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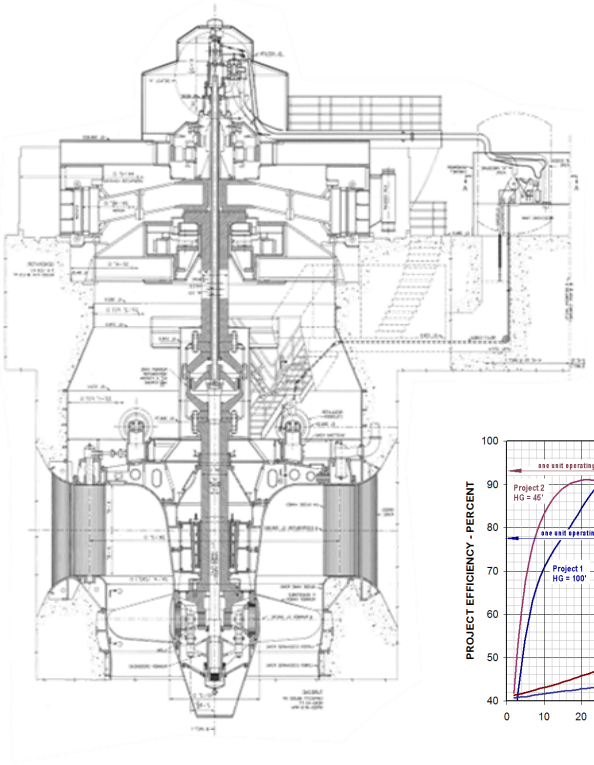

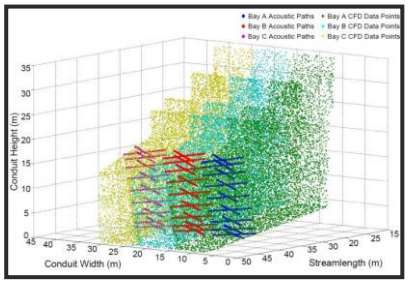

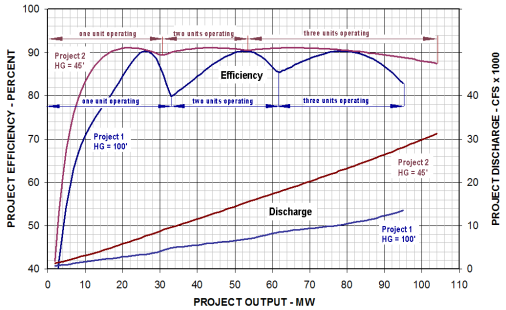

Hydropower Asset Management Research

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[Date of Presentation]

Project Overview

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Hydropower Asset Management Improvement Research:

Improve the tools that asset managers use to craft and implement strategies for greater value and reliability from hydropower assets.

The Challenge:

Data relevant to this endeavor are ubiquitous but compartmentalized, incomplete, of insufficient frequency, of unknown quality, misaligned in time, and altogether inadequate for pattern recognition, cause and effect determination, and trending across time and fleets of units.

Partners:

U.S. Bureau of Reclamation (USBR) PRO/RDO, Corps of Engineers Hydroelectric Design Center (HDC), TVA, Chelan County Public Utility District (CCPUD), Hydro Performance Processes, WolffWare Ltd, Signal Hydropower Consultants, University of Tennessee-Knoxville (UT)

Next Generation Hydropower (HydroNEXT)

Optimization

- **Optimize technical, environmental, and water-use efficiency of existing fleet**
- **Collect and disseminate data on new and existing assets**
- Facilitate interagency collaboration to increase regulatory process efficiency
- Identify revenue streams for ancillary services

Growth

- Lower costs of hydropower components and civil works
- Increase power train efficiency for low-head, variable flow applications
- Facilitate mechanisms for testing and advancing new hydropower systems and components
- Reduce costs and deployment timelines of new PSH plants
- Prepare the incoming hydropower workforce

Sustainability

- Design new hydropower systems that minimize or avoid environmental impacts
- Support development of new fish passage technologies and approaches
- Develop technologies, tools, and strategies to evaluate and address environmental impacts
- Increase resilience to climate change

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The Impact:

- Stimulate and facilitate development and implementation of best practices for data-driven decision making in hydropower asset management consortia

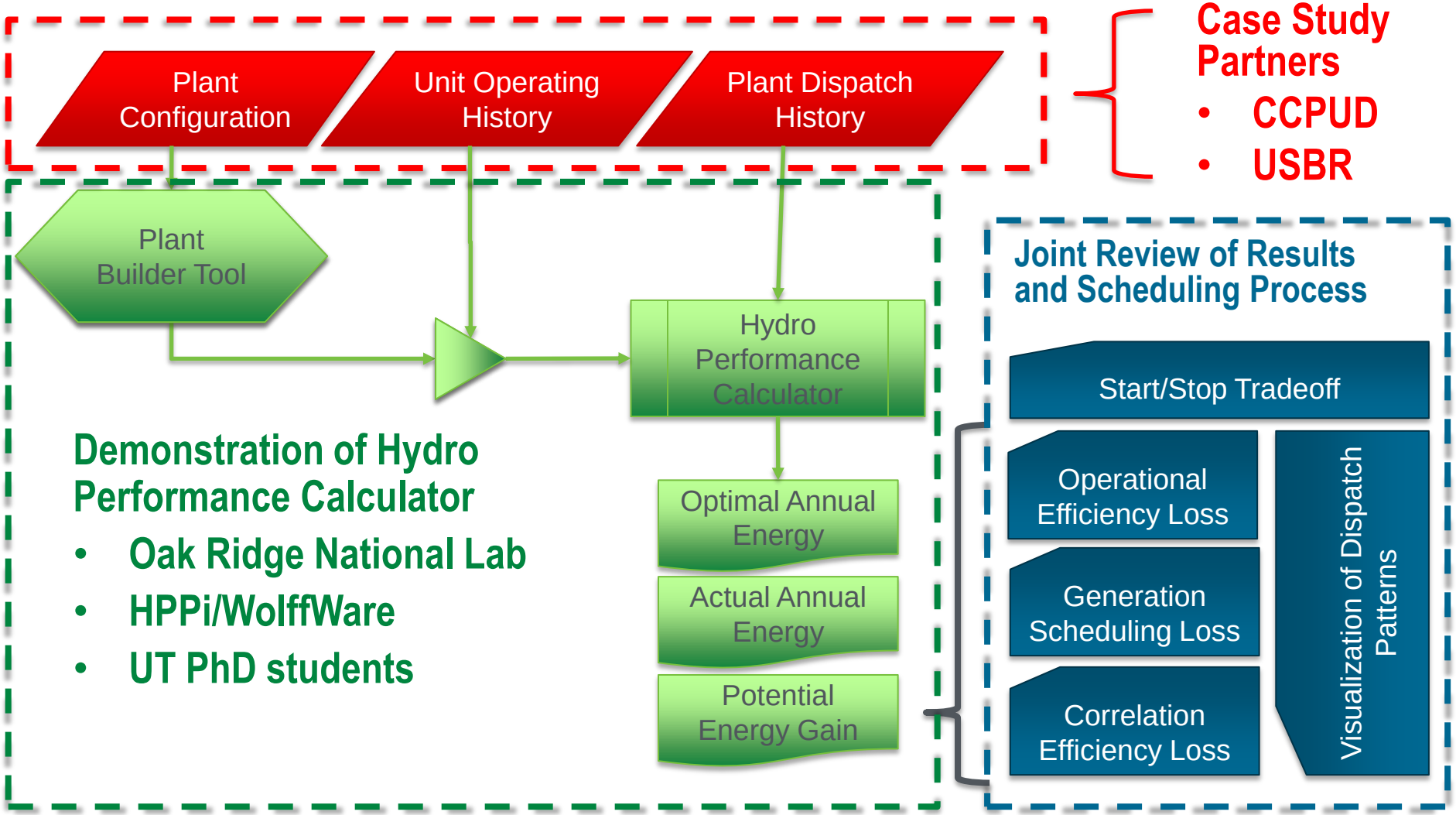
Targets:

- Document the gaps in asset management data and practices that limit decision-making and value
- Demonstrate the role that flow measurement plays in optimizing asset value
- Provide case studies that exemplify opportunities for improving value through data-driven analyses and decisions

Metrics:

- Potential increase in annual generation
- Defined indicator(s) of plant flexibility
- Cost-benefit analytics of data collection and analyses

Technical Approach



Technical Approach

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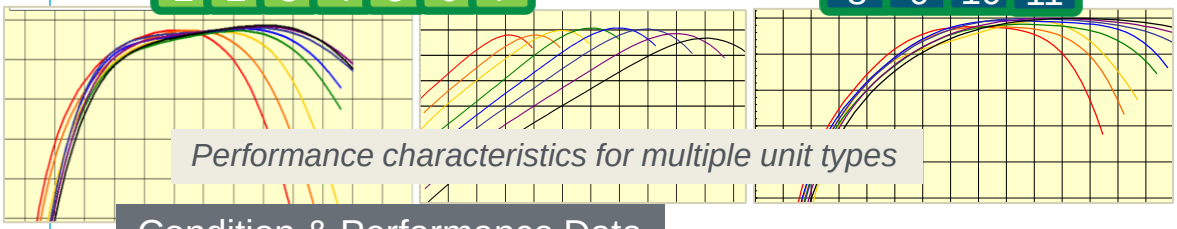
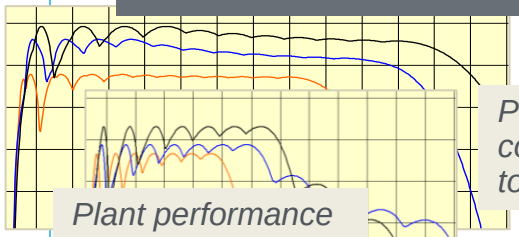
8 9 10 11

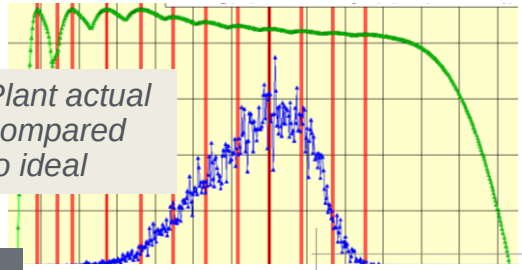


Performance characteristics for multiple unit types

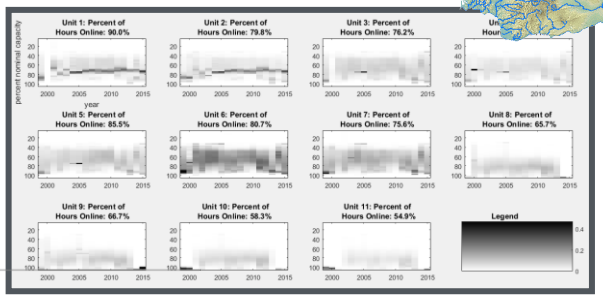
Condition & Performance Data



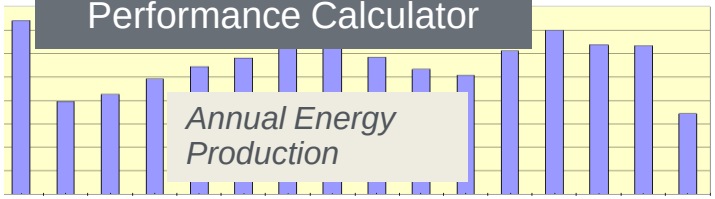
Plant performance



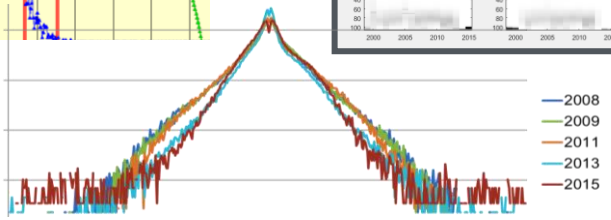
Plant actual compared to ideal



Analyses with Hydroplant Performance Calculator

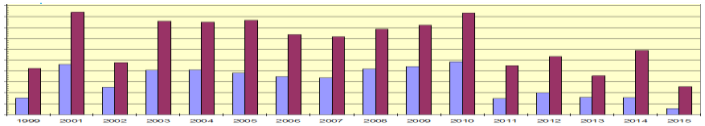


Annual Energy Production



Ramp rates from sub-hourly data

Comparison to Idealized Production

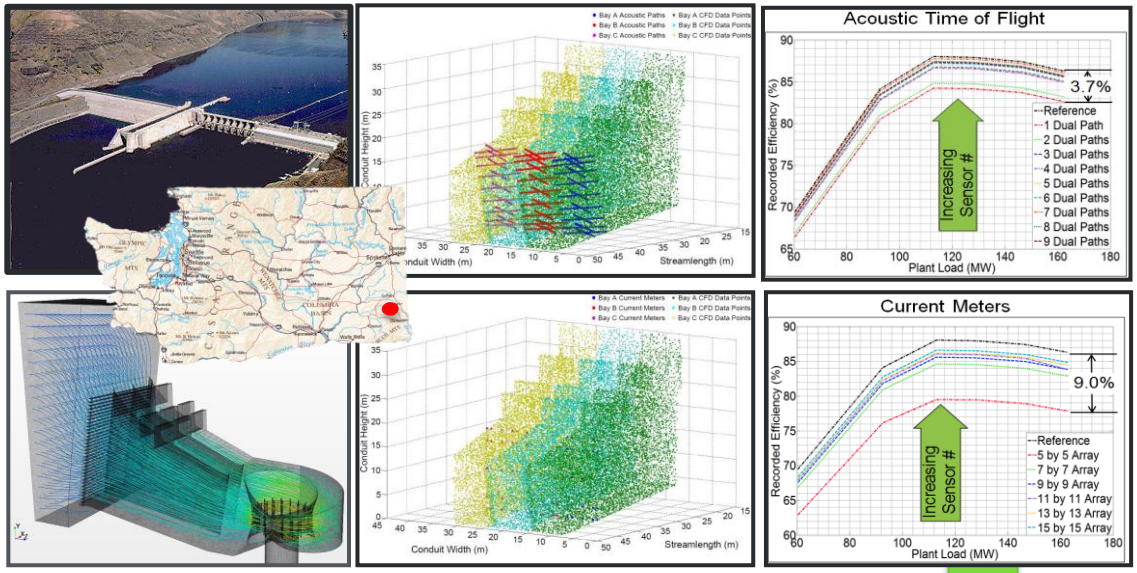


Greater efficiency → more start/stops

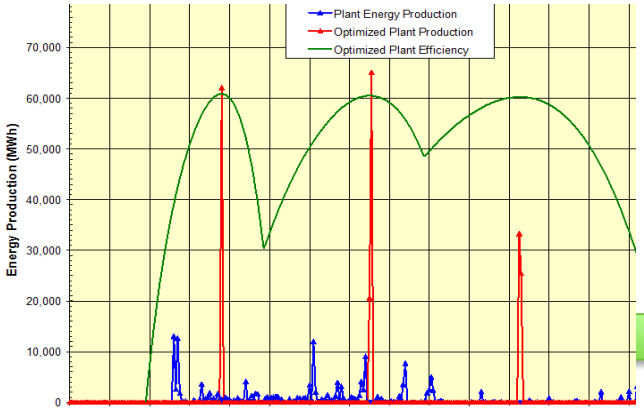
Exemplary Case Study

- Historical plant dispatch, water, and head are preserved
- Moving toward a standardized analysis template with visualization
- Deviations from ideal have causes that can/should be understood
- All types of data are stove-piped and time-consuming to export from plant systems—there needs to be a better way
- Correlation and cause/effect between dispatch and O&M costs are not obvious—subtle linkages may be impossible to detect without more granular data

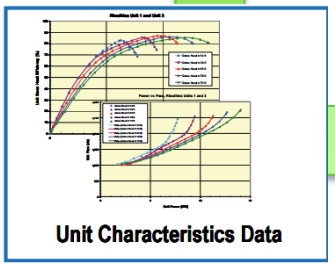
Technical Approach

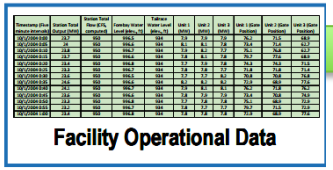


Measurement accuracy improves unit performance characteristics



Historical dispatch provides context for how much efficiency matters





- Short converging intakes represent 10% of domestic capacity
- No code-accepted methods guaranteeing accuracy of flow measurement
- Flow measurement uses
  - verifying performance guarantees
  - detecting efficiency degradation
  - assuring water delivery
  - assuring multi-unit efficiency

Annual Energy and Revenue Benefits of Increased Accuracy

Costs of Technology Deployment to Implement Accuracy Improvement

- Data-driven decisions on flow measurement upgrades
- Installed cost targets for new flow measurement technology

Accomplishments and Progress

Reports

- ORNL/TM-2016/730 *Hydropower Flow Measurement: Technology and Application* (intake type classification)
- Case Study Report on CCPUD-Rocky Reach and USBR-Flaming Gorge (0.4% to 1.8% annual generation potential increase)

Papers

- Hydrovision 2014
  - *Developing and Verifying a Hydroplant Performance Calculator* by March et al.
- Hydrovision 2015
  - *Impact of the Number of Applied Current Meter Sensors on the Accuracy of Flow Rate Measurements* by Christian et al.
  - *Development and Application of a Standardized Flow Measurement Uncertainty Analysis Framework* by Lee et al. (1st Prize in Water Management Track)
- Hydrovision 2016
  - *Modelling the Reliability of Hydroelectric Powertrain Component*s by Signore et al.
  - *Numerical Simulation of Flow Measurement Instrumentation in Hydropower Intakes* by Christian et al.
- 11th Int'l Conference on Hydraulic Efficiency Measurement, Linz, Austria, 2016
  - *Simulation of Hydropower Flow Measurement Accuracy as a Function of Sensor Density and Placement* by Christian and Smith

Project Plan & Schedule

- Initiated in August 2013. Completion by September 2017.
- Multiple milestones and reports delayed by data availability
  - Partner staff resources for extracting data are limited
  - "Export" is much more tedious than analysis with internal software
  - Cost, maintenance, and condition monitoring data are disparate and managed for short-term, local use rather than long-term fleet trending
  - Data completeness, timeliness, and licensing difficulties with NERC-GADS access.
- FY16 Go/No-Go (not completed): Do case study outcomes warrant a pilot study of advanced data collection at a federal facility?

Project Budget

Budget History					
FY2014		FY2015		FY2016	
DOE	Cost-share	DOE	Cost-share	DOE	Cost-share
$650K		$350K		$300K	

Research Integration & Collaboration

Partners

- Chelan County PUD (Rocky Reach Plant)
- Bureau of Reclamation (Power Resources Office, Research an& Development Office, Flaming Gorge Plant)
- Corps of Engineers (Hydroelectric Design Center)
- Tennessee Valley Authority (Hydro Generation, River Management)
- HydroAMP and CEATI-HPLIG (Hydraulic Plant Life)
- Electric Power Research Institute Renewables

Subcontractors and Collaborators

- Hydro Performance Processes, Inc. (Pat March)
- WolffWare Ltd. (Paul Wolff)
- Signal Hydropower Consultants (L. Jim Miller)
- Principia Corporation (Charlie Almquist)
- Rennasonic (Jim Walsh)
- University of Tennessee-Knoxville (Bredesen Center)
- HydroAMP and CEATI-HPLIG

Communications and Technology Transfer

Reports

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Presentations: NHA Hydraulic Power Committee, CEATI (HPLIG and HOPIG), NHA Regional Meetings, Electric Utility Cost Group

Next Steps and Future Research

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FY17/Current research:

- FY14-FY17 efforts and findings summarized in *Data-Driven Asset Management State of the Art Report*
- Hydropower Generating Availability Data System (GADS) improvement memo drafted, reviewed and finalized with North American Electric Reliability Corporation (NERC) committee
- DOE-ORNL-CEATI/HydroAMP partnership evaluated
- TVA Hydropower Fleet Data Laboratory completed

Proposed future research:

- HydroAMP condition assessment analytics
- Hydropower Fleet Intelligence Consortium
- Hydro Performance Calculator WaterView Upgrade and Online Capability