Target: Heat Rate

Condition: NetUnitHeatRate > 9400

Message

0 item(s) of custom content available to subscribers

0 customized delivery format(s) configured for Email

Subscriptions

1 subscription(s) to this notification

4. On the trigger tab, click the “Select Target...” and choose our Heat Rate template.
5. Click the “New Condition” button and select “Comparison” from the drop down menu.

\\PISRV1\UC2015 - PI System Ex

Back | Check In | Refresh | New Template

**Template14**

Overview | Trigger | Message | Subscriptions

Target: Heat Rate

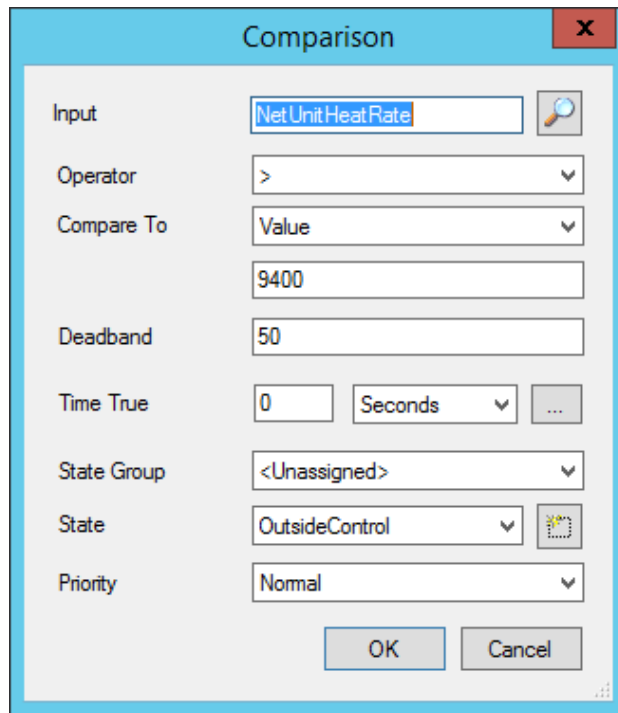
Conditions

New Condition

- Comparison
- SQC
- Performance Equation
- And Conditions
- Or Conditions

Time True | Result ... | Priority

6. In the comparison dialog,
  - a. Select the input attribute template “NetUnitHeatRate”
  - b. Select the Operator “>”.
  - c. Set “Compare To” to “Value” and enter 9400 in the box.
  - d. Set the Deadband to 50.
  - e. Click OK.



A screenshot of a 'Comparison' dialog box. The dialog has a title bar with a close button (X). It contains several fields for configuring a comparison rule. The 'Input' field is set to 'Net Unit Heat Rate'. The 'Operator' is set to '>'. The 'Compare To' dropdown is set to 'Value', and the adjacent text box contains '9400'. The 'Deadband' field contains '50'. The 'Time True' field contains '0', and the unit dropdown is set to 'Seconds'. The 'State Group' dropdown is set to '<Unassigned>'. The 'State' dropdown is set to 'OutsideControl'. The 'Priority' dropdown is set to 'Normal'. At the bottom are 'OK' and 'Cancel' buttons.

Input	Net Unit Heat Rate
Operator	>
Compare To	Value
	9400
Deadband	50
Time True	0
	Seconds
State Group	<Unassigned>
State	OutsideControl
Priority	Normal

7. Our trigger tab should look like the image below. Note that we are going to leave the Time Rule option as "Natural" to cause the trigger to be checked whenever there is new data in the input PI Point.



Heat Rate Max

Overview Trigger Message Subscriptions

Target: Heat Rate Select Target...

Conditions

New Condition ✕ ✎ ⬆ ⬇

Rule	Configuration	Time True	Result When...	Priority
Comparison	NetUnitHeatRate > 9400	0	OutsideControl	Normal

Time Rule: Natural ...

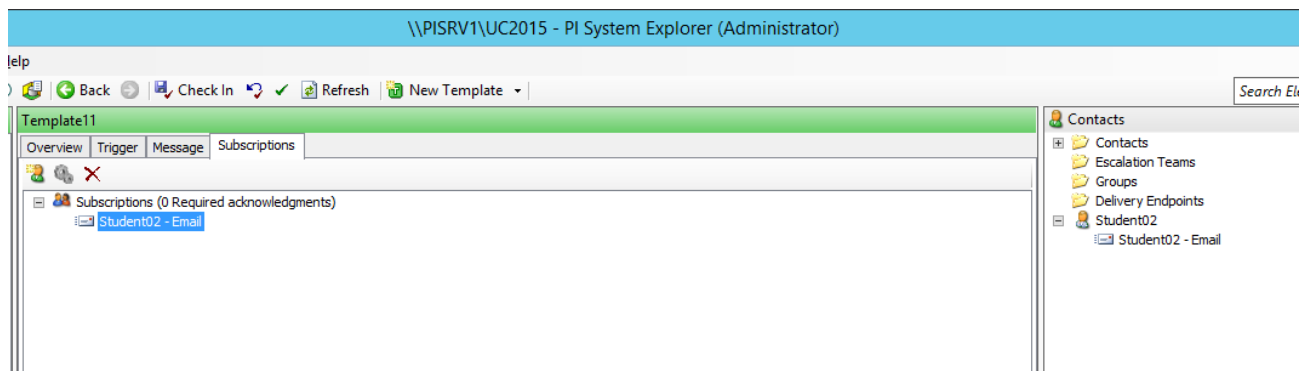
Options

☒ Notify only on change in status

Resend Interval: 0 Seconds

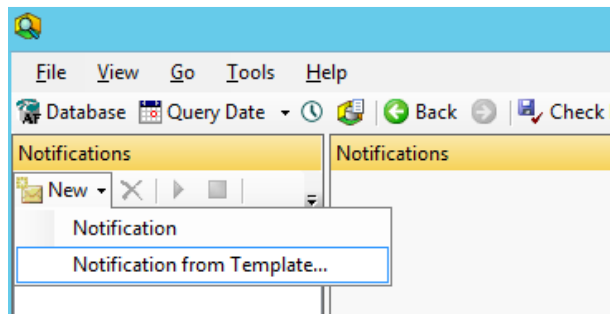
Non Repetition Interval: 0 Seconds

8. We are just going to use the default message, so we can skip the “Message” tab this time.
9. Finally, on the Subscriptions tab, we will add subscribers to the notification. In the palette on the right, expand our contact (here Student02) and drag-and-drop the email channel onto the subscription area. We now are subscribed to receive an email notification.



### Creating a Notification from a Template

1. In the Notifications tab of PI System Explorer. Click the New button and “Notification from Template...” from the drop down menu.



2. In the first list, select the template “Heat Rate Max”
3. In the second list, check the elements for which notifications will be created.
4. Click OK. (This may take some time if there are a large number of elements.)

Create Notifications

Select a notification template

Name	Description
<No Notification Template>	
Heat Rate Max	Maximum heat rate exceeded
HP Turbine Efficiency Min	alarms when the HP turbine efficiency is too low
IP Turbine Efficiency Min	alarms when the IP turbine efficiency is too low

Select target elements

☒ Select

Name	Path	Has Existing Notifi...	Categories	Description
<input checked="" type="checkbox"/> Heat Rate	\\PISRV1\UC201...	No	Heat Rate	Heat Rate Calcula...

OK

Cancel

- Finally, Check In, select the Notifications to be started, and s the Start button.

## Directed Activity 8 – Advanced Notifications Uses

In this section we will configure notifications to demonstrate features that allow you to customize the content of your notification messages and use Performance Equations in notification triggers.

### Customizing Notification Content

In this section, we will add more information to the message we receive. We want to configure this notification to alert us when our HP Turbine efficiency is less than 87.5 %, indicating suboptimal operating conditions.

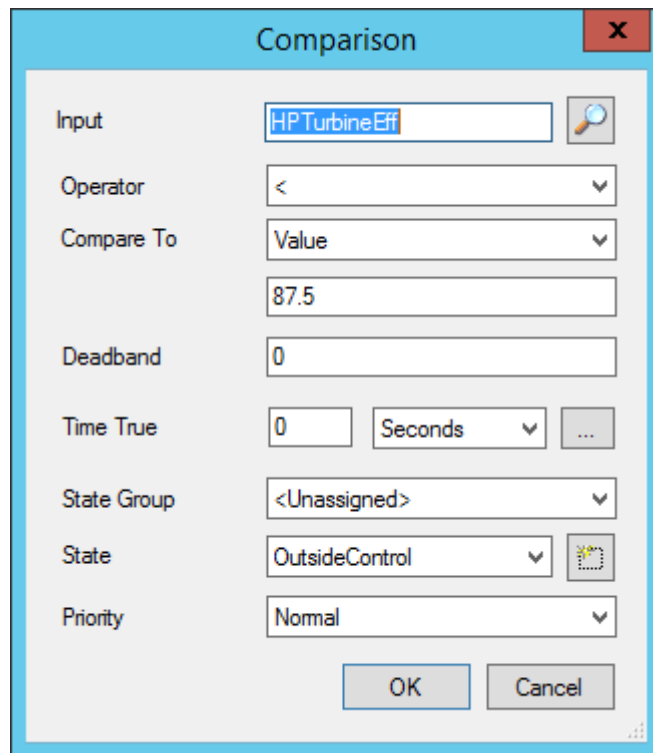
1. Go to your Library -> Notification Template section.
2. Create a new Notification Template by right clicking on the node and clicking “New Template...”.
3. On the Overview tab, give the template a name like “HP Turbine Efficiency Min” and a description like “Alarms when the HP turbine efficiency is too low”. We have also added it to the “HP Turbine” category.

The screenshot shows the configuration interface for a notification template titled "HP Turbine Efficiency Min". The interface has four tabs: Overview, Trigger, Message, and Subscriptions. The Overview tab is active, showing the following fields:



- Name:** HP Turbine Efficiency Min
- Description:** Alarms when the HP turbine efficiency is too low
- Status:** (empty field)
- Categories:** HP Turbine

Below these fields is a section titled "Creation and Startup Options" with a radio button and the text "Automatically create a notification for each element, and start it".

4. Next, on the Trigger tab, click “Select Target...” and select the “HP Turbine” element template as the target.
5. Click the “New Condition” button and select “Comparison” from the drop down menu.
6. In the comparison dialog,
  - a. Select the input attribute template “HPTurbineEff”
  - b. Select the Operator “<”.
  - c. Set “Compare To” to “Value” and enter 87.5 in the box.
  - d. Click OK

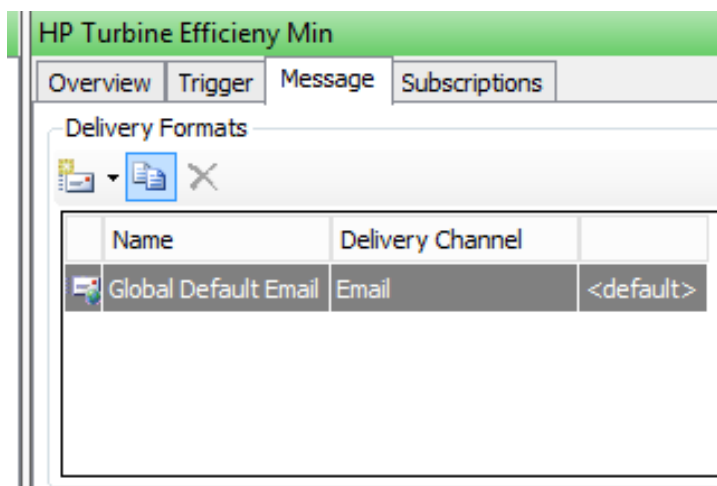


A dialog box titled "Comparison" with a red close button in the top right corner. It contains several input fields and dropdown menus for configuring a comparison rule.

Input	HPTurbineEff	
Operator	<	
Compare To	Value	
	87.5	
Deadband	0	
Time True	0	Seconds ...
State Group	<Unassigned>	
State	OutsideControl	
Priority	Normal	


At the bottom are "OK" and "Cancel" buttons.

7. We will leave the Time Rule option as "Natural".
8. On the "Message" tab we will customize our message. Select the Global Default Email and Click the "Duplicate" button. Rename it to something like "Efficiency Values Email"

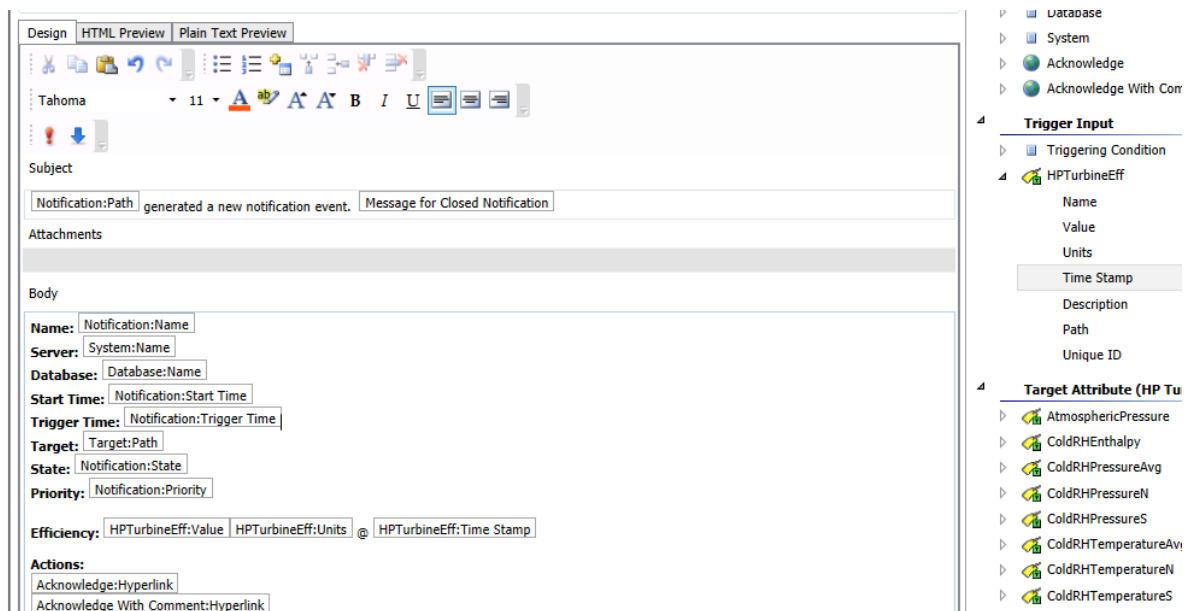


A configuration window titled "HP Turbine Efficiency Min" with tabs for Overview, Trigger, Message, and Subscriptions. The Message tab is selected.

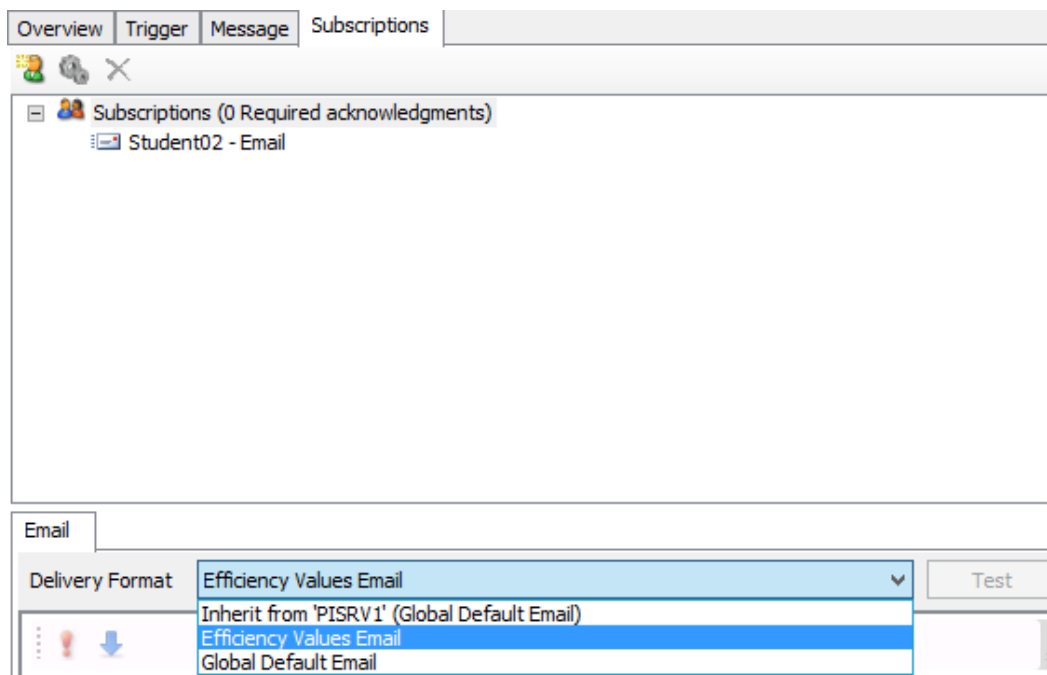
Under "Delivery Formats", there is a toolbar with icons for adding, removing, and refreshing formats. Below it is a table:

Name	Delivery Channel	
 Global Default Email	Email	<default>

9. Next, drag-and-drop content from the HPTurbineEff attribute into the body of the message. Useful items are Value, Units, and Time Stamp.



10. Take a moment to check what the message will actually look like on the Preview Tab.
11. On the Subscriptions tab, drag and drop the email endpoint for your contact onto the subscriptions list.
12. Select the "Subscriptions" root element in the tree and select "Efficiency Value Email" as the "Delivery Format". This will ensure that subscribers receive this format by default.



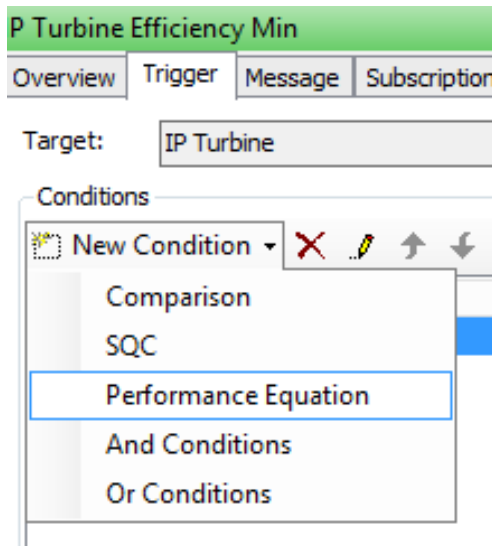
13. Finally, check in the notification template.

That completes the walkthrough of the configuration. You can create instances from the template as described in the section [Creating a Notification from a Template](#).

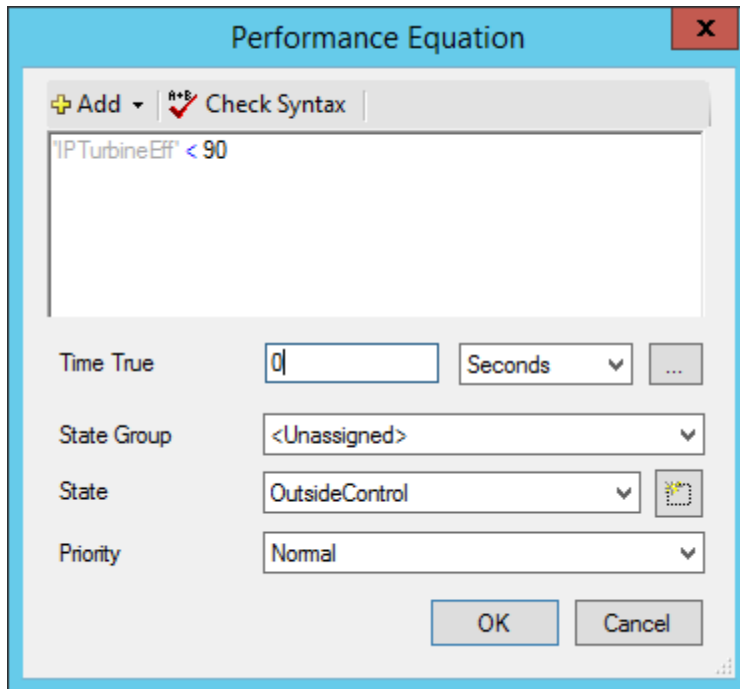
## Performance Equation Triggers

In this section we will configure a Notification Template to alarm when the IP Turbine's efficiency is less than 90% using a Performance Equation Trigger.

1. Go to your Library -> Notification Template section.
2. Create a new Notification Template by right clicking on the node and clicking "New Template...".
3. On the Overview tab, give the template a name like "HP Turbine Efficiency Min" and a description like "Alarms when the HP turbine efficiency is too low". We have also added it to the "HP Turbine" category.
4. Next, on the Trigger tab, click "Select Target..." and select the "IP Turbine" element template as the target.
5. Click the "New Condition" button and select "Performance Equation" from the drop down menu.



6. Type the expression " 'IPTurbineEff' < 90 " into the box and click OK.



The image shows a 'Performance Equation' dialog box. At the top, there is a title bar with the text 'Performance Equation' and a close button (X). Below the title bar, there is a toolbar with an 'Add' button (plus icon) and a 'Check Syntax' button (checkmark icon). The main area of the dialog is a text box containing the equation `'IPTurbineEff' < 90`. Below the text box, there are several configuration options: 'Time True' with a text input field containing '0' and a unit dropdown menu set to 'Seconds'; 'State Group' with a dropdown menu set to '<Unassigned>'; 'State' with a dropdown menu set to 'OutsideControl' and a small icon button to its right; and 'Priority' with a dropdown menu set to 'Normal'. At the bottom right, there are 'OK' and 'Cancel' buttons.

7. On the Subscriptions tab, drag and drop the email endpoint for your contact onto the subscriptions list.
8. Finally, check in the notification template.

That completes the walkthrough of the configuration. You can create instances from the template as described in the section [Creating a Notification from a Template](#).



## Directed Activity 9 – PI Coresight

Now that you have built an AF model for some of the most important assets in your plant and also created some calculation to model and track the most important process in your plant, it's time for you to take a look at what information you can receive from your efforts. PI Coresight is the perfect visualization tool to do that.

1. Start Internet Explorer and select the Bookmark to PI Coresight on the ribbon.
2. Create some new displays, tables, etc. for the model you have just built.
3. Navigate the AF hierarchy and “look around”.
4. Create some trends.
5. Create a trend to include the forecasts. Is it what you expected?

## Summary

In this TechCon lab, you created an AF model for your coal mills, created analyses to mark important events, modeled a part of your steam cycle, created some notifications to warn of suboptimal conditions and visualized your data all using capabilities of the PI System. These are some of the most important assets and process as they have large impact on the operation (cost and efficiency) of your plant. You did not have to model your entire plant to derive value. As a matter of fact, the steam cycle is not modelled completely but rather contains some estimates. However, even without fully modeling your steam cycle, you are able to track changes over time which gives you an indication of your process efficiency. You can of course continue to build on this over time and personalize it as much as you like.

## OSIsoft Virtual Learning Environment

The OSIsoft Virtual Environment provides you with virtual machines where you can complete the exercises contained in this workbook. After you launch the Virtual Learning Environment, connect to **PISRV1** with the credentials: **pischool\student01, student**.

The environment contains the following machines:

**PISRV1**: a windows server that runs the PI System and that contains all the software and configuration necessary to perform the exercises on this workbook. This is the machine you need to connect to.

**PIDC**: a domain controller that provides network and authentication functions.

The system will create these machines for you upon request and this process may take between 5 to 10 minutes. During that time you can start reading the workbook to understand what you will be doing in the machine.

After you launch the virtual learning environment your session will run for up to 8 hours, after which your session will be deleted. You can save your work by using a cloud storage solution like onedrive or box. From the virtual learning environment you can access any of these cloud solutions and upload the files you are interested in saving.

System requirements: the Virtual Learning Environment is composed of virtual machines hosted on Microsoft Azure that you can access remotely. In order to access these virtual machines you need a Remote Desktop Protocol (RDP) Client and you will also need to be able to access the domain cloudapp.net where the machines are hosted. A typical connection string has the form cloudservicename.cloudapp.net:xxxxx, where the cloud service name is specific to a group of virtual machines and xxxxx is a port in the range 41952-65535. Therefore users connecting to Azure virtual machines must be allowed to connect to the domain \*.cloudapp.net throughout the port range 41952-65535. If you cannot connect, check your company firewall policies and ensure that you can connect to this domain on the required ports.