OAK RIDGE National Laboratory

Hydropower Fleet Intelligence

O&M Effects of Intensifying Dispatch Variability - Overview

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Outline

- Hydropower Fleet Intelligence (HFI) Overview
- Overview of Use Case 1: O&M Effects of Intensifying Dispatch Variability
- Suggested topics for discussion

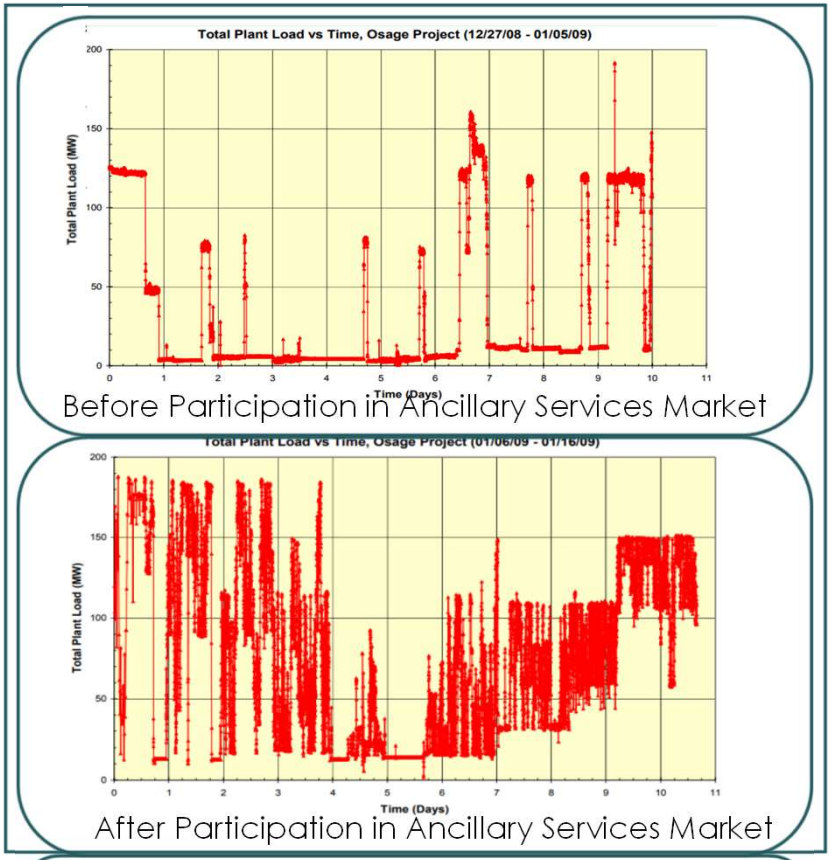
Hydropower Fleet Intelligence

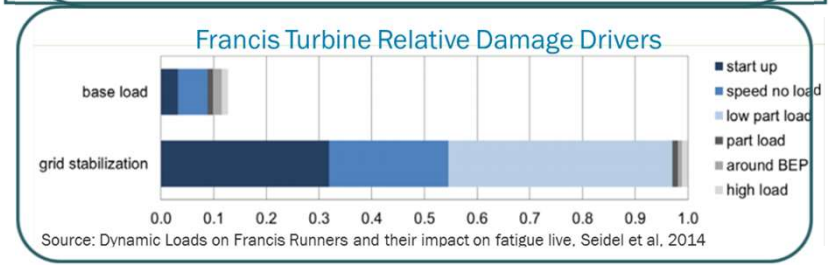
Project Summary

- Hydropower Fleet Intelligence develops a standard process to make data-driven decisions for hydropower generating unit asset management
  - Incorporates evolving contexts for hydropower operations and maintenance
  - Recognizes data-driven decisions requires efficient and automated processes for acquiring, qualifying, archiving, analyzing, and sharing hydropower data and results

Project Objective and Impact

- Enhance and coordinate disparate cost, condition, operation, and reliability information to maintain or improve hydropower value and reliability
- Demonstrate metric-based, data-driven decision-making enhanced hydropower asset management outcomes for multiple use-cases





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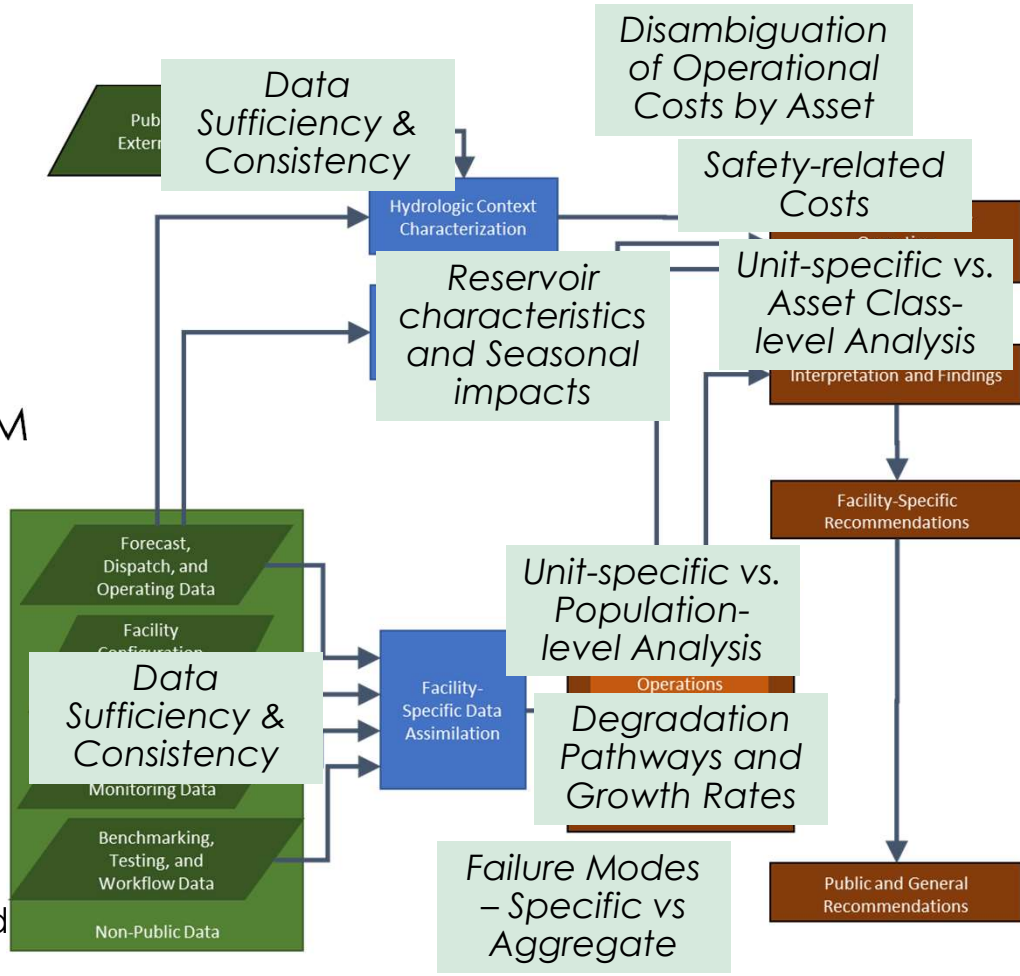
Hydropower Fleet Intelligence: Use Cases

- Use Case 1: O&M Impacts of Intensifying Dispatch Variability
  - More flexible operations required by changing power system may be challenging for generating units designed for baseline operation
  - Intensity of dispatch variability influences reliability, availability, and O&M/capital investment costs
- Use Case 0: Correlation of fleet cost, condition, and availability data
  - Asset managers need rationale and methodology to benchmark the cost and performance of the generating unit asset fleet and manage risk by allocating resources and operations duty among assets

(Image courtesy PG&E)

O&M Impacts of Intensifying Dispatch Variability: Summary

- Research process a combination of fleet-wide data sets and owner specific, unit-specific information
- Analysis of unit-specific dispatch states, maintenance history, O&M practices, and O&M costs to calculate cost of dispatch variability
  - Dispatch and monitoring data (plant Historian)
  - Unit-level age and degradation
  - EUCG defined functional cost categories
  - Whole life cost models
- Available data supports population-based asset class-level analyses
  - Available data sources for unit-specific analysis (based on current degradation state and age) may require normalization based on unit type, size, manufacturer, operational profile, etc.



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Key Findings to Date

- Initial set of methods for dispatch variability cost analysis developed
  - Change detection algorithms for automating detection from operations data
    - Unit startup/stop identification and turbine mileage calculation
    - Pattern recognition of unique power patterns of different operating modes
  - Reliability estimation for dispatch variability
    - Estimation based on effective age calculated using damage coefficients
    - Quantifying asset mission time for damage pathways
  - Whole life cost models for dispatch variability
    - Bayesian statistics to estimate and update damage coefficients
- Unit level cost and O&M information (cost, maintenance work orders and operations logs, etc.) are expected to be important for accurate assessment of dispatch variability impact on O&M.
  - Computerized Maintenance Management System (CMMS) work orders can be a key source of component expense information as these track labor and parts used on each generating unit.

Key Findings to Date (Cont'd.)

- Approaches to use unit condition monitoring for calculating effective age will be important to improving accuracy of reliability and cost models
  - Applying condition monitoring technologies to assess current condition of assets and predict change in degradation/remaining life of asset
  - Updating unit degradation state as additional condition information becomes available
  - Grouping data and information by asset life stage to address data sparsity at various stages of asset life
  - Adapting cost models to specific types of facilities (standardizing) using facility O&M data
- Data from other units/facilities may be a resource for addressing information gaps but it is unclear whether any normalization of data across facilities/units will be necessary

Expected Project Focus in the Next 1-2 years

- Demonstrate value proposition for data-driven metric-based O&M decision making
  - Demonstrate unit-specific O&M strategy that meets demand (baseload or variable) while optimizing lifetime component O&M cost and replacement expense
  - Integrate insights from asset condition monitoring to move from time-based towards predictive condition-based maintenance practices to improve equipment longevity
- Data (fleet-wide, facility-level and unit-level) will be at the core of this effort, as will analysis methods that provide actional information from data
  - Contextual information (hydrologic, power system), facility and unit configuration and specification, operations, condition, cost (O&M), reliability
  - Relevant questions based on recent analyses include
    - Does the data contain the level of granularity expected for O&M cost optimization based on dispatch variability?
    - What additional data sources (new sensors) are necessary to reduce uncertainty? If new sensors are needed, where should they be located?
    - How can analysis results (cost, condition, etc.) be updated in a meaningful way as additional data becomes available? How can the uncertainty in the results be quantified?

Some Suggested Topics for Discussion

- Data sharing opportunities
  - What data is available and can be shared? What are the expected restrictions on use and publication?
  - Data sufficiency and consistency guidelines
- O&M optimization methods research
  - Unit- and fleet-level predictive analyses integrating cost, condition, and operations
  - Condition monitoring and predictive maintenance planning
  - Models and algorithms
- Desired outcomes of collaboration
  - Joint papers?
  - Guidance to industry?
  - Input to consensus standards?
  - Recommendations for standardized plant models (electrical and mechanical)?