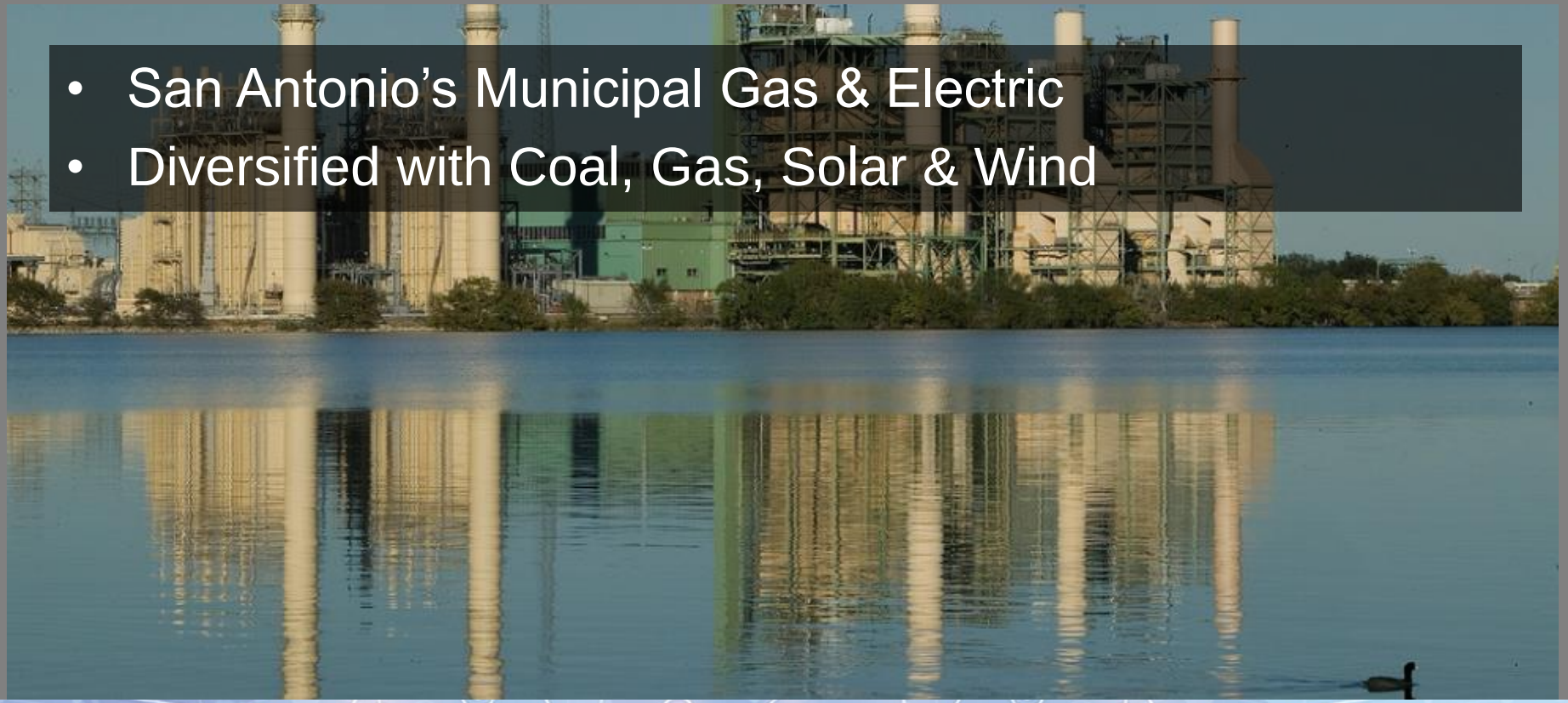
Turbine Efficiency
Pump Performance

Using AF

OSIsoft.

CPS Energy



- San Antonio’s Municipal Gas & Electric
- Diversified with Coal, Gas, Solar & Wind

Business Decision

- Enterprise Asset Customer – “Downtown decision”
- Comes with “All You Can Eat Buffet”
- Now, what do we do?
- Test Crew – needs help!

HP & IP Turbine Efficiency

- AF Jump Start Workshop
- Developed HP Turbine Efficiency tool
  - One set of data inputs
  - But, some units had 2, 3 or 4
- Take two – Developed Data Preparation Modules
  - Average points, unit conversions, time averaging, validation
  - Each unit has separate data preparation module
  - Outputs to standardized attributes & PI Tags

    Braunig1.Throttle Pressure Abs Avg

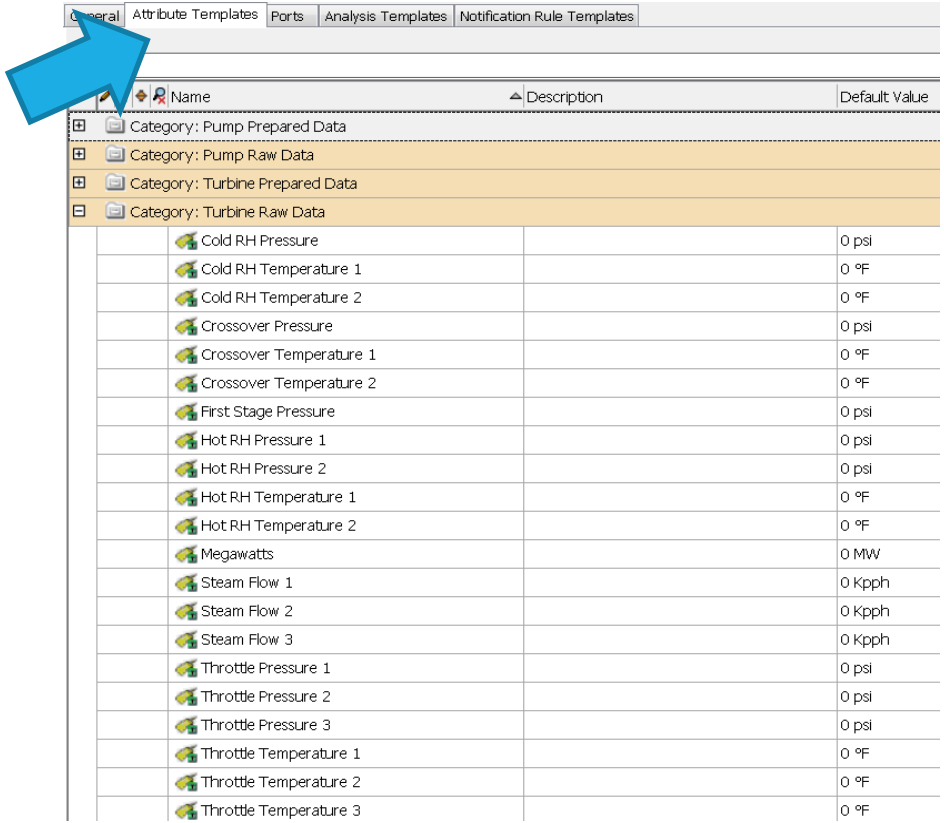
    Braunig2.Throttle Pressure Abs Avg
- One HP-IP turbine template; multiple elements

Turbine Calculations (Engineer Talk)

- Turbine efficiency is a function of inlet condition (Temp, Press) and outlet conditions (Temp, Press)
- Efficiency = (Input Enthalpy – Output Enthalpy)/ (Input Enthalpy – “Ideal” Output Enthalpy)
- AF has Steam Property calculations built in (enthalpy, entropy, etc.)
- So… next step is to build ONE HP and IP turbine template

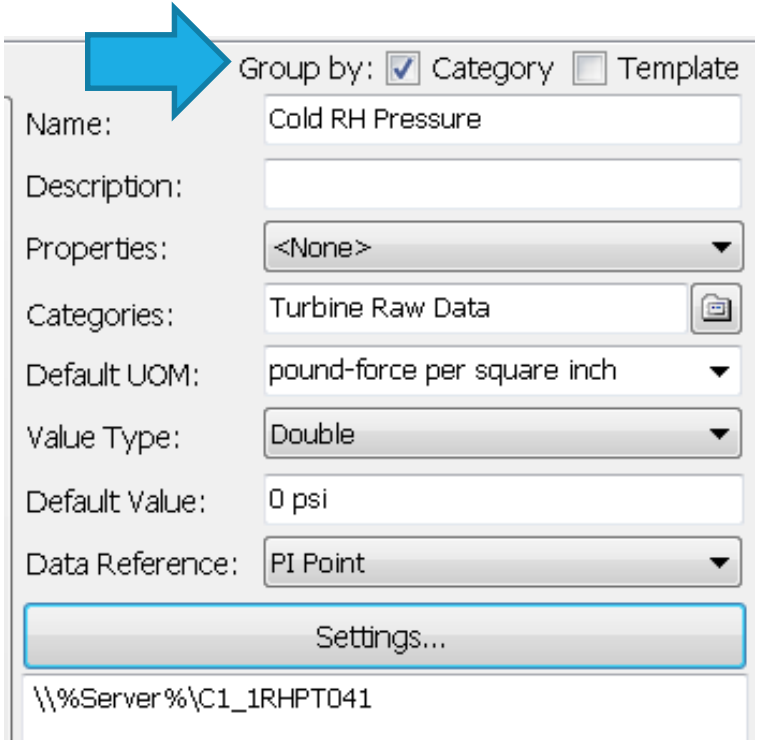
Data Preparation: Turbine Raw Data

- Some points are single (e.g. Cold RH Pressure)
- Some have two (e.g. Hot RH Pressure)
- Some have 3 (e.g. Steam Flow)
- As many as 4 (not shown)
- No two units are the same!



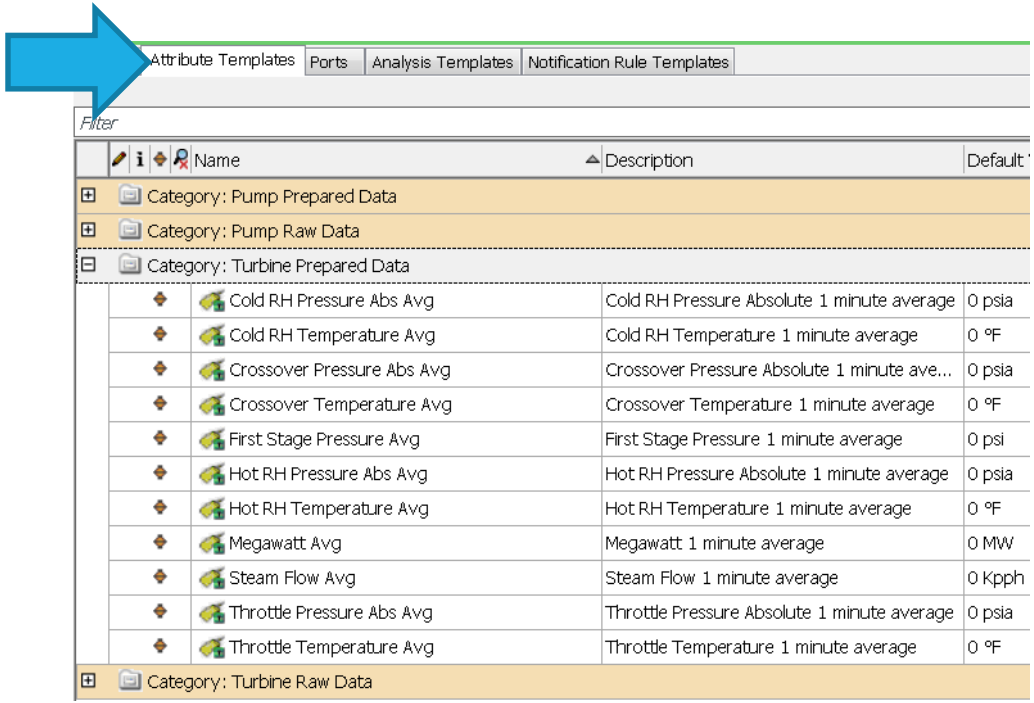
Data Preparation: Turbine Raw Data (Details)

- Group by Category (more on that later)
- Name – follow a naming convention
- Description – not necessary
- Properties – skip
- Categories – more on this later
- Default Unit of Measure (UOM)
- Value Type: Double is “standard”
- Default Value: skip
- Data Reference: PI Point
- Settings: This maps PI Point to AF



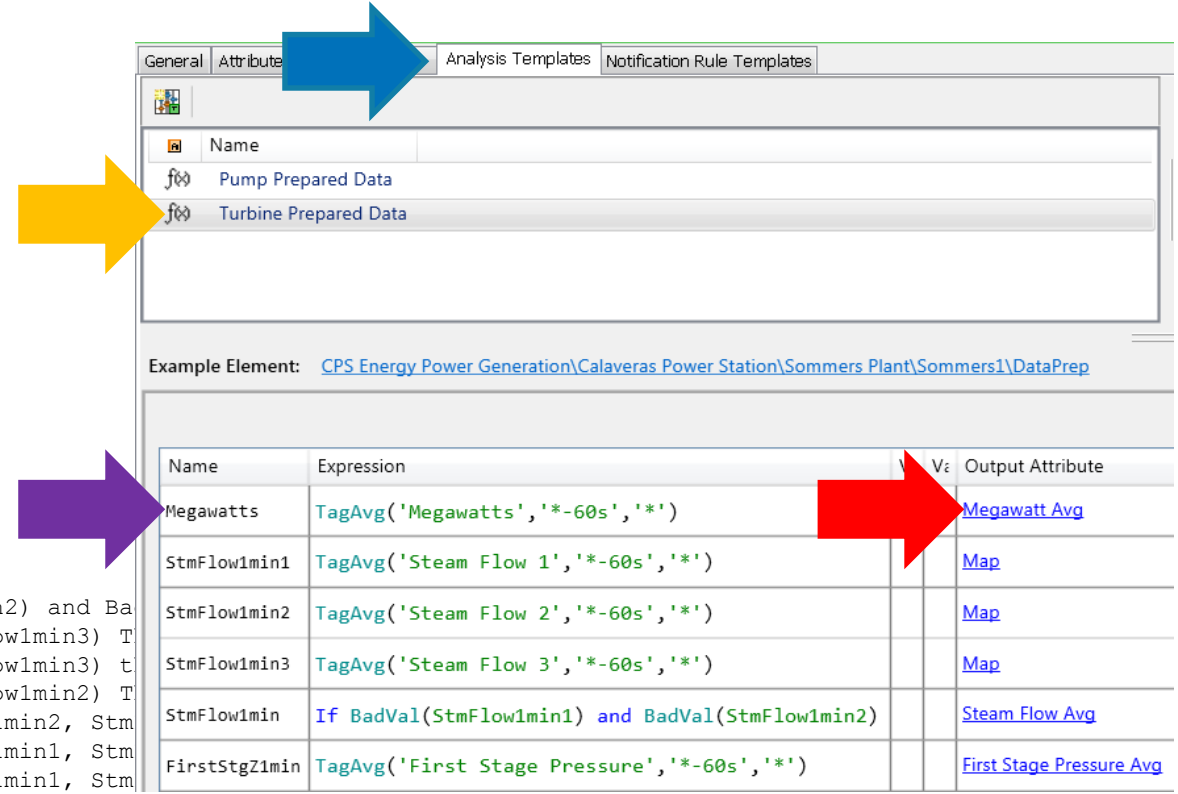
Data Preparation: Turbine Prepared Data

- Follow a naming convention!
- For turbines, absolute pressure is important
- HP Turbine requires 4 inputs and an “X-axis”
- IP Turbine requires 4 inputs and an “X-axis”
- All of these require calculations…
- Where do the calculations happen?



Data Preparation: Customized Calculations

- Analysis Templates
- Note organization
- Scope of variables
- Output Attributes
- Equations
- Data validation




```
If BadVal(StmFlow1min1) and BadVal(StmFlow1min2) and Ba
Else If BadVal(StmFlow1min2) and BadVal(StmFlow1min3) T
Else If BadVal(StmFlow1min1) and BadVal(StmFlow1min3) t
Else If BadVal(StmFlow1min1) and BadVal(StmFlow1min2) T
Else If BadVal(StmFlow1min1) Then Avg(StmFlow1min2, Stm
Else If BadVal(StmFlow1min2) Then Avg(StmFlow1min1, Stm
Else If BadVal(StmFlow1min3) Then Avg(StmFlow1min1, Stm
Else Avg(StmFlow1min1, StmFlow1min2, StmFlow1min3)
```

Steam Turbine Template: Turbine Raw & Prepared Data

- Output from Data Prep…
- Are inputs for Steam Turbine Template!
- Calculation Limit
- Categories

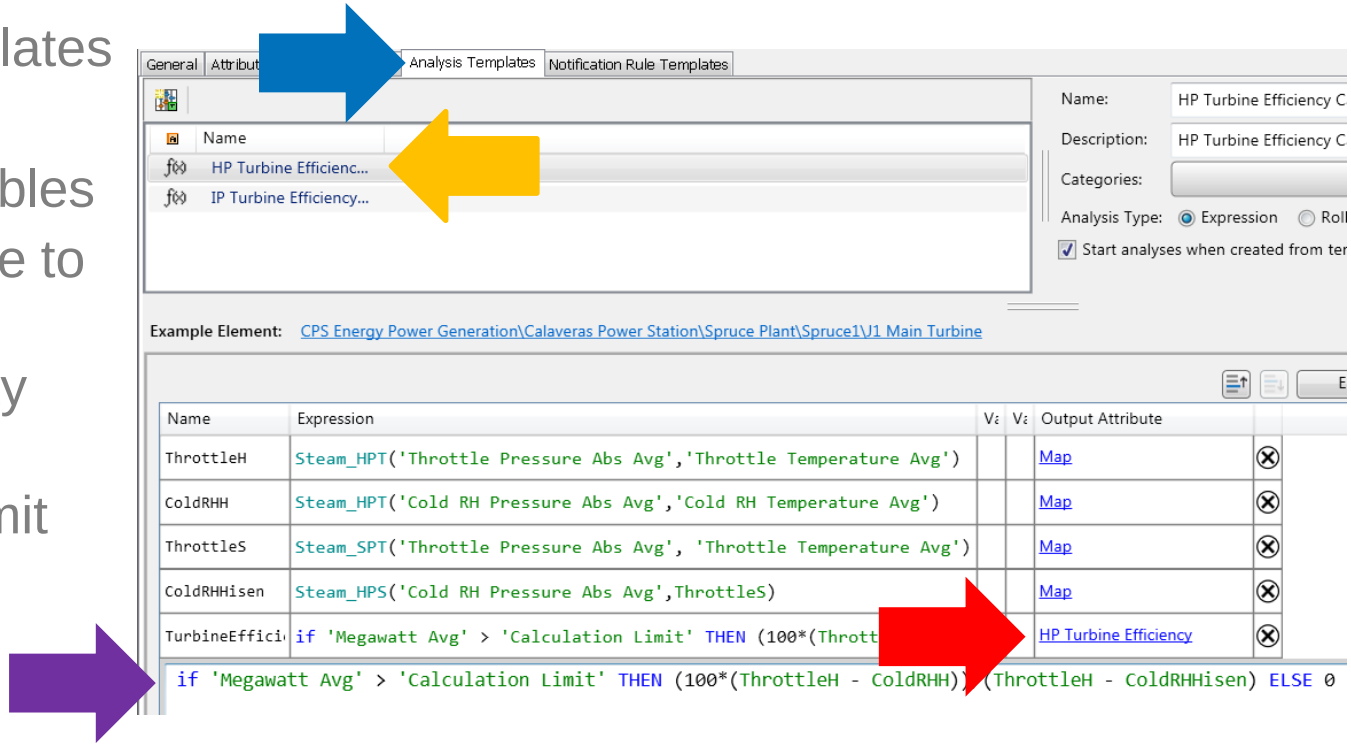
General | Attribute Templates | Ports | Analysis Templates | Notification Rule Templates

Filter

Name	Description	Default Value
Category: Turbine Efficiency		
Calculation Limit	Do Not Calc if MW below Limit	100 MW
Cold RH Pressure Abs Avg	Cold RH Pressure Absolute 1 minute average	0 psia
Cold RH Temperature Avg	Cold RH Temperature 1 minute average	0 °F
Crossover Pressure Abs Avg	Crossover Pressure Absolute 1 minute ave...	0 psia
Crossover Temperature Avg	Crossover Temperature 1 minute average	0 °F
First Stage Pressure Avg	First Stage Pressure 1 minute average	0 psi
FW Flow Avg	FW Flow 1 minute average	0 Kpph
Hot RH Pressure Abs Avg	Hot RH Pressure Absolute 1 minute average	0 psia
Hot RH Temperature Avg	Hot RH Temperature 1 minute average	0 °F
HP Turbine Efficiency	HP Turbine Efficiency	0 %
IP Turbine Efficiency	IP Turbine Efficiency	0 %
Megawatt Avg	Megawatt 1 minute average	0 MW
Steam Flow Avg	Steam Flow 1 minute average	0 Kpph
Throttle Pressure Abs Avg	Throttle Pressure Absolute 1 minute average	0 psia
Throttle Temperature Avg	Throttle Temperature 1 minute average	0 °F

Steam Turbine Template: Calculations

- Analysis Templates
- Organization
- Scope of variables
- Output Attribute to PI Tags
- Steam Property Calcs
- Calculation Limit



HP/IP Turbine At-A-Glance

- Data Preparation Steps
  - What input data is required? – goal setting
  - Locate point(s) for each input – find the PI points
  - Create AF points, mapped to PI points
  - Do numerical averaging (60 second averages)
  - Do other intermediate calcs (e.g. convert psig to psia)
  - Do averaging for multiple points, with data validation
- Create HP/IP Turbine Template
- Create HP\IP Turbine Element (specific unit & data prep element)

Visualization

Next Project: Pump Performance

- All centrifugal pumps have similar characteristic curves
- Pump affinity equations will work for most pumps
- Required data
  - Inlet temperature & pressure
  - Outlet temperature & pressure
  - Pump flow
  - Pump speed (rpm) – may be constant
  - Design pump speed

Pump Performance - Nuances

- Boiler Feed Pumps – sort of easy
- Condensate Pumps – suction pressure in $inHg_{abs}$
- Boiler Feed Booster Pumps – ratioed speed
- Some points are single, some have 2, some have 3 (need to average and use data verification)

Asset Framework Nuances

- When list of points gets longer, organization is more important
- Rule of thumb: keep it all visible on one page
- Categories – very useful!

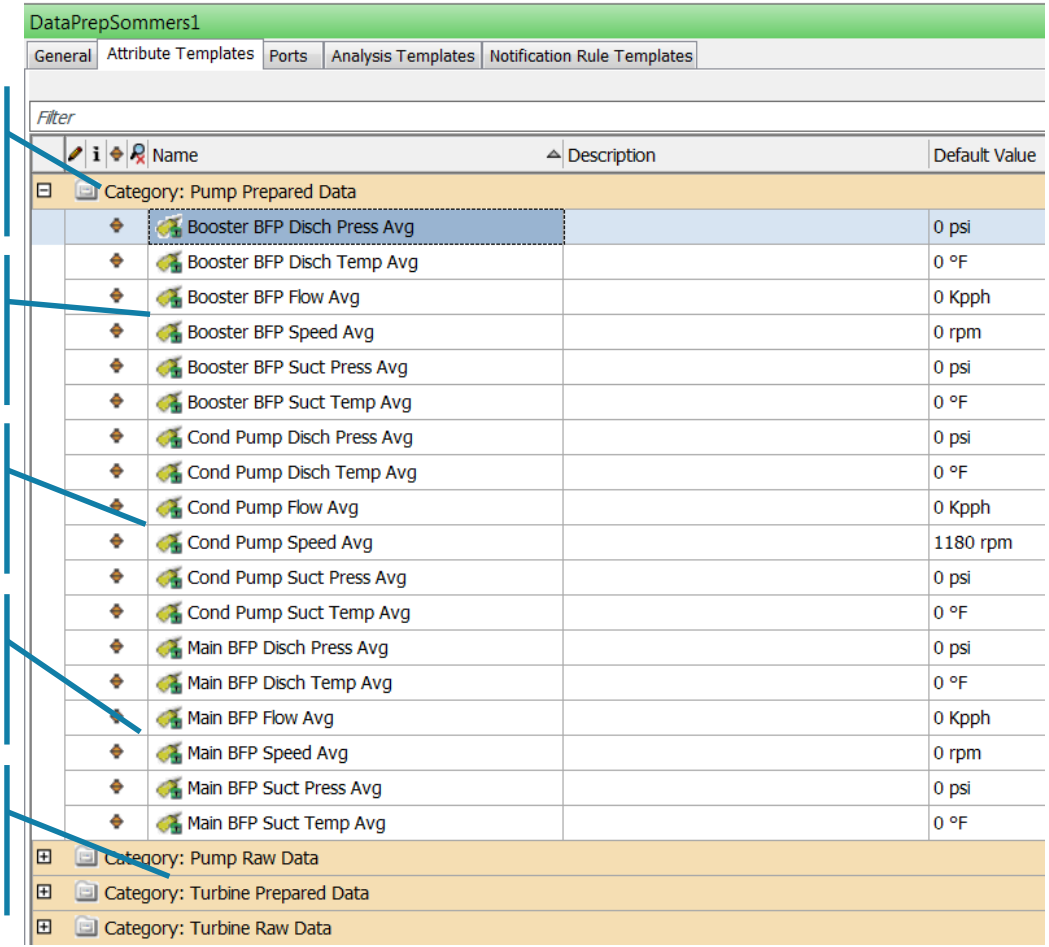
Pump Prepared Data

6 points for Booster BFP

6 points for Cond Pumps

6 points for Main BFP

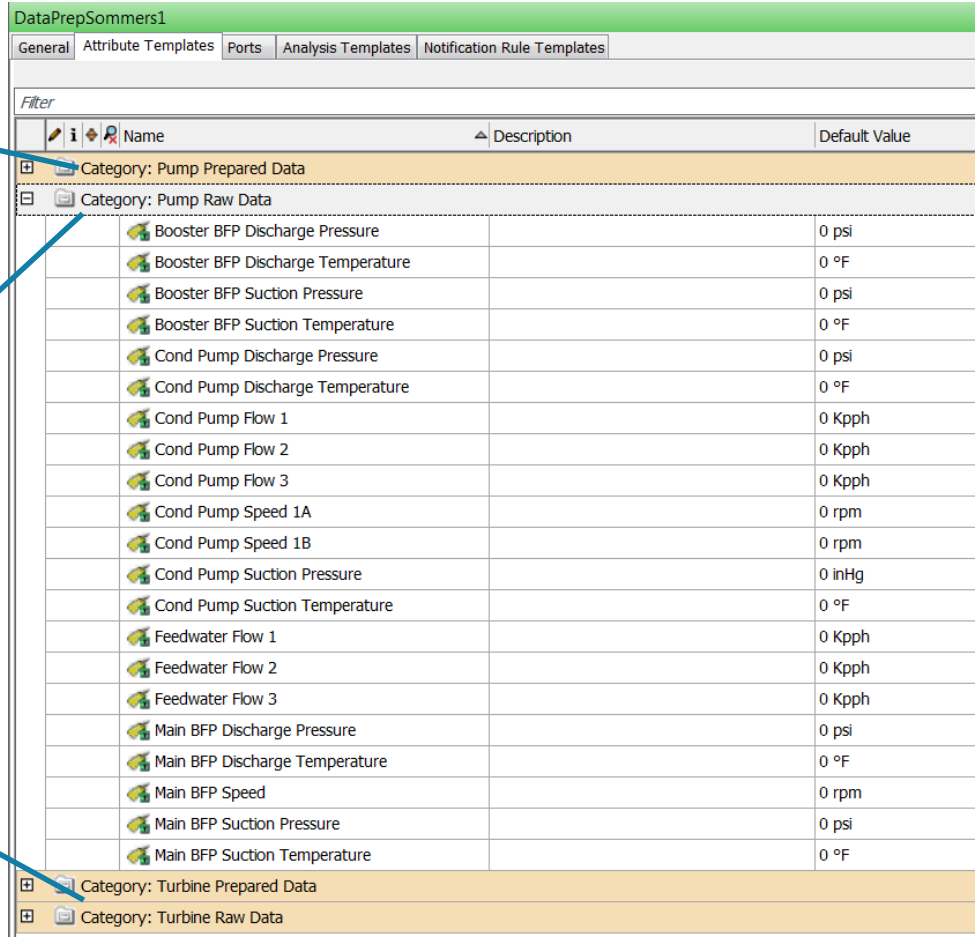
Other Categories



Prepared Data (collapsed)

Pump Raw Data

Turbine Categories



Analysis Templates

Name	Expression	Va	Va	Output Attribute	
Megawatts	TagAvg('Megawatts','*-60s','*')			Megawatt Avg	⊗
StmFlow1min1	TagAvg('Steam Flow 1','*-60s','*')			Map	⊗
StmFlow1min2	TagAvg('Steam Flow 2','*-60s','*')			Map	⊗
StmFlow1min3	TagAvg('Steam Flow 3','*-60s','*')			Map	⊗
StmFlow1min	If BadVal(StmFlow1min1) and BadVal(StmFlow1min2) and BadVal(StmFlo			Steam Flow Avg	⊗
FirstStgZ1min	TagAvg('First Stage Pressure','*-60s','*')			First Stage Pressure Avg	⊗
ThrStmZ1min1	TagAvg('Throttle Pressure 1','*-60s','*')+14.696			Map	⊗
ThrStmZ1min2	TagAvg('Throttle Pressure 2','*-60s','*')+14.696			Map	⊗
ThrStmZ1min3	TagAvg('Throttle Pressure 3','*-60s','*')+14.696			Map	⊗
ThrStmZ1min	If BadVal(ThrStmZ1min1) and BadVal(ThrStmZ1min2) and BadVal(ThrStm			Throttle Pressure Abs Avg	⊗
ThrStmQ1min1	TagAvg('Throttle Temperature 1','*-60s','*')			Map	⊗

Analysis Templates

- Calculations cannot be grouped by category
- But, more than one Asset Template may be used
- So I put these in a “logical sequence”
- “X-axis” – first stage pressure/ megawatts/ steam flow
- HP turbine inlet steam
- HP turbine outlet steam
- IP turbine inlet steam
- IP turbine outlet steam
- Double (triple) readings come first, then averages

Summing Up…

- Goal Setting (HP/IP Turbine Efficiency)
- Start Somewhere (Jump Start)
- Goal Refinement
- Go slow to go fast
  - Data Preparation for Turbines
  - Template for Turbines
  - Data Preparation for Pumps
  - Template for Pumps
  - Categorize/ Organize along the way
  - Leave Space for future work

The Ultimate Win

- Test Crew Past – once 5 (+5)
- Test Crew Present – one guy
- Test Crew Future - AF

Contact Information

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Questions

Please wait for the **microphone** before asking your questions

State your **name & company**

Please don't forget to…

complete the Post Event Survey

감사합니다

谢谢

Danke

Merci

Gracias

Thank You

ありがとう

Спасибо

Obrigado