The PI System:
A Data and Notification Hub for Machine Learning, Modeling, and Analytics using Hybrid Cloud Technology

Peter Vanney

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Agenda

- A Bit About Me
- Chelan County Public Utility District
  - Who, What, Where
  - Historical PI Usage
- PI Use Cases
  - “We Make Power” PI Vision
  - Event Frame Notifications Create Maximo Work Orders
  - River Elevation App
  - PI Web API
    - C#, R, and Python integration with PI system
    - Azure Active Directory Authentication
    - Machine Learning Models
  - Future Work

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A Bit About Me

- Data analyst/data scientist/statistician
- Business Intelligence and Data Analytics (BIDA) business unit
- MS in Statistics and BA in Math
  - Not an engineer, but I like formulas
- Favorite programming language: R
- New to the Utility Industry as of September 2018. Former:
  - Statistician for Texas Highway Patrol
  - Grad student and math/stats instructor
  - Peace Corps Volunteer teacher in Ghana

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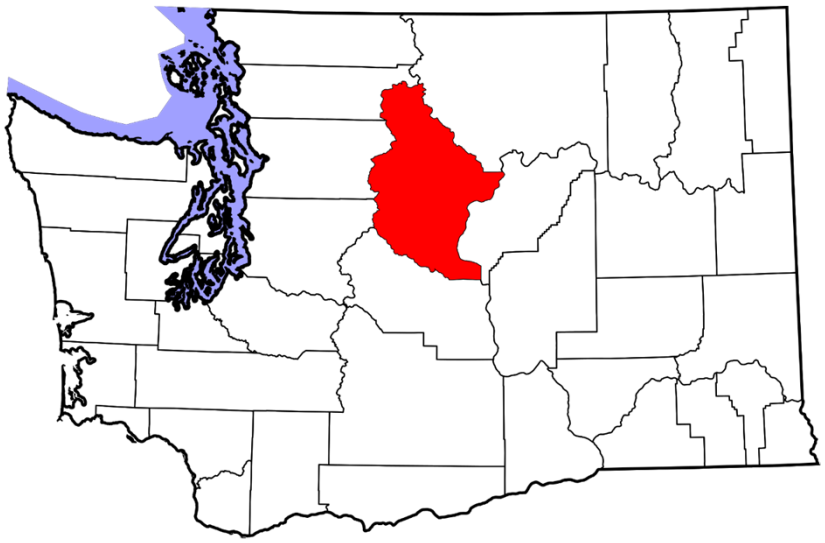
Chelan County Public Utility District (Chelan County PUD)



https://en.wikipedia.org/wiki/Chelan_County,_Washington

- Nonprofit and customer-owned
- Electric, water, wastewater, and telecommunications
- 3 hydroelectric dams ~2,000MW nameplate capacity
  - 2 on the Columbia River (mix of Kaplan and Bulb turbines)
  - 1 at the base of Lake Chelan (Francis turbines)
- Meet local load and export ~80+%
- Average residential rate just over $0.03 per KWH
- Serve about 50,000 retail electric customers

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PI System at Chelan County PUD, Historically

- PI System installed in 2002
- PI Historian used primarily as a database for after-the-fact root cause analysis
- Some reporting and dashboarding using DataLink and ProcessBooks
- Knowledge silos formed because people are busy and there were few cross-functional promoters of the PI System
- No AF structure
- Less operational insight above manager-level; required active engagement and monitoring

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PI System at Chelan County PUD, Transforming

Directives

- Innovate
- Broaden operational data access and visibility
- Leverage existing investments in systems
- Move up the analytics value curve
- Bridge knowledge bases (be a proper cross-functional team)
- Stay flexible with solutions
- Emphasize safety and security

Solutions

- Learn more about the PI System and its capabilities
- Invest in PI Vision
- Allocate resources to create hierarchy for PI AF
- Develop internal knowledge base to support complex technology solutions
- Meet with internal experts

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New (to us) PI Use Cases

- “We Make Power” Daily Dashboard
- Event Frame Notifications Create Maximo Work Orders
- River Elevation App – PI Data Model
- PI Web API Development
- C#, R, and Python Integration with PI System
- Azure Active Directory Token Authentication for PI Web API
- Using Cloud Services with PI System
- Machine Learning Models & Operationalizing Them

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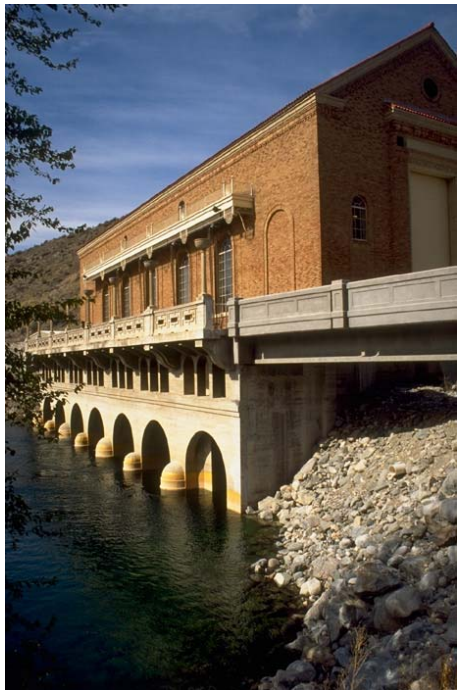
We Make Power – Daily Dashboard

- Increase access to operational data
- Daily summary dashboard; not metrics, KPIs, or ‘gold star days’ (yet)
- Shows operating conditions and constraints
- Combines data from multiple sources using PI AF (PI, SQL databases, static tables)
- Use PI Vision so all employees can view
- On 24hr display at two locations
- Small group training/education sessions



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Price Forecast

Project Summaries

Local Load Corner

Pond Head-waters & Inflows

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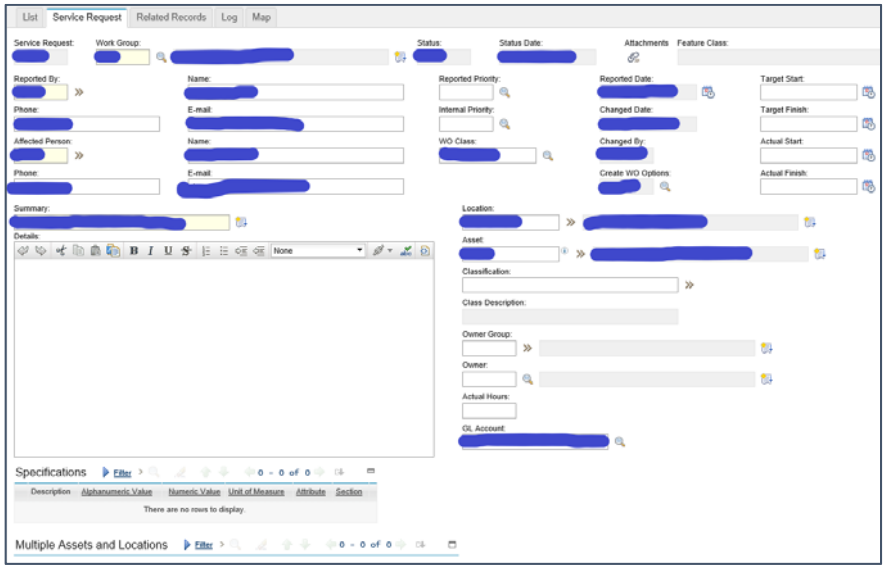
Using Event Frame (EF) Notifications to Create Maximo Work Orders

Watch Allex Smith's talk from T&D Track



- High value feeder breaker
- Move from time-based to event-based maintenance
- Instead of monitoring constantly (or rolling trucks), create EF based on breaker status

1. EF notifies Oracle SOA Suite and sends JSON data file
2. Middleware POST to Maximo
3. Work Order is created
4. Manager assigns WO if necessary

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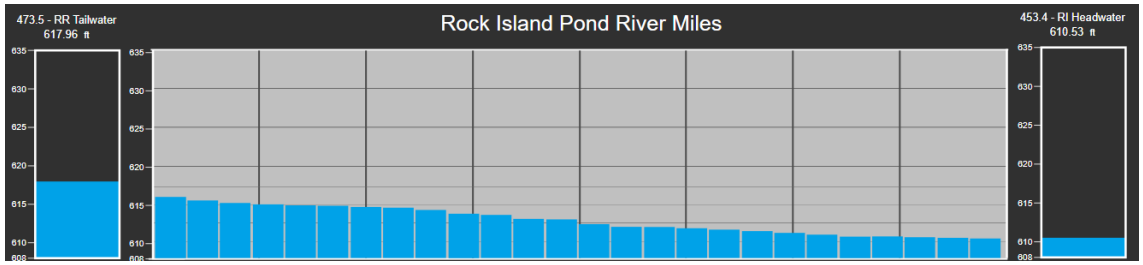
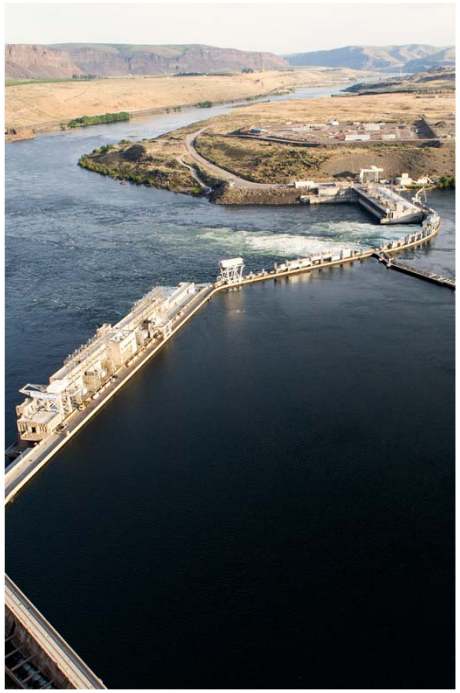
River Elevation App – PI Data Model

- Use PI AF and Analysis Server to digitize backwater curve studies
- Combines real-time sensor data with reference tables to calculate river elevation estimates every mile and at points of interest
- Templatized
- App data access controlled via PI Web API





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PI Web API as the Analytic Hub

- RESTful web services enable developers to use their preferred programming language
- Packages for C#, R, and Python ease integration with the PI Web API
- Azure Active Directory setup allows external users to access PI System
- Using cloud services with PI System
- Machine learning models

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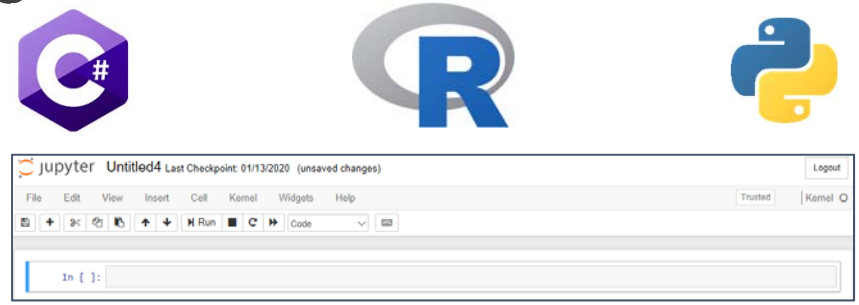
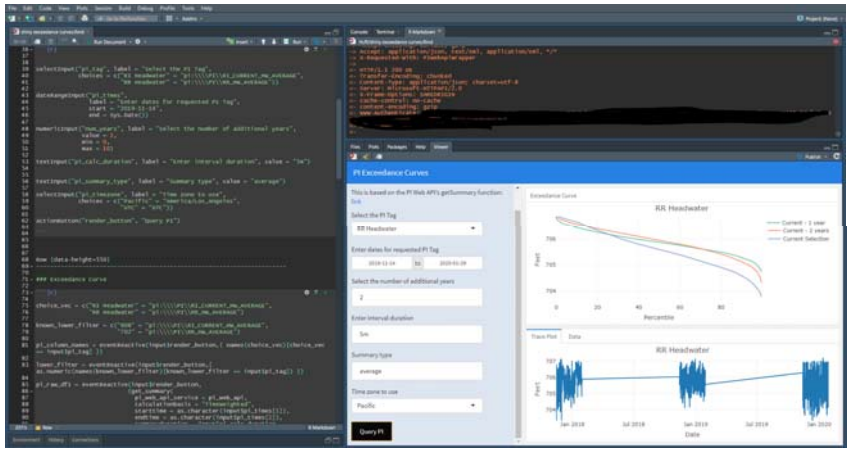
C#, R, and Python Integration with the PI Web API

- It is worth investing in development time
  - Greater understanding of PI System
  - Unified IT solutions require infrastructure
  - IT and OT collaborate on focused projects
- Create packages/libraries
- Transform PI System data into more structured form
- Write modeled data back to PI System





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Using Azure Active Directory (AAD) to Manage Authentication

- Allow secured, external access to your on-prem PI System using the Web API and AAD.
- Setup PI Web API Bearer Authentication

https://techsupport.osisoft.com/Documentation/PI-Web-API/help/topics/bearer-authentication.html

- Hint: [Bearerissuer] is login.microsoft.com/<tenant_id>

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AAD Token Auth with the PI Web API

Create the PI Web API Service in Azure AD

1. Register an application page
   - **Name**: PI Web API Service
   - **Supported account types**: Accounts in this organizational directory only
   - **Redirect URI**: Web **(url)** *should point to your PI Web API URL*
   1. Click Register
   2. Save your Application ID
2. Expose the API
   1. Click “Set”
   2. Change “api://” to *your Azure Microsoft Login page*
3. Add a Scope
   - **Scope name**: PIData.Read
   - **Who**: Admins and Users
   - **Admin & User consent name**: Read PI Data
   - **Admin & User consent description**: Allow applications to read data from the PI Web API
   - **State**: Enabled

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AAD Token Auth with the PI Web API

Create the Client Application in Azure AD

1. Register an application page
   - **Name**: PI Web API Service
   - **Supported account types**: Accounts in this organizational directory only
   - **Redirect URI**: Public client/native **(url)** http://localhost:8080
   1. Click Register
   2. Save your Application ID
2. Change Authentication Settings

   Under: Authentication > Implicit Grant, check “Access tokens” and “ID tokens”
3. Set the API Permissions
   1. Add a permission
      - Under: “Select an API” choose “APIs my organization uses”
      - Find and click “PI Web API Service”
        - Under: “PERMISSION” expand “PIData”
        - Check “PIData.Read”
        - Click “Add permissions”
   2. “Grant admin consent for *your domain*”

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Using Cloud Services and PI

- Use AAD token auth to connect to your PI System from any machine!
- Find your AAD package/library and use it. You'll need some of these:
  - Tenant ID
  - Client ID
  - Redirect URI
  - Resource ID
  - Resource Base Address

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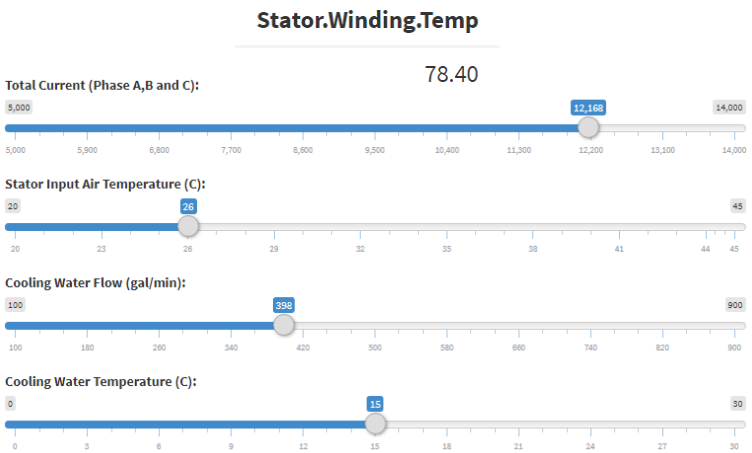
Machine Learning Models: Stator Winding Temperature

Goal: Track cooling system efficiency to create condition-based maintenance schedules



- Use machine learning models (instead of having your engineers solve thousands of simultaneous differential equations)
- Data analysts/scientists need to collaborate with and gather information from engineers
- Make sure your model does not break engineering principles
- Train model on cloud server
- Display results using an interactive web app, or…

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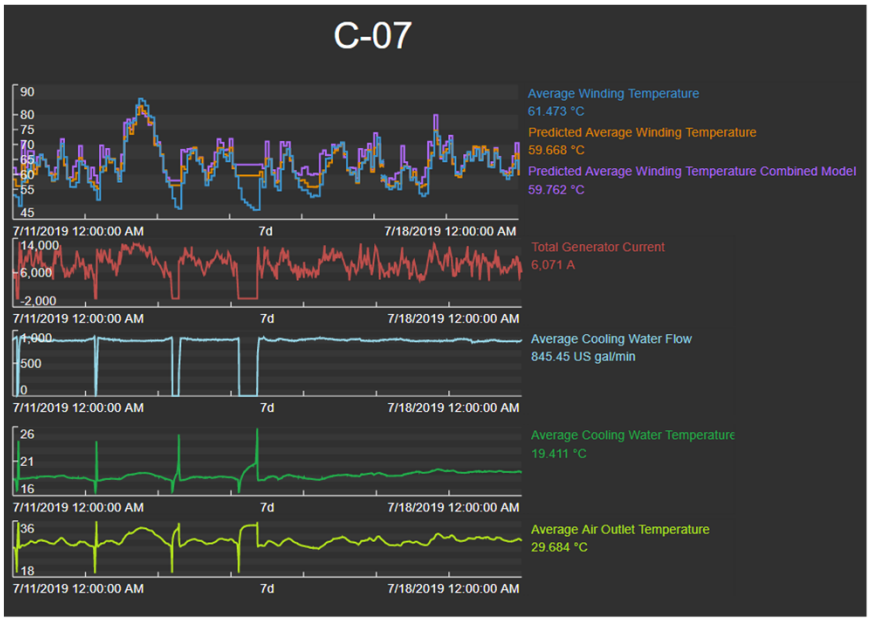
Operationalize Machine Learning Models

- Export production model to internal network computer/server
- Move data aggregation to PI System (averaging, summing, totaling, etc.)
- Write script to extract data from Web API and run inputs through the model
- Write resulting predictions/expected values back to PI System via the Web API
- Visualize model results in PI Vision
- Iterate on model



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Future PI Work at Chelan County PUD

- Incorporate anomaly detection results into workflows
- Continue to build out digital twin models in PI AF
- AMI & AMDM?
- More predictive modeling, forecasting, automated reporting, and workflow routing
- More C#, R, and Python software development
- Showcase PI System successes and gather more use cases

https://www.tasteofhome.com/recipes/winning-rhubarb-strawberry-pie/

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Value Analytics at Chelan County PUD

CHALLENGES

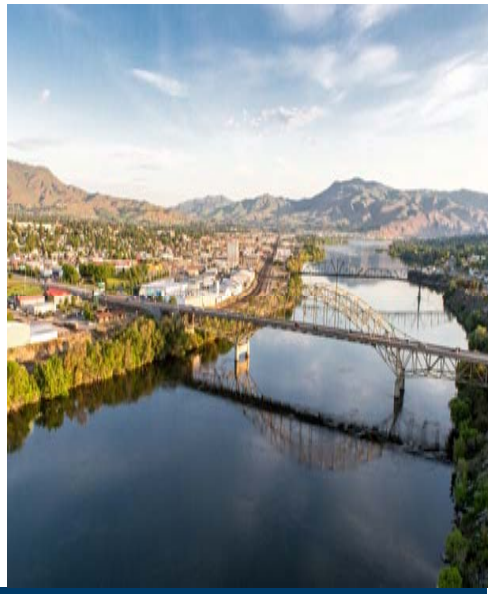
- Broaden operational data access and visibility
- Leverage existing investments in systems
- Stay flexible with solutions
- Emphasize safety and security

SOLUTION

- Learn and invest in the PI System and PI Vision
- Allocate resources to create hierarchy for PI AF
- Develop internal knowledge base to support complex technology solutions

BENEFITS

- Combine sensor and relational data in PI AF
- Work Flow Integration
- Data modeling
- PI Web API for data access and analytic connections



> The PI System is a powerful and worthwhile investment; even small data analytics teams can benefit from what it offers.

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Contact Information

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Questions?

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