2015 OSIsoft TechCon

Modeling your processes using the PI System

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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

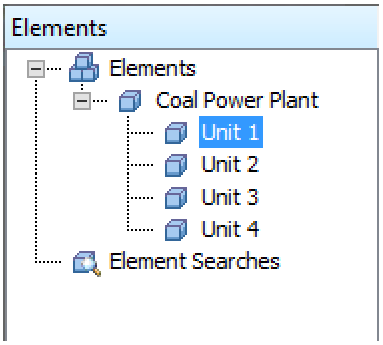
Plan of attack

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.

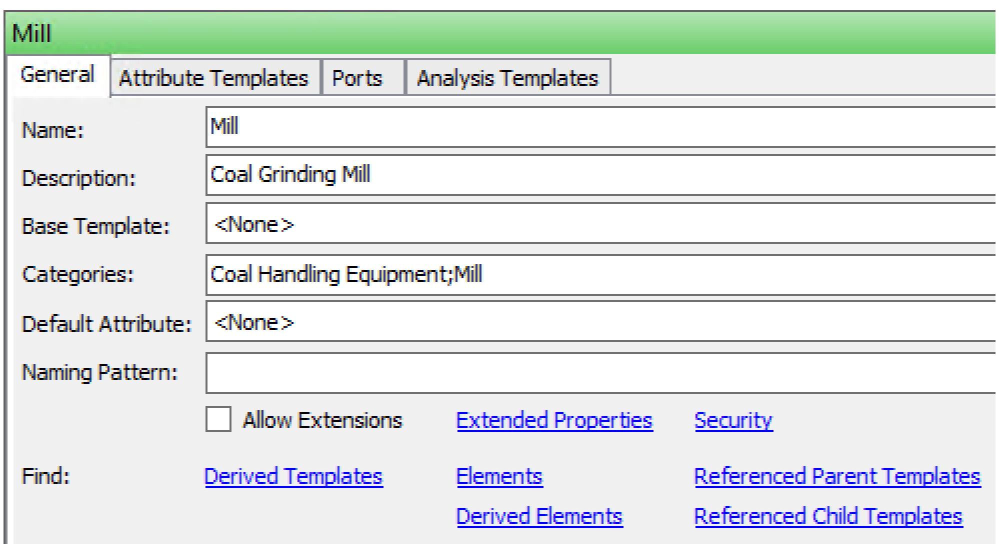
Directed Activity 1 – Building a Template and PI AF Hierarchy for your Coal Mills

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".

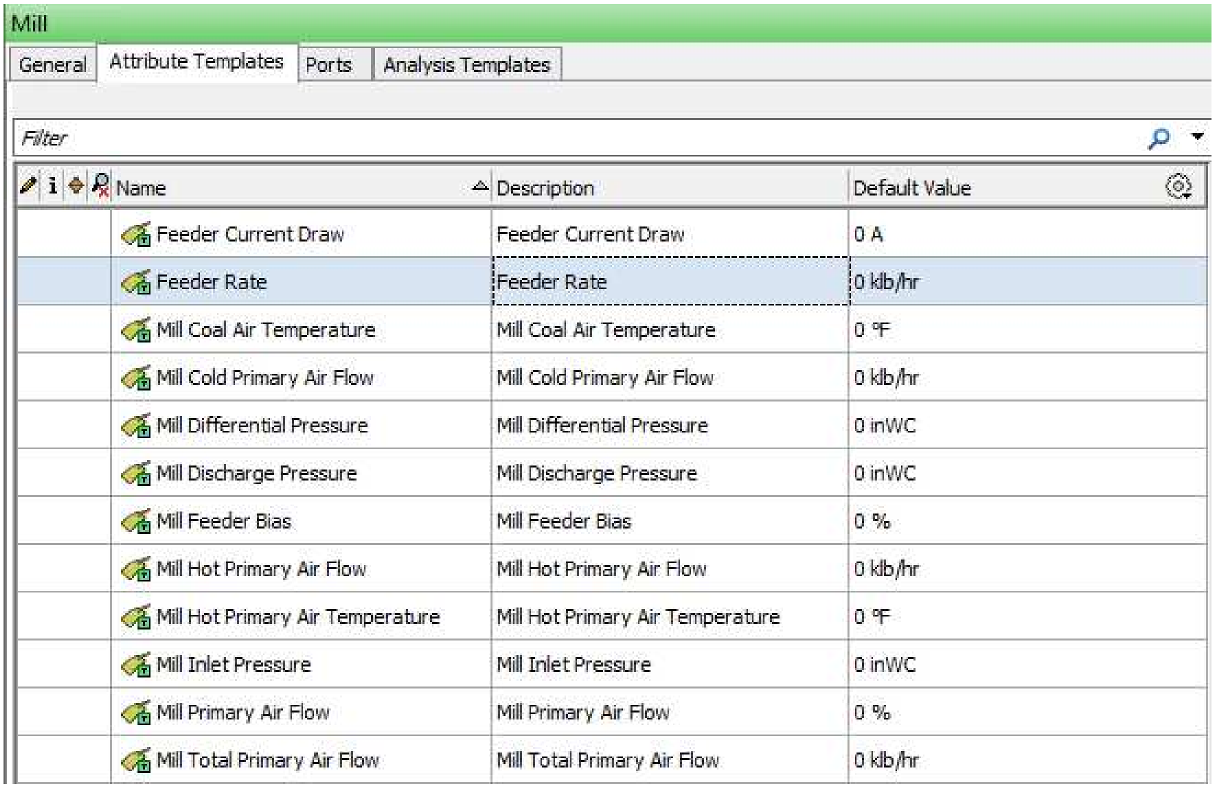


7. Select "OK" and answer "Yes" to create the new Category.
8. Go to the Attribute Templates tab.

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

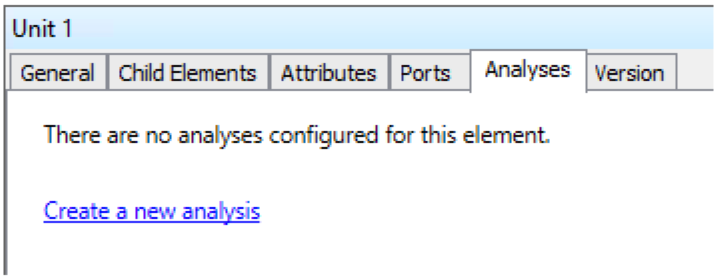
Name	Description	Default Value
Feeder Current Draw	Feeder Current Draw	0 A
Feeder Rate	Feeder Rate	0 klb/hr
Mill Coal Air Temperature	Mill Coal Air Temperature	0 °F
Mill Cold Primary Air Flow	Mill Cold Primary Air Flow	0 klb/hr
Mill Differential Pressure	Mill Differential Pressure	0 inWC
Mill Discharge 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

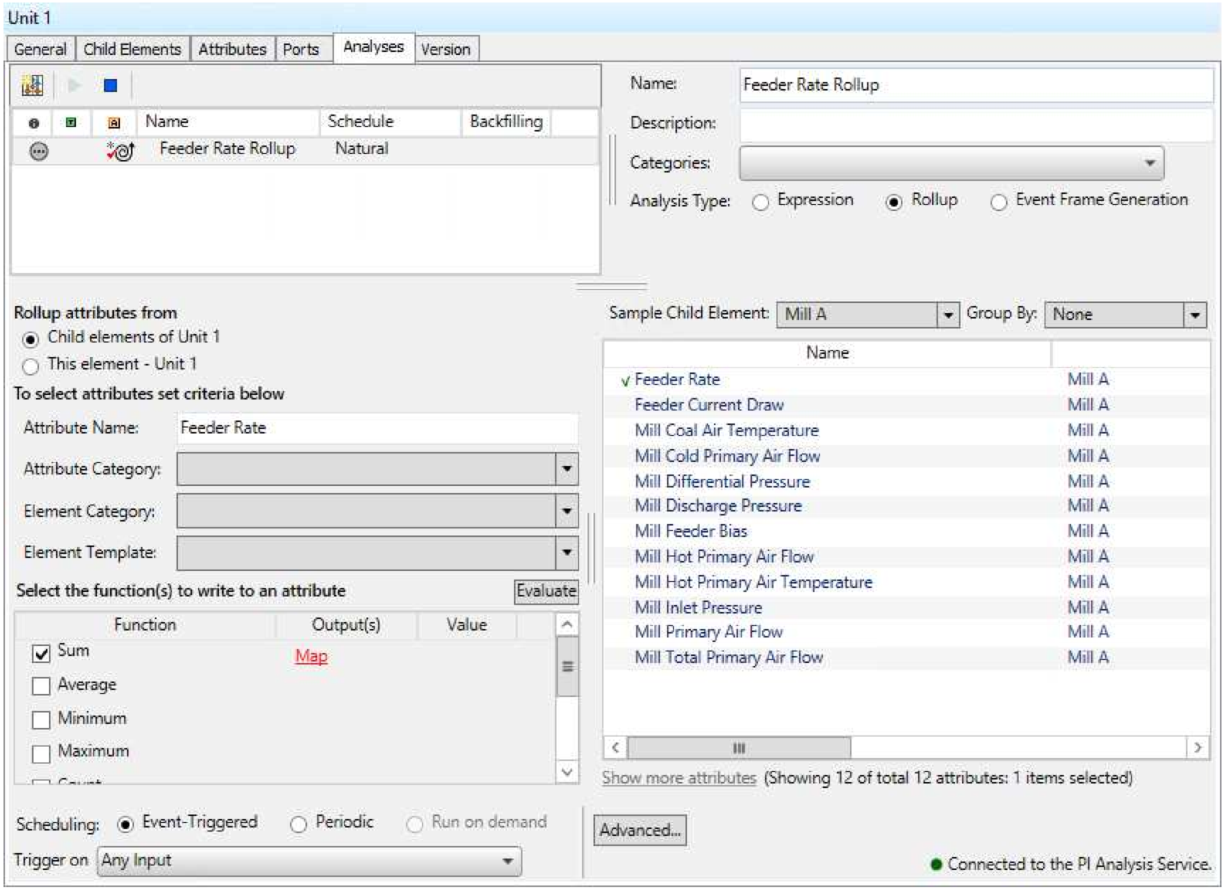
Directed Activity 2 – Building Analyses for your Coal Mills to Track Coal Usage

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

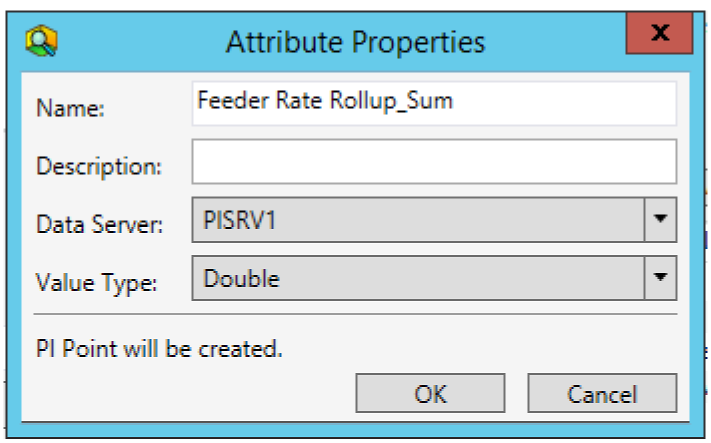
1. Go to the Unit 1 Analyses tab
2. Create a new analysis



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



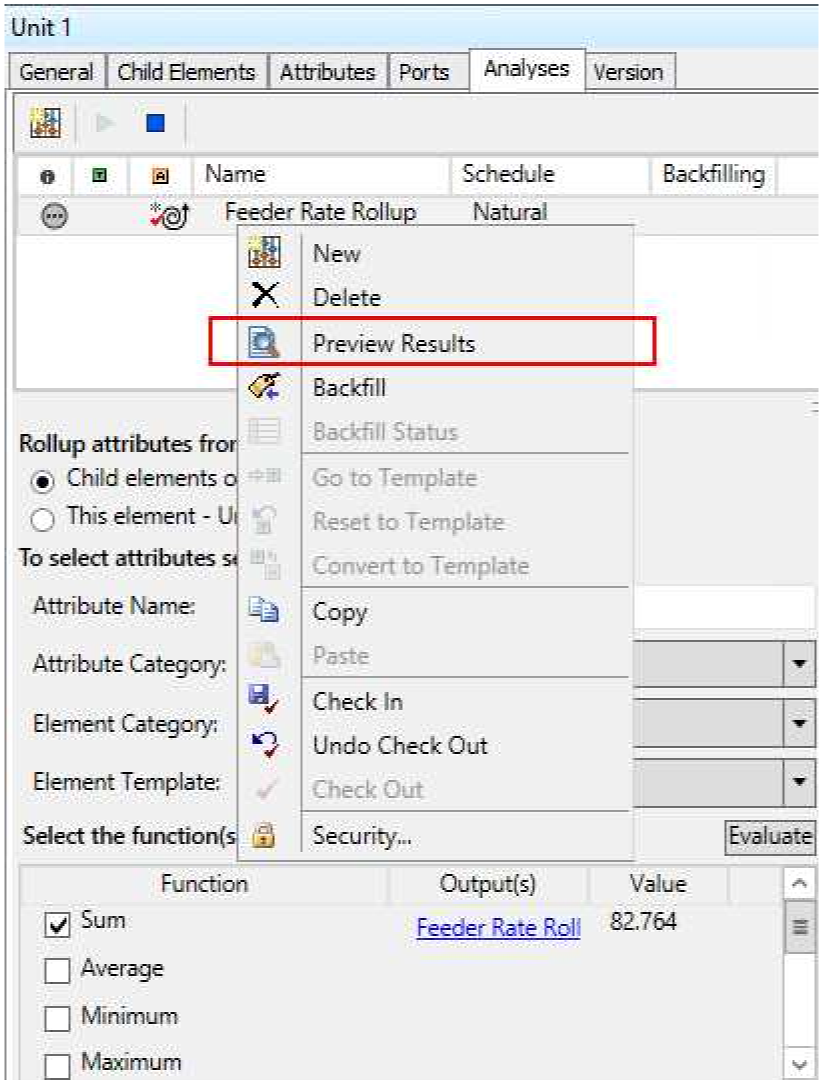
f. Map the output to a new attribute and create a PI Point to store the output.



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

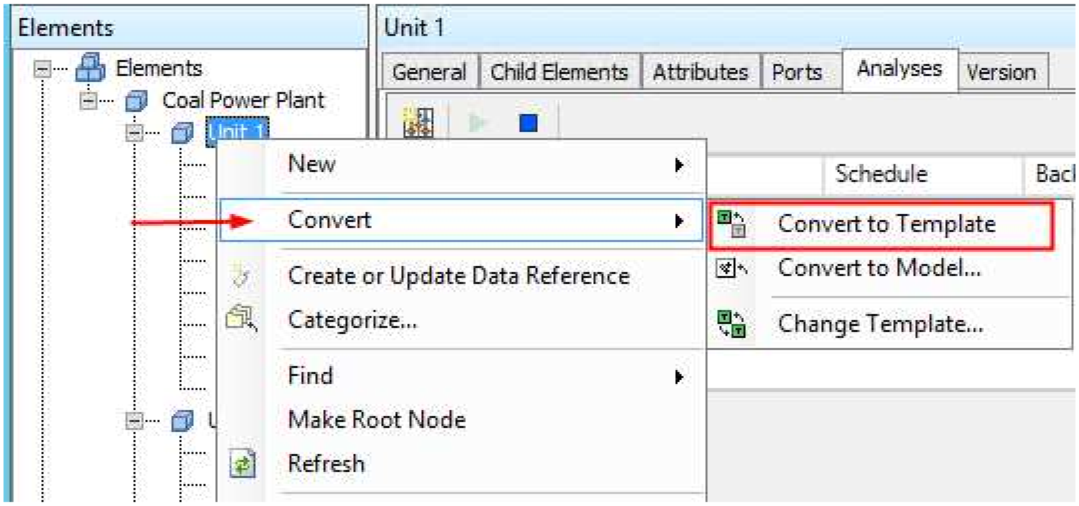
j. Right-click on the Analysis and select Backfill to backfill the output over some historical time range.

   i. Choose *-30d to * to backfill over the last 30 days

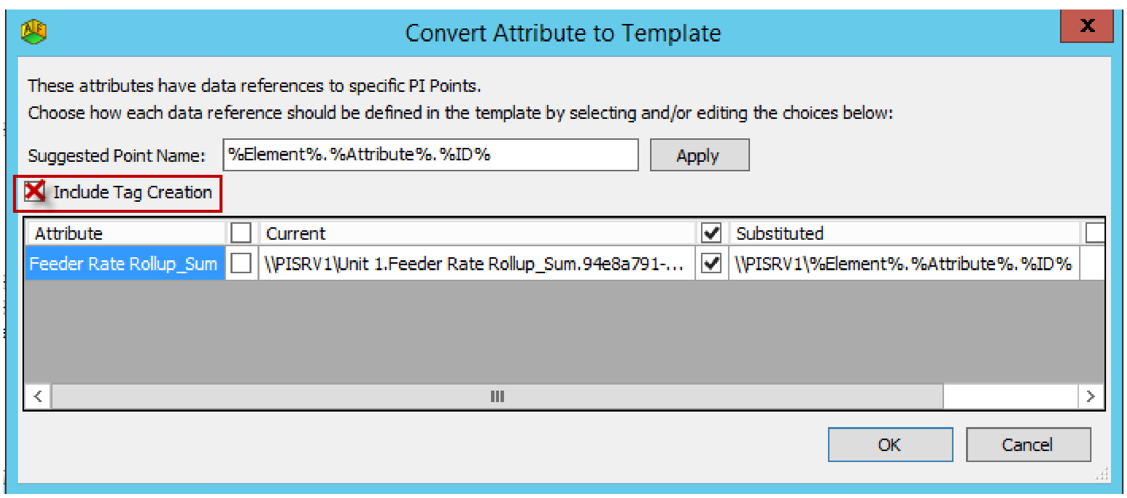
   ii. Once backfill is done, examine the results by right-clicking on the Feeder Rate Rollup attribute and selecting Time Series Data

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

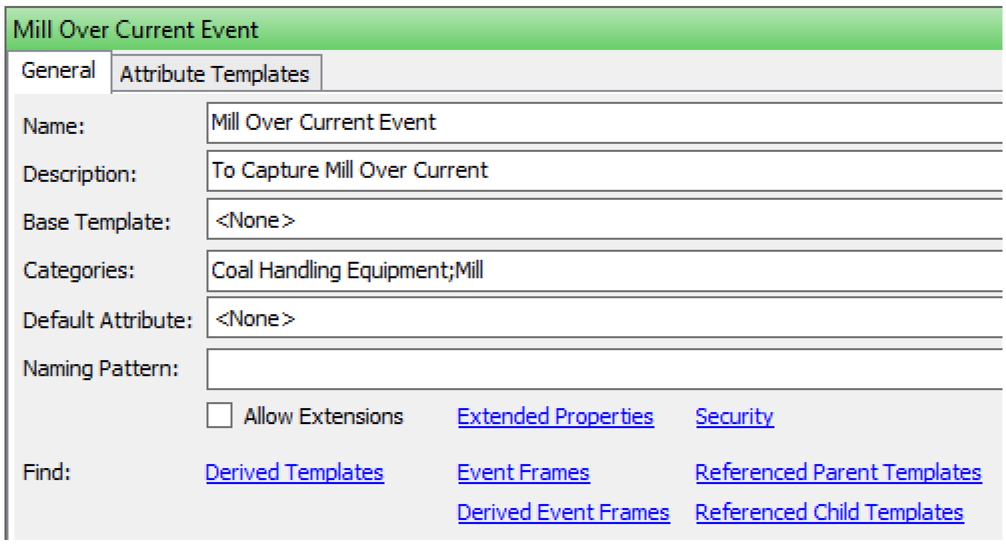
vi. Examine the asset hierarchy:

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

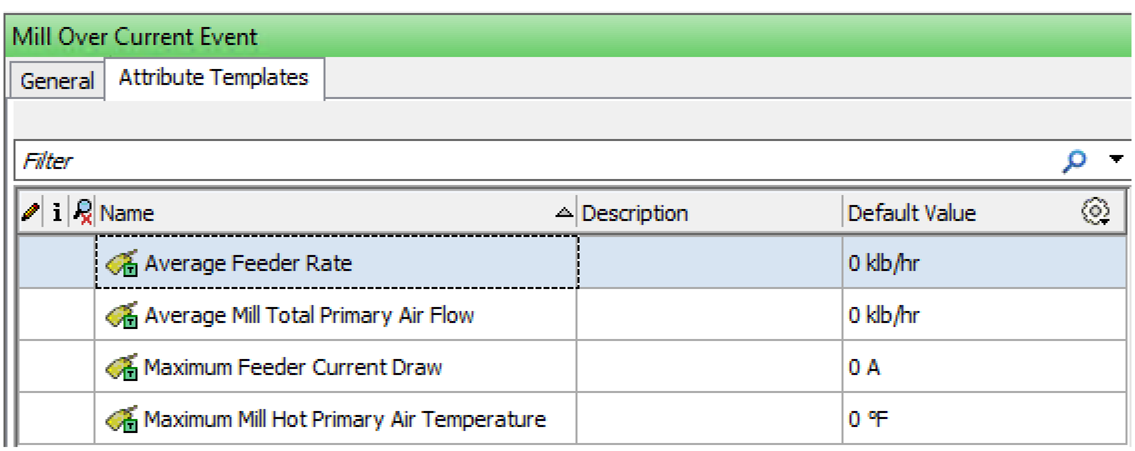
Directed Activity 3 – Marking Important Events for your Coal Mills

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

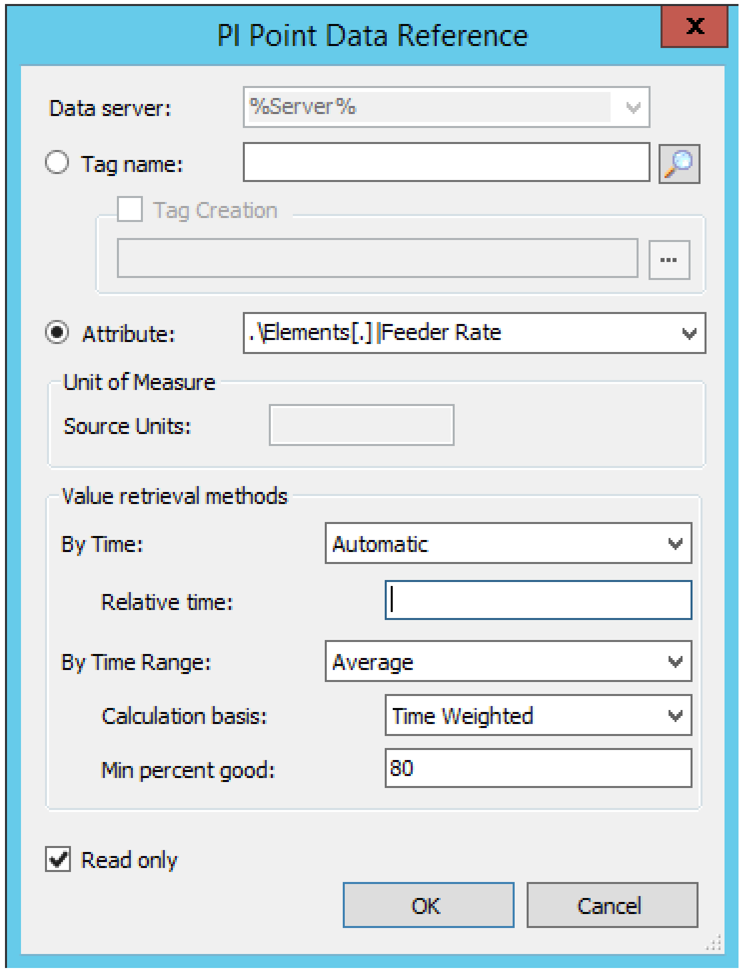


    d. Select the “Attribute Templates” tab
    e. Create attributes that you want to have in every event frame. These attributes will refer back to attributes of the referenced element. Ensure you configure the UOM properly for these attributes.



        i. Average Feeder Rate

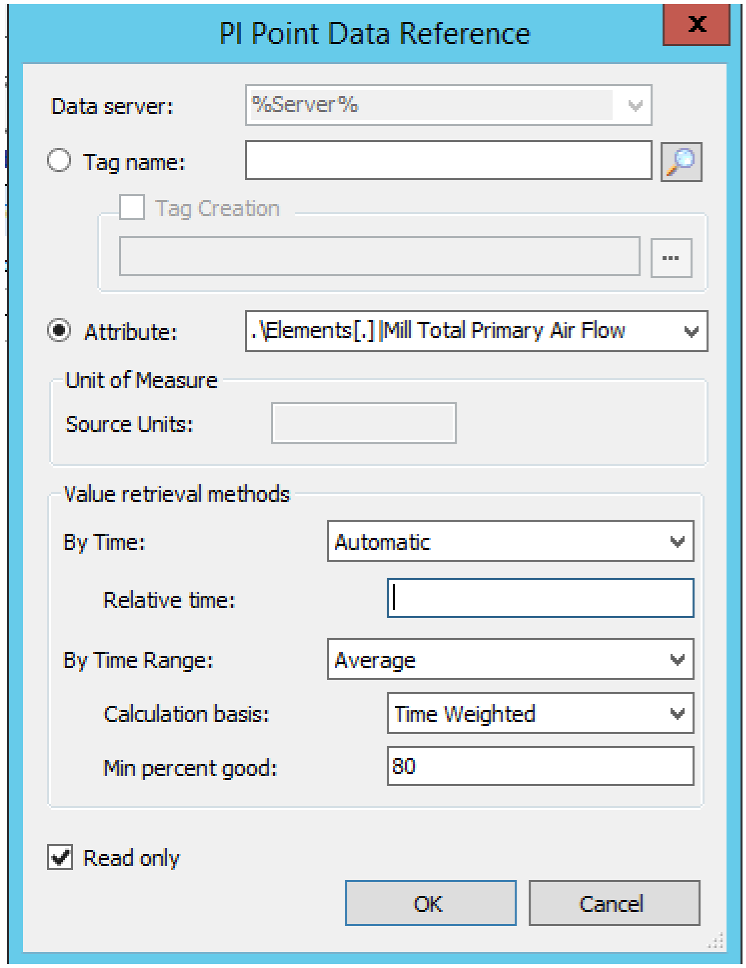
1. Configure this attribute to be a PI Point Data Reference with the following settings:



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

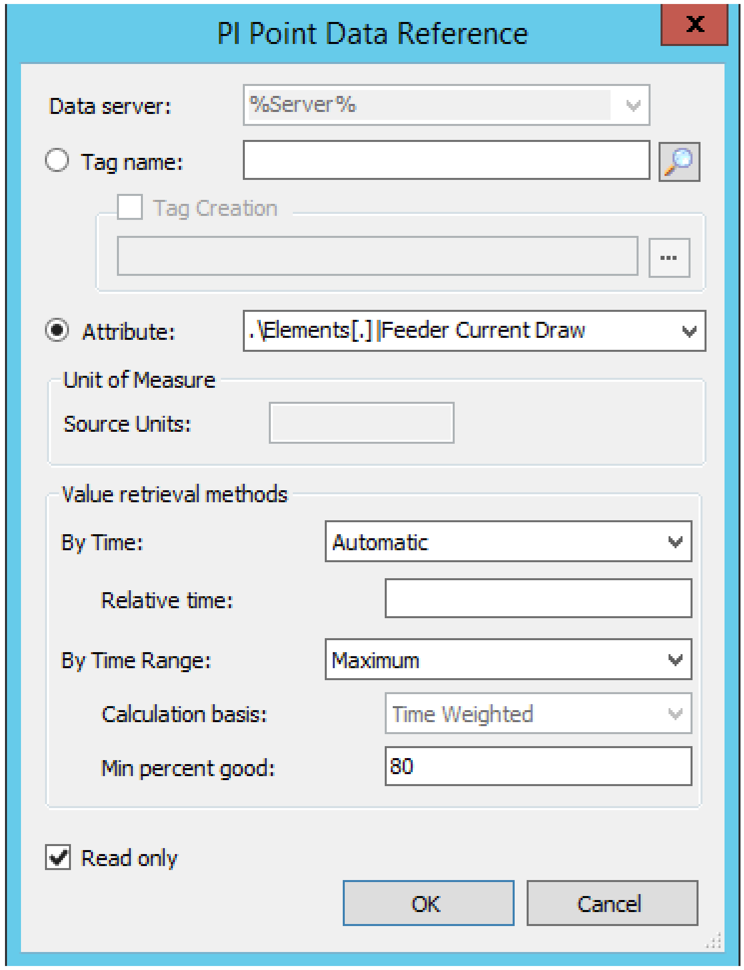
1. Configure this attribute to be a PI Point Data Reference with the following settings:



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

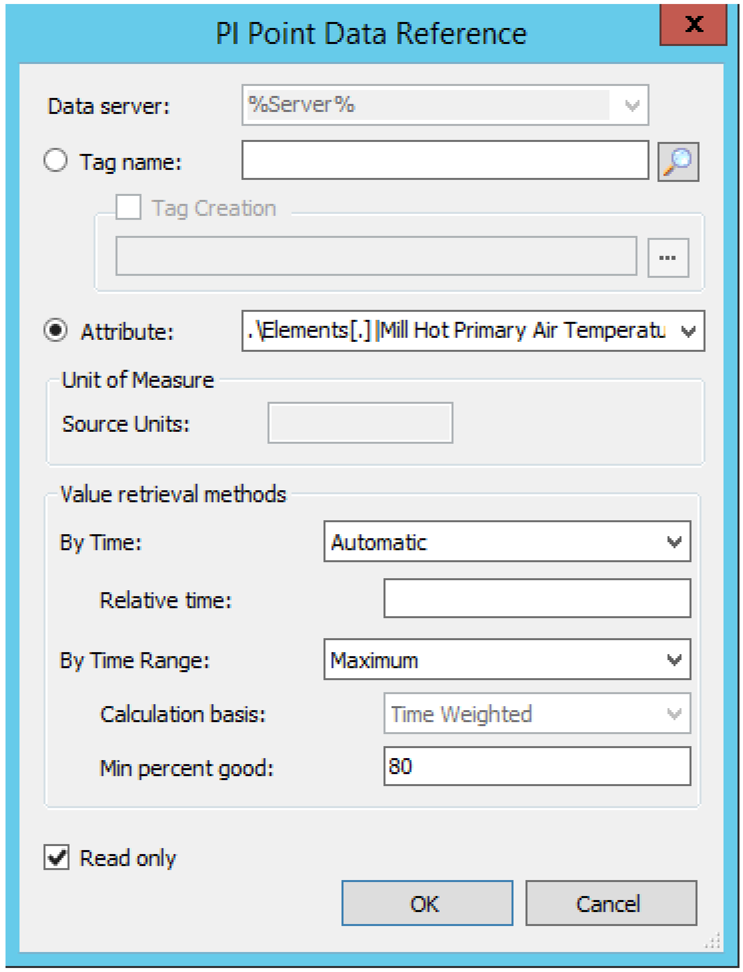
1. Configure this attribute to be a PI Point Data Reference with the following settings:



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

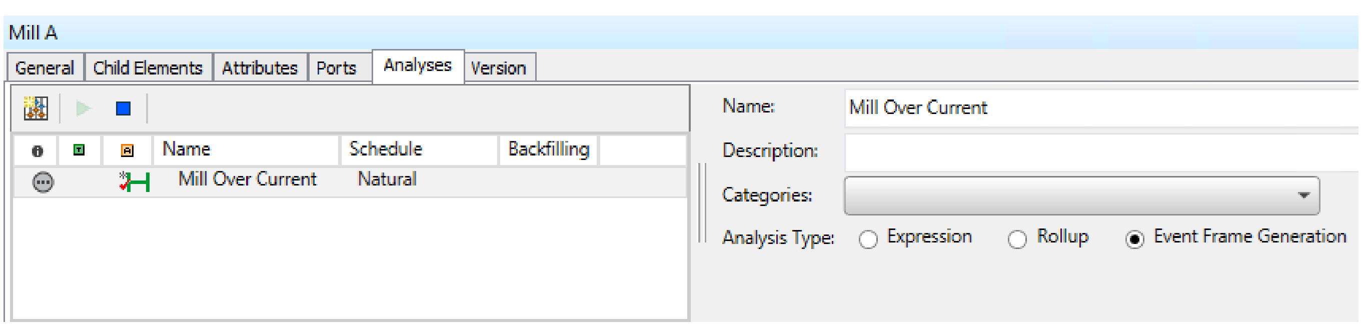
1. Configure this attribute to be a PI Point Data Reference with the following settings:



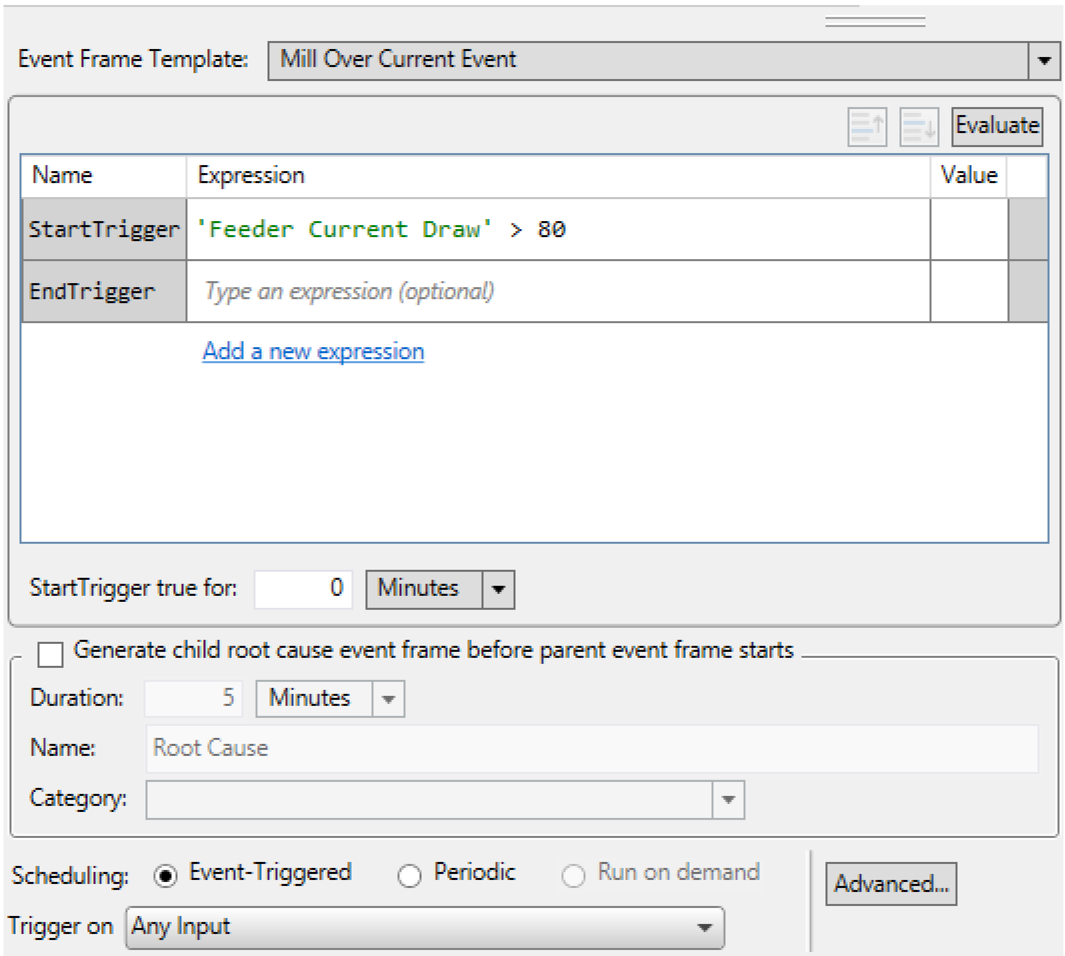
2. When the event frame is created, this attribute will hold the maximum value of the Mill Hot Primary Air Temperature for the duration of the event frame

v. Check in your changes

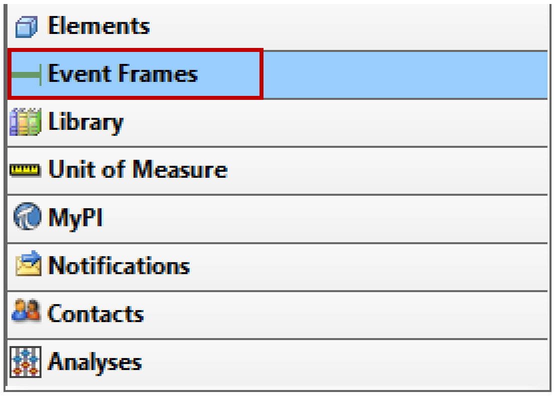
3. Select Unit 1 -> Mill A in the element hierarchy and go to the Analyses tab
4. Create a new analysis
   a. Select Event Frame Generation Analysis type
   b. Name the Analysis "Mill Over Current"



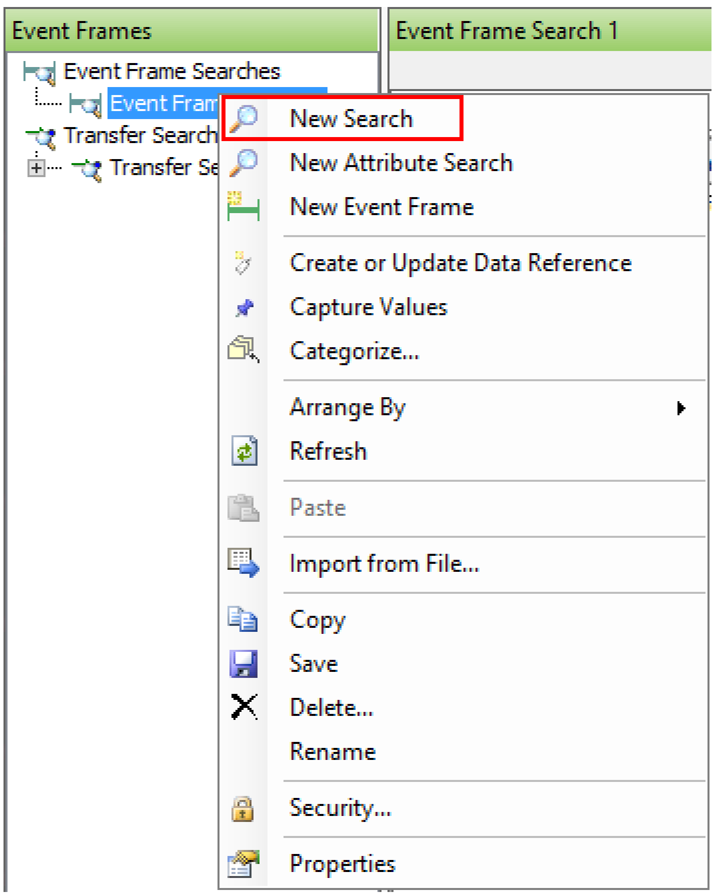
5. Select the event frame template you just built from the drop down
6. Configure the Start Trigger
    a. 'Feeder Current Draw' > 80. This is the threshold whereby an event frame will be created. When the current draw drops back below 80, the event frame will close.
7. Select Event-Triggered Scheduling



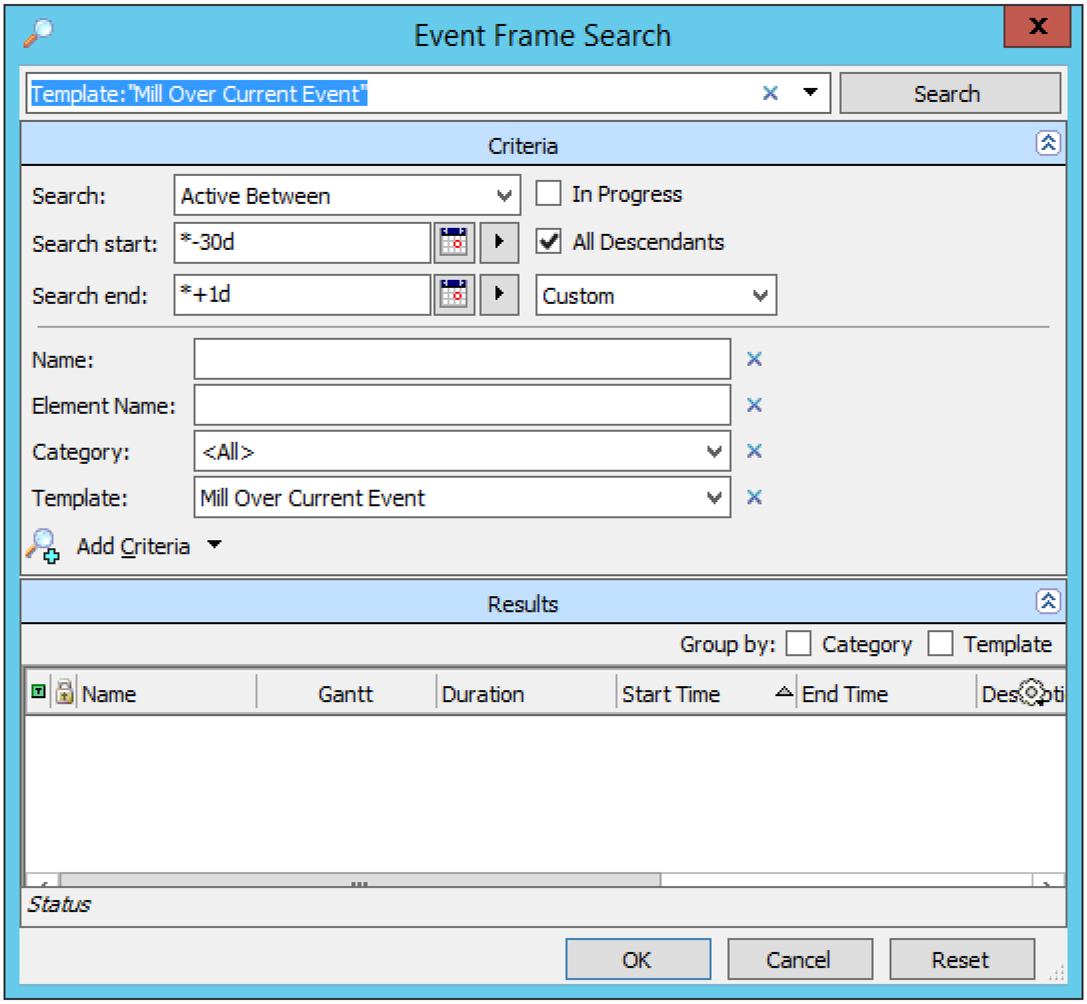
8. Select the Evaluate button to check whether the Start Trigger is currently true or false
9. Check in your changes
10. Right-click on the analysis and Preview over the last 30 days
11. Right-click on the analysis and Backfill over the last 30 days
12. Go to the Event Frames plug-in in PI System Explorer



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



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

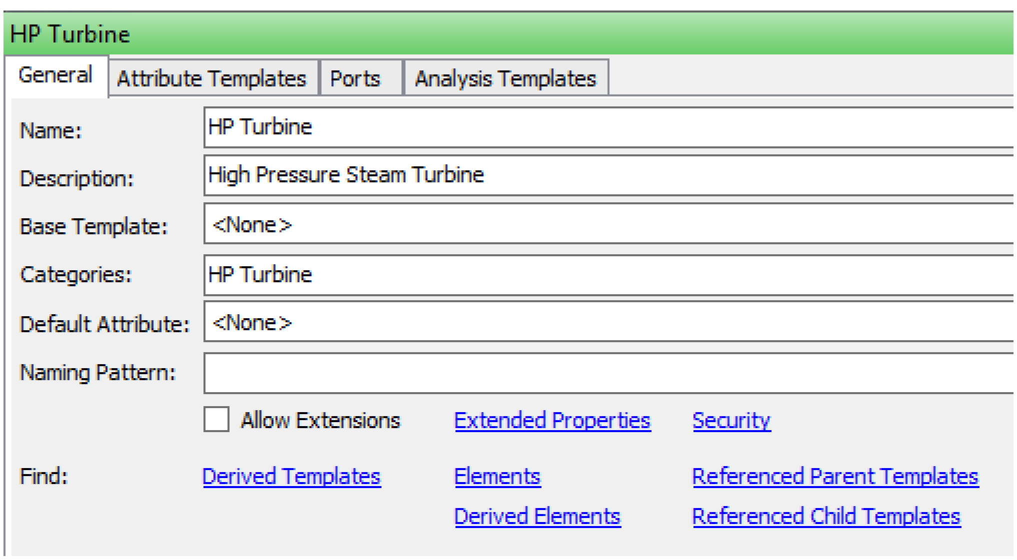
Directed Activity 4 – Building a Template and PI AF Hierarchy for your HP Turbines and IP Turbines for Efficiency Monitoring

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".



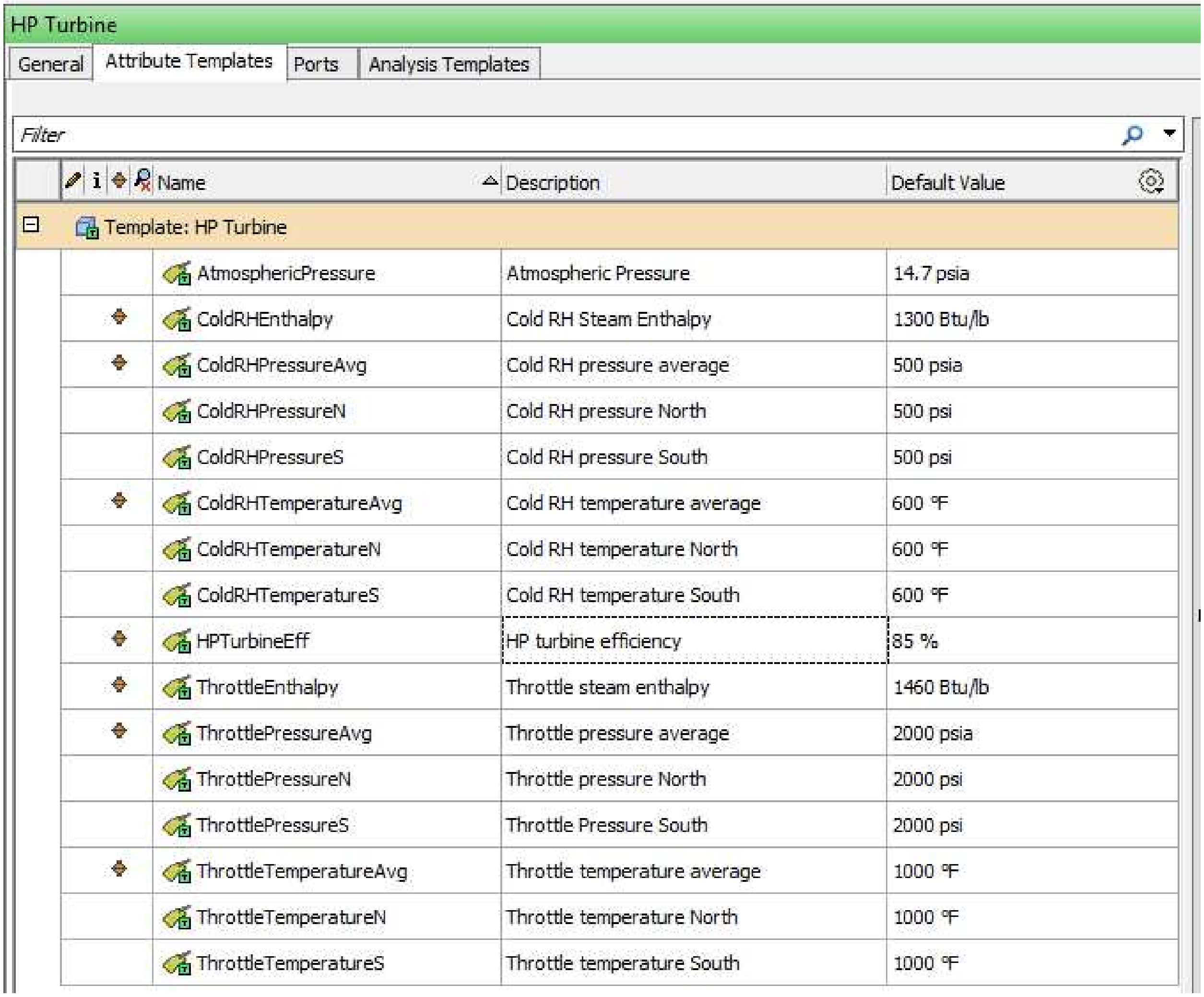
5. Select "OK" and answer "Yes" to create the new Category.
6. Go to the Attribute Templates tab.
7. Right-click in the right pane and create the following attributes for your template. For all the attributes listed below, configure them as PI Point Data Reference, with a Setting of:

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

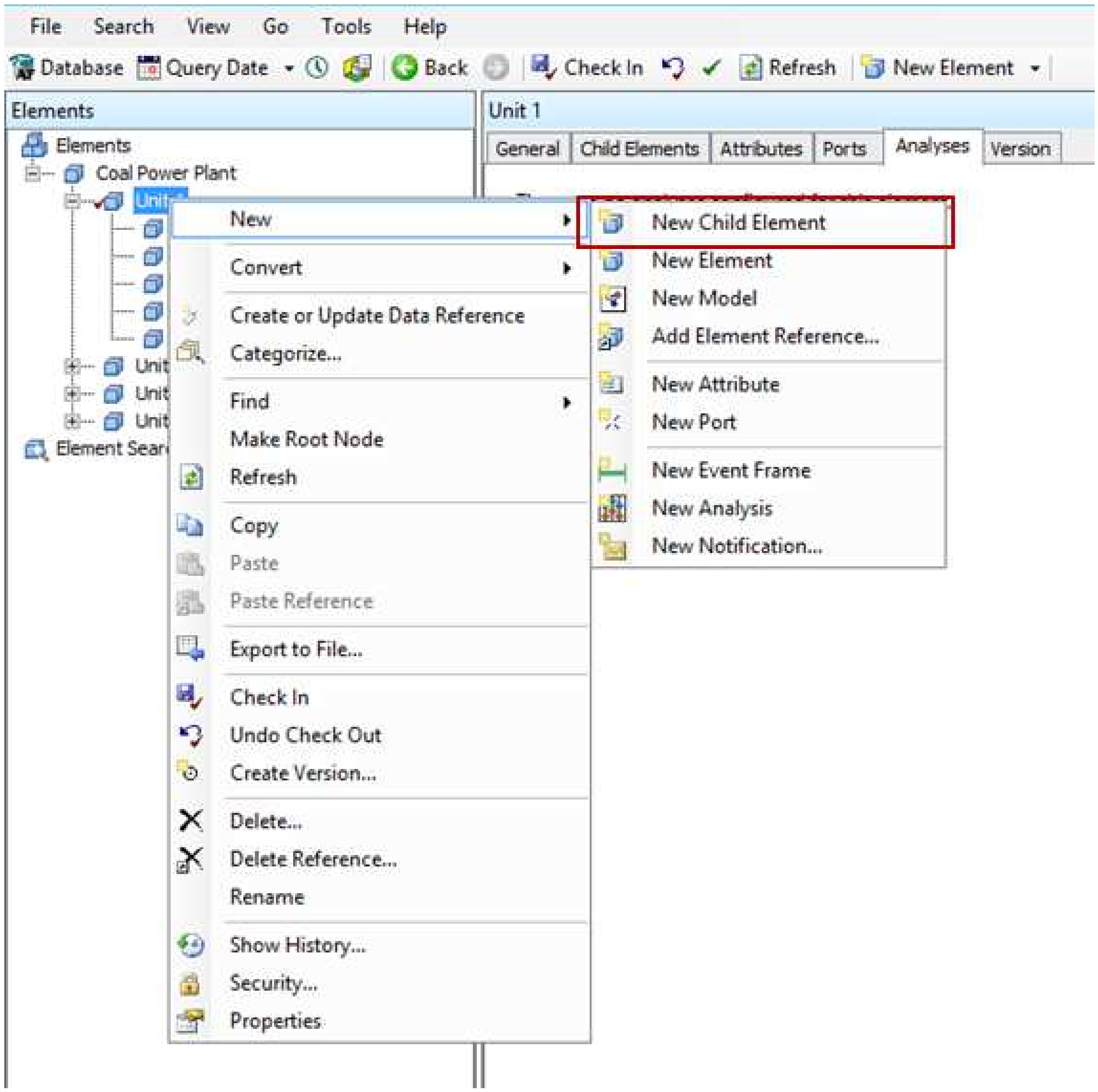
a. AtmosphericPressure, UOM = pound-force per square inch (customary), default value = 14.7. Note that since the atmospheric pressure is measured at one place in the station, there are no individual unit pressure transmitters. Therefore the PI point data reference does not include the unit designation.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



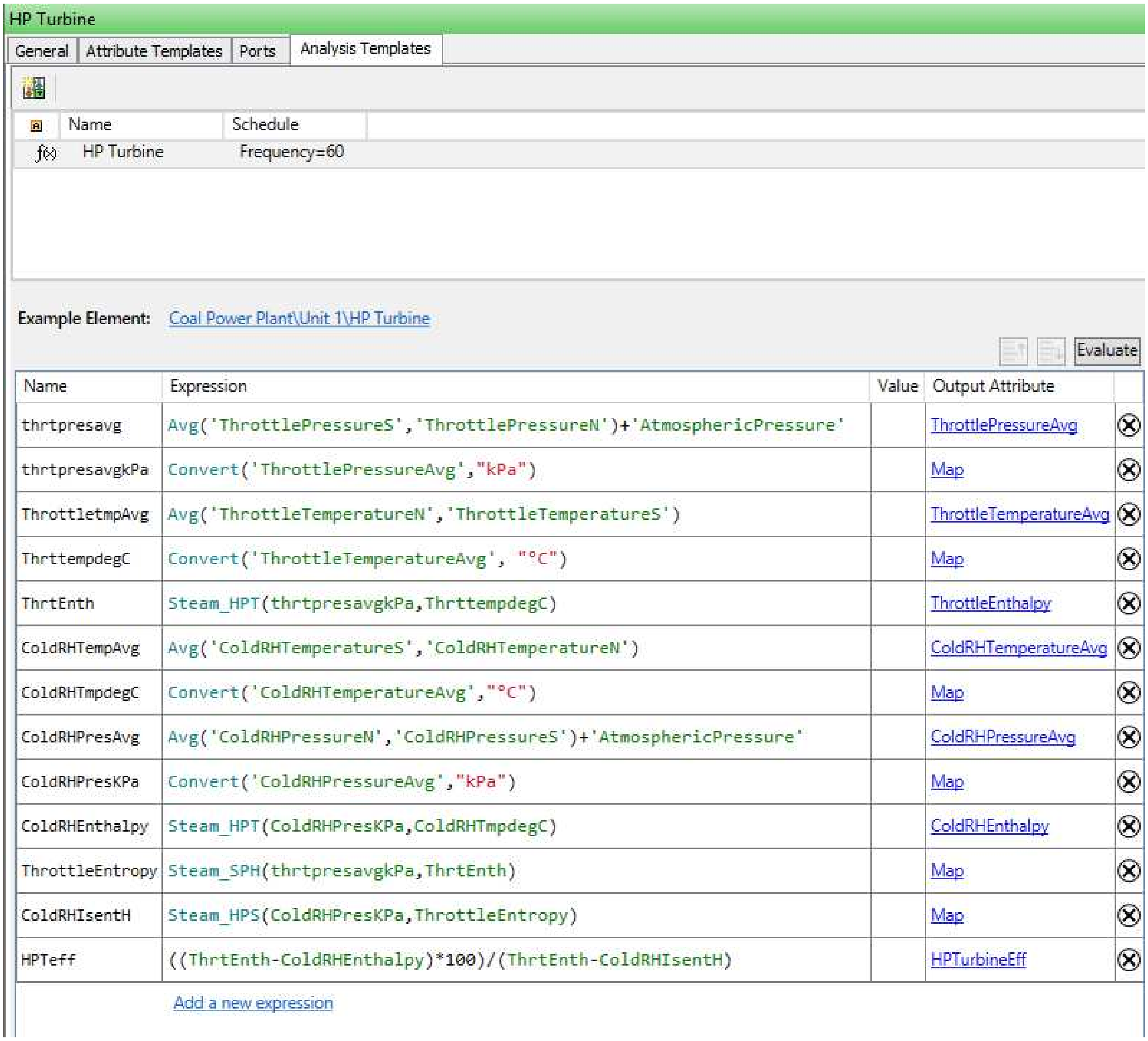
Name	Description	Default Value
AtmosphericPressure	Atmospheric Pressure	14.7 psia
ColdRHEnthalpy	Cold RH Steam Enthalpy	1300 Btu/lb
ColdRHPressureAvg	Cold RH pressure average	500 psia
ColdRHPressureN	Cold RH pressure North	500 psi
ColdRHPressureS	Cold RH pressure South	500 psi
ColdRHTemperatureAvg	Cold RH temperature average	600 °F
ColdRHTemperatureN	Cold RH temperature North	600 °F
ColdRHTemperatureS	Cold RH temperature South	600 °F
HPTurbineEff	HP turbine efficiency	85 %
ThrottleEnthalpy	Throttle steam enthalpy	1460 Btu/lb
ThrottlePressureAvg	Throttle pressure average	2000 psia
ThrottlePressureN	Throttle pressure North	2000 psi
ThrottlePressureS	Throttle Pressure South	2000 psi
ThrottleTemperatureAvg	Throttle temperature average	1000 °F
ThrottleTemperatureN	Throttle temperature North	1000 °F
ThrottleTemperatureS	Throttle temperature South	1000 °F



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.



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

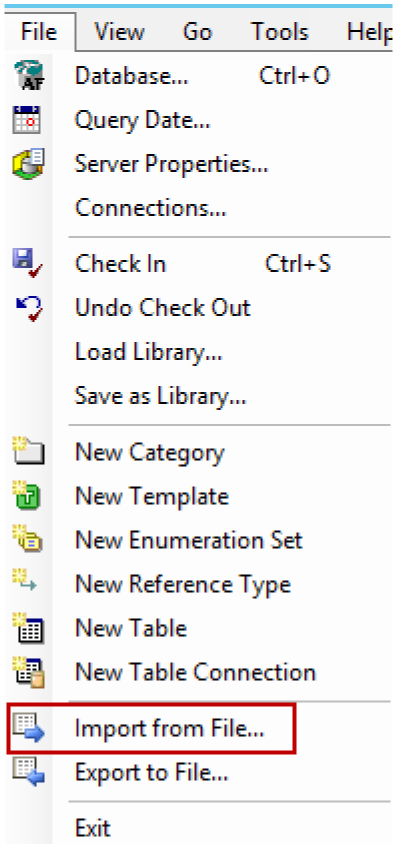
p. Click on the Evaluate button to ensure the calculations work properly.

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



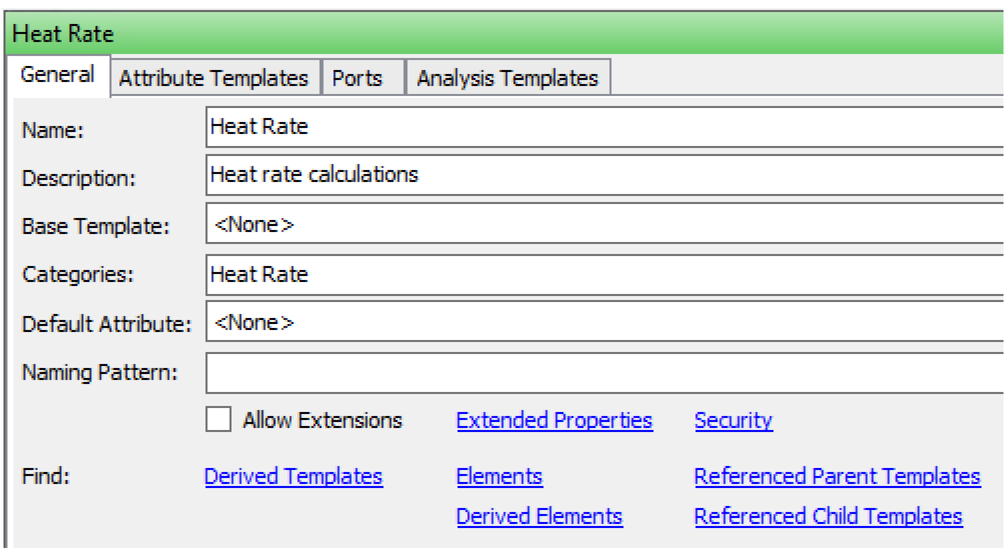
b. Navigate to the UC2015 folder on your desktop and import the IP Turbine, HP Turbine (SI) and IP Turbine (SI) templates.
c. In the element hierarchy, right-click Unit 1 and create new child elements based on the IP Turbine template.
d. Optionally you can create child elements for HP Turbine (SI) and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

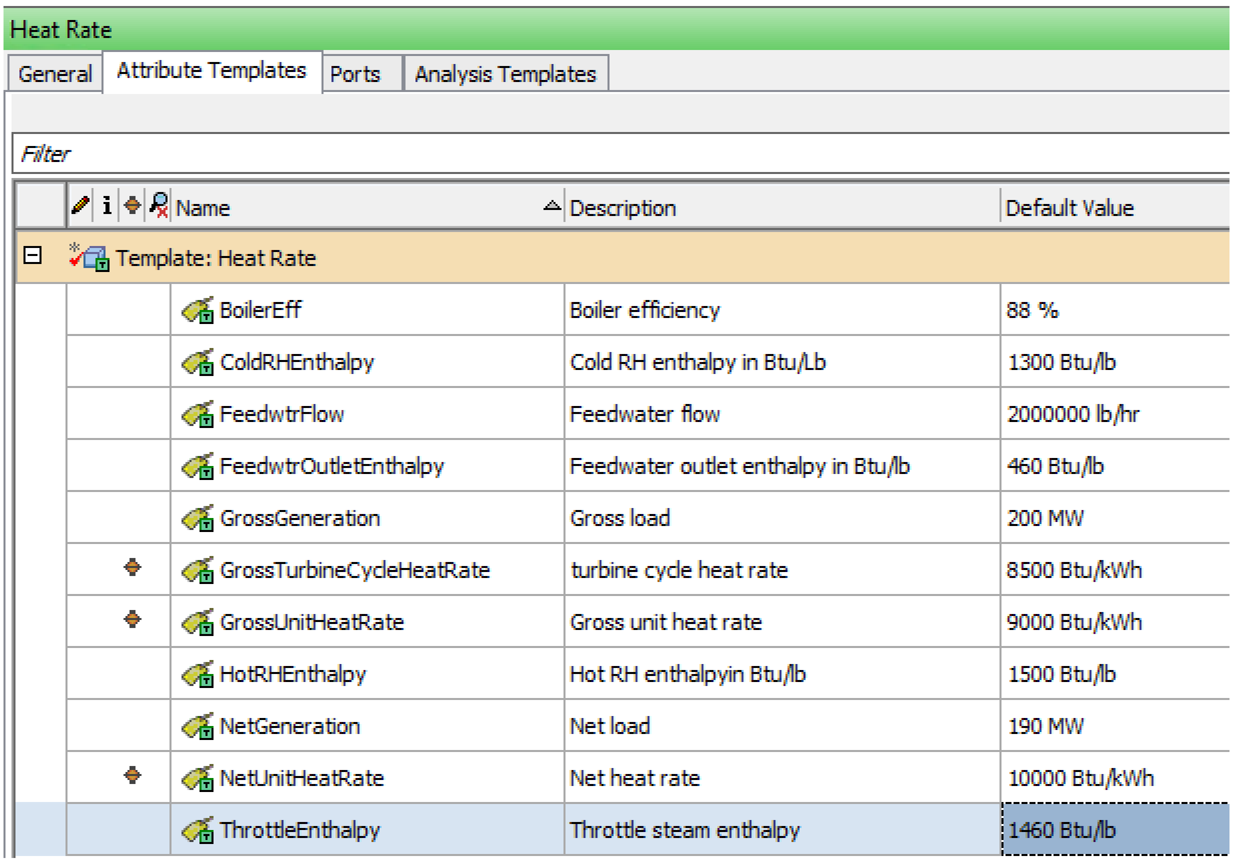


4. Select "OK" and answer "Yes" to create the new Category.
5. Go to the Attribute Templates tab.
6. Right-click in the right pane and create the following attributes for your template. For all the attributes listed below, configure them as PI Point Data Reference, with a Setting of:

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

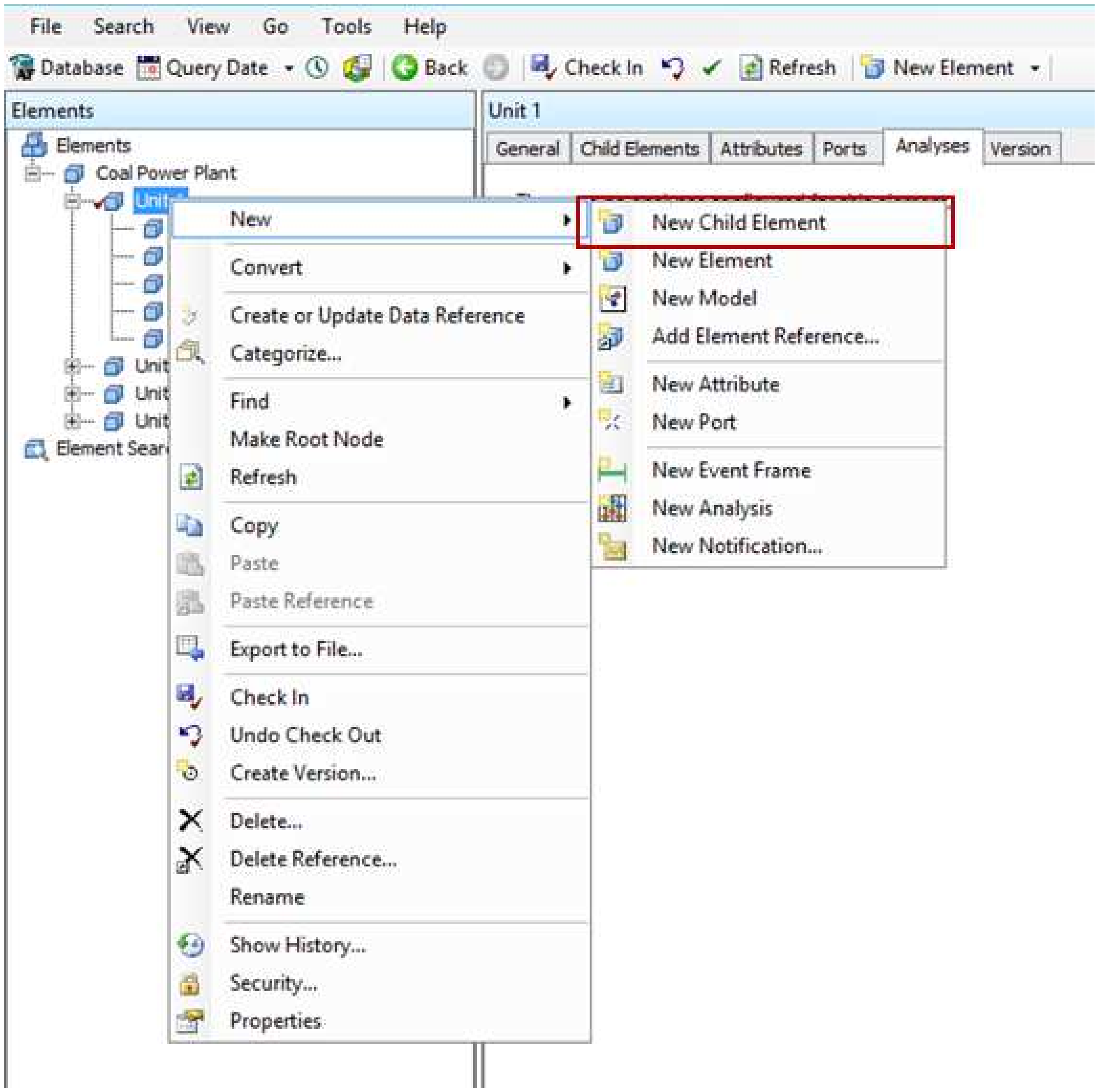
   a. BoilerEff, UOM = %, default value = 88
   b. ColdRHEnthalpy, UOM = Btu/lb, default value = 1300

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.



Name	Description	Default Value
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 enthalpyin 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

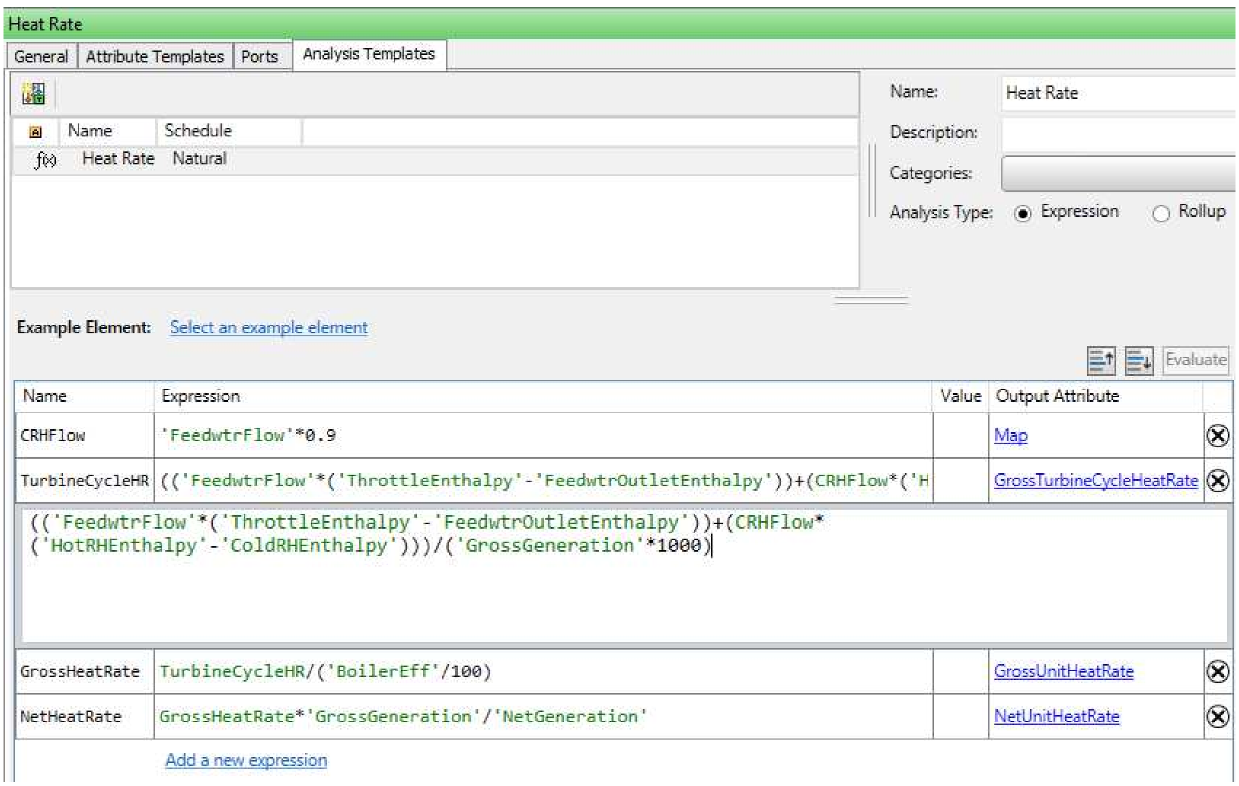
7. Go back to the Library and the Heat Rate element template. Click on the Analysis Template Tab and create a new analysis template.
   a. Select Expressions analysis type. Provide a name and description for your analysis.
   b. Select the Example Element to be the new Heat Rate element you just created 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.



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.

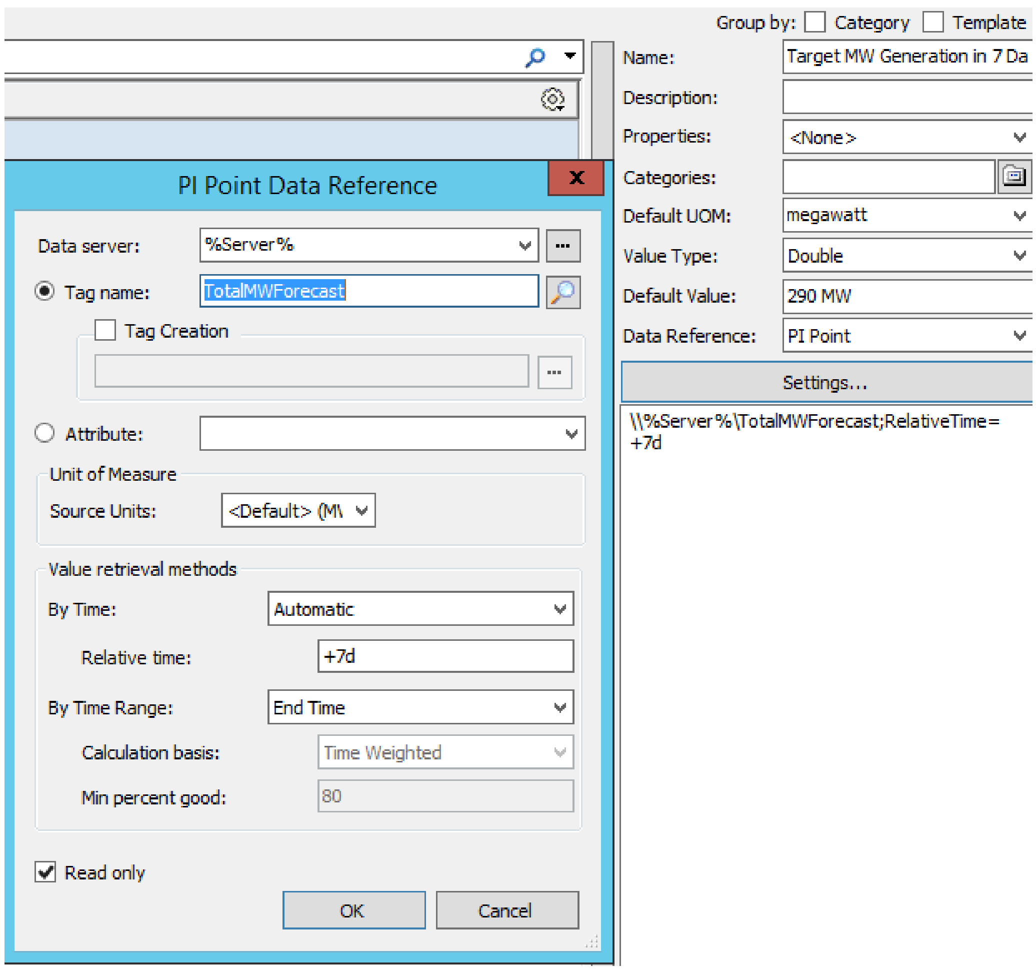
   a. In PI System Explorer, select File -> Import from File

b. Select the Heat Rate-SI file

Directed Activity 6 – Project Coal Usage Based on Generation Forecasts

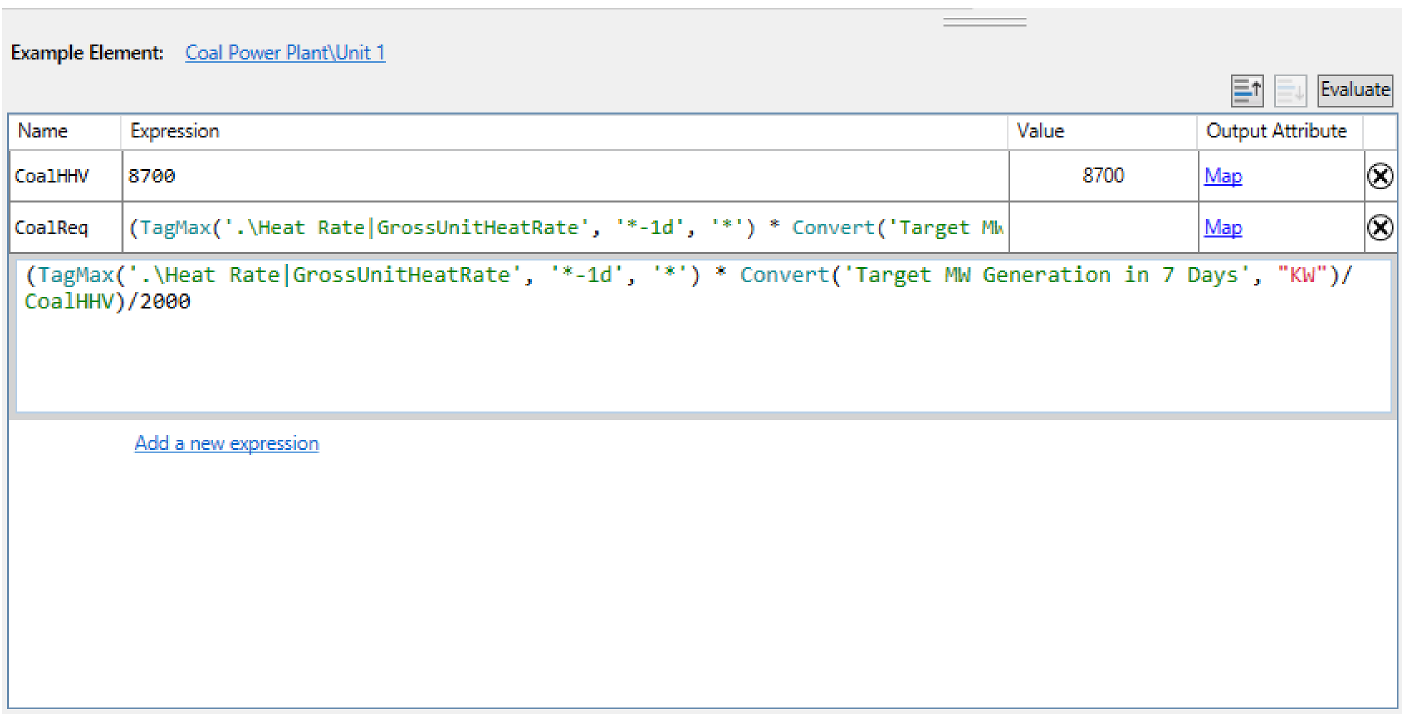
In this exercise, you will use the results from the calculations you have developed so far to project how much coal you will need on an hour by hour basis based on power generation forecasts. A PI Point has been pre-created which contains power generation forecasts through end of June 2015. You will 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:

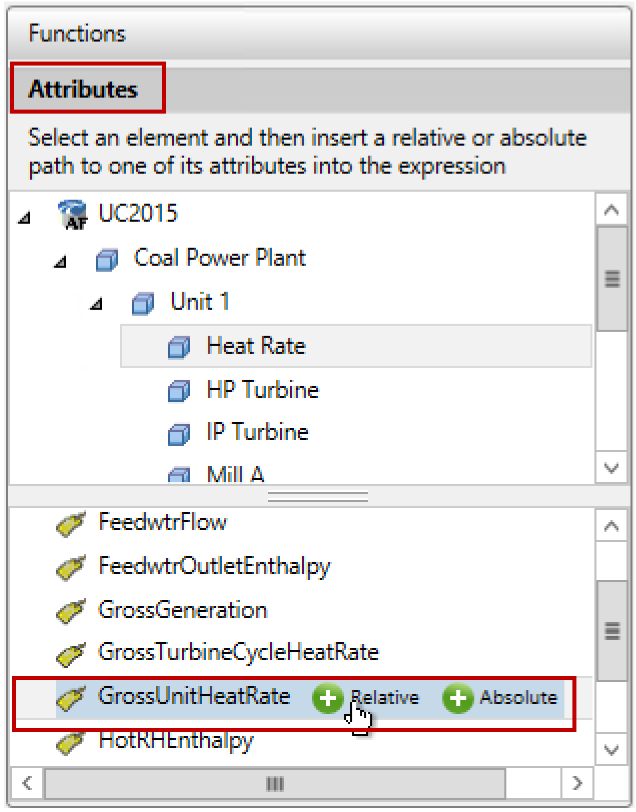


        ii. The Relative Time offset in the PI Point DR configuration will retrieve data from 7 days into the future. For the purpose of this exercise, the PI Point "TotalMWForecast" has been prepopulated with hourly MW forecast for ~3 Months into the future.
        iii. Go to the Analysis Template tab and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

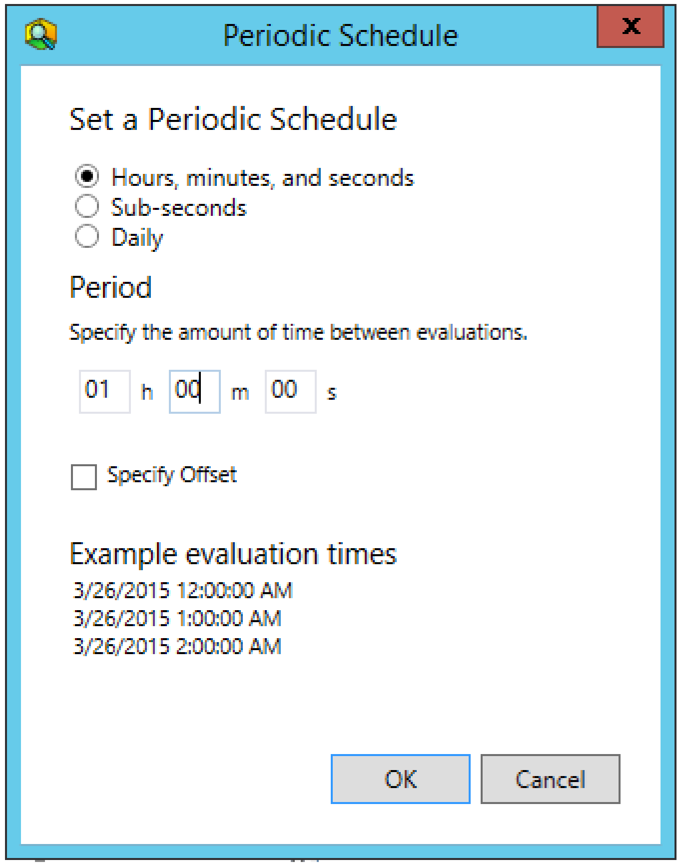
iv. Provide a name for the new analysis
v. Select Expression analysis type
vi. Select an Example element and choose Unit 1
vii. Create an analysis that would use the highest gross heat rate from Unit 1 in the last day to calculate the estimated required tonnage of Coal to support the MW forecast 7 days 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.



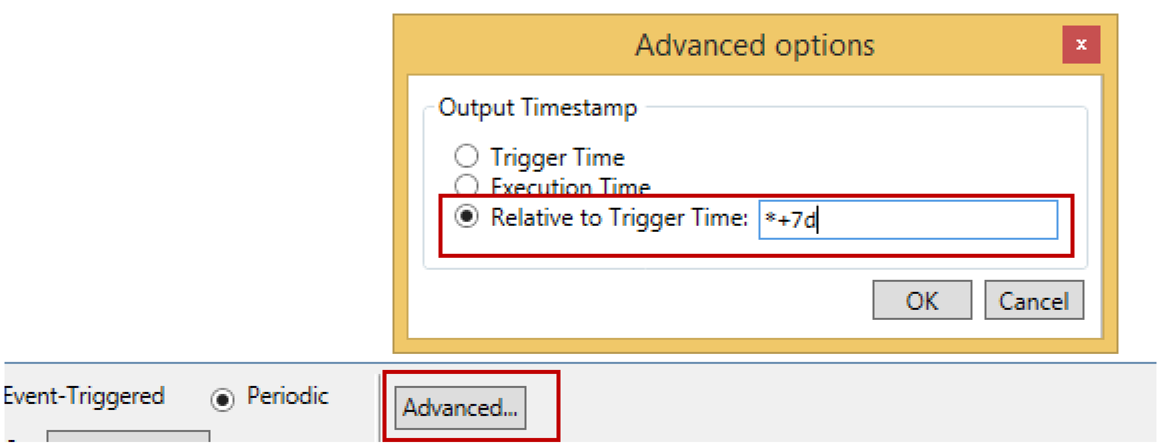
NOTE: Use the Attributes pane, located under the Functions pane, to traverse the element hierarchy in order to select the attribute that you need.



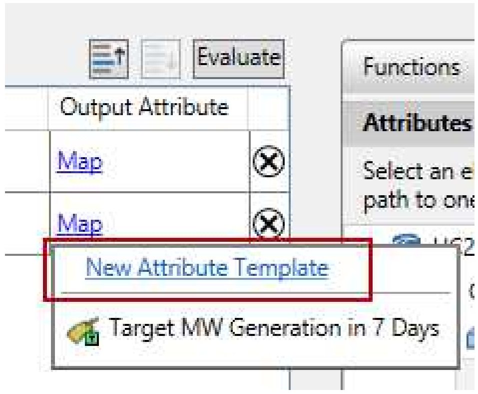
3. Configure the analysis to run Periodically every hour



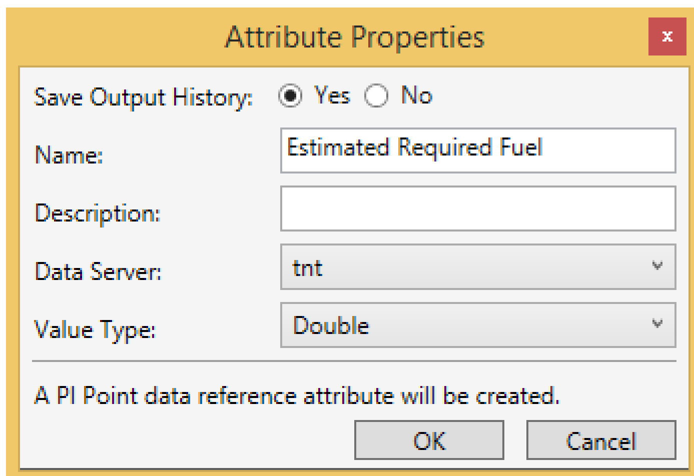
4. Select the Advanced button and configure the output to write the result 7 days into the future. This would enable you to have a time synchronized pair of values – the forecast MW and the calculated (estimated) coal required to satisfy the forecast based on the current condition of your Unit.



5. Map the output to a new attribute template



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



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.

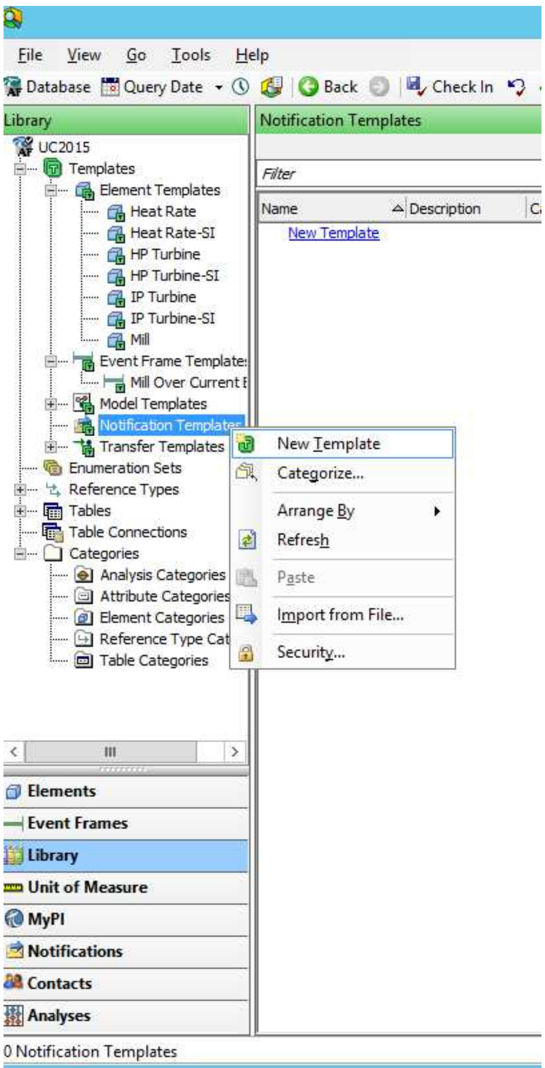
Directed Activity 7 – Building Notifications

Creating a Notification Template

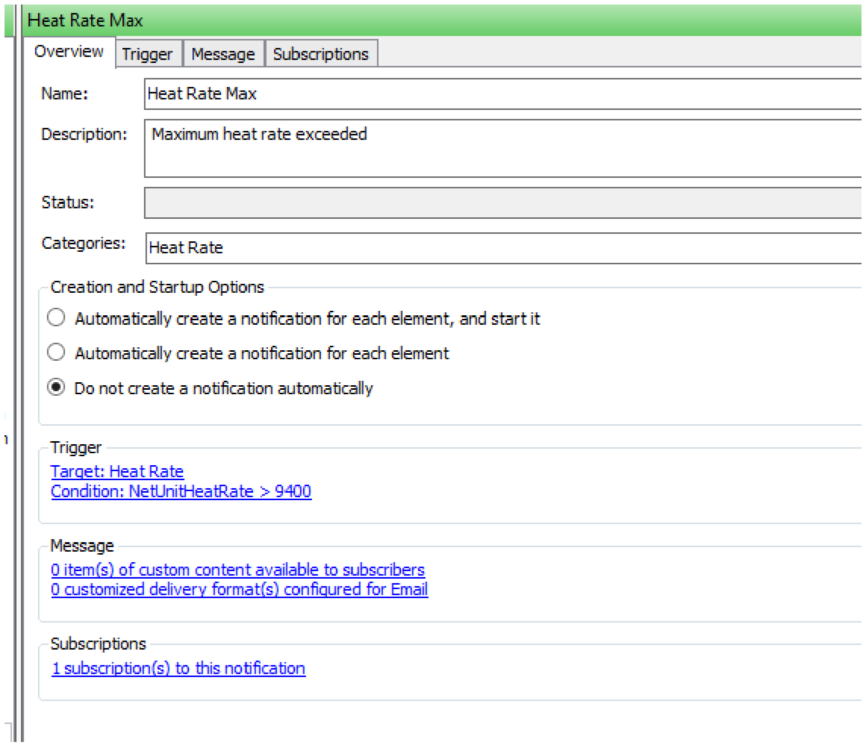
In this section, we will build AF Notifications to inform us when our process is operating in dangerous or suboptimal conditions. We would like to be notified when our Net Unit Heat Rate exceeds 9400 Btu/kWh. If the heat rate falls back to 9350 Btu/kWh or lower, then the assets are running well. This 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.

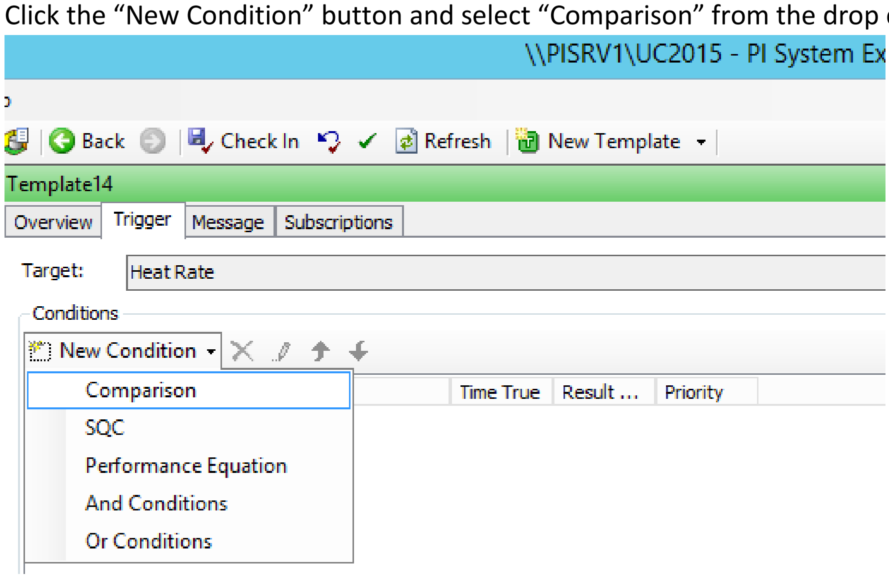
1. Go to your Library -> Notification Template section.
2. Create a new Notification Template by right clicking on the node and clicking "New Template…".



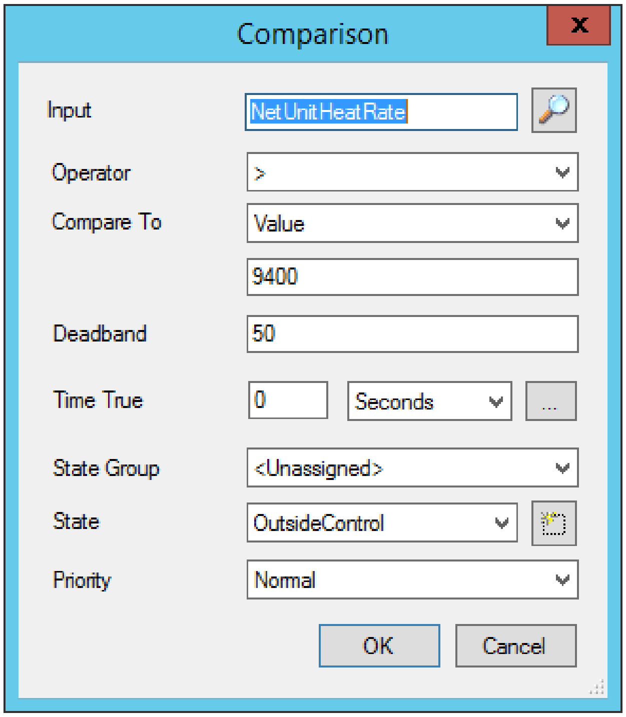
3. On the Overview tab, give the template a name like "Heat Rate Max" and a description like "Maximum heat rate exceeded". We have also added it to the "Heat Rate" category.



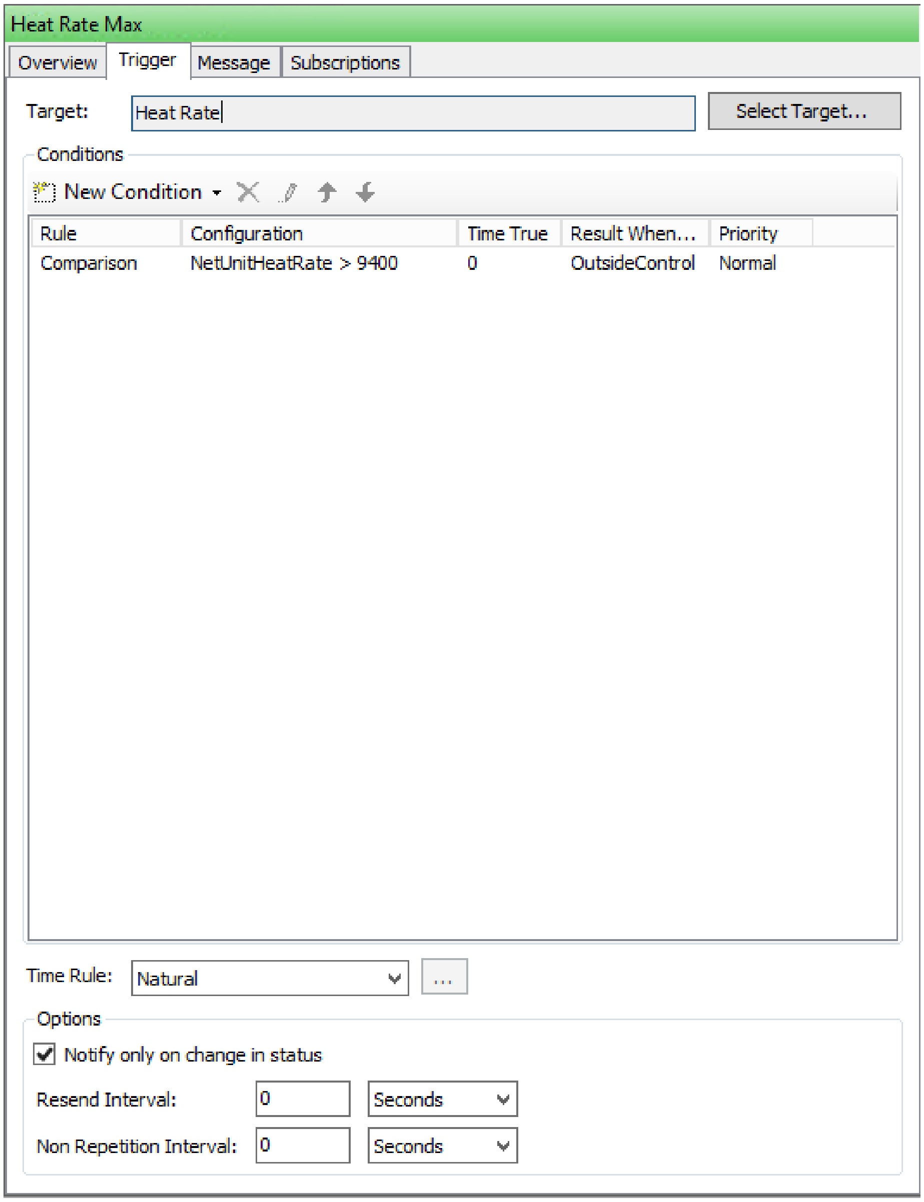
4. On the trigger tab, click the "Select Target…" and choose our Heat Rate template.
5. Click the "New Condition" button and select "Comparison" from the drop down menu.



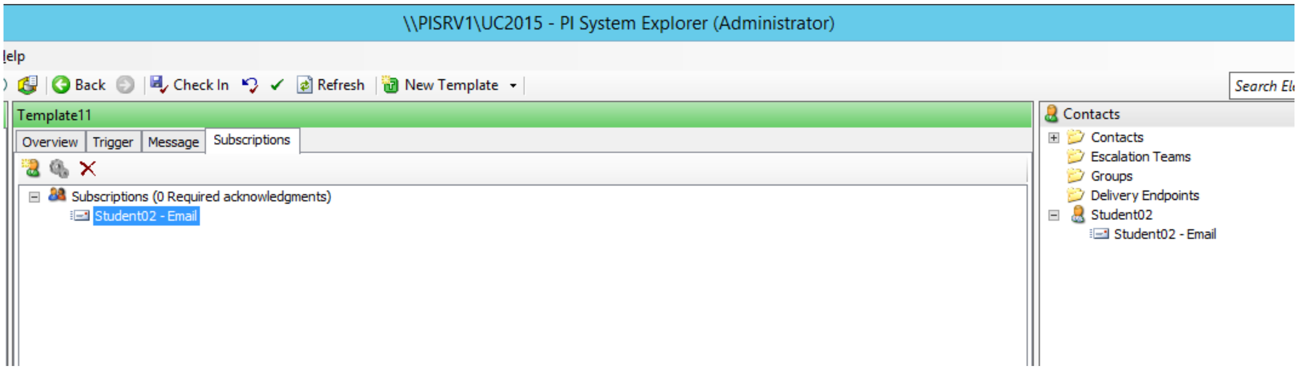
6. In the comparison dialog,
    a. Select the input attribute template "NetUnitHeatRate"
    b. Select the Operator ">".
    c. Set "Compare To" to "Value" and enter 9400 in the box.
    d. Set the Deadband to 50.
    e. Click OK.



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.

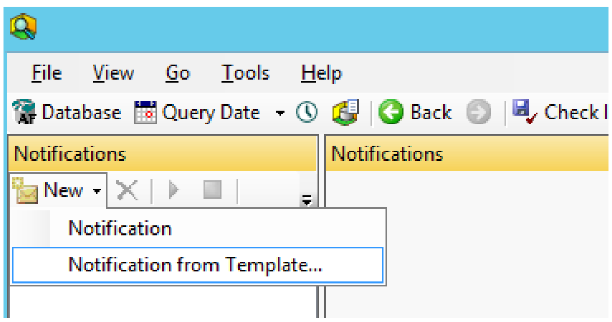


8. We are just going to use the default message, so we can skip the "Message" tab this time.
9. Finally, on the Subscriptions tab, we will add subscribers to the notification. In the palette on the right, expand our contact (here Student02) and drag-and-drop the email channel onto the subscription area.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

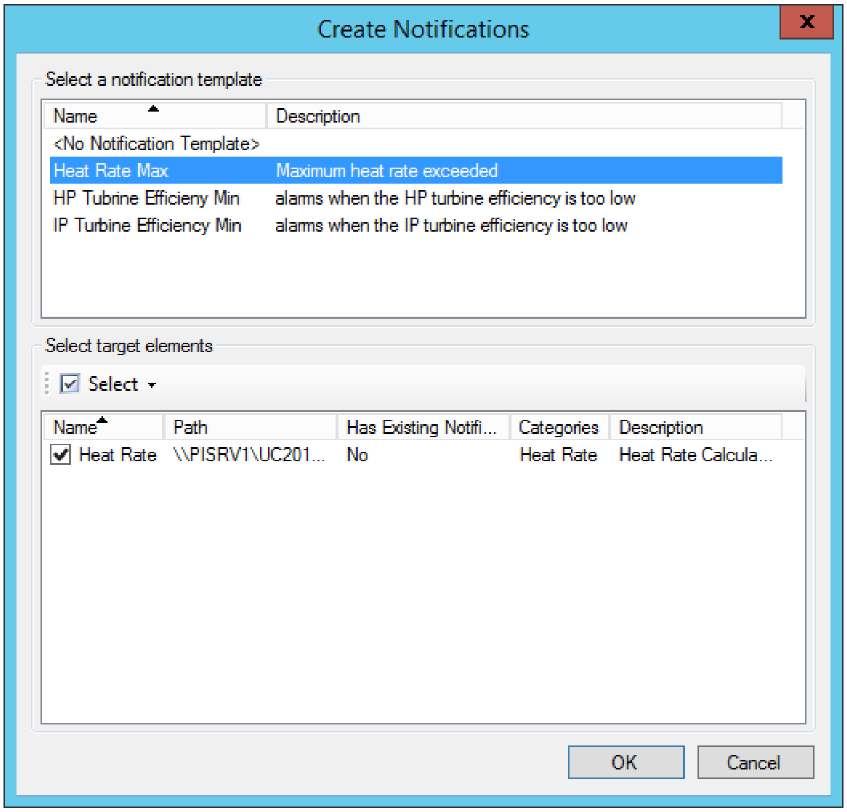


Creating a Notification from a Template

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.)



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

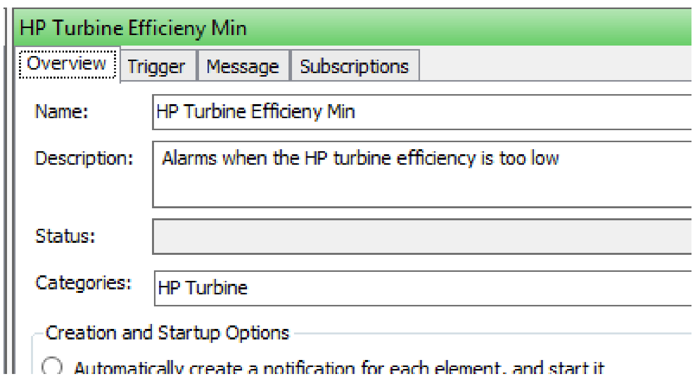
Directed Activity 8 – Advanced Notifications Uses

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.

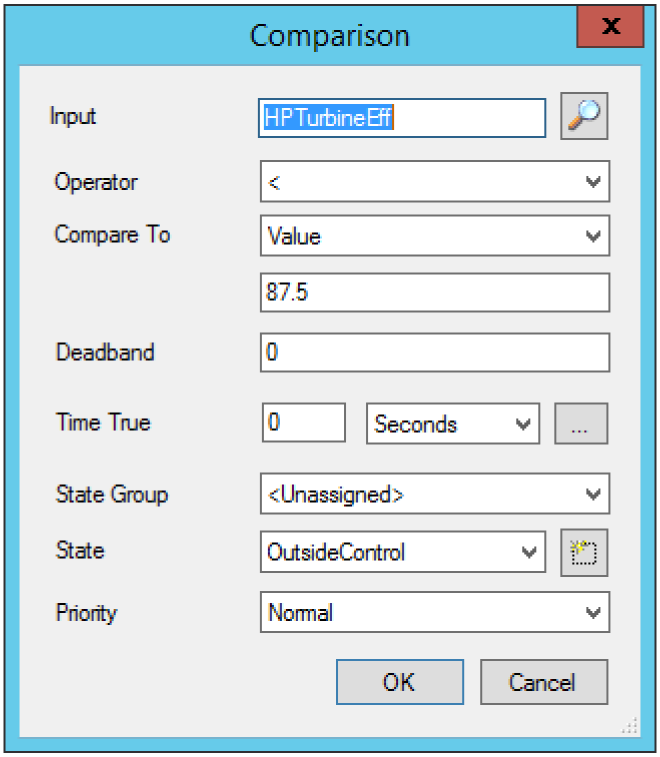
Customizing Notification Content

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.

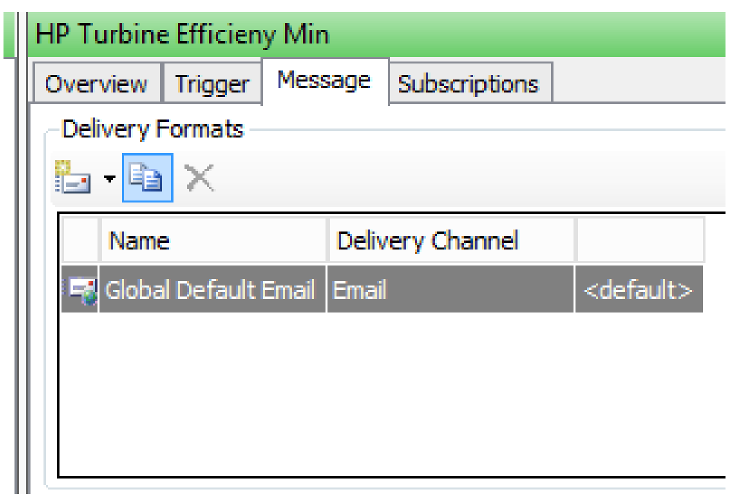
1. Go to your Library -> Notification Template section.
2. Create a new Notification Template by right clicking on the node and clicking “New Template…”.
3. On the Overview tab, give the template a name like “HP Turbine Efficiency Min” and a description like “Alarms when the HP turbine efficiency is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



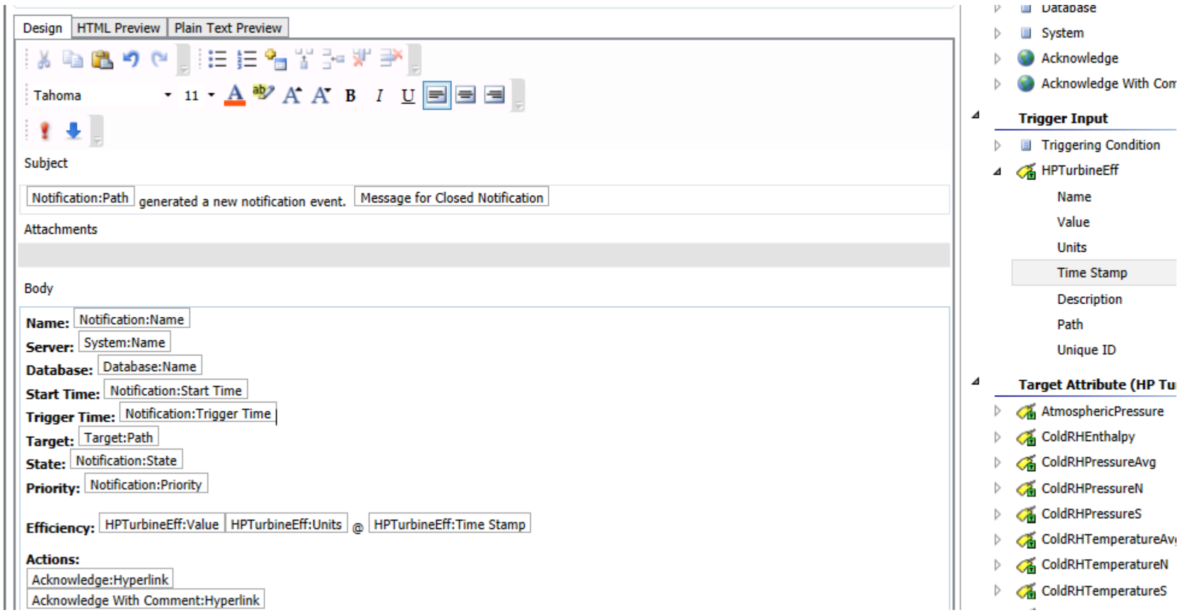
4. Next, on the Trigger tab, click “Select Target…” and select the “HP Turbine” element template as the target.
5. Click the “New Condition” button and select “Comparison” from the drop down menu.
6. In the comparison dialog,
   a. Select the input attribute template “HPTurbineEff”
   b. Select the Operator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



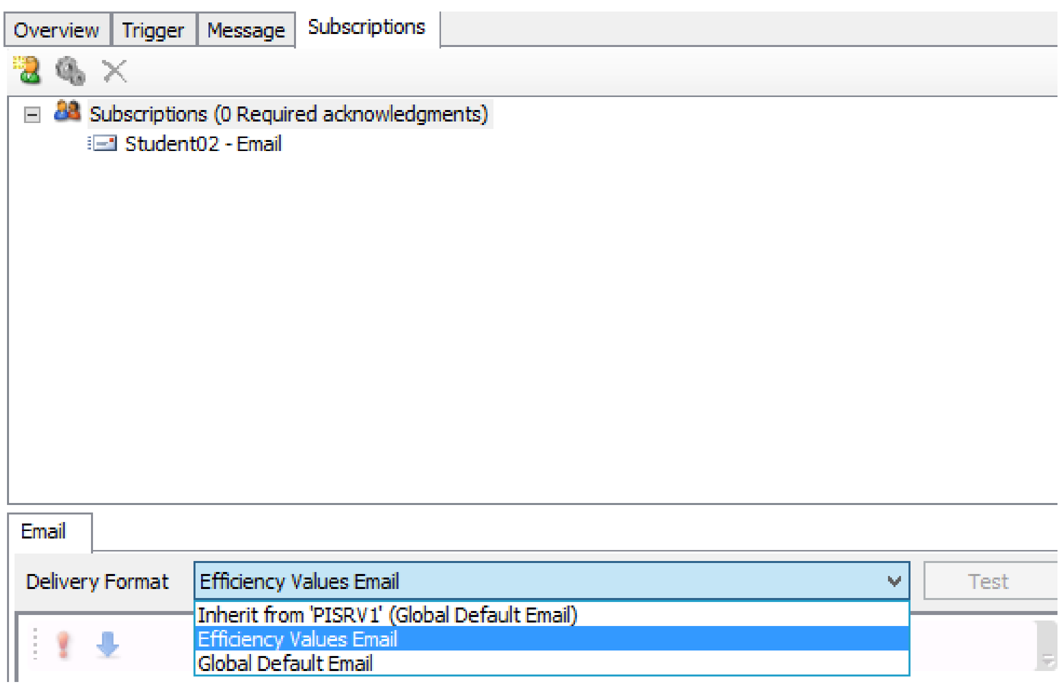
7. We will leave the Time Rule option as "Natural".
8. On the "Message" tab we will customize our message. Select the Global Default Email and Click the "Duplicate" button. Rename it to something like "Efficiency Values Email"



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.



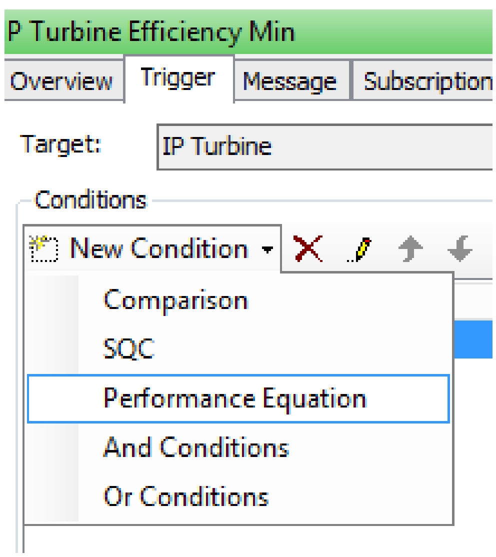
13. Finally, check in the notification template.

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.

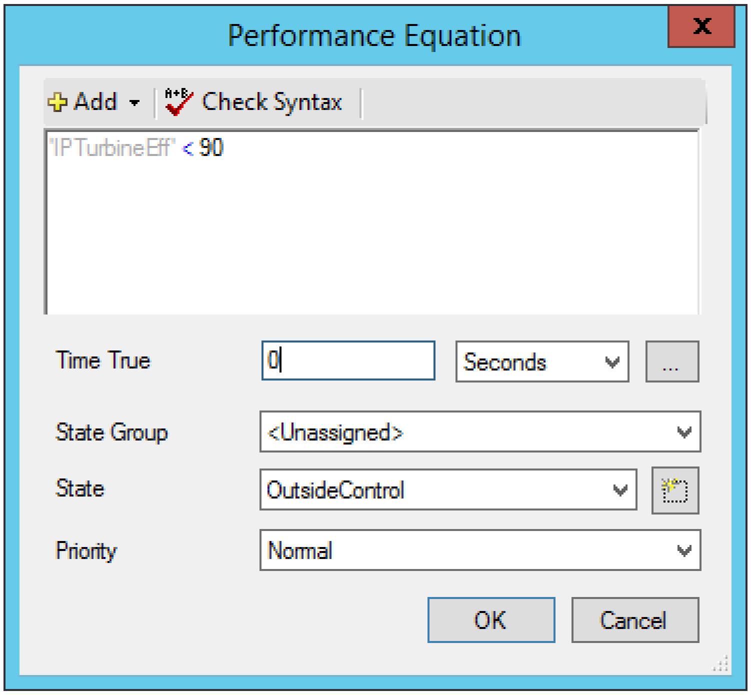
Performance Equation Triggers

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 "HP 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.



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.