

AVEVAWORLD
PARIS

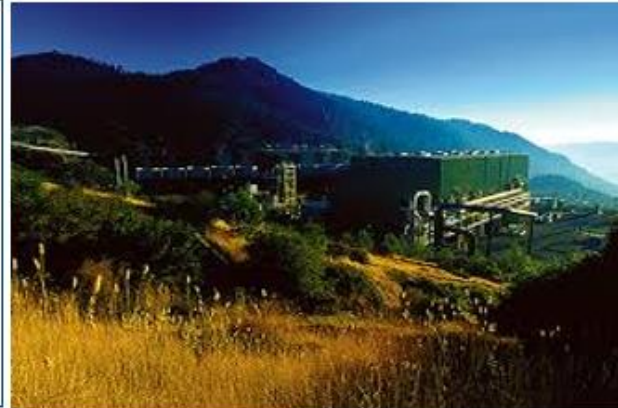
OCTOBER 2024

Modernizing Calpine's Data Infrastructure

with the AVEVA PI System & AVEVA Predictive Analytics

Presented by: Sridhar Makkapati (Calpine) & Joe Rose (RoviSys)

AVEVA



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With **76 energy facilities in operation** and **two battery storage facilities under construction**, Calpine's fleet has the capacity to generate over **26,500 megawatts** of electricity - enough to power approximately **26 million homes**. Our geographically diverse fleet capitalizes on trends in the nation's most robust power markets.

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+120 Experienced PI System Solution Resources



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Initial Migration Struggles

Attempted migration for four plants

- Process was very slow and manual – export, manipulate, import
- Approach was prone to mistakes and unmanageable at scale
- eDNA calculated values had to be tabled with no clear way to move them into the PI System
- Plants had unique asset structures built in eDNA, lacking standardization
- Many plants had direct OPC connections between the plant systems and customers for data sharing
- On-prem, distributed server architecture and eDNA thick client application and plug-ins were difficult to install, manage, and support

Partnering with an SI

An unexpected bottleneck...

- Simplifying architecture from many site eDNA historians to one Enterprise PI Server meant eDNA tag names may not be unique
- The architecture uses dedicated migration instances of the PI Server to convert the data, then a PItoPI Interface moves it into the Production PI Server
- With many years of data funneling into a single Production environment, ingress of live production data saw long delays
- To overcome this challenge, the RoviSys team developed a custom PItoPI Interface that monitors system resources and throttles itself to avoid overloading the target environment
- With this in place, live data access was restored

Partnering with an SI

Overcoming the Calculations Hurdle

- With data migration streamlined, the next challenge was moving calculations to the PI System & AF Analytics
 - Over 100,000 calculated tags, with no out-of-the-box way to migrate them
 - Developed scripts that identify calculation syntax and recreates them in PI Asset Framework Analytics
 - Some calculation structures not natively compatible between eDNA and PI AF Analytics - flagged for follow-up
 - 70% of existing calculations converted automatically
- Calculations programmatically recreated in an Analysis Warehouse within the AF Hierarchy
 - Allowed for Template-based AF Hierarchy to be built in parallel
 - Attributes updated with respective Analyses

```
[08/30 14:45:10] Translating eDNA Equation: /* Forever Totalizers */
/* eDNA CALCSERV SCAN RATE MUST MATCH SCAN_RATE VARIABLE */

PT_SOURCE$ = "AG.AG.C0000014"
PT_CALC$ = "AG.AG.C0000061"

/*Scan_Rate = 10*/
PT_SOURCE_STATUS = RELIABILITY(PT_SOURCE$)
PT_CALC_STATUS = RELIABILITY(PT_CALC$)

If PT_SOURCE_STATUS != 2 Then
  VAL1 = DNAGETRTVALUE(PT_SOURCE$)

If PT_CALC_STATUS != 2 Then
  VAL2 = DNAGETRTVALUE(PT_CALC$)

  VALUE = VAL1 * (1/360) + VAL2

Else

If PT_CALC_STATUS = 2 Then
  PERIOD = 86400
  ENDTIME = CALCTIME()
  STARTTIME = ENDTIME - PERIOD

  KEY = DNAHISTSTARTRAWUTC(PT_CALC$, STARTTIME)

If KEY > 0 THEN
  DO
  TEST = DNAHISTGETVAL(KEY)
  RET = DNAHISTNEXT(KEY)
  LOOP WHILE RET = 0
  ENDIF

STATUS = OK
Value = TEST + VAL1*(1/360)

EndIf
ENDIF
ENDIF
```

```
[08/30 14:45:10] Starting Translation...
Translating eDNA Equation: If MOD(SECONDS(), 10) = 0 Then

/* AG0100.SITplELmw01a short ID: C0000005 */
If RELIABILITY("ag.ag.C0000005") = 2 Then ReliabilityStatus = 2 Else ReliabilityStatus = 1
AG0100_SITplELmw01a = DNAGETRTVALUE("ag.ag.C0000005") EndIf

/*----- C0000001: AG0100.SITgbOPsu01a ----- 5/13/2013 2:21:32 PM
**
if 'AG0100.SITplELmw01a' < 1 then 0 else 1
**/

If AG0100_SITplELmw01a < 1
Then AG0100_SITgbOPsu01a = 0
Else AG0100_SITgbOPsu01a = 1
EndIf

If ReliabilityStatus != 2 Then
VALUE = AG0100_SITgbOPsu01a
EndIf

EndIf
```

Name	Expression	Output Attribute
PIFR0210CTGGNELMW01A	/* TEST := TagVal('FR0200_SITPLLELMW01A'); IF(TEST = 1) THEN /* FR0200_SITPLLELMW01A SHORT ID: C0000273 */ IF((BadVal('FR0200_SITPLLELMW01A', FR0200_SITPLLELMW01A))) THEN NoOutput() TagVal('FR0200_SITPLLELMW01A', FR0200_SITPLLELMW01A)	Map
PIFR0211CTGGNELMW01A	/* FR0200_SITPLLELMW01A SHORT ID: C0000295 */ IF((BadVal('FR0200_SITPLLELMW01A', FR0200_SITPLLELMW01A))) THEN NoOutput() TagVal('FR0200_SITPLLELMW01A', FR0200_SITPLLELMW01A)	Map
PIFR0220STGGNELMW01A	/* FR0200_SITPLLELMW01A SHORT ID: C0000316 */ IF((BadVal('FR0200_SITPLLELMW01A', FR0200_SITPLLELMW01A))) THEN NoOutput() TagVal('FR0200_SITPLLELMW01A', FR0200_SITPLLELMW01A) /*----- C0000245: FR0200_SITPLLELMW01A ----- 10/24/2012 11:56:36 -----*/ /** 'FR0200_SITPLLELMW01A' + 'FR0200_SITPLLELMW01A' **/	Map
FR0200SITPLELMW01A	PIFR0210CTGGNELMW01A+PIFR0211CTGGNELMW01A+PIFR0220STGGNELMW01A	
VALUE	FR0200_SITPLELMW01A /* */	

Refining the Approach

Continuous Improvements in Action

- Selected 10 additional sites within ERCOT (Texas) jurisdiction to fine tune the approach
 - Began migrating multiple sites in parallel
 - Able to identify clear tasks and handoffs for various migration phases to further streamline the collaborative Calpine-RoviSys team
- Team prototyping an API version of the Utility
 - Connects directly to eDNA API
 - Eliminates two manual steps for each migration iteration
 - API documentation is very limited
 - Building confidence in this approach

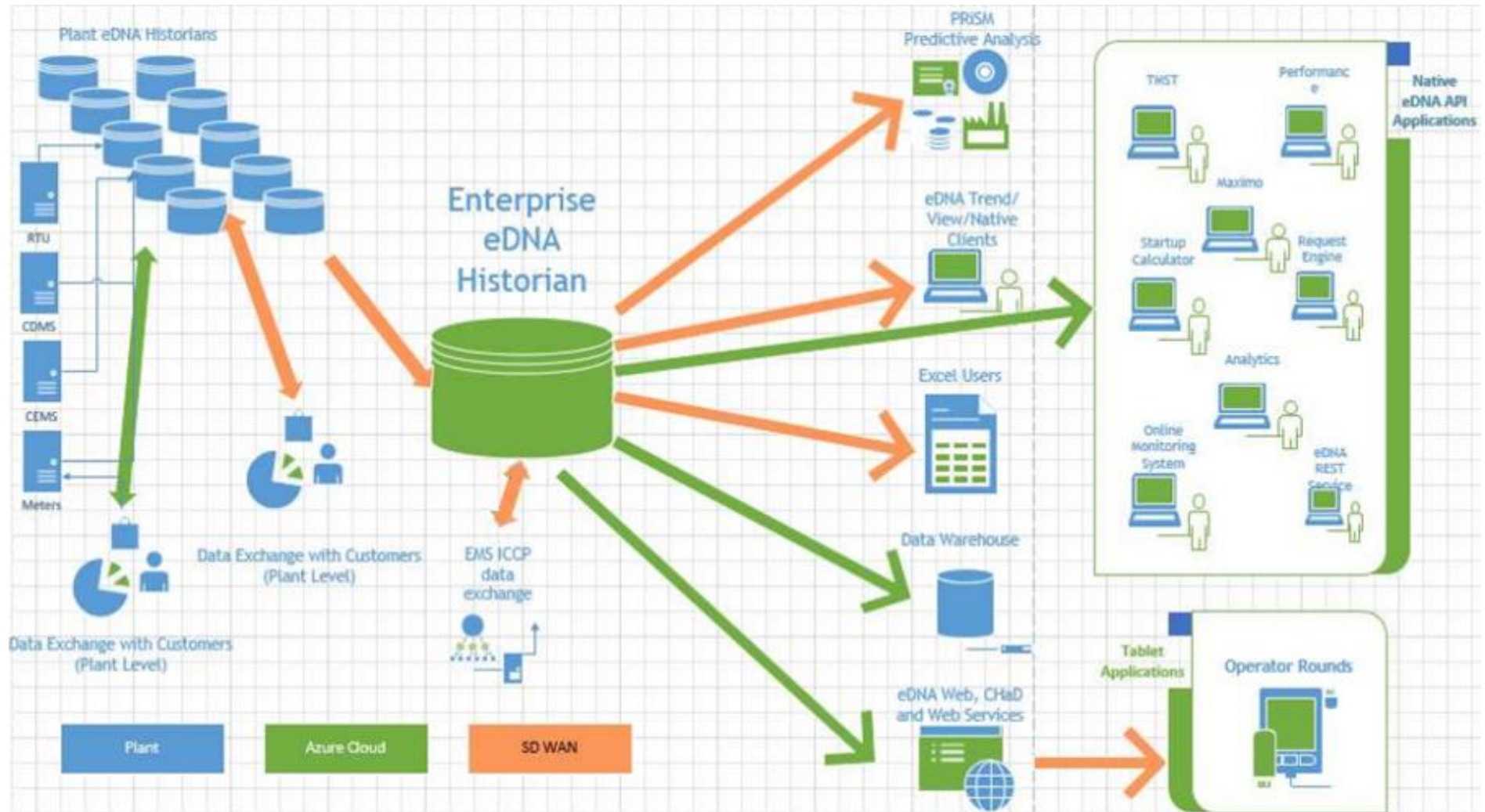
The screenshot displays the AVEVA software interface, divided into several sections:

- Elements Tree (Top Left):** A hierarchical tree structure showing the organization of data. The path is: Elements > MRAnalysisWarehouse > PI Database > Power Plant > Morgan > Power Block - 1 > Balance of Plant > Gas Turbine > CTG-1, CTG-2, CTG-3 > Heat Recovery Steam Generator > HRSG-1, HRSG-2, HRSG-3 > Steam Turbine > STG-1.
- Table (Right):** A table titled "Power Block" showing various attributes and their default values. The table is filtered by "Category: Analytics".
- Bottom Left Panel:** A navigation menu with options: Elements, Event Frames, Library, Unit of Measure, Contacts, and Management.
- Bottom Right:** The AVEVA logo.

Name	Description	Default Value
Category: Analytics		
Ambient Temperature	MORGAN SITE AMBIENT TEMPERATURE D...	0 °F
Auxiliary Power	MORGAN SITE AUXILIARY POWER (calc)	0 MW
Barometric Pressure	MORGAN SITE Barometric Pressure (psia)	0 inHg
Condensate Return Energy		0 MM Btu/h
Condenser Calculated Saturation En...		0 Btu/lb
Fuel Gas Total Energy	MORGAN SITE FUEL GAS ENERGY FLOW ...	0 MM Btu/h
Fuel Gas Total Energy Totalizer Daily	Morgan Fuel Use Today	0 MM Btu
Gross Heat Rate	Morgan Site Gross Heat Rate	0
Gross Power	MORGAN SITE GROSS POWER (calc)	0 MW
Net Heat Rate	MORGAN SITE NET HEAT RATE (calc)	0 Btu/kwh
Net Power	MORGAN SITE NET POWER (calc)	0 MW
Process Steam Energy		0 MM Btu/h
Process Steam Mass Flow		0 kpph
Purchased Power	MORGAN SITE PURCHASED POWER (calc)	0 MW
Relative Humidity	MORGAN SITE HUMIDITY (calc)	0 %
Site Fuel Gas Density	MORGAN SITE FUEL GAS DENSITY (calc)	0 lb/ft3
Site Fuel Gas Higher Heating Value	MORGAN SITE FUEL GAS HIGHER HEATI...	0 Btu/(lb °F)
Site Fuel Gas Specific Gravity	MORGAN SITE FUEL GAS SPECIFIC GRA...	0
Steam Adj. Net Heat Rate	MORGAN SITE STEAM ADJUSTED NET H...	0 MM Btu/MW
Category: MetaData		
Power Block Short Code		SIT
Power Block Unit Number		0
Site Code		

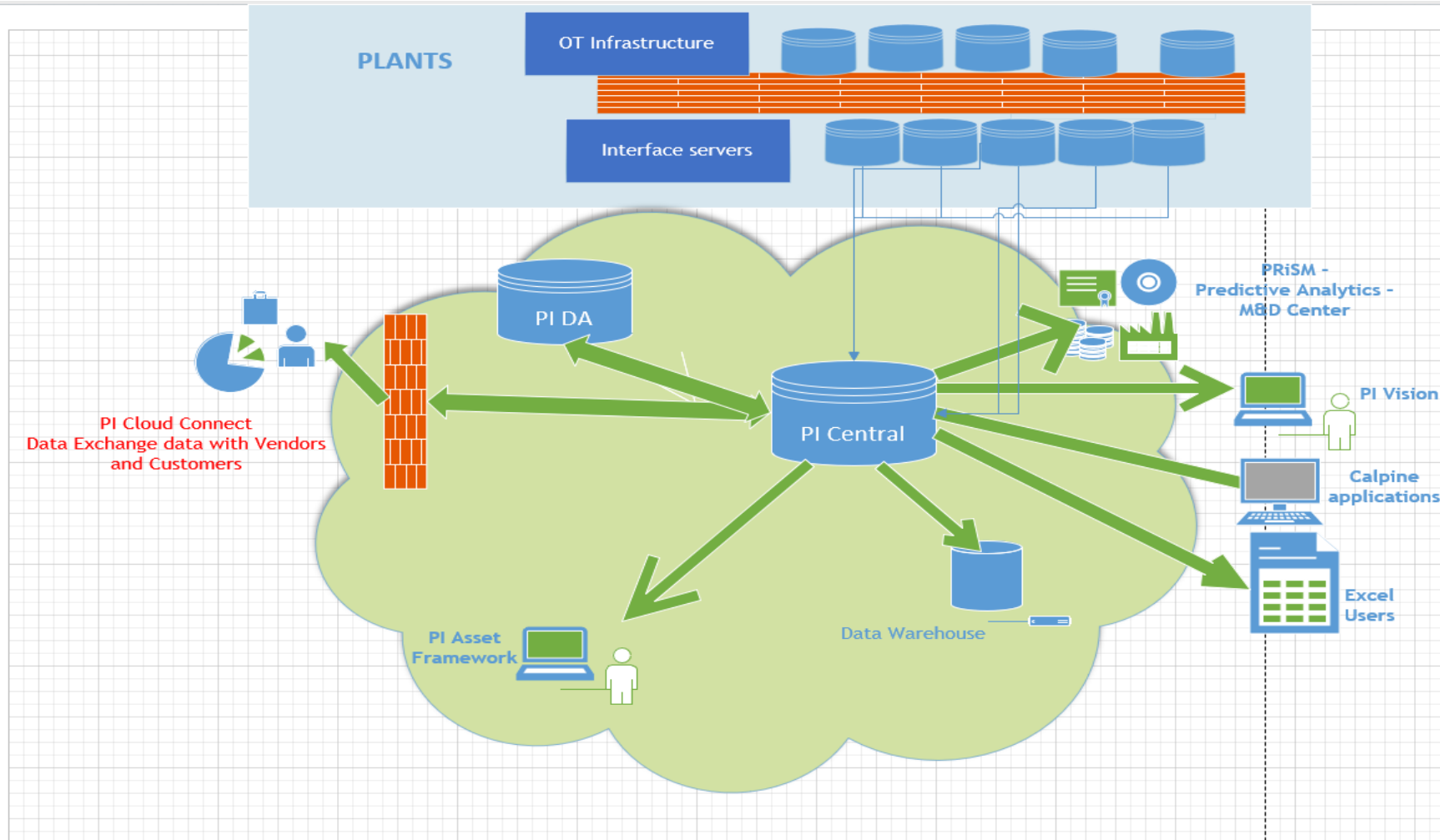
A Centralized Cloud-based Architecture

OLD: Distributed eDNA Architecture



A Centralized Cloud-based Architecture

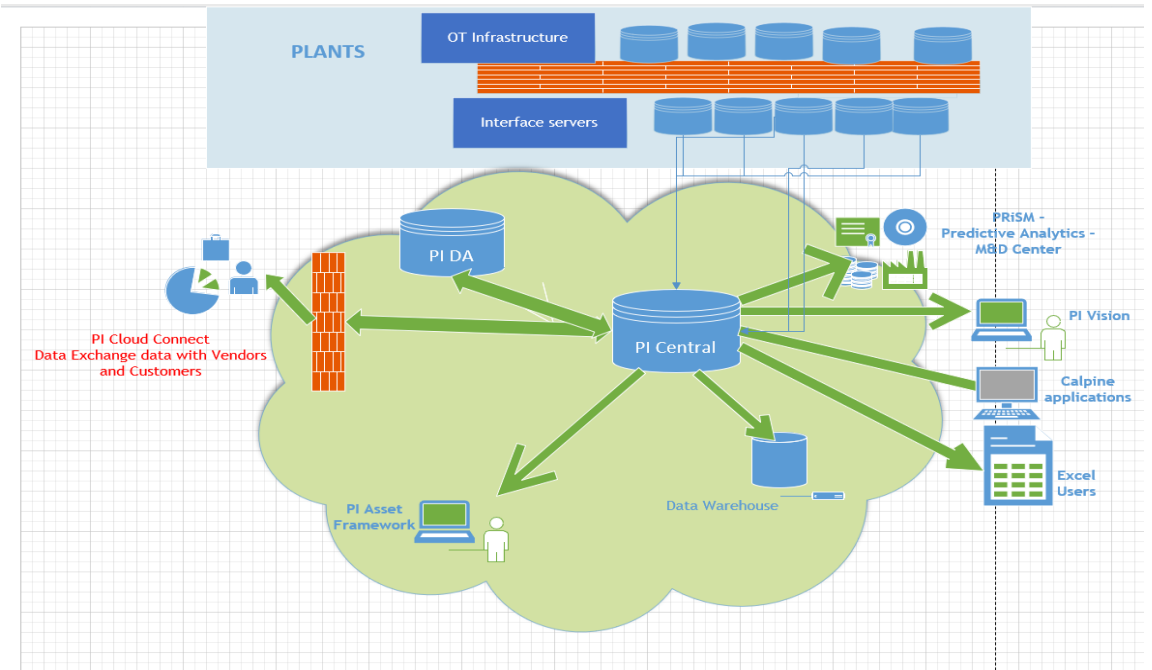
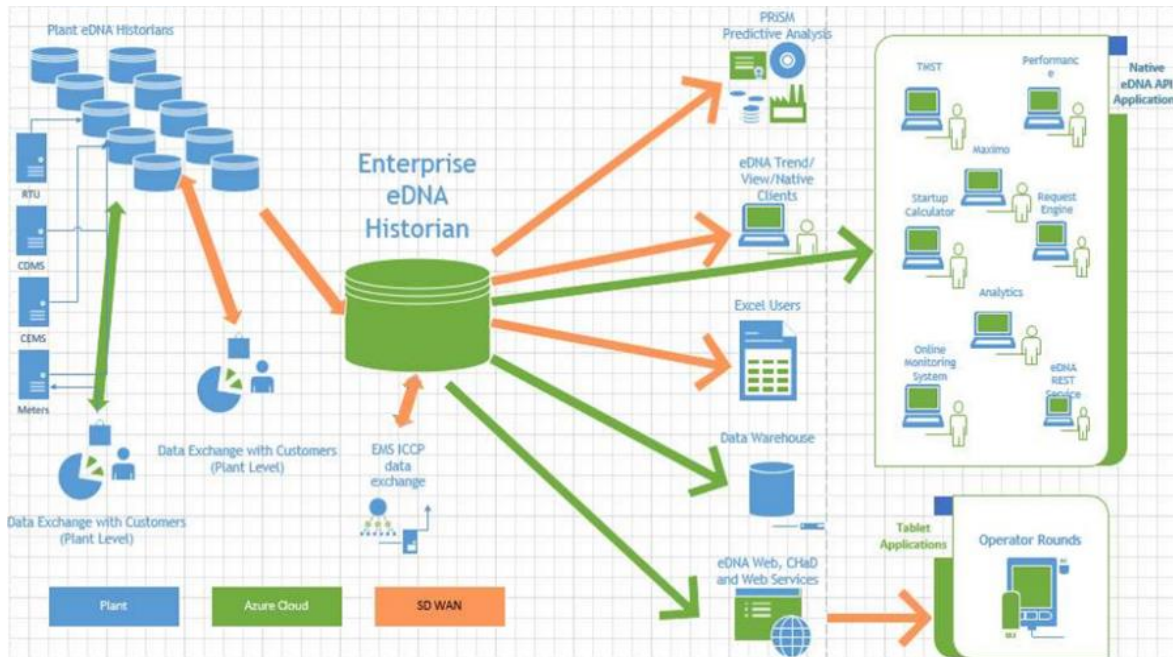
NEW: Cloud-hosted Enterprise PI System Architecture



- In Plants
 - Interfaces
- In Cloud
 - PI Vision
 - PI Asset Framework
 - Predictive Analytics
 - Azure Data Lake
 - Data Warehouse
- Data Sharing
 - PI Cloud Connect
 - Vendors
 - Customers
 - Canadian Plant

A Centralized Cloud-based Architecture

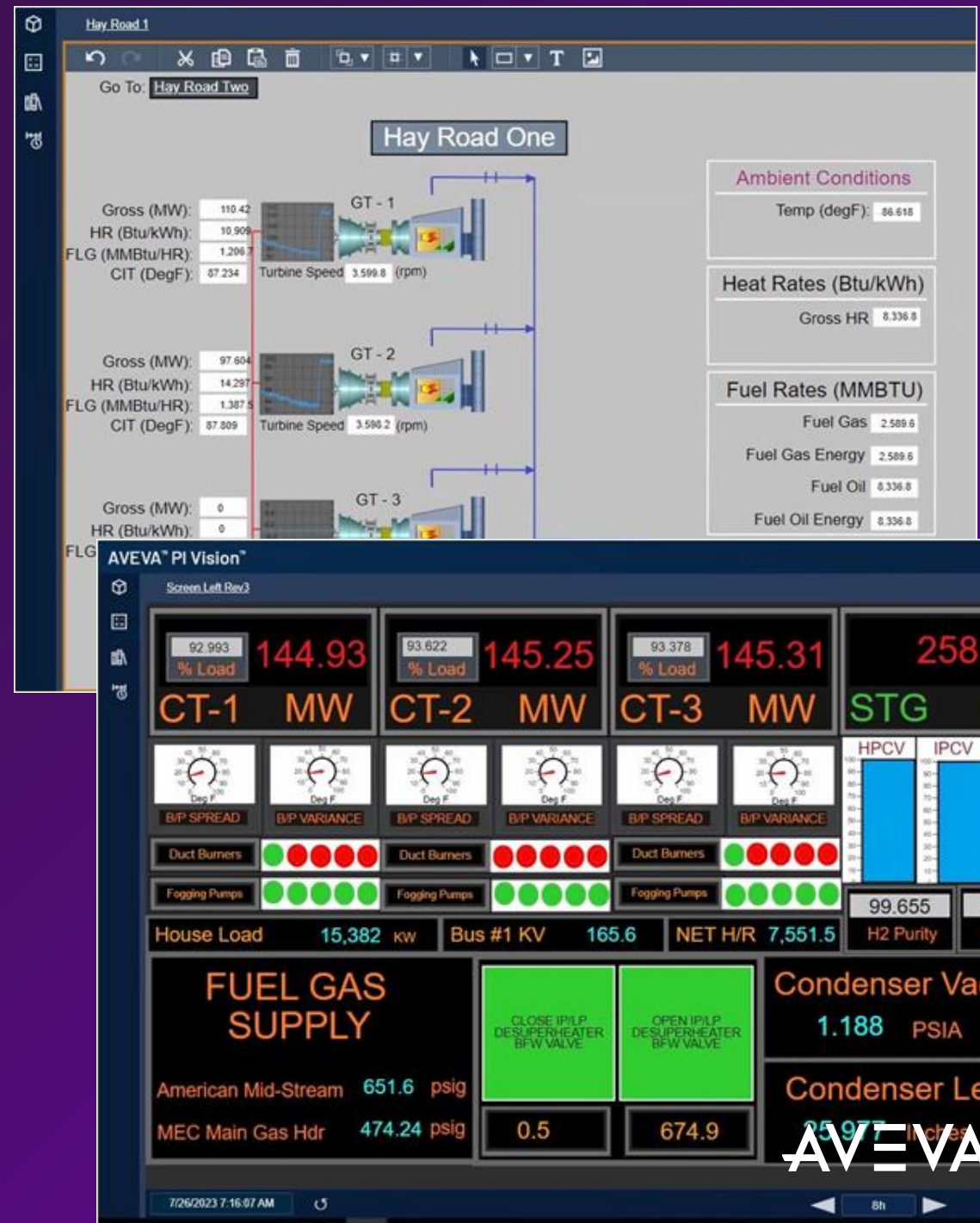
- OLD: Distributed eDNA Architecture
 - Most sites had their own on-premise server, few regions shared
 - Large maintenance effort to keep all sites updated
- NEW: Cloud-hosted Enterprise PI System Architecture
 - All sites feed data to one cloud-hosted server
 - Significantly reduced site maintenance requirements



New Architecture

A Centralized Cloud-based Solution

- Common Standards
 - All sites leverage same AF Templates for Assets and Calculations
 - All downstream applications have normalized view of the data and AF Analytics in context
- Client Application Deployment Reduced
 - Central PI Vision Server with no thick client installation at each site
 - Standardized displays with centralized management





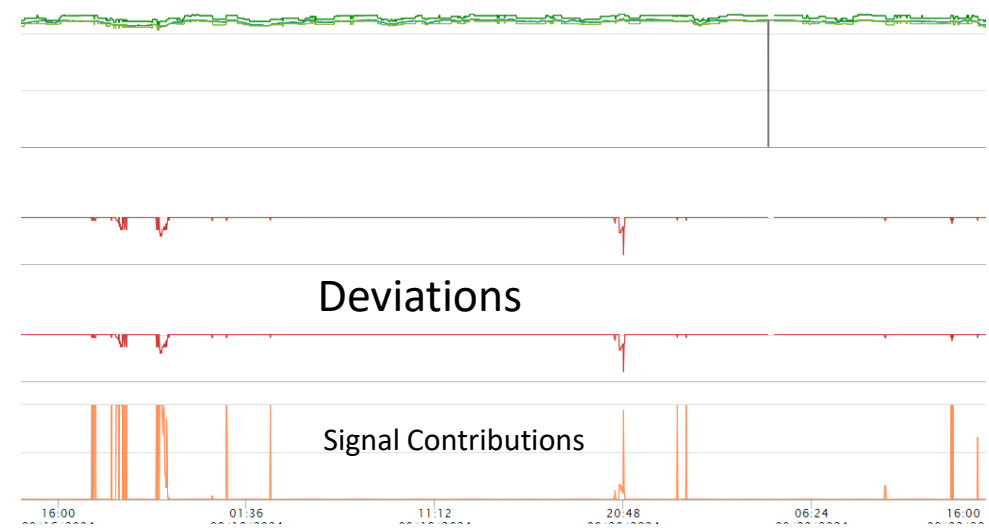
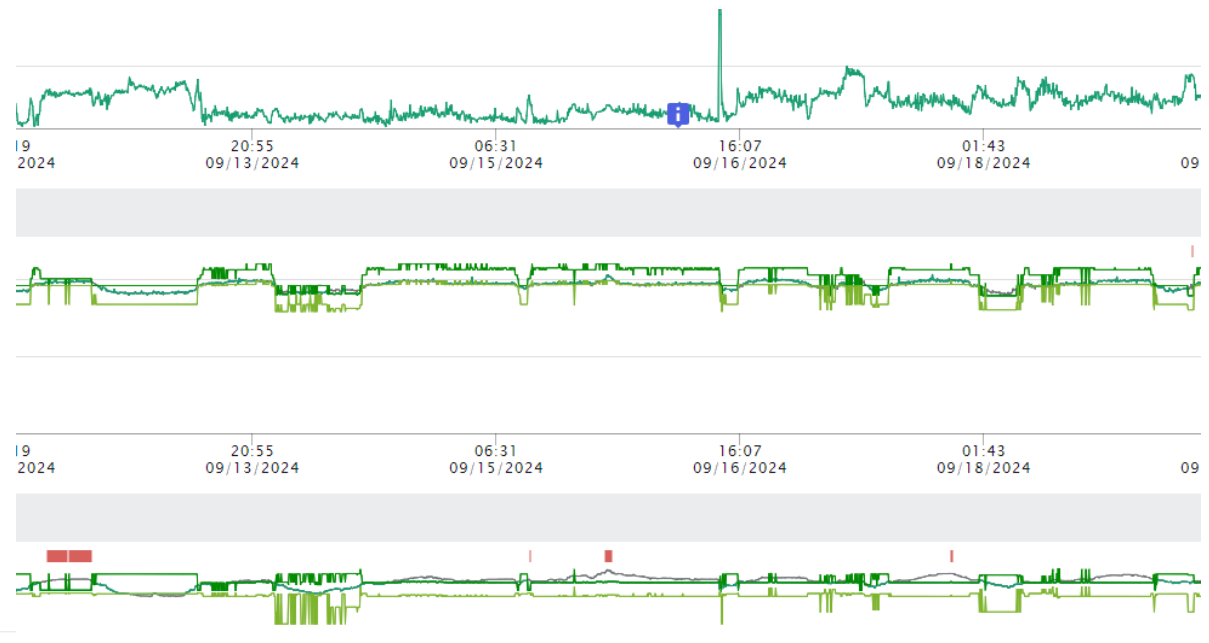
Roadmap for What Remains

Cruising Along, but Never Content

- Have migrated over 300 years' worth of data, but still have about 30 plants to go
 - Continuously improving the process and utilities for more efficiency – a big benefit of working with a partner
 - Balancing the load to move as quickly as possible without overwhelming Calpine IT team
- Migrating Custom-built eDNA Apps to the PI System
 - Many custom apps were built over time to provide functionality not available in eDNA
 - Being converted to interface with the PI System
 - Example: Turbine Parts Management

Machine Learning Models for Gas Turbine Lifecycle Tracking

- Calpine is currently running over 2,600 AVEVA Predictive Analytics Models
- Able to reuse these models and switch from eDNA to PI System as the data source – No Redesign Required
- Predictions from these models save Calpine manhours, unplanned downtime, and maintenance dollars



AF Template-based Reporting Solutions

- Reports leverage contextualized standard data infrastructure based on PI AF Templates
- Automatic ESG reporting solution saves hours of manual data collection and report manipulation
- PI AF Hierarchy enables standardized Compliance reporting

	GROSS POWER MW	PLANT NET MW	HOST NET MW	AEP NET MW	NG MMBTU	TOTAL FUEL RG MMBTU	TOTAL MMBTU	TOTAL HOST KLBS/HR	AVE KLBS/HR	STM FLOW ENERGY MMBTU'S	TOTAL COND RTN MMBTU'S	GROSS BTU/KW	PLT-NET BTU/KW	STM BTU/KW
8/1														
8/2														
8/3														
8/4														
8/5														
8/6														
8/7														
8/8														
8/9														
8/10														
8/11														
8/12														

Group by: Category Template

Name: BP_TEMP_10S

Description:

Properties: <None>

Categories: Turbine

Default UOM: degree Fahrenheit

Value Type: Double

Default Value: 0 °F

Display Digits: -5

Data Reference: PI Point

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

Elements

Event Frames

Library

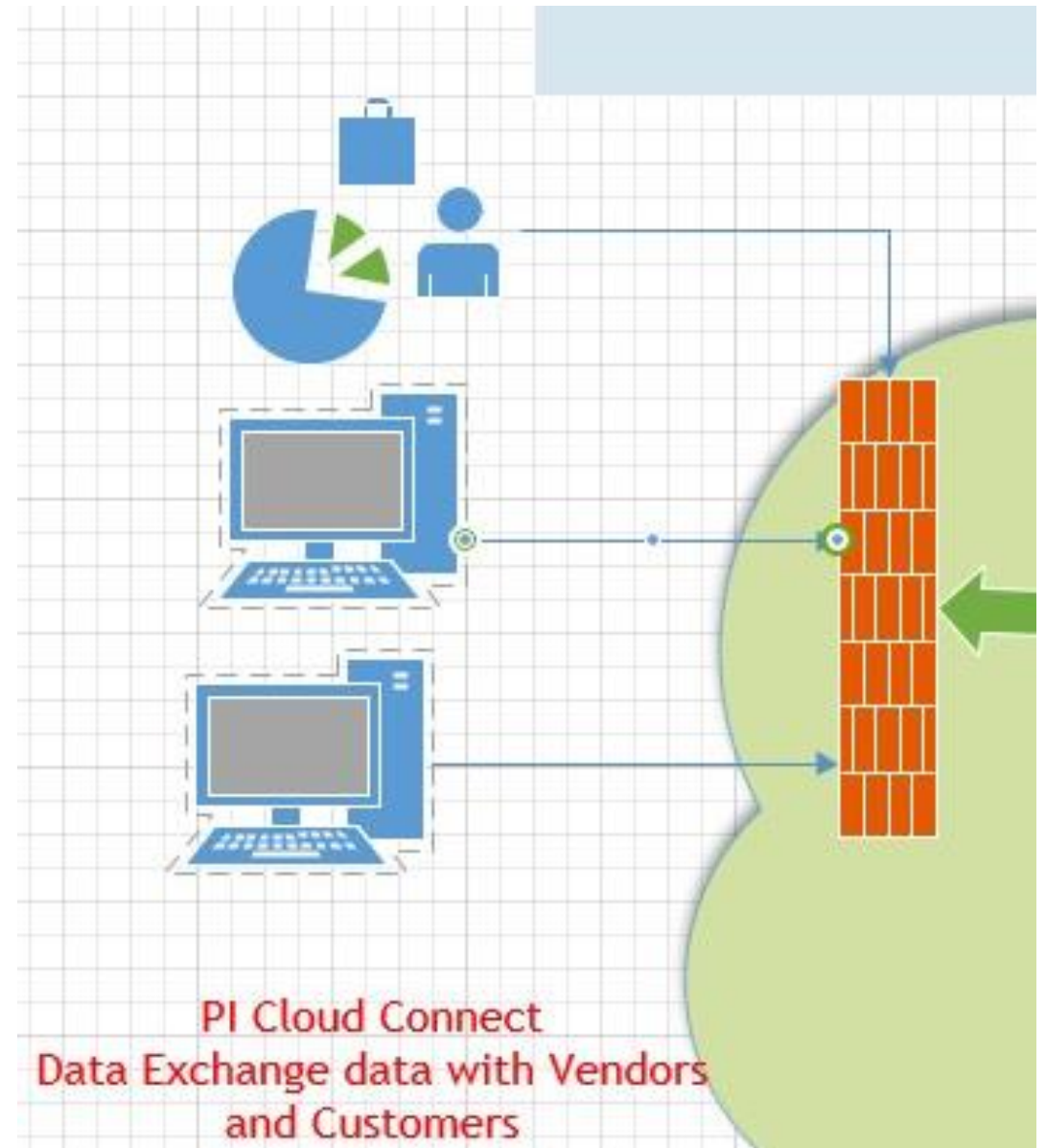
Unit of Measure

Contacts

Limits Forecasts

External Customer Data Sharing

- Many customers still rely on direct OPC connectivity to the plants
- Share data to refineries on Steam, Power, and Water usage
- Share data with vendor to monitor air filter differential pressure
- Monitor remote plant generation via PI Cloud Connect
- Shift to PI Cloud Connect provides secure and efficient data sharing
- Plans to retire PI Cloud Connect for AVEVA CONNECT data services



Additional Data Infrastructure Solutions

Many Calpine applications benefit from a standardized enterprise data infrastructure

- Integration to ADX (Azure Data explorer) / Event Data Grids for Root Cause Analysis
- Online Monitoring System
- Turbine Maintenance & Scheduling Tool
- Maximo integration for condition monitoring
- ETRM system for billing support
- Generation management system as alternative source of data
- RTU and Meter data
- Continuous Emissions Monitoring
- Combustion Dynamics Monitoring System
- Enterprise Data Warehouse



Calpine's automated migration approach saves ~70% of efforts in digital transformation journey

Challenge

- Retired software used at almost 80 installations
- Slow manual migration process for 100,000 calculated values and displays
- Distributed installation architecture very difficult to manage

Solution

- Automate migration of data and calculations to the AVEVA PI System with custom utilities built by RoviSys
- Simplify architecture with enterprise data archive and template-based solutions for centralized management
- Feed over 2,600 AVEVA Predictive Analytics models from a central PI System solution

Results

- **Saved over 70% of the manual efforts for over 300 years of data and thousands of calculation migrations through automated utilities with built in validation**
- **Template-based PI AF Data Infrastructure enables sustainable, standardized approach to ESG reporting, Compliance reporting, Predictive Analytics models, and other client applications**





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