

OCTOBER 2024

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# AVEVA PI System™ for Asset Health

AVEVA Enable 2024

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AVEVA



# Outcomes from today's session

- Leverage the PI Asset Framework to monitor the health of transformers
  - Model a transformer
  - Apply the model to a fleet of transformers
  - Use analytics to track the health of the assets
  - (If time permits) Create a PI Vision dashboard to visualize the asset health highlighting the ones in need of attention
- Learn a reproducible design process, applicable to other solutions
- While we're learning, think if this strategy could be applied to other assets. Could we do something similar with other KPIs?



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# Agenda

01 The PI System

02 Exercise

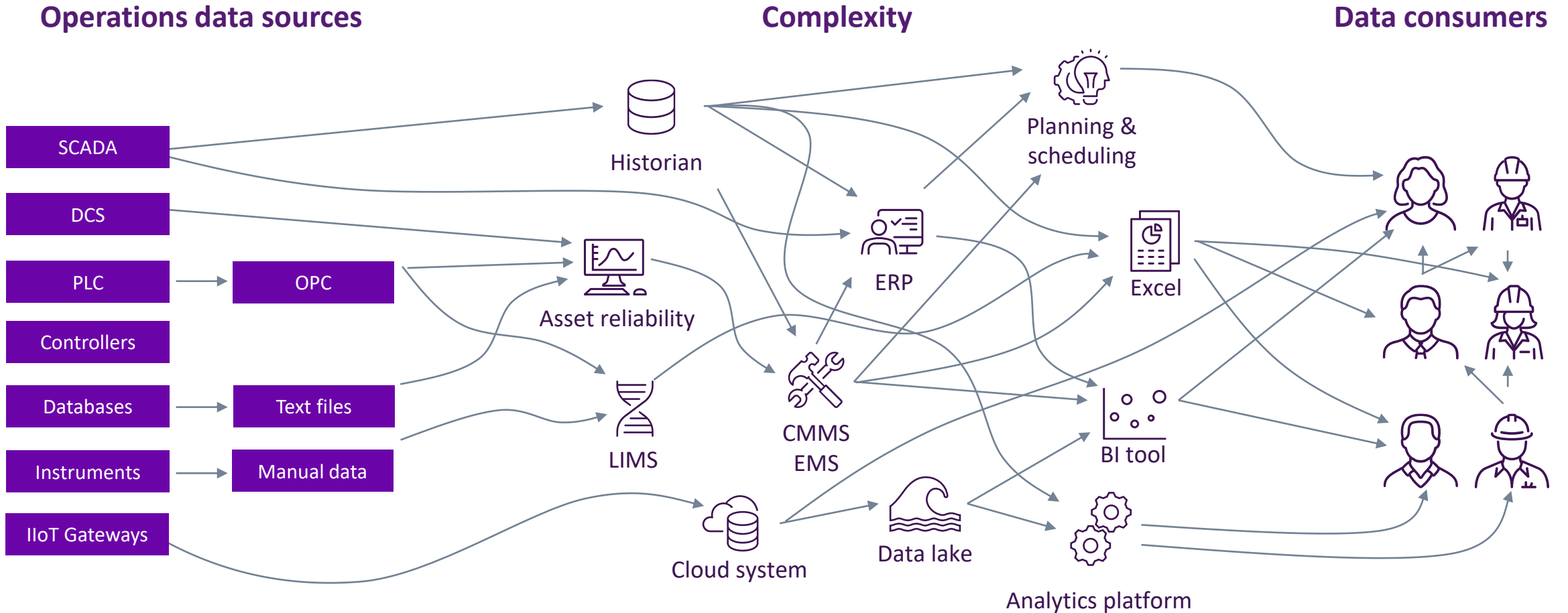
03 Discussion: What's Next?

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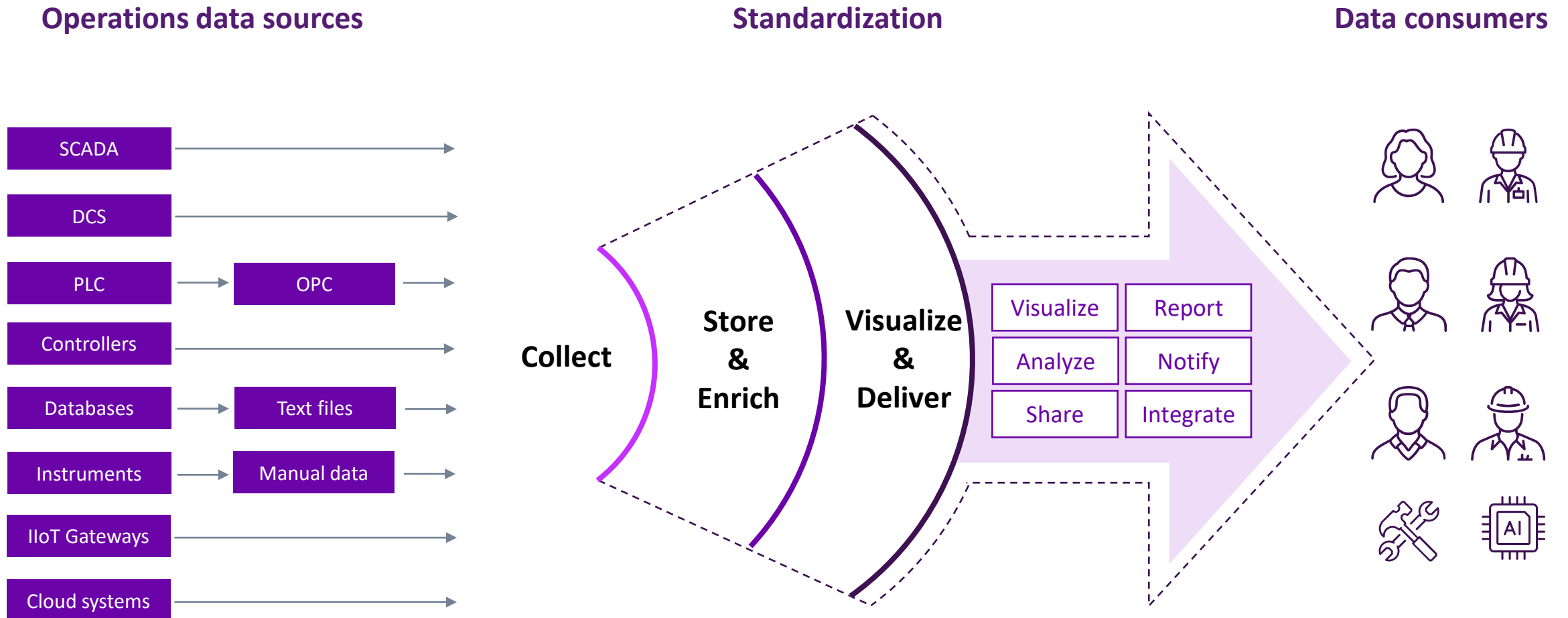
# The PI System



# Managing operations data is complex

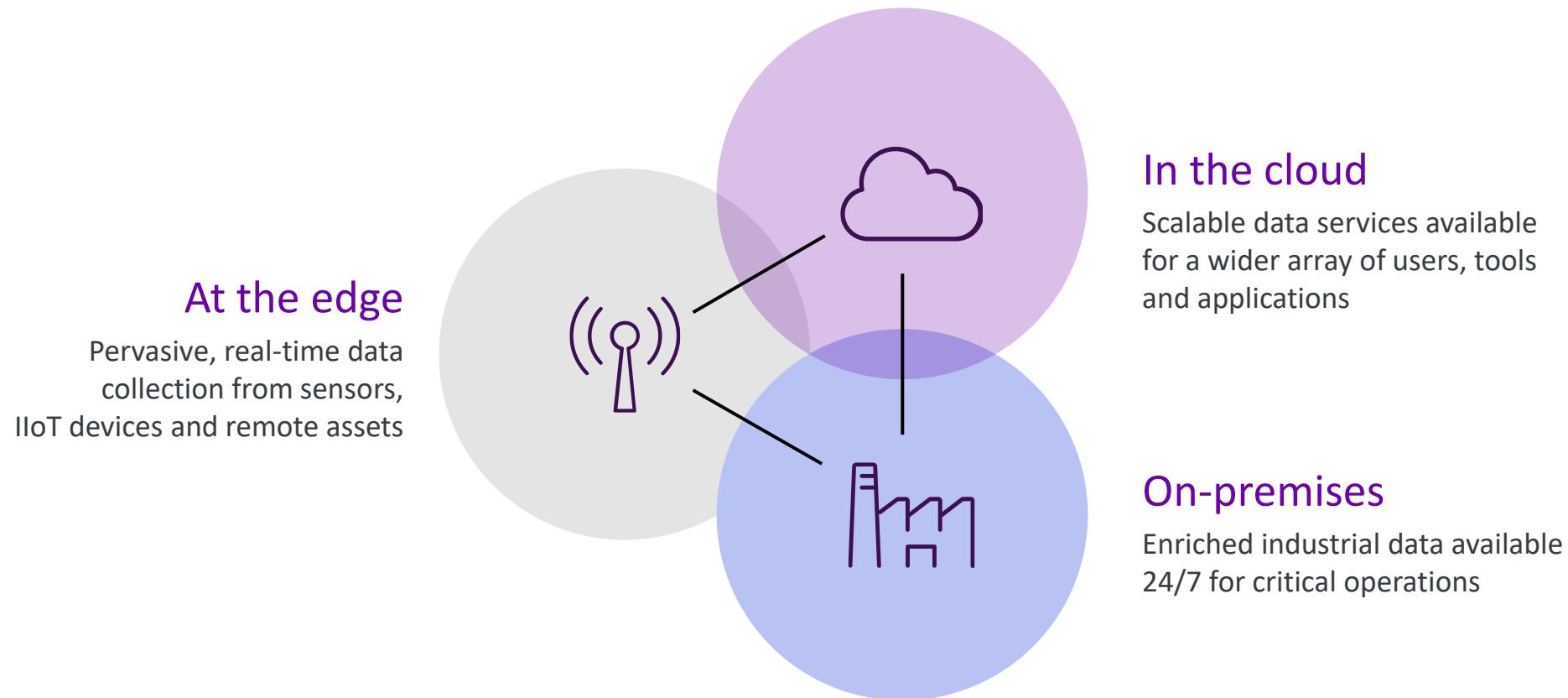


# Connect people to data with an infrastructure approach

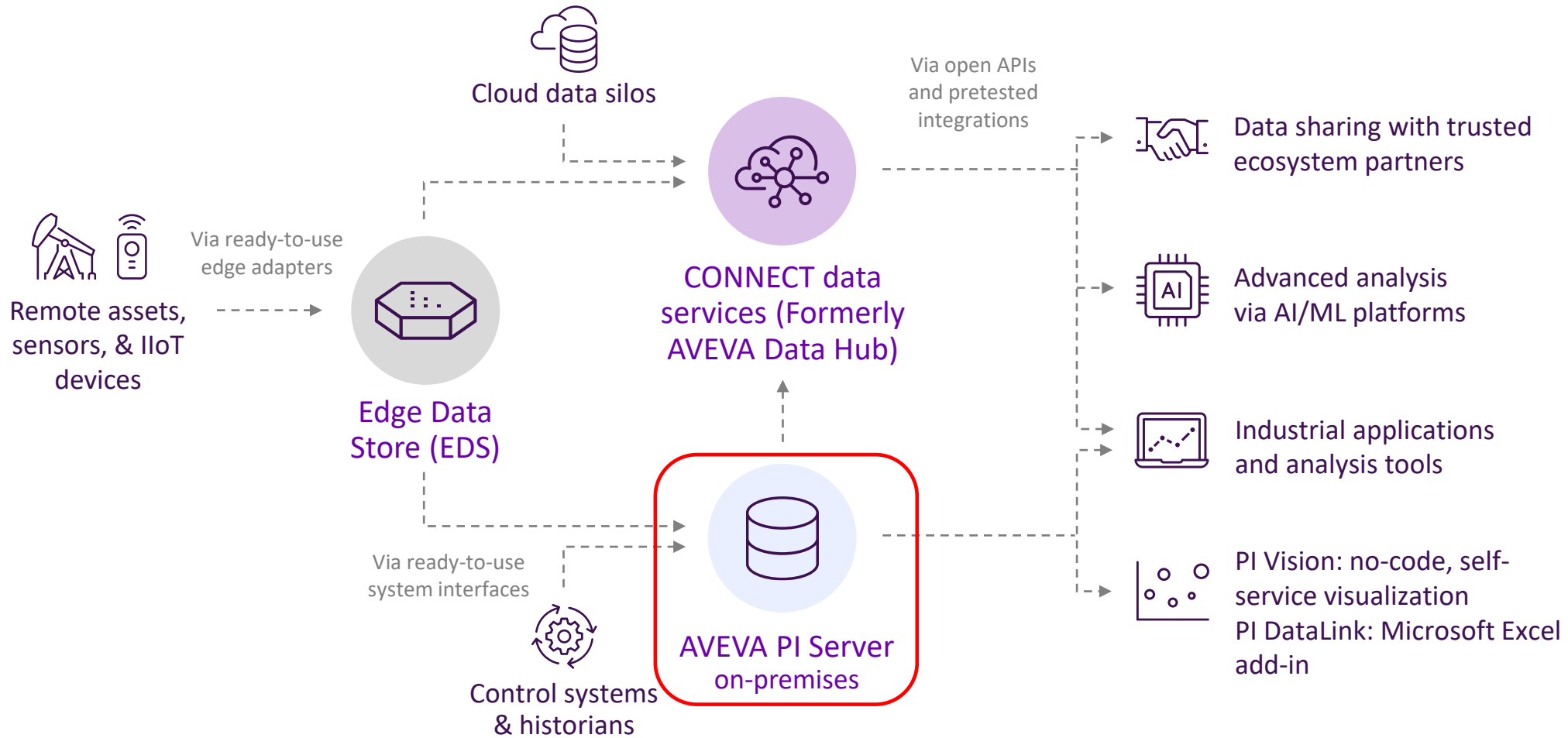


# AVEVA PI System's edge to plant to cloud data management

An integrated, edge-plant-cloud architecture supports OT, IT and IIoT use cases

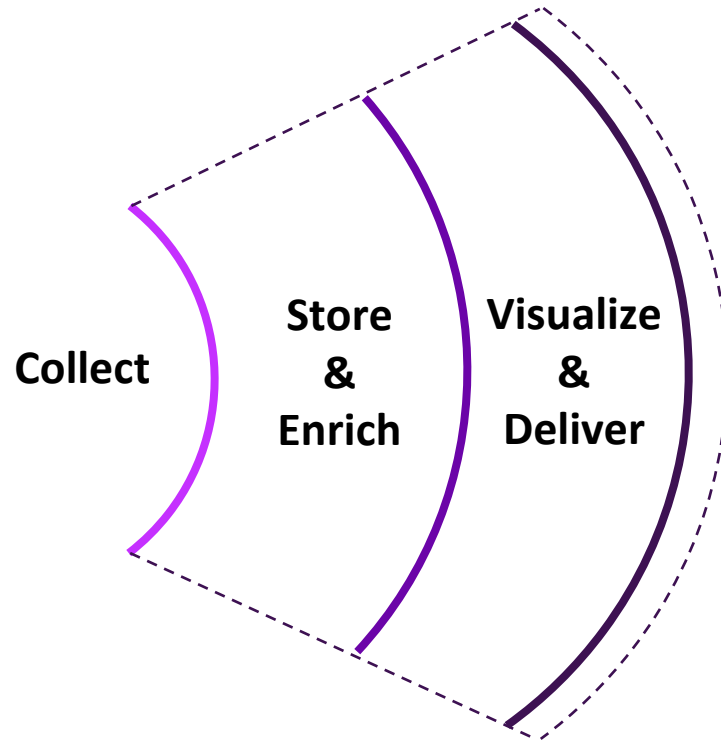


# Proven components accelerate time-to-value





# How AVEVA PI System technology helps our users



- It can **collect** the data that you need to make decisions
- It can **enrich** that raw data to turn it into actionable information
- And it can **deliver** it where and when you need it

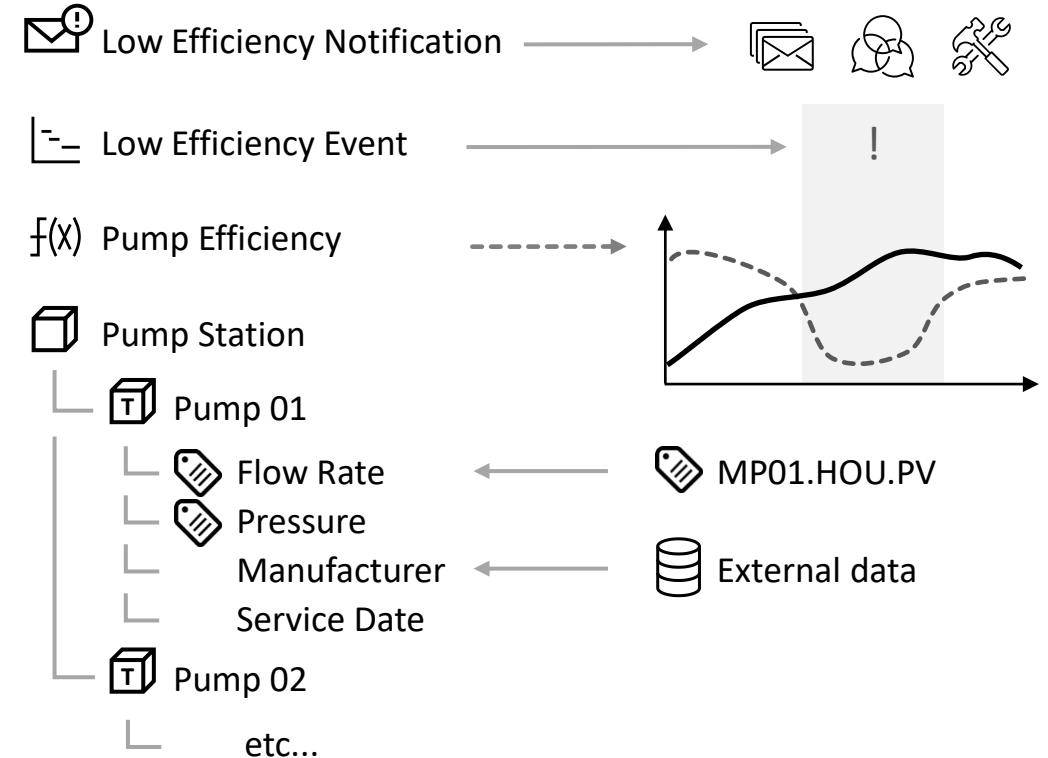
# AVEVA PI Server

PI Server layers data enrichment services on top of an industry-leading real-time operations data store.

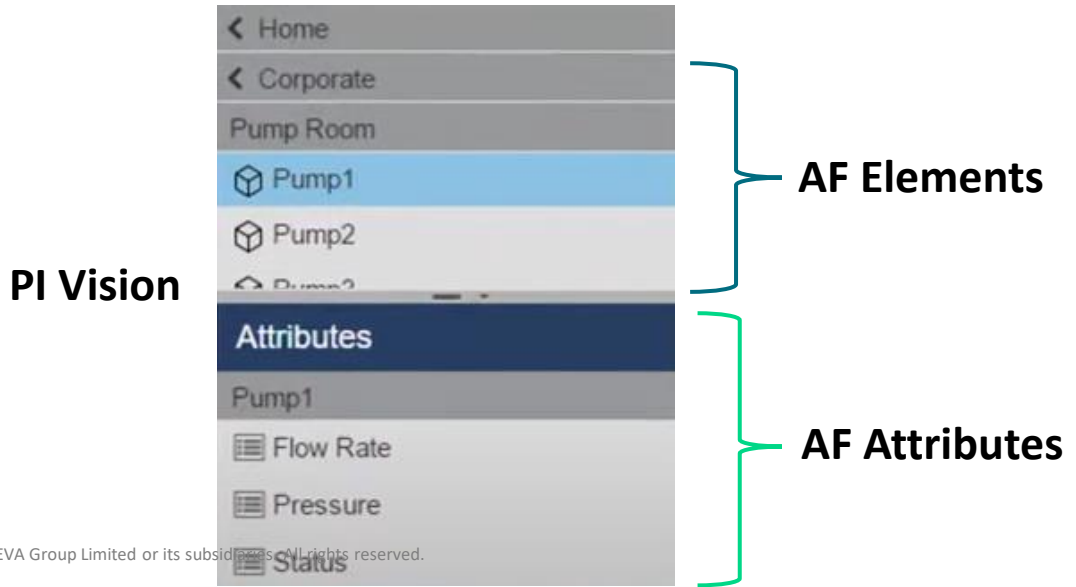
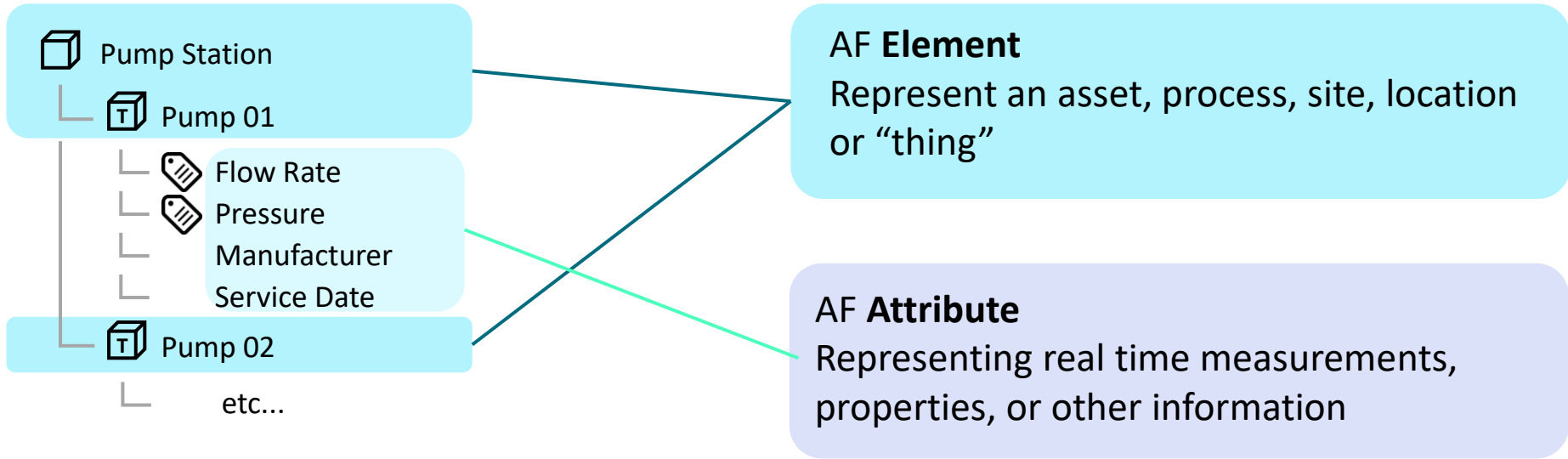
- Data Archive: real-time data storage
- Asset Framework: adds context to raw data streams
- Asset Analytics: user-defined calculations
- Event Frames: bookmark important events
- Notifications: send email or alerts when action is needed



PI Server



# AF Element & AF Attribute



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# Training Exercise





# The problem

- We need to monitor a fleet of transformers to identify the ones with bad health KPIs
- We will focus on two main use cases:
  - **High number of Load Tap Changer (LTC) position changes** – we will calculate the number of LTC position changes in the last 24hrs and the time since Last LTC position change and show these in a PI Vision dashboard
  - **High Hot-Spot Temperature** – we will calculate the Hot-Spot temperature using the Load and Top-Oil Temperature and capture high excursions using PI Event Frames



# The asset model

## Time series (e.g. sensor data)

- Current
- Load
- LTC position
- Top oil temperature

## Analysis (e.g. KPIs)

- LTC Position Change
- Hot-spot temperature

## Events (e.g. excursions)

- Hot-spot temperature high excursion



## Metadata (e.g. nameplate, limits)

- Rated current
- Rated hot-spot temperature
- Hot-spot temperature high
- Substation
- Number
- Winding exponent
- Manufacturer
- Model

# The solution

## Health dashboard (Collections)



# The solution

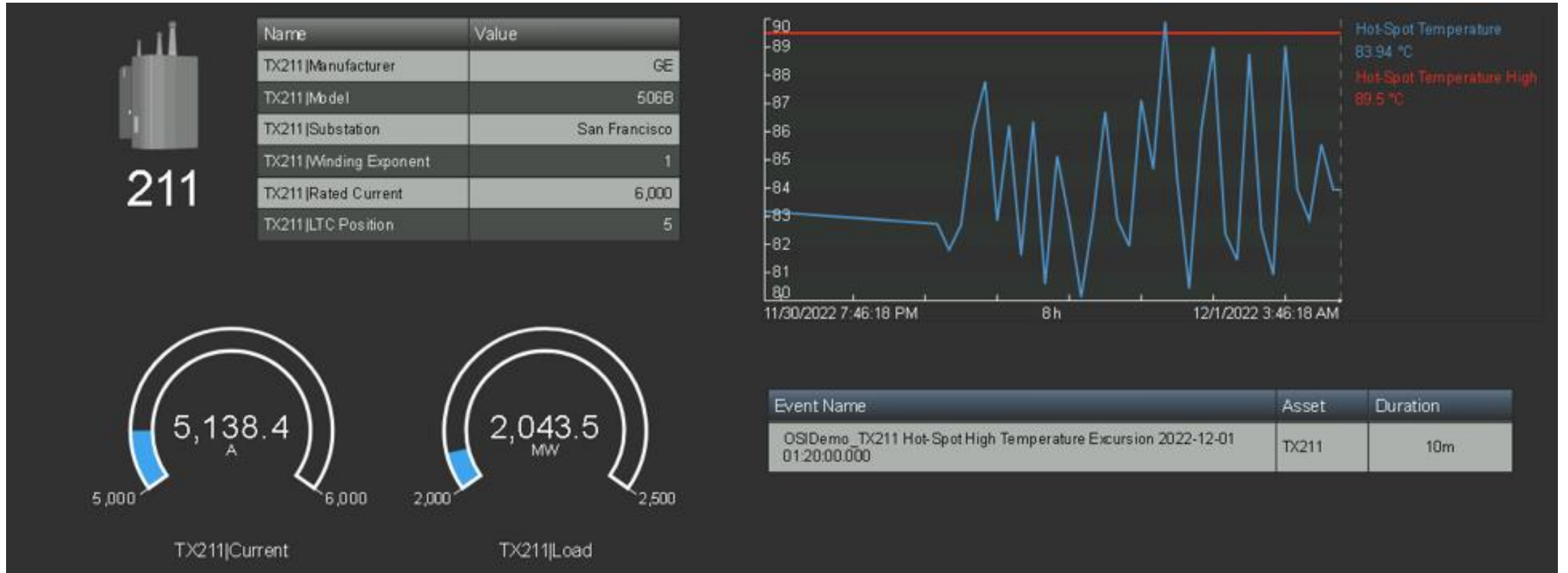
## Health dashboard (Collections)

Asset Comparison Table

Asset	Current	Load	LTC Position Change - 24 Hours	Hot-Spot Temperature	Top-Oil Temperature	Model	Substation
TX211	5,004.5	2,101.3	48	80.33	12.499	506B	San Francisco
TX212	5,022.1	2,374.2	48	80.765	12.353	506B	San Francisco
TX241	5,386.3	2,373.2	51	91.543	14.916	506A	Santa Clara
TX242	5,002.7	2,327.3	50	81.112	15.222	506B	Santa Clara
TX261	5,236.9	2,667.6	43	88.15	18.273	506A	Santa Cruz
TX262	5,000.6	2,531.4	51	81.27	15.924	506B	Santa Cruz
TX511	5,596.5	4,961.8	47	99.849	31.902	506B	Tulare
TX512	5,452.2	5,776.7	43	97.437	37.912	506B	Tulare
TX531	5,407.2	5,132.8	49	95.326	31.875	506A	Mariposa
TX532	5,316.4	6,022.5	52	93.195	31.795	506B	Mariposa
TX551	5,676	5,491.6	50	102.1	34.842	506B	Merced
TX552	5,566	5,414.7	44	99.418	34.115	506B	Merced
TX571	5,454.5	5,913.7	52	97.129	35.847	506A	San Luis Obispo
TX572	5,210.6	5,843.9	40	93.899	44.505	506B	San Luis Obispo

# The solution

## Transformer details



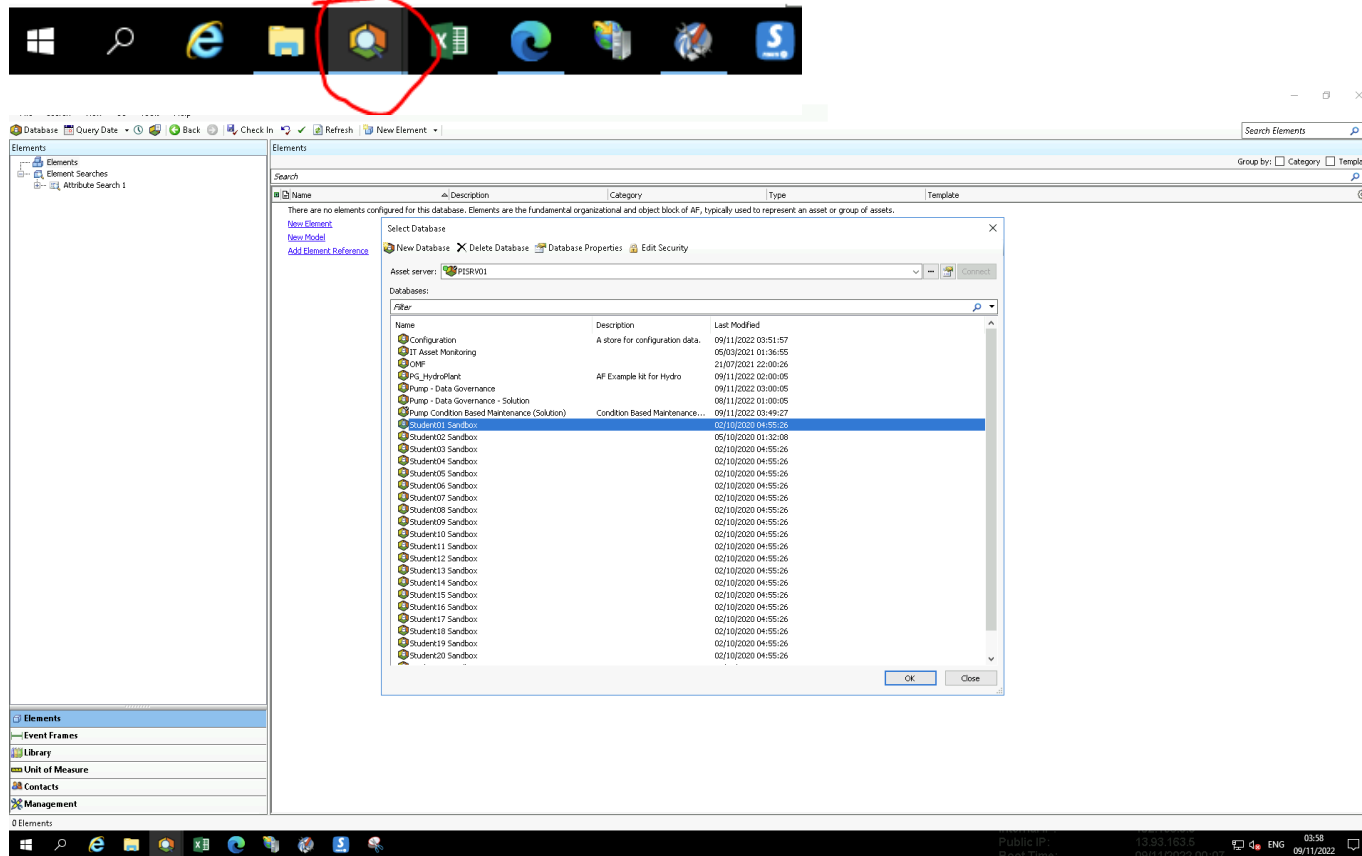
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# Step by Step Approach (Breakout Sessions)



# Step by step approach

## Creating the first asset



- Open PI system Explorer in the taskbar.
- Click Database on the top left.
- Select the 'Database' corresponding to your Student Name (Student XX Sandbox) and click OK

# Step by step approach

## Creating the first asset

The first screenshot shows the 'Elements' tree in PI System Explorer. A right-click context menu is open over the 'Elements' folder, with 'New Element' selected. A purple circle with the number '1' is placed over the 'New Element' option.

The second screenshot shows the 'Choose Element Template' dialog box. The 'Parent' field is set to 'Student01 Sandbox'. Under 'Add child element using the reference type:', 'Parent-Child' is selected. The 'Element Template' field is set to '<None>'. A purple circle with the number '2' is placed over the 'Parent' field.

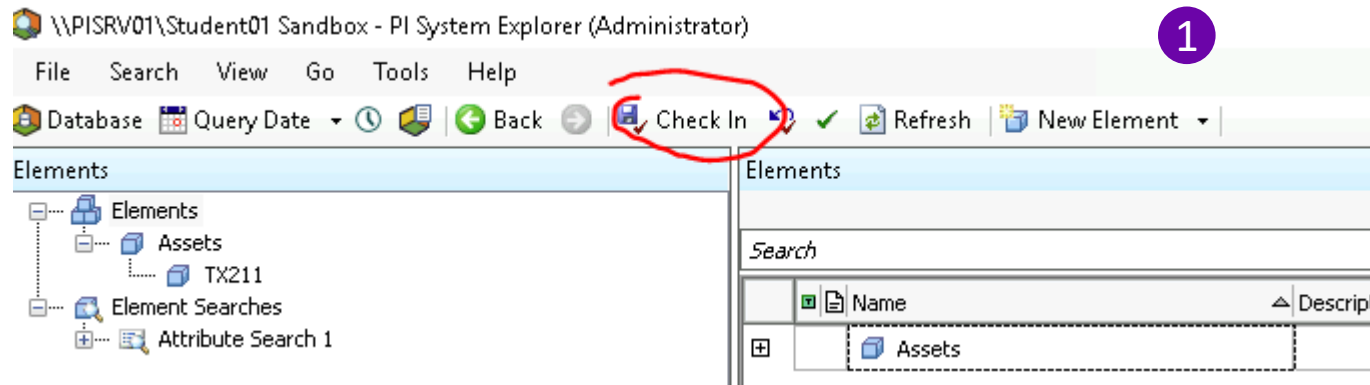
The third screenshot shows the 'Assets' element being created. The 'Assets' element is highlighted in the 'Elements' tree. A purple circle with the number '3' is placed over the 'Assets' element. The 'Assets' properties window is open, showing the 'Name' field set to 'Assets'.

The fourth screenshot shows the final state of the 'Elements' tree. The 'Assets' element is now a child of the 'Elements' folder, and a sub-element 'TX211' is visible under 'Assets'. A purple circle with the number '4' is placed over the 'Elements' folder.

- Right click 'Elements' and 'New Element' and create an Element called 'Assets'.
- Right click on the new element 'Assets' and then **New -> New Child Element**. Create an element called 'TX211'.
- This will be our first transformer. We will have 14 transformers at the end.

# Step by step approach

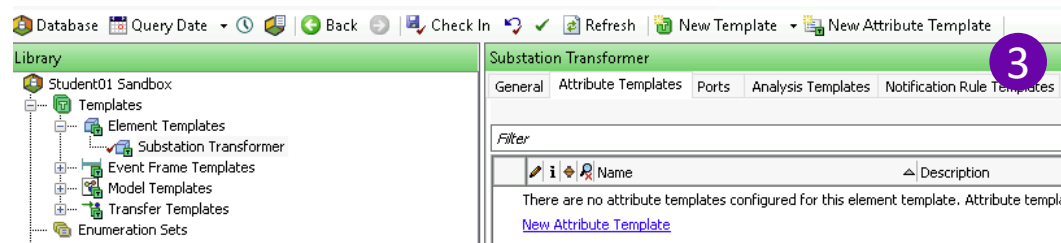
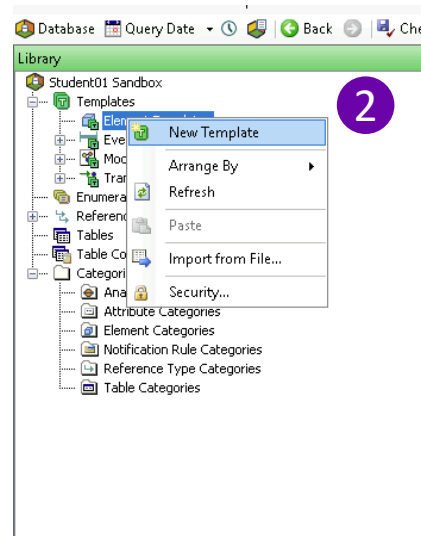
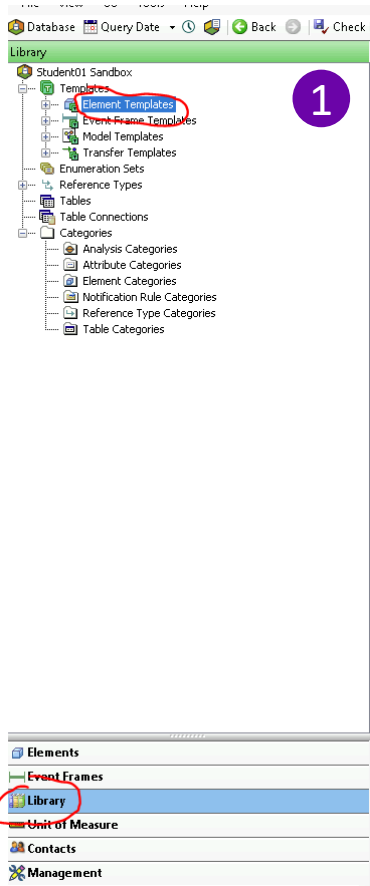
## Creating the first asset



- Note the little 'tick mark' next to the element name. This indicates the changes are still pending and need to be checked-in.
- To do so, click '**Check In**' at the top toolbar. If prompted to confirm click OK.
- Don't forget to Check In your work whenever you make changes and have reviewed what you've created.

# Step by step approach

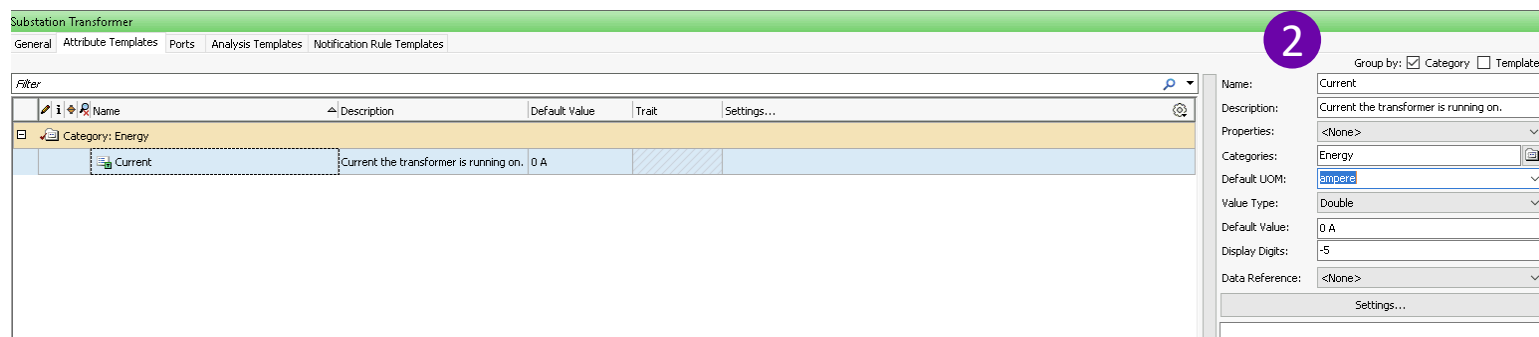
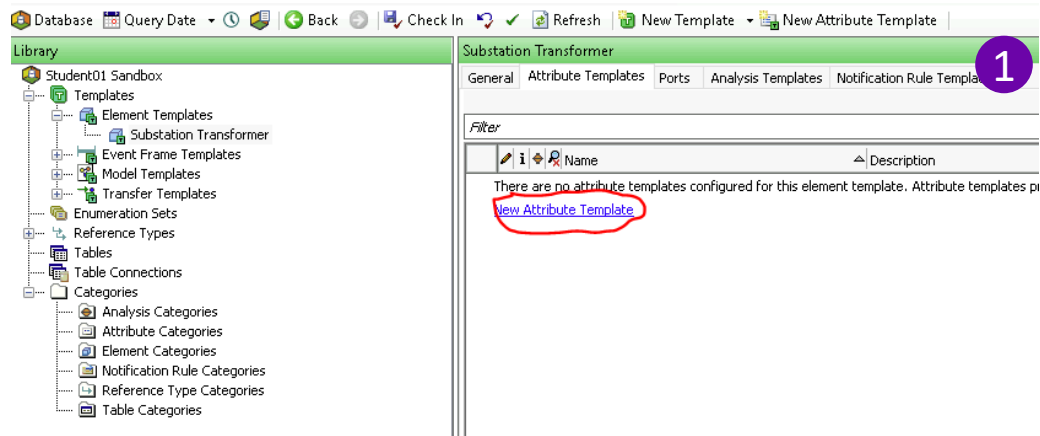
## Creating the asset template



- We could continue to build the asset by adding its 'Attributes' straight away but this would limit us.
- AF has a feature called **Template** that gives us the ability to create one model of the asset and use it multiple types, which is very helpful when dealing with a large number of assets of the same type in the real world.
- So, we will switch to **Library** and start building the asset model from there.
- Right Click 'Element Templates' and create a 'New Template' called '**Substation Transformer**'.

# Step by step approach

## Creating the attribute templates



- Next we will add the attributes to the template. Click on the 'Attribute Templates tab'. Attributes can represent the properties of the transformer such as sensor data and metadata.
- Let's start with the sensor data. Click 'New Attribute Template' and add a new Attribute called Current.
- Fill in the details (**Name, Description, Categories, Default UOM**) according to the screenshot.
- The UOM is an important field and AF can do some unit conversions if necessary. Sometimes we want to display the units differently than the ones sent by the instrumentation.



# Step by step approach

## Creating the attribute templates

Group by:  Category  Template

Name: Current

Description: Current the transformer is running on.

Properties: <None>

Categories: Energy

Default UOM: ampere

Value Type: Double

Default Value: 0 A

Display Digits: -5

Data Reference: PI Point

Settings...

Tag Search

Server(s): PISRV01

\*current\*

Name	Data Server	Display Digits	Description	Point Source	Data Type	Point Class	Energy
GU1 Generator.Current Phase A	PISRV01	2		OSIDemo-AF...	Float64	base	
GU1 Generator.Current Phase B	PISRV01	2		OSIDemo-AF...	Float64	base	
GU1 Generator.Current Phase C	PISRV01	2		OSIDemo-AF...	Float64	base	
GU2 Generator.Current Phase A	PISRV01	2		OSIDemo-AF...	Float64	base	
GU2 Generator.Current Phase B	PISRV01	2		OSIDemo-AF...	Float64	base	
GU2 Generator.Current Phase C	PISRV01	2		OSIDemo-AF...	Float64	base	
GU3 Generator.Current Phase A	PISRV01	2		OSIDemo-AF...	Float64	base	
GU3 Generator.Current Phase B	PISRV01	2		OSIDemo-AF...	Float64	base	
GU3 Generator.Current Phase C	PISRV01	2		OSIDemo-AF...	Float64	base	
GU4 Generator.Current Phase A	PISRV01	2		OSIDemo-AF...	Float64	base	
GU4 Generator.Current Phase B	PISRV01	2		OSIDemo-AF...	Float64	base	
GU4 Generator.Current Phase C	PISRV01	2		OSIDemo-AF...	Float64	base	
OSIDemo_TX211.Current	PISRV01	-5		OSIDemo-AF...	Float32	base	
OSIDemo_TX212.Current	PISRV01	-5		OSIDemo-AF...	Float32	base	
OSIDemo_TX241.Current	PISRV01	-5		OSIDemo-AF...	Float32	base	
OSIDemo_TX242.Current	PISRV01	-5		OSIDemo-AF...	Float32	base	
OSIDemo_TX261.Current	PISRV01	-5		OSIDemo-AF...	Float32	base	

26 results returned in 0.5029514 seconds.

OK Cancel Reset

PI Point Data Reference

Data server: %Server%

Tag name: %Element%.%Attribute%

Tag Creation

Attribute:

Unit of Measure

Source Units: <Default> (A)

Value retrieval methods

By Time: Automatic

Relative time:

By Time Range: End Time

Calculation basis: Time Weighted

Min percent good: 80

Preview

Example instance: [Select example instance](#)

Configuration:

Value:

Read only

OK Cancel

Tag name: OSIDemo\_TX211.Current

Tag Creation

Attribute:

Unit of Measure

Source Units: A

- Now we need to 'map' this Attribute to a PI Point (also called a PI Tag), which is the actual measurement coming from the data source.
- Select '**PI Point**' as Data reference of the Current Attribute and click 'Settings'.
- Click the '**Tag Search**' button and do a Search for **\*current\*** to filter the Current tags.
- Select 'OSIDemo\_TX211.Current' and click OK.
- Make sure the **Unit of Measure is set to A**, not <Default> (A). It is good practice to specify the UOM. Click OK again to close.
- Don't forget to check-in your changes.

# Step by step approach

## Applying the template to the existing element

The screenshot illustrates the process of applying a template to an existing element in three steps:

- Step 1:** In the 'Elements' tree, right-click on the element 'TX211' and select 'Convert' > 'Change Template...'.
- Step 2:** The 'Choose Element Template' dialog box is open. The 'Name' field contains 'TX211'. Under 'Element Template', 'Substation Transformer' is selected. The 'Templates of category' dropdown is set to '<Any>'. A warning message states: 'Warning: Changing the template of an existing Element may have unintended consequences. Use with caution.' The 'OK' button is highlighted.
- Step 3:** The 'Attributes' tab for 'TX211' is displayed. The 'Current' attribute is set to '5034.9 A'.

- We need to make sure that the Element we created before is an instance of the template we just created.
- Go back to the Elements, **right click TX211** and then choose **'Convert' and 'Change Template'**.
- Select **'Substation Transformer'** and click OK.
- Note that the Attribute 'Current' now has a value coming from the mapped tag.

# Step by step approach

## Creating a new element from a template

The screenshot illustrates the process of creating a new element from a template in a software application. It is divided into three numbered steps:

- Step 1:** The user right-clicks on the 'Assets' folder in the 'Elements' tree and selects 'New' > 'New Child Element'.
- Step 2:** The 'Choose Element Template' dialog box is shown. The 'Parent' is set to 'Assets'. Under 'Add child element using the reference type:', 'Composition' and 'Parent-Child' are listed. Under 'Element Template:', '<None>' and 'Substation Transformer' are listed. The 'Substation Transformer' template is selected.
- Step 3:** The 'Filter' table is shown. It has columns for 'Name' and 'Value'. The table contains the following data:

Name	Value
Category: Energy	
Current	5034.9 A

- Let's create another transformer and use the template and see what happens to the Current's value.
- Right click 'Assets', then 'New' and '**New Child Element**'.
- Choose the '**Substation Transformer**' template and name the transformer '**TX212**'.
- Notice it already has inherited the Attribute Current. But there is an issue here. Swap between TX211 and TX212 to see if you can spot it.
- Both transformers have the same value for the Current, because we actually 'hardcoded' the tag for the mapping in the Template. This is not what we want and we **will go back to the Template to fix this**.

# Step by step approach

## Using substitution parameters

Symbol	Description	Examples
%...%	Considers the expression as a substitution parameter.	%Element% %Attribute%
.	Current element or attribute. Use . to navigate down from current element. Use .  to navigate to child attributes of the current attribute.	%.ChildElement Attribute%
..	Navigates a level up.	%. .Element% %. .Attribute%
\	Separates components of a path, except attributes.	%. Element%
	Separates attributes in a path.	%. .Attribute%
@	References the value of the object instead of its name. <b>Note:</b> Only PI point data references use attribute value substitution syntax. Other data references, such as formula, table lookup, and String Builder have a simpler syntax for referencing attribute values.	<ul style="list-style-type: none"><li>Attribute value at same level as attribute: %@Attribute%</li><li>Attribute value at root level of same element: %@ Attribute%</li><li>Attribute value at parent attribute level: %@. .Attribute%</li><li>Attribute value at parent element level: %@. . Attribute%</li><li>Attribute value of child attribute of same element: %@ .Attribute%</li><li>Attribute value of child element attribute: %@ .ChildElement ChildOfChild Attribute%</li><li>Attribute value of primary element of event frame: %@ Elements[ ]Attribute%</li></ul>

- Substitution parameters are variables that can be used in attribute templates so PI AF resolves them when creating the data reference. In our case, we will use it to make the tag name dynamically linked to the corresponding mapped Attribute. This gives great flexibility and allows us to re-use the same template for many assets with some level of automation when mapping source tags.
- More information on this topic can be found in our documentation: <https://docs.osisoft.com/bundle/pi-server/page/substitution-parameters-in-data-references.html>
- Our mapped tag will follow the naming convention: “PI Server\OSIDemo\_Transformer.Current”

# Step by step approach

## Using substitution parameters

Group by:  Category  Template

Name: **1** Current

Description: Current the transformer is running on.

Properties: <None>

Categories: Energy

Default UOM: ampere

Value Type: Double

Default Value: 0 A

Display Digits: -5

Data Reference: PI Point

Settings...

\\%@\\PI Data Archive|Name%\\OSIDemo\_%Element%.Current;pointtype=Float32;pointsource=OSIDemo-AFAnalysis;span=1000;zero=5000

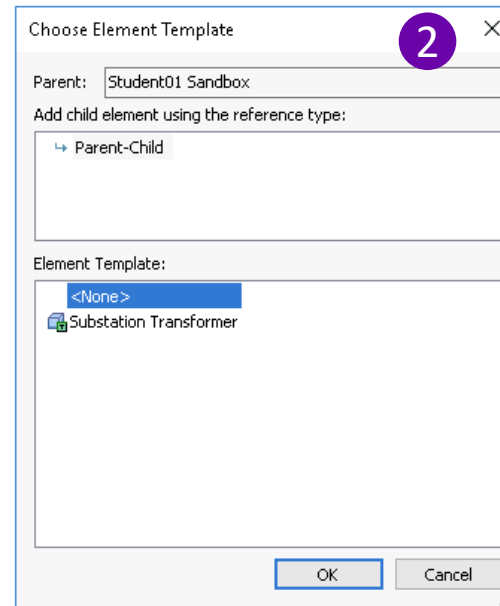
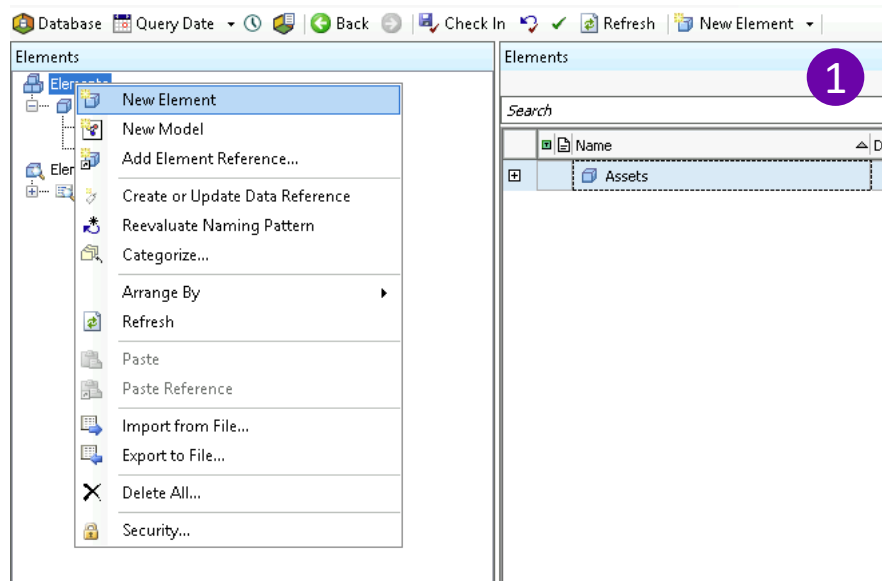
**Note:** The full setting of the tag also includes information such as the data type, the data source and the range.

\\%@\\PI Data  
Archive|Name%\\OSIDemo\_%Element%.Current;pointtype=Float32;pointsource=OSIDemo-  
AFAnalysis;span=1000;zero=5000

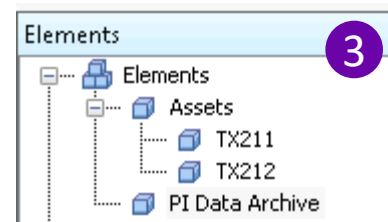
- Our mapped tag will follow the **naming convention: “PI Server\\OSIDemo\_Transformer.Current”**
- For the PI Server we will use the following Substitution Parameter: %@\\PI Data Archive|Name%
- This will search for the PI Server Name under an Element called PI Data Archive which we still have to create.
- For the Tag name we will use: OSIDemo\_%Element%.Current
- This will fetch the name of the transformer and resolve it into the tag name such as OSIDemo\_TX211.Current
- **To properly map the tag, copy the red text on the left into the Settings field.**

# Step by step approach

## Naming the PI data archive



- We also need to Name the PI Server as mentioned before.
- Go back to the Elements tab, right click 'Elements' and create a **New Element** called '**PI Data Archive**'. Do not link it to the Substation Transformer template.
- We will create an **Attribute** called '**Name**' next.



# Step by step approach

## Naming the PI data archive

1

2

3

- Right click the PI Data Archive element and add a New Attribute.
- Enter 'Name' as the Attribute's name.
- Enter 'PISRV01' as the Value.
- The Value Type should be set as **String**.
- Click OK.
- Now check-in the changes and see what happened to the Current values and mapped tags of the two transformers.
- Can you confirm that they now have different real-time values?



# Step by step approach

## Creating the rest of the attribute templates for sensor data

Group by:  Category  Temperature

Name: Load

Description: Electrical load being consumed.

Properties: <None>

Categories: Energy

Default UOM: MW

Value Type: Double

Default Value: 0 MW

Display Digits: -5

Data Reference: PI Point

Settings...

\\%@\\PI Data Archive|Name%\\OSIDemo\_%Element%.Load;pointtype=Float32;pointsource=OSIDemo-AFAnalysis;span=1000;zero=5500

\\%@\\PI Data Archive|Name%\\OSIDemo\_%Element%.Load;pointtype=Float32;pointsource=OSIDemo-AFAnalysis;span=1000;zero=5500

Group by:  Category  Temperature

Name: LTC Position

Description: Position of load tap changer.

Properties: <None>

Categories: Load Tap Changer

Default UOM: <None>

Value Type: Int32

Default Value: 0

Display Digits: -5

Data Reference: PI Point

Settings...

\\%@\\PI Data Archive|Name%\\OSIDemo\_%Element%.LTCP;pointtype=Int32;pointsource=OSIDemo-AFAnalysis

\\%@\\PI Data Archive|Name%\\OSIDemo\_%Element%.LTCP;pointtype=Int32;pointsource=OSIDemo-AFAnalysis

\\%@\\PI Data Archive|Name%\\OSIDemo\_%Element%.TOT;pointtype=Float32;pointsource=OSIDemo-AFAnalysis;span=13;zero=33

Group by:  Category  Temperature

Name: Top-Oil Temperature

Description: Temperature of oil measured near the upper surface.

Properties: <None>

Categories: Temperature

Default UOM: degree Celsius

Value Type: Double

Default Value: 0 °C

Display Digits: -5

Data Reference: PI Point

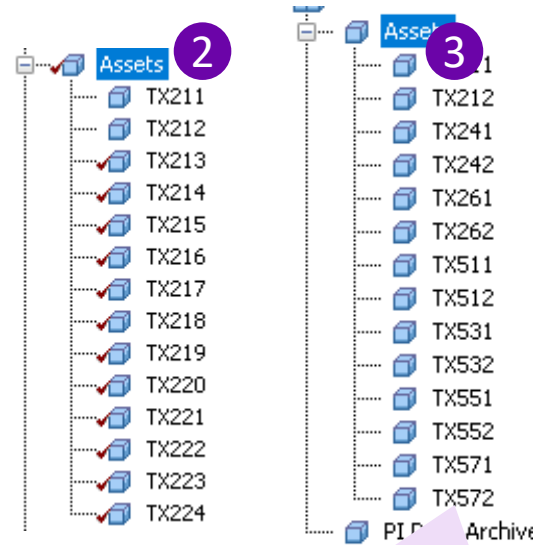
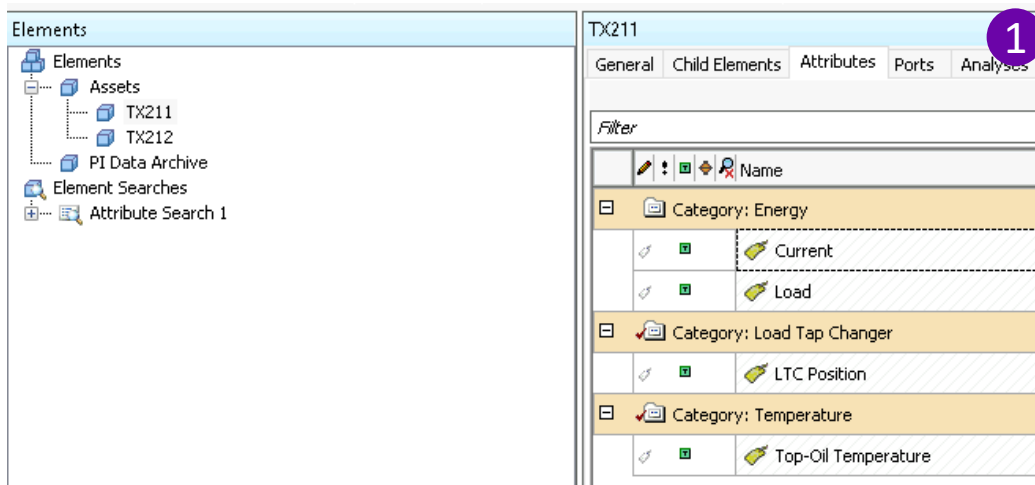
Settings...

\\%@\\PI Data Archive|Name%\\OSIDemo\_%Element%.TOT;pointtype=Float32;pointsource=OSIDemo-AFAnalysis;span=13;zero=33

- Now go back to the Library. It's time to **add the remaining Attributes** to the Transformer template.
- Repeat the process of Creating New Attributes for the **'Load', 'LTC Position' and 'Top-Oil Temperature'**.
- **Check-in.**

# Step by step approach

## Adding the remaining transformers



Notice: Numbers are not in sequence.

- By now we have **two** transformers with 4 Attributes each.
- Let's repeat the Create Element process and add the remaining **12** transformers.
- Right click 'Assets', then 'New' and 'New Child Element'.
- Choose the 'Substation Transformer' template and name the transformer 'TX213' and repeat for remaining transformer.
- **TIP:** It's quicker just to copy and paste one of the transformers in the hierarchy and change their names. The template will be applied.
- Make sure all the Transformers are created and all the Attributes have been mapped correctly to their respective tags.

# Step by step approach

## Adding metadata – String builder

1

String Builder Data Reference

Specify the strings and attribute values to concatenate to produce the string output value:

```
Right("%Element%", 3)
```

2

Right("%Element%", 3);

3

Name	Value	Formula
Transformer Number	0	Right("%Element%", 3);
Transformer Number	211	

- Now that we have all the sensor data mapped, we will need metadata to continue building our Transformer model.
- Metadata can come from multiple places such as data sheets, external databases (e.g. asset management systems), lookup tables and nameplate data.
- We will start by adding the 'Transformer Number' in the template to help identify each transformer.
- Go back to the library and add the Transformer Number attribute.
- Use the String Builder to **get the number from the Element name**. Function we will use is 'Right' with the %Element% substitution parameter.

# Step by step approach

## Adding metadata – Static Values

Group by:  Category  Temp **1**

Name: Winding Exponent

Description: Winding exponent used in hot-spot temperature calculation.

Properties: <None>

Categories: Specifications

Default UOM: <None>

Value Type: Double


Default Value: 1

Display Digits: -5

Data Reference: <None>

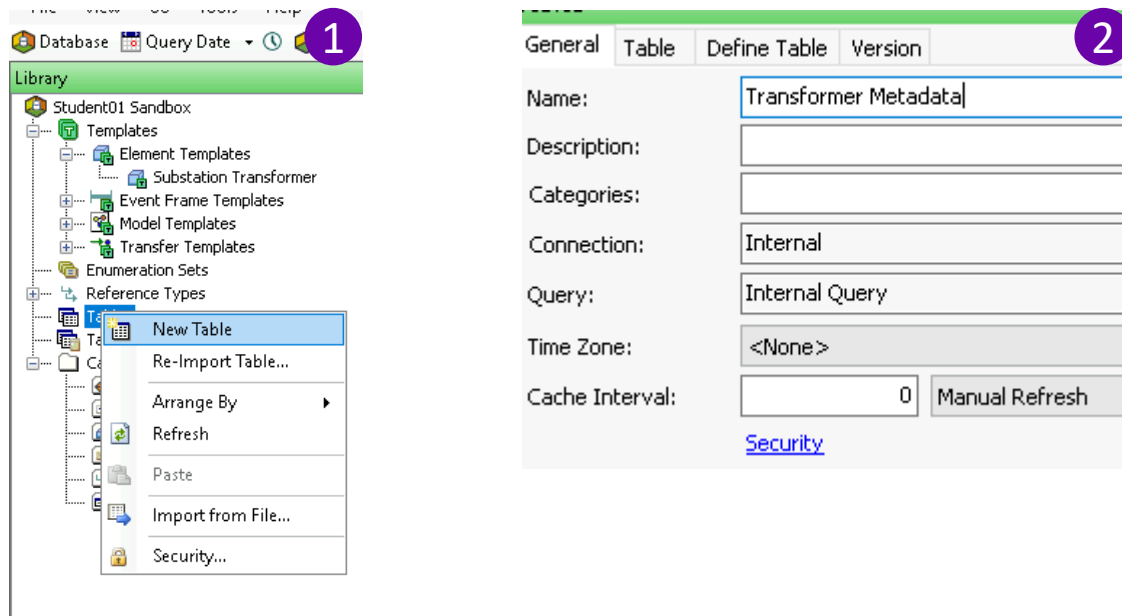
Settings...

- We can also just enter static numbers for metadata when it does not change.
- In our model, the Winding Exponent is the same for all of our transformer models.
- Let's use the static manual entry for that one. In the Attribute Template, we will enter the Default value of "1" and all transformers will inherit that.

 Winding Exponent	Winding exponent used in hot-spot temperature calculation.	1	<b>2</b>
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# Step by step approach

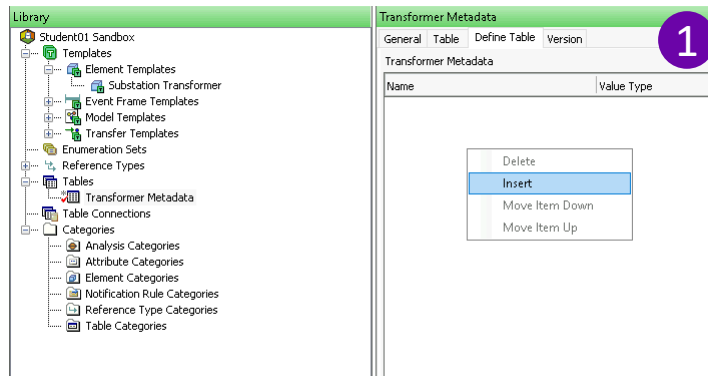
## Adding metadata – Table Lookup



- A good way to organise and look for metadata is by using Lookup Tables.
- We can define a table in AF with the Transformer Name that will be used as reference to filling other fields such as 'Rated Current', 'Manufacturer' and 'Model'.
- Go to the Library and right click 'Tables' then 'New Table'.
- Name it 'Transformer Metadata'.

# Step by step approach

## Adding metadata – Table Lookup



- Next go to the 'Define Table' tab and right click 'Insert'.
- We will define each column of the Table as per screenshot.
- Make sure the **UOMs and Value Types** are correct and double check for typos in the Name column.

This screenshot shows the 'Transformer Metadata' window with the 'Define Table' tab selected. The table structure is visible, with columns for Name, Value Type, Time Zone, Unit Of Measure, and Use Image. A red circle with the number '2' is overlaid on the 'Define Table' tab.

Name	Value Type	Time Zone	Unit Of Measure	Use Image
Transformer Name	String	<None >	<None >	<N/A >
Rated Current	Double	<N/A >	ampere	<N/A >
Rated Hot-Spot Temperature	Double	<N/A >	degree Celsius	<N/A >
Hot-Spot Temperature High	Double	<N/A >	degree Celsius	<N/A >
Substation	String	<None >	<None >	<N/A >
Manufacturer	String	<None >	<None >	<N/A >
Model	String	<None >	<None >	<N/A >

Transformer Name  
Rated Current  
Rated Hot-Spot Temperature  
Hot-Spot Temperature High  
Substation  
Manufacturer  
Model

# Step by step approach

## Adding metadata – Table Lookup

Transformer Metadata 1

General Table Define Table Version

Transformer Metadata

Filter

	Transformer Name	Rated Current	Rated Hot-Spot Temperature	Hot-Spot Temperature High	Substation	Manufacturer	Model
▶	TX211	6000	110	89.5	Arkham	GE	506B
	TX212	6000	110	89.5	Arkham	GE	506B
	TX241	6000	110	89.5	Innsmouth	GE	506A
	TX242	6000	110	89.5	Innsmouth	GE	506B
	TX261	6000	110	89.5	Kingsport	Westinghouse	506A
	TX262	6000	110	89.5	Kingsport	Westinghouse	506B
	TX511	6000	110	103	Dunwich	Westinghouse	506B
	TX512	6000	110	103	Dunwich	Westinghouse	506B
	TX531	6000	110	103	R'lyeh	ABB	506A
	TX532	6000	110	103	R'lyeh	ABB	506B
	TX551	6000	110	103	Yuggoth	ABB	506B
	TX552	6000	110	103	Yuggoth	ABB	506B
	TX571	6000	110	103	Yith	ABB	506A
	TX572	6000	110	103	Yith	ABB	506B
*							

- Once the table is defined, we will enter the values respective to each individual transformer.
- Go to the **'Table' tab** and enter the rows as per screenshot. Make sure the values are correct.
- You can **copy and paste values** that are the same to speed up the process.
- It is also possible to **copy it from an external spreadsheet** (e.g. Excel) if this data is available in that format (check the Desktop for a shortcut to Share\TransformerData.xls file).



# Step by step approach

## Adding metadata – Table Lookup

Group by:  Category  Temp

Name: Rated Current

Description: Highest current transformer was designed to run at.

Properties: <None>

Categories: Energy

Default UOM: ampere

Value Type: Double

Default Value: 0 A

Display Digits: -5

Data Reference: Table Lookup

Settings...

```
SELECT [Rated Current] FROM [Transformer Metadata] WHERE [Transformer Name] = '%Element%' ORDER BY Rated Current
```

Table Lookup Data Reference

Table: Transformer Metadata

Result column: Rated Current

Unit of Measure: A

Behavior

Rule: Select first row matching criteria

Order by: Rated Current ASC

Where

Column: Transformer Name Operator: = Attribute or Value: %Element%

Add And

Add Or

Complete WHERE Clause:

```
[Transformer Name] = '%Element%'
```

Table Parameters

Parameter	Value
-----------	-------

Replacement Values

Value to return when no matching row found: No Data

Value to return when NULL result found: DBNull

OK Cancel

- Now that we have the Table defined and populated, it's time to create the Attributes for the transformer metadata.
- Let's **start with the 'Rated Current'**. We will do a lookup for the 'Transformer Name' and find the respective 'Rated Current' of each.
- We will also fill the UOM, Description, Value Type and Category as usual.
- Under Settings, we will define which column we're using to search and the column that will return the expected value.
- Make sure you configure it like the screenshot. You need to set the 'Table', 'Result Column', 'Rule', 'Order By' and create the 'Where Clause'. Then click 'Add And' so the Clause appears in the box.
- Click OK and check the Rated Current value for each Transformer in the Elements tab.

# Step by step approach

## Adding metadata – Table Lookup

**1**

Name:	Rated Hot-Spot Temperature
Description:	Highest hot-spot temperature transformer was desgiend to run at.
Properties:	<None>
Categories:	Temperature
Default UOM:	degree Celsius
Value Type:	Double
Default Value:	0 °C
Display Digits:	-5
Data Reference:	Table Lookup

Settings...

```
SELECT [Rated Hot-Spot Temperature] FROM [Transformer Metadata] WHERE [Transformer Name] = '%Element%' ORDER BY Rated Hot-Spot Temperature
```

**2**

Name:	Hot-Spot Temperature High
Description:	Lowest hot-spot temperature of concern.
Properties:	<None>
Categories:	Temperature
Default UOM:	degree Celsius
Value Type:	Double
Default Value:	0 °C
Display Digits:	-5
Data Reference:	Table Lookup

Settings...

```
SELECT [Hot-Spot Temperature High] FROM [Transformer Metadata] WHERE [Transformer Name] = '%Element%' ORDER BY Hot-Spot Temperature High
```

- Next, create the remaining Attributes as per screenshots. ('Rated Hot-Spot Temperature', 'Hot-Spot Temperature High' and 'Substation')
- TIP: It may be quicker to **Copy/Paste** the 'Rated Current' Attribute and just **change the setting and properties that are different (e.g. UOM, Type, Description, Where Clause, etc).**

**3**

Name:	Substation
Description:	
Properties:	<None>
Categories:	Specifications
Default UOM:	<None>
Value Type:	String
Value:	Arkham
Display Digits:	-5
Data Reference:	Table Lookup

Settings...

```
SELECT Substation FROM [Transformer Metadata] WHERE [Transformer Name] = '%Element%' ORDER BY Substation
```

# Step by step approach

## Adding metadata – Table Lookup

**1**

Name:	Manufacturer
Description:	
Properties:	<None>
Categories:	Specifications
Default UOM:	<None>
Value Type:	String
Default Value:	0
Display Digits:	-5
Data Reference:	Table Lookup

Settings...

```
SELECT Manufacturer FROM [Transformer Metadata] WHERE [Transformer Name] = '%Element%' ORDER BY Manufacturer
```

**2**

Name:	Model
Description:	
Properties:	<None>
Categories:	Specifications
Default UOM:	<None>
Value Type:	String
Default Value:	0
Display Digits:	-5
Data Reference:	Table Lookup

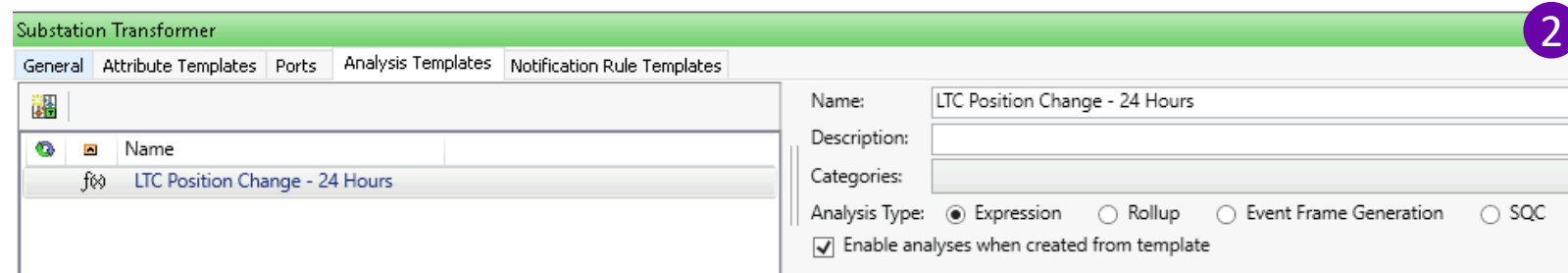
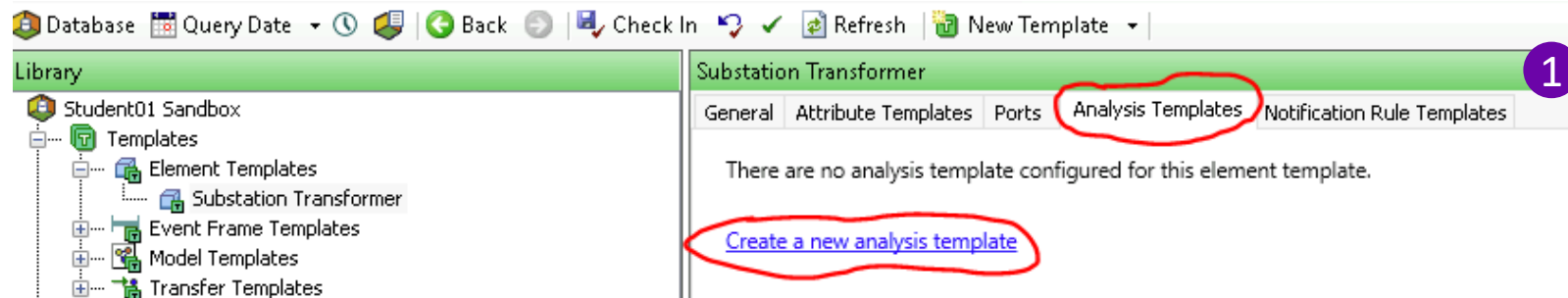
Settings...

```
SELECT Model FROM [Transformer Metadata] WHERE [Transformer Name] = '%Element%' ORDER BY Model
```

- Next, create the remaining Attributes as per screenshots. ('Manufacturer' and 'Model')
- TIP: It may be quicker to Copy/Paste the 'Rated Current' Attribute and just change the setting and properties that are different (e.g. UOM, Type, Description, Where Clause, etc).

# Step by step approach

## Adding analytics - Expression



- Now that we have all the data we need coming from sensors and other databases, it's time to create our own analysis to further enrich the model and turn data into actionable information.
- Go to the Transformer Template and select the '**Analysis Templates**' tab. Then click 'Create a new analysis template'.
- We will name this analysis 'LTC Position Change – 24 Hours' and it is an 'Expression' analysis type.
- We will define the equation next.

# Step by step approach

## Adding analytics - Expression

Name	Expression
LTPC	<code>EventCount('LTC Position','*-24h','*')</code>

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

Name	Expression	Output Attribute
LTPC	<code>EventCount('LTC Position',</code>	<a href="#">Map</a>

Find Derived Elements for 'Substation Transformer'

Group by:  Category  Template

Name	Description	Category	Type	Template
TX211			None	Substation Transformer
TX212			None	Substation Transformer
TX241			None	Substation Transformer
TX242			None	Substation Transformer

OK Cancel

Example Element: [Assets\TX211](#)

Name	Expression	Value at Evaluation	Value at Last Trigger	Output Attribute
LTPC	<code>EventCount('LTC Position','*-24h','*')</code>	113 count	113 count	<a href="#">Map</a>

- The analysis equation can have multiple rows and variables to help with readability but in this case we will need only one equation.
- Name the variable 'LTPC' and enter `EventCount('LTC Position','*-24h','*')` for the Expression. This will basically count the number of times the value of the LTC Position has changed in the last 24 hours.
- Next we should test the equation to see if it is giving us expected results or if we have made any errors in the syntax. We need to click on '**Select an example element**' to pick a transformer, and then click **Evaluate**.
- Note: '\*' means 'now' in the PI Time syntax. More info on PI Time here. <https://docs.osisoft.com/bundle/pi-server/page/pi-time.html>

# Step by step approach

## Adding analytics - Expression

The image consists of three sequential screenshots illustrating the process of adding an analytics expression:

- Step 1:** A screenshot of a software interface showing a table with an 'Output Attribute' column. The word 'Map' is circled in red, indicating the next action.
- Step 2:** A screenshot showing a dropdown menu that appears after clicking 'Map'. The option 'New Attribute Template' is circled in red.
- Step 3:** A screenshot of the 'Attribute Template Properties' dialog box. The 'Name' field is filled with 'LTC Position Change - 24 Hours'. Other fields include 'Description', 'Data Server' (set to '%Server%'), and 'Value Type' (set to 'Double'). The 'Save Output History' option is set to 'Yes'.

- Analysis can be Periodic or Event-triggered. We will keep **'Event-Triggered'** selected, and it means the calculation will happen once the PI Server receives new values for the equation's inputs.
- Finally, we need to **write the result of this calculation to a NEW PI Point** so it can be properly archived and historized. This is good practice because when querying for these values, they will be in the PI Archive and it will very quick to retrieve them without the need for client side calculations on the fly.
- Click **'Map'** under Output Attribute then **'New Attribute Template'** to define a new Attribute.
- The new Attribute should be called **'LTC Position Change – 24 Hours'**.

# Step by step approach

## Adding analytics - Expression

1

Name:	LTC Position Change - 24 Hours
Description:	Number of LTC position changes within the last 24 hours
Properties:	<None>
Categories:	Load Tap Changer
Default UOM:	<None>
Value Type:	Double
Default Value:	0
Display Digits:	-5
Data Reference:	PI Point

**Settings...**

```
\\%Server%\%Element%.LTCPC.%Database  
%;pointtype=Float64;pointsource=OSIDemo-AFAnalysis
```

\\%Server%\%Element%.LTCPC.DBXX;pointtype=Float64;pointsource=OSIDemo-AFAnalysis

3

LTC Position Change - 24 Hours
LTCPC := EventCount('LTC Position', '*-24h', '*');

2

PI Point Data Reference

Data server: %Server%

Tag name: %Element%.LTCPC.DB01

Tag Creation

pointtype=Float64;pointsource=OSIDemo-AFAnalysis

Attribute: <None>

Unit of Measure

Source Units: <None>

Value retrieval methods

By Time: Automatic

Relative time: <None>

By Time Range: End Time

Calculation basis: Time Weighted

Min percent good: 80

Preview

Example instance: [Select example instance](#)

Configuration: <None>

Value: <None>

Read only

OK Cancel

- Now go back to the 'Attribute Templates' and update 'LTC Position Change – 24 Hours\_LTPC' attribute's properties
- Click '**Settings**'. Make sure Tag Creation is enabled. Close the window.
- Copy the syntax into Setting's field. Update the DBXX string.
- Since all students are sharing the same server we will append 'DBXX' to the PI Point name so it will be easier to identify who created it. Please insert your student number in. e.g If you are Student05, then key in DB05. In a real Production environment, results of the same common analytics should be mapped to a single tag so the same tag can be used by many people in the company.
- The little orange diamond icon next to the Attribute's name indicates this tag comes from the Analysis Server and not from an external Data Source.



# Step by step approach

## Adding analytics - Expression

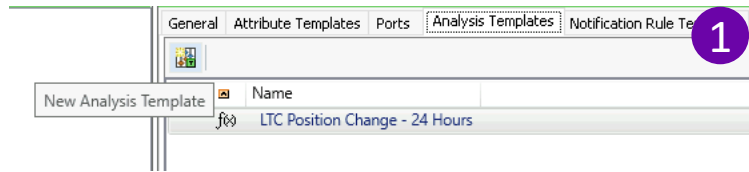
The screenshot shows the software interface with the 'Management' tab selected. The 'Analyses' section is active, displaying a table with the following data:

Status	Element	Name	Template	Backfilling
<input checked="" type="checkbox"/>	f\ Assets\TX532	LTC Position Change - 24 Hours	LTC Position Change - 24 Hours	
<input checked="" type="checkbox"/>	f\ Assets\TX531	LTC Position Change - 24 Hours	LTC Position Change - 24 Hours	
<input checked="" type="checkbox"/>	f\ Assets\TX512	LTC Position Change - 24 Hours	LTC Position Change - 24 Hours	
<input checked="" type="checkbox"/>	f\ Assets\TX511	LTC Position Change - 24 Hours	LTC Position Change - 24 Hours	
<input checked="" type="checkbox"/>	f\ Assets\TX262	LTC Position Change - 24 Hours	LTC Position Change - 24 Hours	
<input checked="" type="checkbox"/>	f\ Assets\TX261	LTC Position Change - 24 Hours	LTC Position Change - 24 Hours	
<input checked="" type="checkbox"/>	f\ Assets\TX242	LTC Position Change - 24 Hours	LTC Position Change - 24 Hours	
<input checked="" type="checkbox"/>	f\ Assets\TX241	LTC Position Change - 24 Hours	LTC Position Change - 24 Hours	
<input checked="" type="checkbox"/>	f\ Assets\TX572	LTC Position Change - 24 Hours	LTC Position Change - 24 Hours	
<input checked="" type="checkbox"/>	f\ Assets\TX571	LTC Position Change - 24 Hours	LTC Position Change - 24 Hours	
<input checked="" type="checkbox"/>	f\ Assets\TX552	LTC Position Change - 24 Hours	LTC Position Change - 24 Hours	
<input checked="" type="checkbox"/>	f\ Assets\TX551	LTC Position Change - 24 Hours	LTC Position Change - 24 Hours	
<input checked="" type="checkbox"/>	f\ Assets\TX212	LTC Position Change - 24 Hours	LTC Position Change - 24 Hours	
<input checked="" type="checkbox"/>	f\ Assets\TX211	LTC Position Change - 24 Hours	LTC Position Change - 24 Hours	

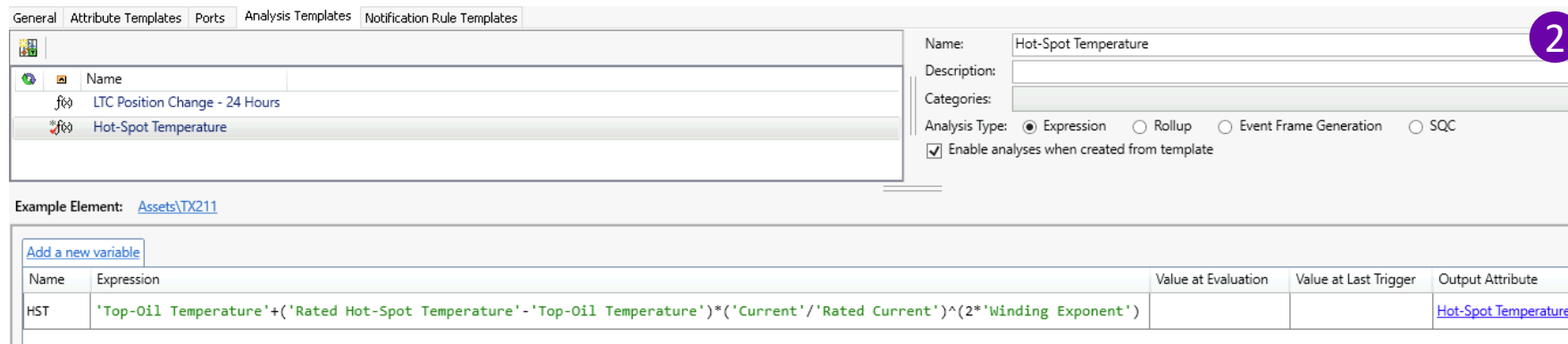
- Let's check if the PI Point has been correctly created. Go back to the Elements and check the value of the 'LTC Position Change – 24 Hours' Attribute.
- If you see 'Pt Created' it means the point has been created but the analysis hasn't yet written any values to it, which is fine. The Analysis should be running and will write the value within a few minutes.
- To check if the Analysis are running, go to the Management tab and check the green tick marks next to them. If not, select the analysis and enable them.

# Step by step approach

## Adding analytics - Expression



- Now repeat the process of creating analysis for the Hot-Spot Temperature analysis. Map the output to an Attribute and Tag.



'Top-Oil Temperature'+('Rated Hot-Spot Temperature'-'Top-Oil Temperature')\*( 'Current'/'Rated Current')^(2\*'Winding Exponent')

# Step by step approach

## Adding analytics - Expression

1

Name:	Hot-Spot Temperature
Description:	Calculated winding hot-spot temperature.
Properties:	<None>
Categories:	Temperature
Default UOM:	degree Celsius
Value Type:	Double
Default Value:	0 °C
Display Digits:	-5
Data Reference:	PI Point

Settings...

```
\\%Server%\%Element%.HST,DB01;pointtype=Float64;pointsource=OSIDemo-AFAnalysis
```

\\%Server%\%Element%.HST.DBXX;pointtype=Float64;pointsource=OSIDemo-AFAnalysis

2

PI Point Data Reference

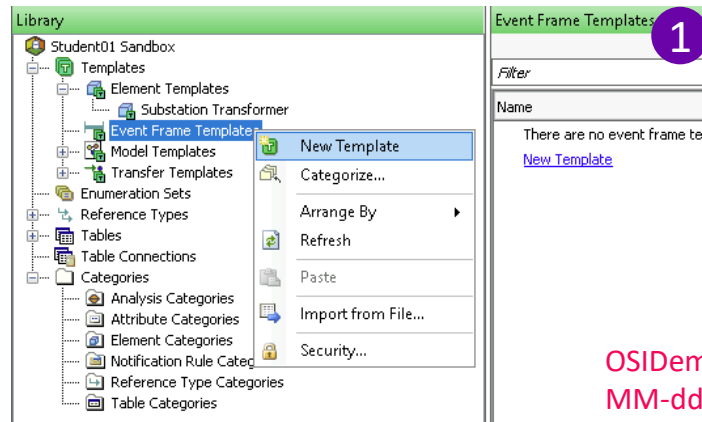
Data server:	%Server%
Tag name:	%Element%.HST.DB01
<input checked="" type="checkbox"/> Tag Creation	pointtype=Float64;pointsource=OSIDemo-AFAnalysis
<input type="checkbox"/> Attribute:	
Unit of Measure	
Source Units:	<Default> (°)
Value retrieval methods	
By Time:	Automatic
Relative time:	
By Time Range:	End Time
Calculation basis:	Time Weighted
Min percent good:	80
Preview	
Example instance:	Select example instance
Configuration:	
Value:	
<input checked="" type="checkbox"/> Read only	

OK Cancel

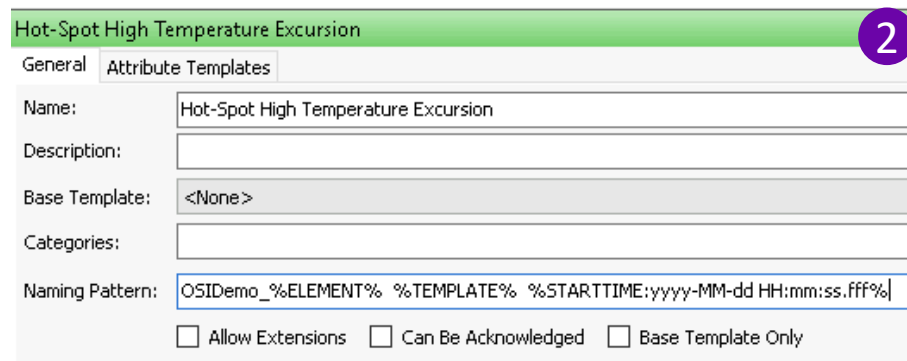
- Make sure you fill all the details of the newly created 'Hot-Spot Temperature' in the Attribute Template.
- Make sure you have DBXX added correctly in the Settings
- Check-in your changes
- Go back to Elements to verify if the values have been written

# Step by step approach

## Adding analytics – Event Frames



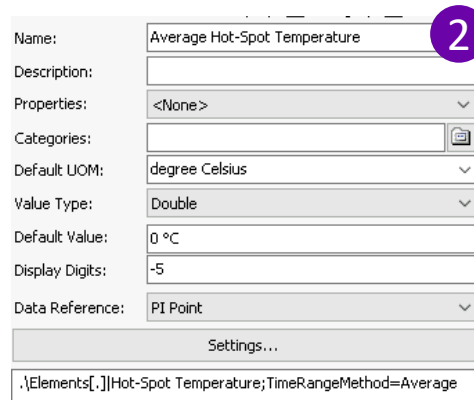
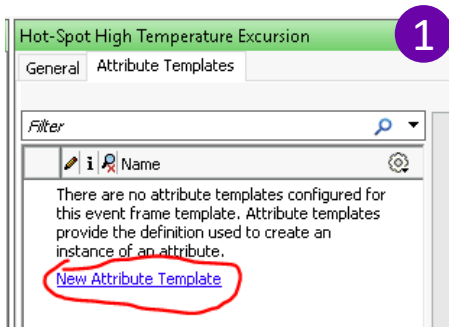
OSIDemo\_%ELEMENT% %TEMPLATE% %STARTTIME:yyyy-MM-dd HH:mm:ss.fff%



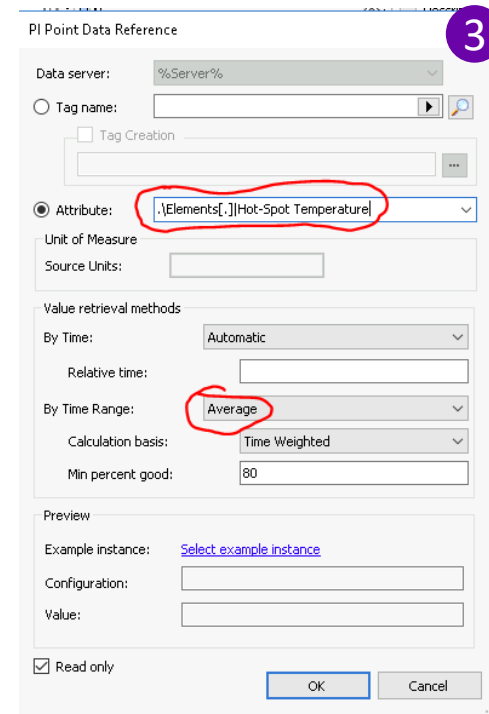
- So far we have all the sensor data and metadata we need for monitoring our assets health. We have also added some analytics to turn data into actionable information.
- The next step now is to use Event Frames to automatically capture when the Hot-Spot Temperature goes above the High limit.
- First we will need to setup a template for the EF and define which data we want to capture within its time context.
- Go to 'Library' and right click 'Event Frame Templates' then select 'New Template'.
- Enter the details in the 'General' Tab.
- We will use the 'Naming Pattern' and add some substitution parameters to make the name of each EF unique so it's easier to browse, identify and find them later.

# Step by step approach

## Adding analytics – Event Attributes



.\Elements[.]Hot-Spot  
Temperature;TimeRangeMethod=Average



- Next go to the 'Attribute Templates' tab and select 'New Attribute Template'.
- For our first Attribute, we will get the AVERAGE of the Hot-Spot Temperature during the duration of the Event Frame.
- We will configure it normally like we did before with one main exception being that we will use the Average retrieval method.
- Copy and paste the string into Settings's field.
- Similar to Substitution Parameters, EFs can reference elements and attributes. We will use 'Elements[.]' and reference the Hot-Spot Temperature so we can get its average.
- For a full list of data references, visit <https://docs.osisoft.com/bundle/pi-server/page/event-frame-templates.html>

# Step by step approach

## Adding analytics – Event Attributes

Name:	Average Load <b>1</b>
Description:	
Properties:	<None>
Categories:	
Default UOM:	MW
Value Type:	Double
Default Value:	0 MW
Display Digits:	-5
Data Reference:	PI Point
Settings...	
.\Elements[.] Load;TimeRangeMethod=Average	

.\Elements[.]|Load;TimeRangeMethod=Average

Name:	Average Top-Oil Temperature <b>2</b>
Description:	
Properties:	<None>
Categories:	
Default UOM:	degree Celsius
Value Type:	Double
Default Value:	0 °C
Display Digits:	-5
Data Reference:	PI Point
Settings...	
.\Elements[.] Top-Oil Temperature;TimeRangeMethod=Average	

.\Elements[.]|Top-Oil Temperature;TimeRangeMethod=Average

Name:	Maximum Hot-Spot Temperature <b>3</b>
Description:	
Properties:	<None>
Categories:	
Default UOM:	degree Celsius
Value Type:	Double
Default Value:	0 °C
Display Digits:	-5
Data Reference:	PI Point
Settings...	
.\Elements[.] Hot-Spot Temperature;TimeRangeMethod=Maximum	

.\Elements[.]|Hot-Spot Temperature;TimeRangeMethod=Maximum

- We will repeat this process for the other Event Attributes: **'Average Load'**, **'Average Top-Oil Temperature'**, **'Maximum Hot-Spot Temperature'**.
- TIP: It might be quicker to copy/paste other Attributes and just change its properties. Don't forget to select the correct UOM.
- NOTE: For the 'Maximum' Attributes, the Retrieval method is Maximum and not Average.

# Step by step approach

## Adding analytics – Event Attributes

Name: Maximum Top-Oil Temperature  
Description:  
Properties: <None>  
Categories:  
Default UOM: degree Celsius  
Value Type: Double  
Default Value: 0 °C  
Display Digits: -5  
Data Reference: PI Point

Settings...

.\Elements[.]|Top-Oil Temperature;TimeRangeMethod=Maximum

Name: Substation  
Description:  
Properties: <None>  
Categories:  
Default UOM: <None>  
Value Type: String  
Default Value: 0  
Display Digits: -5  
Data Reference: String Builder

Settings...

.\Elements[.]|Substation;;

Name: Substation Transformer  
Description:  
Properties: <None>  
Categories:  
Default UOM: <None>  
Value Type: String  
Default Value: 0  
Display Digits: -5  
Data Reference: String Builder

Settings...

%Element%;;

- We will repeat this process for the other Event Attributes: **'Maximum Top-Oil Temperature'**, and string type attributes **'Substation'** and **'Substation Transformer'**.
- NOTE: For the **String types**, the Retrieval Method is not applicable as the Attribute is just a static metadata value. We **will use the String Builder** instead as this is not a PI Point Data Reference.

.\Elements[.]|Substation;;

%Element%;;

.\Elements[.]|Top-Oil Temperature;TimeRangeMethod=Maximum

String Builder Data Reference

Specify the strings and attribute values to concatenate to produce the string output value:

.\Elements[.]|Substation

Value:  
.\Elements[.]|Substation

OK Cancel

String Builder Data Reference

Specify the strings and attribute values to concatenate to produce the string output value:

%Element%

Value:  
%Element%








OK Cancel



# Step by step approach

## Adding analytics – Event Attributes

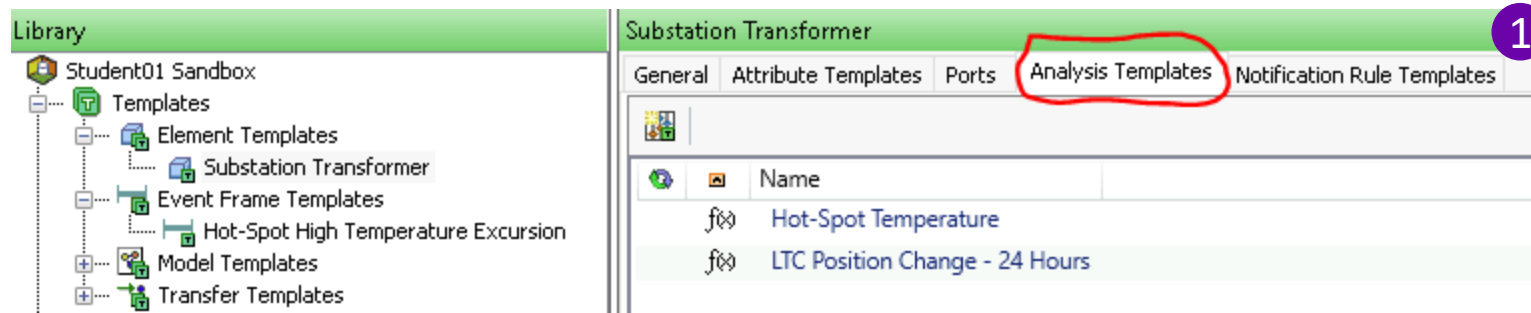
- The final list of Event Frame Attribute templates is presented here.

Category: <None>				
 Average Hot-Spot Temperature		0 °C		.\Elements[.] Hot-Spot Temperature;TimeRangeMethod=Average
 Average Load		0 MW		.\Elements[.] Load;TimeRangeMethod=Average
 Average Top-Oil Temperature		0 °C		.\Elements[.] Top-Oil Temperature;TimeRangeMethod=Average
 Maximum Hot-Spot Temperature		0 °C		.\Elements[.] Hot-Spot Temperature;TimeRangeMethod=Maximum
 Maximum Top-Oil Temperature		0 °C		.\Elements[.] Top-Oil Temperature;TimeRangeMethod=Maximum
 Substation		0		.\Elements[.] Substation;;
 Substation Transformer		0		%Element%;;

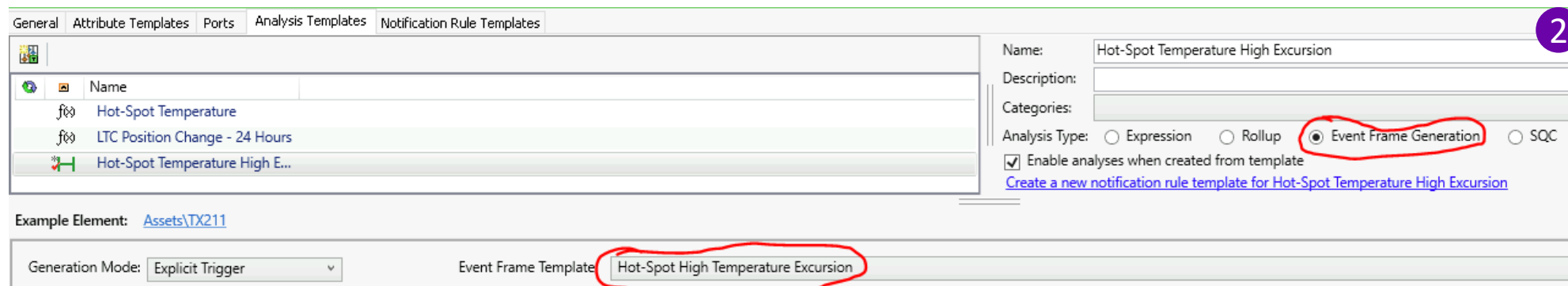
1

# Step by step approach

## Adding analytics – Event Frame Generation



- For the event frames to be generated, one last step is necessary. We need to add a new analysis to the transformer Template, and this analysis will use the Event Frame Template we just created.
- Create a new Analysis Template. The type will be **Event Frame Generation**.
- Use the EF Template we just created (**Hot-Spot High Temperature Excursion**).



# Step by step approach

## Adding analytics – Event Frame Generation

Generation Mode:  Event Frame Template:  1

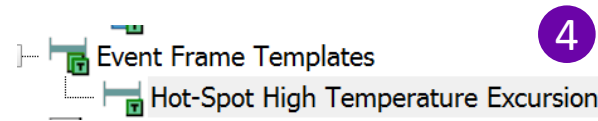
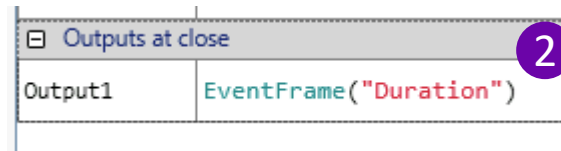
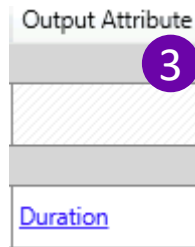
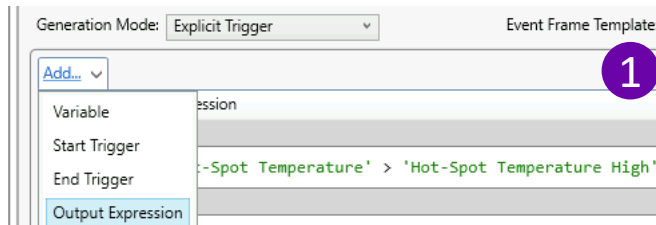
Name	Expression	True for	Severity
Add... ▾			
Start triggers			
StartTrigger1	'Hot-Spot Temperature' > 'Hot-Spot Temperature High'	30 seconds	Warning

'Hot-Spot Temperature' > 'Hot-Spot Temperature High'

- Next we will enter the Event Start Trigger which is the condition(s) for the event to be captured. In this case, we are interested in events when the 'Hot-Spot Temperature' is above the 'Hot-Spot Temperature High' limit.
- **Set True For as 30 Seconds.** This means that condition needs to be true for a minimum amount of time so the event starts. This is very useful for noise signals and sensors to avoid multiple 'start and close' type of occurrences.
- **Set Severity for 'Warning'.**

# Step by step approach

## Adding analytics – Event Frame Generation



Name:	Duration
Description:	
Properties:	<None>
Categories:	
Default UOM:	minute
Value Type:	Double
Default Value:	0 min
Display Digits:	-5
Data Reference:	<None>
Settings...	

- We're also interested in the Duration of the Event. Which will be an Output when the event is closed.
- Click 'Add' then select 'Output Expression'. Define the expression as 'EventFrame("Duration")'.
- Map it to a New Attribute Template called Duration. Do not save output to history. Check-in.
- Go back to the Event Frame Template and click 'Hot-Spot High Temperature Excursion' template. Double check that a new Attribute called 'Duration' has been created. Change the UOM to 'minute'.
- We're done with the model creation, make sure you check-in your work.

# Step by step approach

## Backfilling analytics

Management

Choose a type

- Analysis
- Notification Rules

Analysis Searches

All

Enabled

Disabled

42 analyses selected (42 on this page)

Status	Element	Name	Template
✓	Assets\TX211	Hot-Spot Temperature	Hot-Spot Temperature
✓	Assets\TX212	Hot-Spot Temperature	Hot-Spot Temperature
✓	Assets\TX241	Hot-Spot Temperature	Hot-Spot Temperature
✓	Assets\TX242	Hot-Spot Temperature	Hot-Spot Temperature
✓	Assets\TX261	Hot-Spot Temperature	Hot-Spot Temperature
✓	Assets\TX262	Hot-Spot Temperature	Hot-Spot Temperature
✓	Assets\TX511	Hot-Spot Temperature	Hot-Spot Temperature
✓	Assets\TX512	Hot-Spot Temperature	Hot-Spot Temperature
✓	Assets\TX531	Hot-Spot Temperature	Hot-Spot Temperature
✓	Assets\TX532	Hot-Spot Temperature	Hot-Spot Temperature
✓	Assets\TX551	Hot-Spot Temperature	Hot-Spot Temperature
✓	Assets\TX552	Hot-Spot Temperature	Hot-Spot Temperature
✓	Assets\TX571	Hot-Spot Temperature	Hot-Spot Temperature
✓	Assets\TX572	Hot-Spot Temperature	Hot-Spot Temperature
✓	Assets\TX532	Hot-Spot Temperature High Excursion	Hot-Spot Temperature High Excursion
✓	Assets\TX531	Hot-Spot Temperature High Excursion	Hot-Spot Temperature High Excursion
✓	Assets\TX512	Hot-Spot Temperature High Excursion	Hot-Spot Temperature High Excursion
✓	Assets\TX511	Hot-Spot Temperature High Excursion	Hot-Spot Temperature High Excursion
✓	Assets\TX262	Hot-Spot Temperature High Excursion	Hot-Spot Temperature High Excursion
✓	Assets\TX261	Hot-Spot Temperature High Excursion	Hot-Spot Temperature High Excursion
✓	Assets\TX242	Hot-Spot Temperature High Excursion	Hot-Spot Temperature High Excursion
✓	Assets\TX241	Hot-Spot Temperature High Excursion	Hot-Spot Temperature High Excursion
✓	Assets\TX572	Hot-Spot Temperature High Excursion	Hot-Spot Temperature High Excursion
✓	Assets\TX571	Hot-Spot Temperature High Excursion	Hot-Spot Temperature High Excursion
✓	Assets\TX552	Hot-Spot Temperature High Excursion	Hot-Spot Temperature High Excursion
✓	Assets\TX551	Hot-Spot Temperature High Excursion	Hot-Spot Temperature High Excursion
✓	Assets\TX212	Hot-Spot Temperature High Excursion	Hot-Spot Temperature High Excursion
✓	Assets\TX211	Hot-Spot Temperature High Excursion	Hot-Spot Temperature High Excursion
✓	Assets\TX532	LTC Position Change - 24 Hours	LTC Position Change - 24 Hours
✓	Assets\TX531	LTC Position Change - 24 Hours	LTC Position Change - 24 Hours
✓	Assets\TX512	LTC Position Change - 24 Hours	LTC Position Change - 24 Hours
✓	Assets\TX511	LTC Position Change - 24 Hours	LTC Position Change - 24 Hours
✓	Assets\TX262	LTC Position Change - 24 Hours	LTC Position Change - 24 Hours
✓	Assets\TX242	LTC Position Change - 24 Hours	LTC Position Change - 24 Hours
✓	Assets\TX241	LTC Position Change - 24 Hours	LTC Position Change - 24 Hours
✓	Assets\TX572	LTC Position Change - 24 Hours	LTC Position Change - 24 Hours
✓	Assets\TX571	LTC Position Change - 24 Hours	LTC Position Change - 24 Hours
✓	Assets\TX552	LTC Position Change - 24 Hours	LTC Position Change - 24 Hours
✓	Assets\TX551	LTC Position Change - 24 Hours	LTC Position Change - 24 Hours
✓	Assets\TX212	LTC Position Change - 24 Hours	LTC Position Change - 24 Hours
✓	Assets\TX211	LTC Position Change - 24 Hours	LTC Position Change - 24 Hours

Operations

[Enable](#) | [Disable](#) selected analyses

[Enable](#) | [Disable](#) automatic recalculation for selected analyses

**Queue** | [Cancel](#) backfilling or recalculation for selected analyses

Start: \*-2d

End: \*

What should we do with existing data?

Leave existing data and fill in gaps

Permanently delete existing data and recalculate

I acknowledge that my selection contains event frame analyses. Event frames in the time range will be permanently deleted. This will result in loss of annotations and acknowledgements associated with the event frames.

**Queue**

Pending Operations

Backfilling 42 analyses [Dismiss](#)

Time Submitted: 30/11/2022 22:40:49 [Cancel](#)

Queued by: PISCHOOL\student01

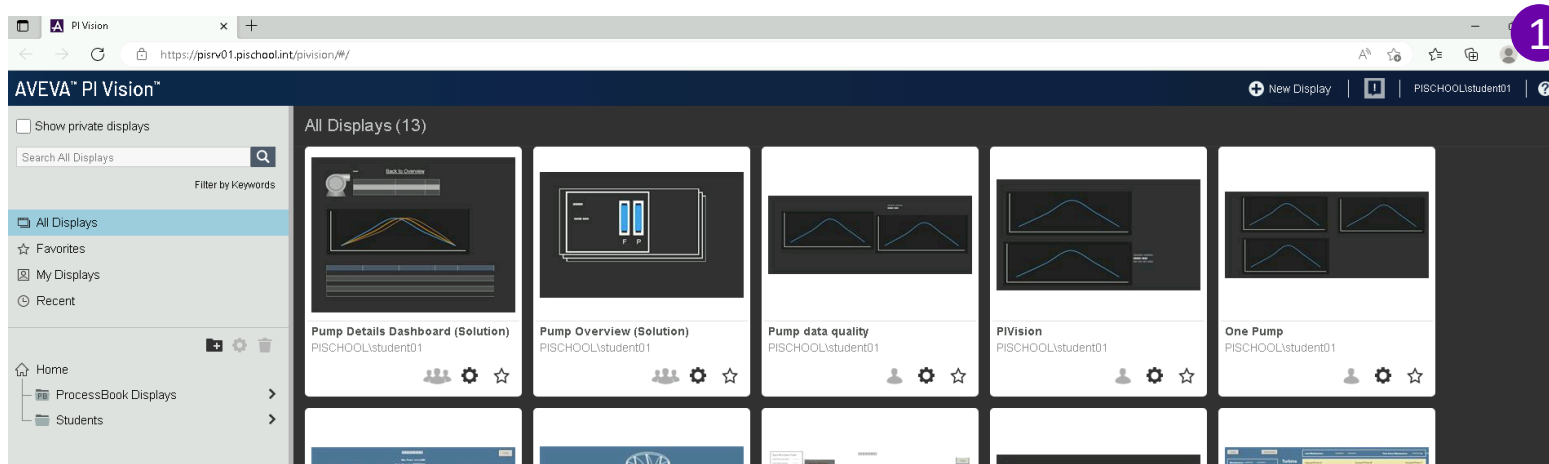
19.0 %

**Backfilling**

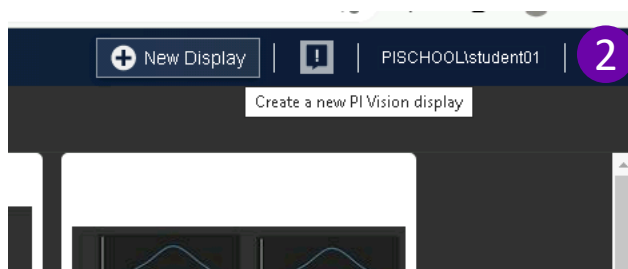
- This step is not strictly necessary but helps to show how we can use the Asset Analytics to leverage existing data in the Archive to look back in time and get KPIs and Event Frames in the past.
- Go to the Management tab and **select ALL** Analysis. Make sure they're all running, including the newly created EFs.
- On the right hand side, click 'Queue' and enter '\*-2d' for Start and '\*' for End. This means we will backfill 2 days of data.
- Tick the Acknowledgement box and click Queue.
- NOTE: This can take a few minutes and the progress is shown at the bottom right. After this is complete, the 'Backfilling' column for all the Analysis should have a green tick.

# Step by step approach

## Creating PI Vision displays

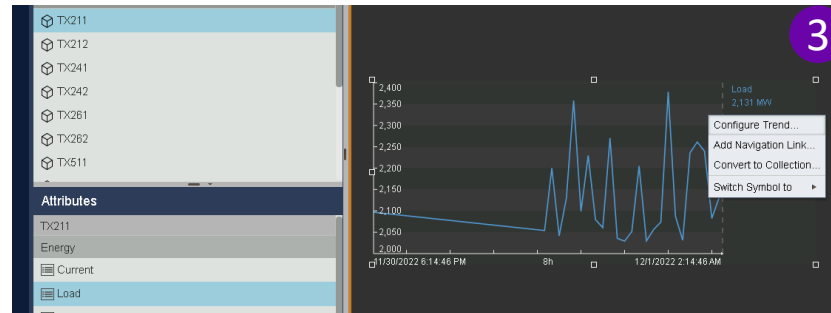
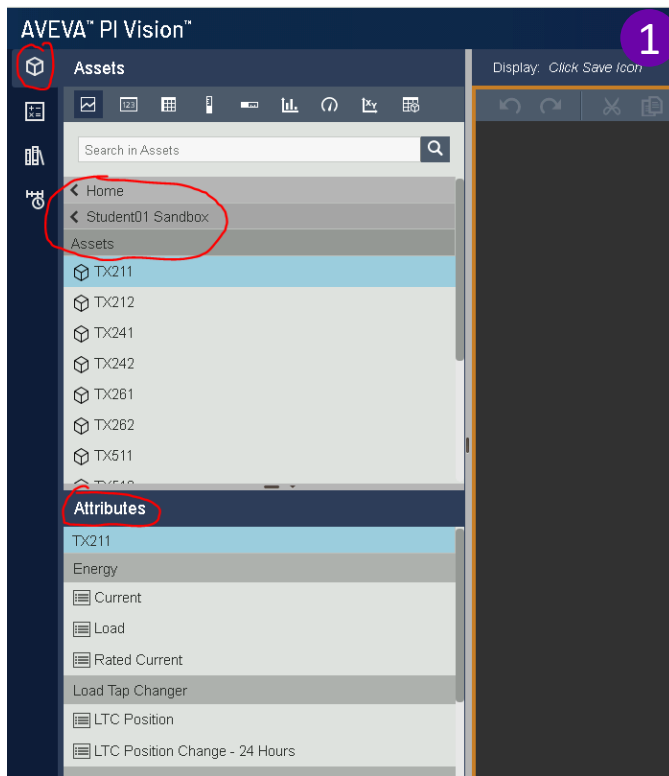


- Now it's time to create our PI Vision dashboards, which will help us monitor and track the health of our transformers.
- Open the Edge browser and enter <https://pisrv01.pischool.int/pivision>
- This is the landing page with all the displays that have been created by us or by our colleagues and then shared with us.
- Click 'New Display'.



# Step by step approach

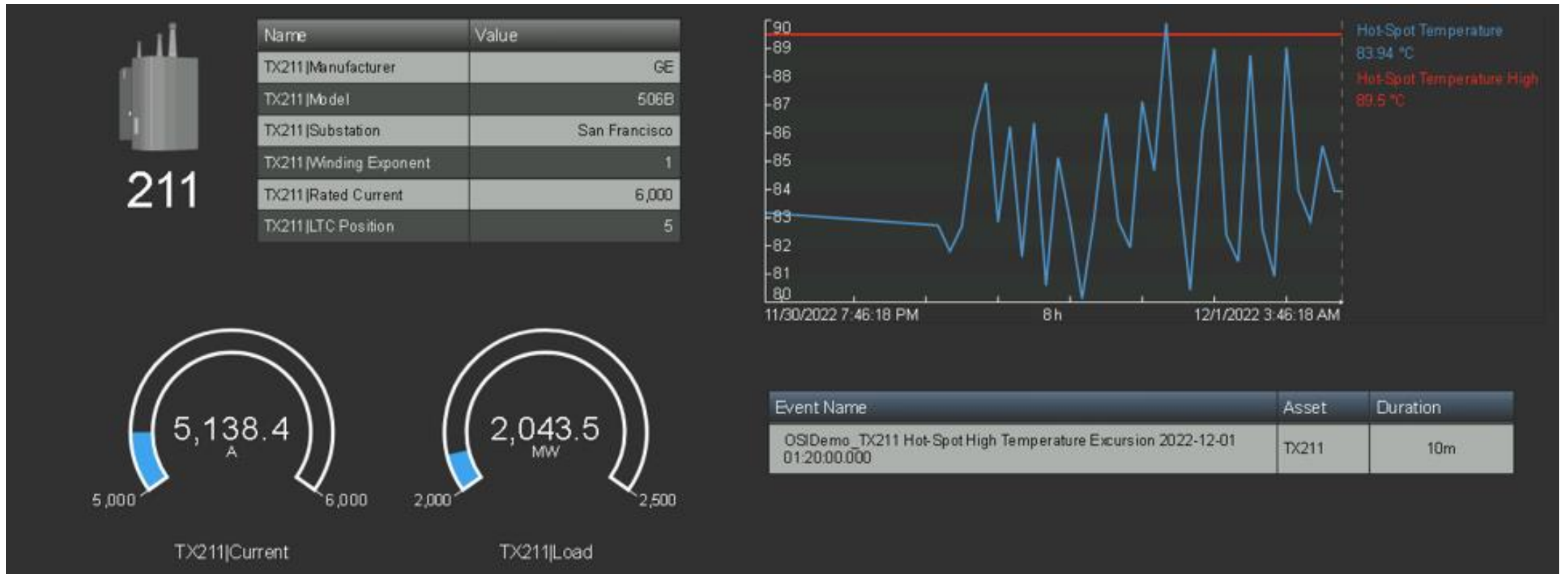
## Creating PI Vision displays



- PI Vision provides an intuitive web-based experience. We will not do a step by step here but rather let you use the tools at your disposal to build one or more displays to help monitor the health of assets and identify poor health KPIs.
- On the left hand side panel, **navigate to your database 'StudentXX Sandbox'** and you should see the hierarchy you just created.
- There are a list of Elements and their respective Attributes.
- You can select which symbol to use at the top, **there are trends, tables, gauges, charts and XY-plots**. Then you select and drag one or more Attributes to the drawing area in the middle and you should have symbols with data in them.
- You can also right click on a symbol that you dragged to the drawing area to bring up its formatting properties, configurations and add multi-states.

# The solution

## Transformer details (< 10 min)





# The solution

## Health dashboard (Collections) (<15 min)



- Bar symbol: Hot-Spot Temp & Top-Oil Temp

# The solution

## Health dashboard (Collections) (<7 min)

Asset Comparison Table

Asset	Current	Load	LTC Position Change - 24 Hours	Hot-Spot Temperature	Top-Oil Temperature	Model	Substation
TX211	5,004.5	2,101.3	48	80.33	12.499	506B	San Francisco
TX212	5,022.1	2,374.2	48	80.765	12.353	506B	San Francisco
TX241	5,386.3	2,373.2	51	91.543	14.916	506A	Santa Clara
TX242	5,002.7	2,327.3	50	81.112	15.222	506B	Santa Clara
TX261	5,236.9	2,667.6	43	88.15	18.273	506A	Santa Cruz
TX262	5,000.6	2,531.4	51	81.27	15.924	506B	Santa Cruz
TX511	5,596.5	4,961.8	47	99.849	31.902	506B	Tulare
TX512	5,452.2	5,776.7	43	97.437	37.912	506B	Tulare
TX531	5,407.2	5,132.8	49	95.326	31.875	506A	Mariposa
TX532	5,316.4	6,022.5	52	93.195	31.795	506B	Mariposa
TX551	5,676	5,491.6	50	102.1	34.842	506B	Merced
TX552	5,566	5,414.7	44	99.418	34.115	506B	Merced
TX571	5,454.5	5,913.7	52	97.129	35.847	506A	San Luis Obispo
TX572	5,210.6	5,843.9	40	93.899	44.505	506B	San Luis Obispo

- Link to Transformer detail display when click the asset name
- Multistate symbols

---

# Discussion: What's next?





## What's next?

- Discuss what could be done next
  - (e.g. KPIs, Event Frames, Notifications, 3<sup>rd</sup> Party Integration)

---

# Appendix: Full AF Solution



**Library**

- Transformer Monitoring Solution
  - Templates
    - Element Templates
      - District
      - Local Grid
      - PI Data Archive
      - Substation
      - Substation Transformer
    - Event Frame Templates
    - Model Templates
    - Transfer Templates
  - Enumeration Sets
  - Reference Types
  - Tables
    - Table Connections
    - Categories
      - Analysis Categories
      - Attribute Categories
      - Element Categories
      - Notification Rule Categories
      - Reference Type Categories
      - Table Categories

**Elements**

**Event Frames**

**Library**

**Unit of Measure**

**Contacts**

**Management**

**Substation Transformer**

General Attribute Templates Ports Analysis Templates Notification Rule Templates

Group by:  Category  Template

Filter

Name	Description	Default Value	Trait	Settings...
<b>Category: Energy</b>				
Current	Current the transformer is running on.	0 A		\\%@\PI Data Archive\Name%\OSIDemo_%Element%. Current;pointtype=Float32;pointsource=OSIDemo-AFAnalysis;span=1000;zero=5000
Load	Electrical load being consumed.	0 MW		\\%@\PI Data Archive\Name%\OSIDemo_%Element%. Load;pointtype=Float32;pointsource=OSIDemo-AFAnalysis;span=1000;zero=5500
Rated Current	Highest current transformer was de...	6000 A		
<b>Category: Load Tap Changer</b>				
LTC Position	Position of load tap changer.	0		\\%@\PI Data Archive\Name%\OSIDemo_%Element%.LTCP;pointtype=Int32;pointsource=OSIDemo-AFAnalysis
LTC Position Change - 24 Hours	Number of LTC position changes wit...	0		\\%@\PI Data Archive\Name%\OSIDemo_%Element%.LTCPC;pointtype=Int32;pointsource=OSIDemo-AFAnalysis
LTC Unbalanced Time	Time since last LTC position change.	0 s		\\%@\PI Data Archive\Name%\OSIDemo_%Element%.LTCUT;pointtype=Int32;pointsource=OSIDemo-AFAnalysis
<b>Category: Location</b>				
Latitude		0 °		
Longitude		0 °		
<b>Category: Specifications</b>				
Manufacturer		0		
Model		0		
Substation		0		
Transformer Number		0		
Winding Exponent	Winding exponent used in hot-spot ...	1		
<b>Category: Temperature</b>				
Hot-Spot Temperature	Calculated winding hot-spot temper...	0 °C		\\%@\PI Data Archive\Name%\OSIDemo_%Element%.HST;pointtype=Float32;pointsource=OSIDemo-AFAnalysis
Hot-Spot Temperature High	Lowest hot-spot temperature of co...	90 °C		
Rated Hot-Spot Temperature	Highest hot-spot temperature trans...	110 °C		
Temperature High Total Time	Time hot-spot temperature is above...	0 s		\\%@\PI Data Archive\Name%\OSIDemo_%Element%.THHT;pointtype=Float32;pointsource=OSIDemo-AFAnalysis
Top-Oil Temperature	Temperature of oil measured near t...	0 °C		\\%@\PI Data Archive\Name%\OSIDemo_%Element%.TOT;pointtype=Float32;pointsource=OSIDemo-AFAnalysis;span=13;zero=33

**Library**

- Transformer Monitoring Solution
  - Templates
    - Element Templates
      - District
      - Local Grid
      - PI Data Archive
      - Substation
      - Substation Transformer
    - Event Frame Templates
      - Hot-Spot High Temperature Excursion
    - Model Templates
    - Transfer Templates
  - Enumeration Sets
  - Reference Types
  - Tables
  - Table Connections
  - Categories
    - Analysis Categories
    - Attribute Categories
    - Element Categories
    - Notification Rule Categories
    - Reference Type Categories
    - Table Categories

Elements  
Event Frames  
**Library**  
Unit of Measure  
Contacts  
Management

**Hot-Spot High Temperature Excursion**

General Attribute Templates

Filter

Name	Description	Default Value	Trait	Settings...
Category: <None>				
Average Hot-Spot Temperature		0 °C		.\Elements[. ]Hot-Spot Temperature;TimeRangeMethod=Average
Average Load		0 MW		.\Elements[. ]Load;TimeRangeMethod=Average
Average Top Oil-Temperature		0 °C		.\Elements[. ]Top-Oil Temperature;TimeRangeMethod=Average
Duration		0 s		.\Elements[. ]Top-Oil Temperature;TimeMethod=NotSupported;TimeRangeMethod=Count;UOM=s
Maximum Hot-Spot Temperature		0 °C		.\Elements[. ]Hot-Spot Temperature;TimeRangeMethod=Maximum
Maximum Top Oil-Temperature		0 °C		.\Elements[. ]Top-Oil Temperature;TimeRangeMethod=Maximum
Substation		0		.\Elements[. ]Substation;
Substation Transformer		0		%Element%;

Group by:  Category  Template

Name: Average Hot-Spot Temperature

Description:

Properties: <None>

Categories:

Default UOM: degree Celsius

Value Type: Double

Default Value: 0 °C

Display Digits: -5

Data Reference: PI Point

Settings...

.\Elements[. ]Hot-Spot Temperature;TimeRangeMethod=Average

[Limits](#) [Forecasts](#)

Elements

- Assets
  - TX211
  - TX212
  - TX241
  - TX242
  - TX261
  - TX262
  - TX511
  - TX512
  - TX531
  - TX532
  - TX551
  - TX552
  - TX571
  - TX572
- California
  - Fresno
    - Mariposa
      - TX531
      - TX532
    - Merced
      - TX551
      - TX552
    - San Luis Obispo
      - TX571
      - TX572
    - Tulare
      - TX511
      - TX512
  - Oakland
    - San Francisco
      - TX211
      - TX212
    - Santa Clara
      - TX241
      - TX242
    - Santa Cruz
      - TX261
      - TX262
- PI Data Archive
- Element Searches
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TX211

General Child Elements Attributes Ports Analyses Notification Rules Version

Filter

Name	Value	Time Stamp	Settings...
<b>Category: Energy</b>			
Current	5156.4 A	09/11/2022 02:40:00	\\PISR\01\OSIDemo_TX...
Load	2328 MW	09/11/2022 02:40:00	\\PISR\01\OSIDemo_TX...
Rated Current	6000 A	01/01/1970 00:00:00	
<b>Category: Load Tap Changer</b>			
LTC Position	1	09/11/2022 02:40:00	\\PISR\01\OSIDemo_TX...
LTC Position Change - 24 Hours	119	09/11/2022 02:40:00	\\PISR\01\OSIDemo_TX...
LTC Unbalanced Time	0 s	09/11/2022 02:40:00	\\PISR\01\OSIDemo_TX...
<b>Category: Location</b>			
Latitude	37.758 °	01/01/1970 00:00:00	
Longitude	-122.44 °	01/01/1970 00:00:00	
<b>Category: Specifications</b>			
Manufacturer	GE	01/01/1970 00:00:00	
Model	506B	01/01/1970 00:00:00	
Substation	San Francisco	01/01/1970 00:00:00	
Transformer Number	211	01/01/1970 00:00:00	
Winding Exponent	1	01/01/1970 00:00:00	
<b>Category: Temperature</b>			
Hot-Spot Temperature	85.533 °C	09/11/2022 02:40:00	\\PISR\01\OSIDemo_TX...
Hot-Spot Temperature High	89.5 °C	01/01/1970 00:00:00	
Rated Hot-Spot Temperature	110 °C	01/01/1970 00:00:00	
Temperature High Total Time	7741.1 s	09/11/2022 02:40:00	\\PISR\01\OSIDemo_TX...
Top-Oil Temperature	16.411 °C	09/11/2022 02:40:00	\\PISR\01\OSIDemo_TX...

Group by:  Category  Template

Name: Load

Description: Electrical load being consumed.

Properties: <None>

Categories: Energy

Default UOM: MW

Value Type: Double

Value: 2328 MW

Display Digits: -5

Data Reference: PI Point

Settings...

\\PISR\01\OSIDemo\_TX211.Load

[Limits](#) [Forecasts](#)



Elements

- Assets
  - TX211
  - TX212
  - TX241
  - TX242
  - TX261
  - TX262
  - TX511
  - TX512
  - TX531
  - TX532
  - TX551
  - TX552
  - TX571
  - TX572
- California
  - Fresno
    - Mariposa
      - TX531
      - TX532
    - Merced
      - TX551
      - TX552
    - San Luis Obispo
      - TX571
      - TX572
    - Tulare
      - TX511
      - TX512
  - Oakland
    - San Francisco
      - TX211
      - TX212
    - Santa Clara
      - TX241
      - TX242
    - Santa Cruz
      - TX261
      - TX262
- PI Data Archive
- Element Searches
  - Attribute Search 1

Elements

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### TX211

General Child Elements Attributes Ports Analyses Notification Rules Version

Name	Backfilling
Hot-Spot Temperature	✓
Hot-Spot Temperature High Excursion	✓
LTC Position Change - 24 Hours	✓
LTC Unbalanced Time	✓

Name: Hot-Spot Temperature

Description:

Categories:

Analysis Type:  Expression  Rollup  Event Frame Generation  SQC

Add a new variable

Name	Expression	Output Attribute
HST	'Top-Oil Temperature'+('Rated Hot-Spot Temperature'-'Top-Oil Temperature')*( 'Current'/'Rated Current')^(2*'Winding Expon	Hot-Spot Temperature

Evaluate

#### Functions

Insert functions into the expression

All

- Abs
- Acos
- And
- ArrayLength
- Ascii
- Asin
- Atn
- Atn2
- Avg
- BadVal
- Bod
- Bom
- Bonm
- Ceiling
- Char
- Compare
- Concat
- Contains
- Convert
- Cos
- Cosh
- Cot
- Coth
- Cov

Abs(number x)  
Return the absolute value of an integer or real number.  
Example: Abs(-2.2) [Returns 2.2]

Attributes

Scheduling:  Event-Triggered  Periodic

Trigger on: Any Input

Advanced...

Connected to the PI Analysis Service.

Elements

- Assets
  - TX211
  - TX212
  - TX241
  - TX242
  - TX261
  - TX262
  - TX511
  - TX512
  - TX531
  - TX532
  - TX551
  - TX552
  - TX571
  - TX572
- California
  - Fresno
    - Mariposa
      - TX531
      - TX532
    - Merced
      - TX551
      - TX552
    - San Luis Obispo
      - TX571
      - TX572
    - Tulare
      - TX511
      - TX512
  - Oakland
    - San Francisco
      - TX211
      - TX212
    - Santa Clara
      - TX241
      - TX242
    - Santa Cruz
      - TX261
      - TX262
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TX211

General Child Elements Attributes Ports Analyses Notification Rules Version

Name	Backfilling
Hot-Spot Temperature	✓
Hot-Spot Temperature High Excursion	✓
LTC Position Change - 24 Hours	✓
LTC Unbalanced Time	✓
OSIDemo_SimulatedData	✓
Temperature High Total Time	✓

Name: Hot-Spot Temperature High Excursion

Description:

Categories:

Analysis Type:  Expression  Rollup  Event Frame Generation  SQL

[Create a new notification rule for Hot-Spot Temperature High Excursion](#)

Generation Mode: Explicit Trigger Event Frame Template: Hot-Spot High Temperature Excursion

Name	Expression	True for	Severity
Start triggers			
StartTrigger	'Hot-Spot Temperature' > 'Hot-Spot Temperature High'	30 seconds	None

Advanced Event Frame Settings...

> Functions

Insert functions into the expression

All

- Abs
- Acos
- And
- ArrayLength
- Ascii
- Asin
- Atn
- Atn2
- Avg
- BadVal
- Bod
- Bom
- Bonm
- Ceiling
- Char
- Compare
- Concat
- Contains
- Convert
- Cos
- Cosh

Abs(number x)  
Return the absolute value of an integer or real number.  
Example: Abs(-2.2) [Returns 2.2]

< Attributes

Scheduling:  Event-Triggered  Periodic

Trigger on: Any Input

Elements

- Assets
  - TX211
  - TX212
  - TX241
  - TX242
  - TX261
  - TX262
  - TX511
  - TX512
  - TX531
  - TX532
  - TX551
  - TX552
  - TX571
  - TX572
- California
  - Fresno
    - Mariposa
      - TX531
      - TX532
    - Merced
      - TX551
      - TX552
    - San Luis Obispo
      - TX571
      - TX572
    - Tulare
      - TX511
      - TX512
  - Oakland
    - San Francisco
      - TX211
      - TX212
    - Santa Clara
      - TX241
      - TX242
    - Santa Cruz
      - TX261
      - TX262
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General Child Elements Attributes Ports Analyses Notification Rules Version

Name	Backfilling
Hot-Spot Temperature	✓
Hot-Spot Temperature High Excursion	✓
LTC Position Change - 24 Hours	✓
LTC Unbalanced Time	✓
OSIDemo_SimulatedData	✓
Temperature High Total Time	✓

Name: LTC Position Change - 24 Hours

Description:

Categories:

Analysis Type:  Expression  Rollup  Event Frame Generation  SQC

Add a new variable

Name	Expression	Output Attribute
LTCPC	EventCount('LTC Position', '*-24h', '*')	LTC Position Change - 24 Hours

Evaluate

> Functions

Insert functions into the expression

All

- Abs
- Acos
- And
- ArrayLength
- Ascii
- Asin
- Atn
- Atn2
- Avg
- BadVal
- Bod
- Bom
- Bonm
- Ceiling
- Char
- Compare
- Concat
- Contains
- Convert
- Cos
- Cosh

Abs(number x)  
Return the absolute value of an integer or real number.  
Example: Abs(-2.2) [Returns 2.2]

< Attributes

Scheduling:  Event-Triggered  Periodic

Trigger on: Any Input

Advanced...

Elements

- Assets
  - TX211
  - TX212
  - TX241
  - TX242
  - TX261
  - TX262
  - TX511
  - TX512
  - TX531
  - TX532
  - TX551
  - TX552
  - TX571
  - TX572
- California
  - Fresno
    - Mariposa
      - TX531
      - TX532
    - Merced
      - TX551
      - TX552
    - San Luis Obispo
      - TX571
      - TX572
    - Tulare
      - TX511
      - TX512
  - Oakland
    - San Francisco
      - TX211
      - TX212
    - Santa Clara
      - TX241
      - TX242
    - Santa Cruz
      - TX261
      - TX262
- PI Data Archive
- Element Searches
- Attribute Search 1

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Event Frames

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TX211

General Child Elements Attributes Ports Analyses Notification Rules Version

Name	Backfilling
✓ <input type="checkbox"/> f80 Hot-Spot Temperature	✓
✓ <input type="checkbox"/> H Hot-Spot Temperature High Excursion	✓
✓ <input type="checkbox"/> f80 LTC Position Change - 24 Hours	✓
✓ <input type="checkbox"/> f80 LTC Unbalanced Time	✓
✓ <input type="checkbox"/> f80 OSIDemo_SimulatedData	✓
✓ <input type="checkbox"/> f80 Temperature High Total Time	✓

Name: LTC Unbalanced Time

Description:

Categories:

Analysis Type:  Expression  Rollup  Event Frame Generation  SQC

Add a new variable

Name	Expression	Output Attribute
LTCUT	<code>Int(TimeEq('LTC Position',prevent('LTC Position','*'),'*', 'LTC Position'))</code>	LTC Unbalanced Time

Evaluate

> Functions

Insert functions into the expression

All

- Abs
- Acos
- And
- ArrayLength
- Ascii
- Asin
- Atn
- Atn2
- Avg
- BadVal
- Bod
- Bom
- Bonm
- Ceiling
- Char
- Compare
- Concat
- Contains
- Convert
- Cos
- Cosh

Abs(number x)  
Return the absolute value of an integer or real number.  
Example: Abs(-2.2) [Returns 2.2]

< Attributes

Scheduling:  Event-Triggered  Periodic

Trigger on: Any Input

Advanced...

Connected to the PI Analysis Service.

Elements

- Assets
  - TX211
  - TX212
  - TX241
  - TX242
  - TX261
  - TX262
  - TX511
  - TX512
  - TX531
  - TX532
  - TX551
  - TX552
  - TX571
  - TX572
- California
  - Fresno
    - Mariposa
      - TX531
      - TX532
    - Merced
      - TX551
      - TX552
    - San Luis Obispo
      - TX571
      - TX572
    - Tulare
      - TX511
      - TX512
  - Oakland
    - San Francisco
      - TX211
      - TX212
    - Santa Clara
      - TX241
      - TX242
    - Santa Cruz
      - TX261
      - TX262
- PI Data Archive
- Element Searches
- Attribute Search 1

Elements

Event Frames

Library

Unit of Measure

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Management

TX211

General Child Elements Attributes Ports Analyses Notification Rules Version

Name	Backfilling
Hot-Spot Temperature	✓
Hot-Spot Temperature High Excursion	✓
LTC Position Change - 24 Hours	✓
LTC Unbalanced Time	✓
OSIDemo_SimulatedData	✓
Temperature High Total Time	✓

Name: Temperature High Total Time

Description:

Categories:

Analysis Type:  Expression  Rollup  Event Frame Generation  SQC

Add a new variable

Name	Expression	Output Attribute
THTT	if BadVal('Temperature High Total Time') then 0 else PrevVal('Temperature High Total Time','*') + TimeGT('Hot-Spot Temper	Temperature High Total Time

Evaluate

> Functions

Insert functions into the expression

All

- Abs
- Acos
- And
- ArrayLength
- Ascii
- Asin
- Atn
- Atn2
- Avg
- BadVal
- Bod
- Bom
- Bonm
- Ceiling
- Char
- Compare
- Concat
- Contains
- Convert
- Cos
- Cosh

Abs(number x)  
Return the absolute value of an integer or real number.  
Example: Abs(-2.2) [Returns 2.2]

Attributes

Scheduling:  Event-Triggered  Periodic

Trigger on: Any Input

Advanced...

Connected to the PI Analysis Service.

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AVEVA is a world leader in industrial software, providing engineering and operational solutions across multiple industries, including oil and gas, chemical, pharmaceutical, power and utilities, marine, renewables, and food and beverage. Our agnostic and open architecture helps organizations design, build, operate, maintain and optimize the complete lifecycle of complex industrial assets, from production plants and offshore platforms to manufactured consumer goods.

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