Hydropower Advancement Project

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Request for Information

Webinar

January 10, 2012

Conventional Hydropower Technology Development

Wind and Water Power Program

Department of Energy - EERE

Wind and Water Power Program

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Agenda

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- Introduction
- Hydropower Advancement Project (HAP) Description and Request for Information (RFI) Overview
- Hydropower Advancement Project Methodology Review
- Clarifications
- Closing

Attendees will be muted during the presentation. Submit your questions for clarifications via the dialog box to the organizer. The organizer will pose questions after the presentations.

Conventional Hydropower and PSH

Existing Facility Improvements

Pumped Storage

New Small Hydro

Constructed Waterways

Non-powered Dams

- Improving technologies and processes for the efficiency, flexibility, and environmental performance of hydropower.
- Investigating opportunities for new hydropower development at small and/or low-head sites, non-powered dams, constructed waterways and pumped storage hydropower development.

RFI Logistics

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RFI Posted to **Fed Connect** December 21, 2011
-Reference Number DE-FOA-0000629

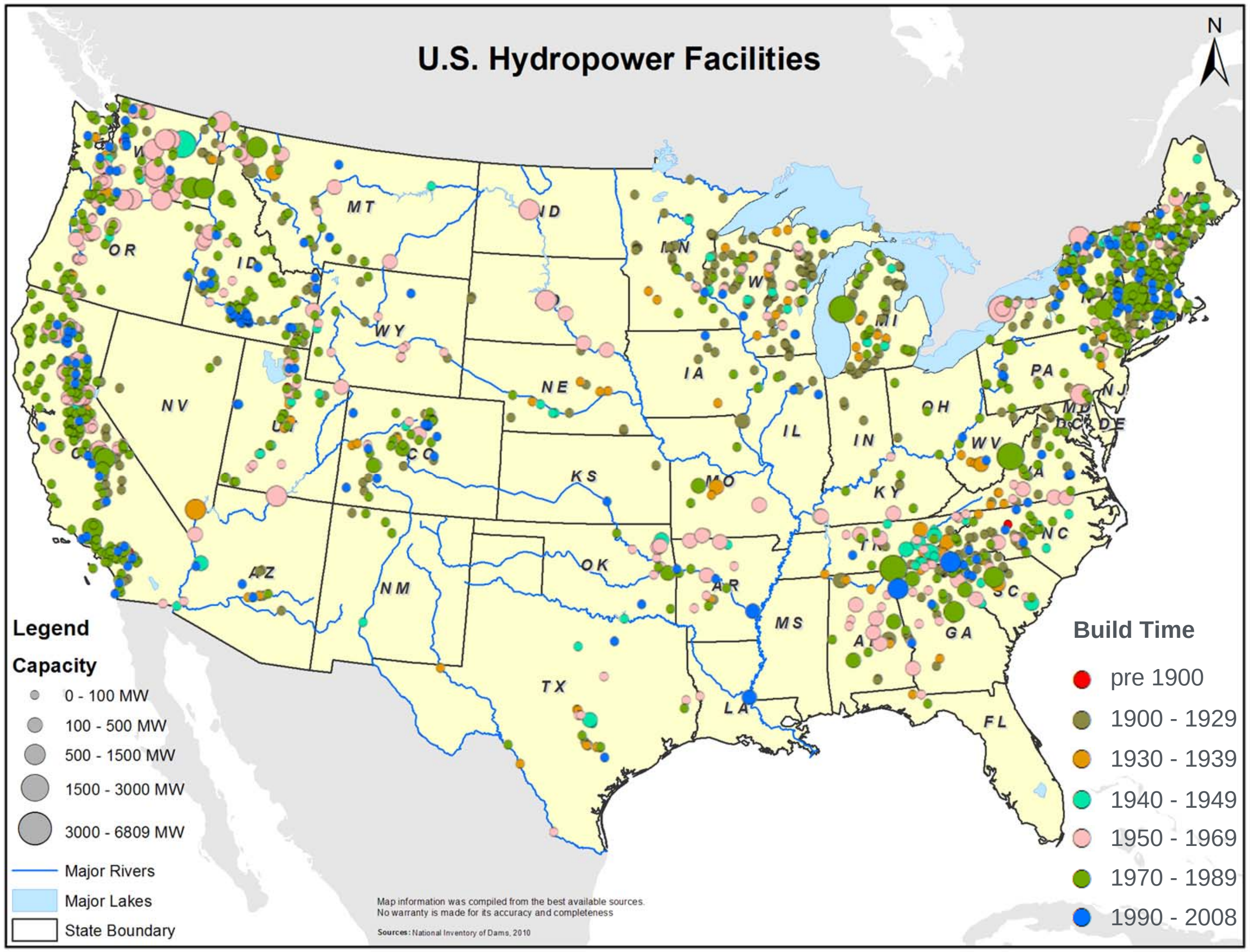
Hydropower Advancement Project Supporting documents: http://hydropower.ornl.gov/HAP/

Submit Responses via email HAPHydroRFI@go.doe.gov

Response due: **February 6, 2012** 11:59 PM EST

Fed Connect registration not required to respond

Conventional Hydropower
US Fleet Capacity



United States:

- Over 6% of Electric Production in 2010
- 78 GW Conventional Hydropower

Worldwide:

- 16% of Electric Production
- 723 GW

Hydropower is currently the nation’s largest source of renewable energy with over 6% of total US electricity production, and comprising nearly 70% of all renewable generation.

Conventional Hydropower
Existing Fleet Status

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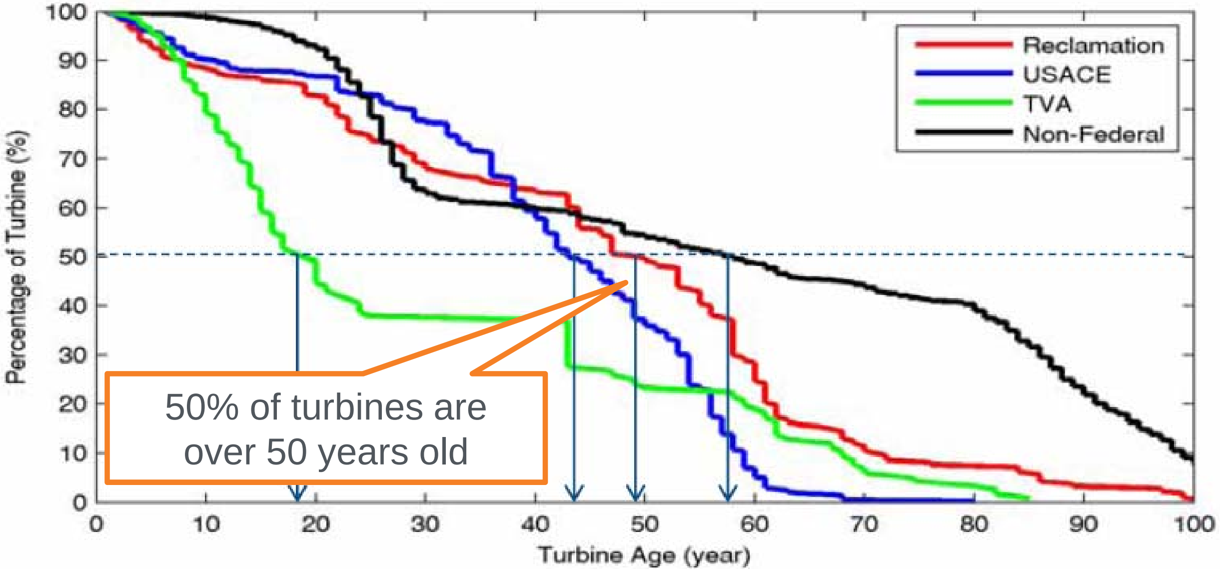

The status of the existing fleet demonstrates the potential to modernize hydropower for additional capacity, flexibility and generation

Turbine	Median Age	Older than 50 Years		Older than 75 Years	
Non-Federal	58	54.6%	18.4 GW	41.9%	8.1 GW
Reclamation	49	49.8%	4.1 GW	8.2%	.058 GW
Corps	44	37.2%	6.1 GW	0.3%	.002 GW
TVA	18	23.3%	0.8 GW	4.3%	.061 GW
Total US	**53**	**52.5%**	29.5 GW	**36.8%**	8.2 GW

***Percentages calculated by number of turbines**

HAP Approach

Purpose: Accelerate **improvement and expansion** of existing U.S. hydropower facilities to **increase of annual generation and value**

1. Establish a systematic and standard approach to evaluate and assess existing hydropower facilities
   - Develop Best Practices Catalog (reference material for assessments)
   - Assessment Manual (guide to perform assessments)
2. Train Assessment Teams to perform standard assessments
3. Perform 40-50 standard assessments
4. Report the results to facility owners on the current condition and opportunities for improvements and expansions
5. Catalog and trend the results to develop a high level estimate for U.S. hydropower improvement potential
6. Identify current barriers to improvements

Request for Comment

(See pages 5 and 6 of the RFI)

The numbered list has been regrouped in the following categories:

1. Government role
2. Objectives, rationale and methodology
3. Assessment scope, cost and team formation
4. Commitment by facility owner and consultants
5. Value to owner/operator

What can be done to accelerate the improvement and expansion of existing federally and non-federally owned hydropower facilities? (3a)*

- What role can U.S. Government play in the improvement and expansion of existing hydropower facilities?
- What incentives and/or policy changes would expedite improvements and expansions to existing hydropower assets?

What are the barriers to implementing improvements and expansions? (3a)*

**Corresponding list number for the Request for Comment is given in parenthesis*

3a

Request for Comment – HAP Approach

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Comments requested as they relate to:

- The appropriateness of the **objectives and rationale** that a standard assessment methodology and analysis of improvement opportunities can **accelerate improvements** and expansions **to increase annual generation and/or value** of hydropower assets at existing U.S. hydropower facilities. (1)*
- **Alternatives or adjustments** to the HAP methodology that would enable DOE and stakeholders to accelerate the increase of hydropower generation through efficiency, capacity and water utilization improvements at existing U.S. hydropower facilities. (4)*

Request for Comment – HAP Methodology

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Comments on the Assessment Scope including:

- **Table 1** on page 8 of the RFI – Scope of Assessments and Personnel Requirements
- Manpower requirements as it relates to a cost estimate of **$50,000-$100,000** (depending on the facility size) per assessment. (3j)*
- Facility and team selection, including (2)*:
  - Whether teams and facilities should be selected jointly or independently and
  - How independent teams and facilities should be coordinated for multiple assessments?

Request for Comment – HAP Assessment Commitment

What are the challenges and timelines associated with obtaining commitments from facility owners for assessment? (3g)*

- As a hydropower facility owner, would you allow and participate in HAP assessments at your facility? (3d)*
- As a hydropower consultant, would you consider participation in the facility assessment team(s) that will execute standard facility assessments? (3e)*
- As a hydropower consultant, would you consider providing proposals with five to ten facilities for assessment by a team assembled by you? If so, would that team be consistent with the team proposed in Table 1 of the RFI? (3f)*

Request for Comment – HAP Assessment Commitment (continued)

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Is it practical to require facilities to provide sensitive data to facilitate analyses of condition and performance correlation? (3h)*

Would hydropower facility owners/operators allow the use of business sensitive data for aggregate analyses if such data is protected and presented only in aggregate form for multiple facilities that are assessed? (3i)*

Request for Comment – Assessment Results

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How will the collective assessment results be useful to facility managers in benchmarking facility condition and performance? (3k)*

What information is needed to develop a case to move forward to feasibility studies leading to improvement or expansion projects? (3b)*

What information is needed from a feasibility study to develop a business case for investment decisions on improvement or expansion projects? (3c)*

Comments to the RFI should be submitted separate from HAP document comments with the subject line: "Response to Hydropower Advancement Project **Request for Information**."

Request for Comment – HAP Documents

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Comments are also sought on the HAP systematic and standard approach as outlined in the Best Practices Catalog, Assessment Manual and the Hydropower Technology Taxonomy – available for review on the HAP website.

HAP documents will be appropriately revised based on the suggestions and comments received.

Comments to the HAP documents should be submitted separate from RFI comments with the subject line: "Response to **HAP Documents**."

Why HAP?

Project	Owner	Pre-Improvement MW	Post-Improvement MW	Increase
Nickajack	TVA	101	115	14%
Wilson	TVA	670	742	11%
Palisades	Reclamation	177	206	17%
Cheoah	APGI	88	110	25%
Bonneville1	Corps	519	531	2%
Lake Chelan	CCPUD	59	70	19%
Chief Joseph	Corps	2457	2497	2%
Folsom	Reclamation	199	212	7%
Jocassee	Duke	660	710	8%
Roanoke	Corps	227	291	28%
Kelsey	Manitoba Hydro	224	308	38%
Snoqualamie Falls	PSE	44	54	23%
Wanapum	GCPUD	1038	1194	15%
Webbers Falls	Corps	69	75	9%
Overall		**6531**	**7116**	**9%**

Sources: www.tva.gov, http://www.renewableenergyworld.com/rea/news/article/2011/03/snapshots-of-north-american-rehabilitation

What to expect in future upgrades (and when)? What technology is needed?

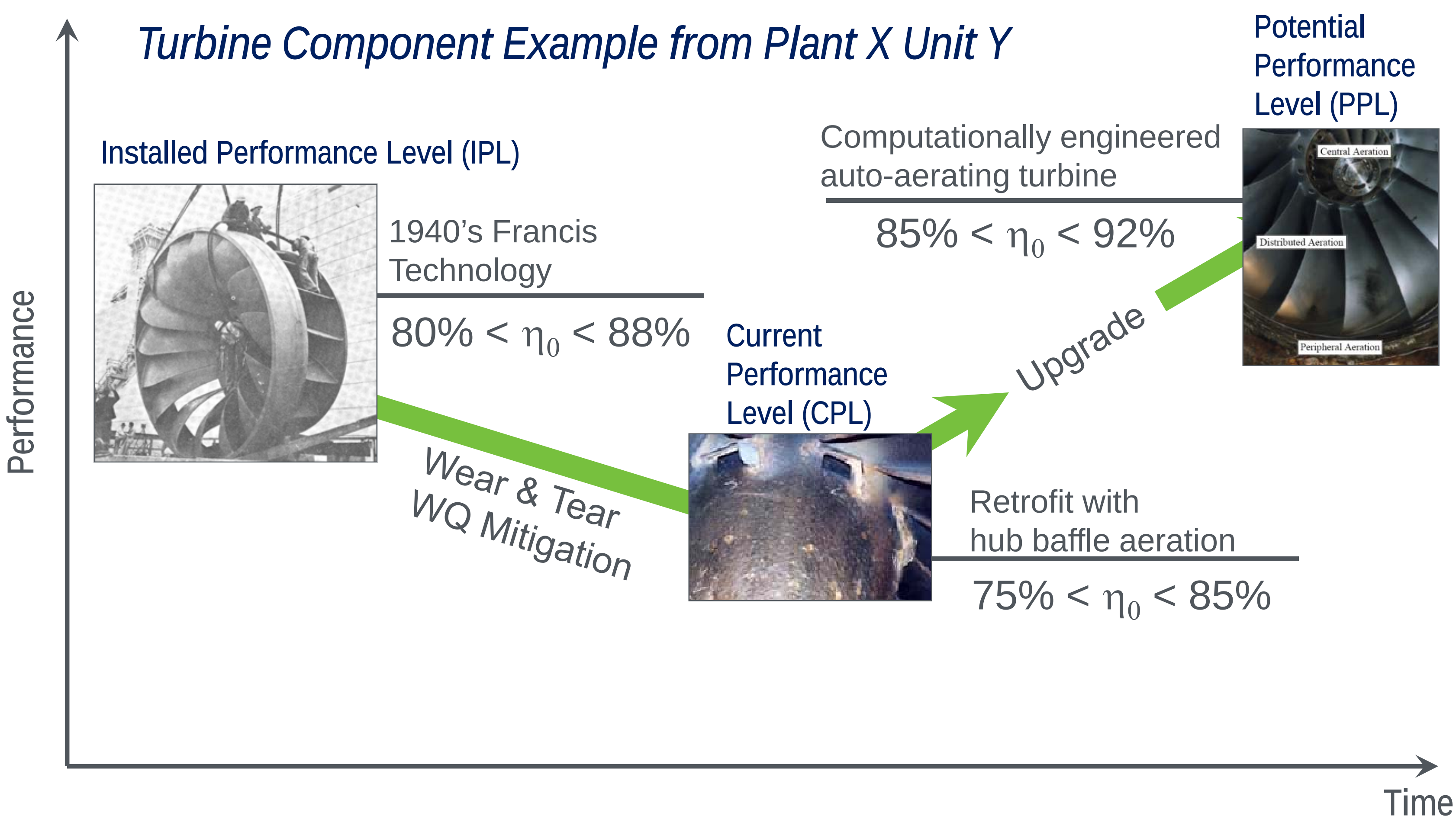
HAP Performance Levels & Assessment (RFI Page 2)

Installed performance level (IPL) – achievable by the facility under design conditions and constraints that existed immediately after commissioning (installed name-plate capacity performance in most cases).

Current performance level (CPL) – usually lower than the installed performance level (IPL) due to wear and tear, or due to the operational changes in the constraints placed on a facility that prevent it from operating as originally designed.

Potential performance level (PPL) – achieved under current operating constraints through upgrading or expanding to the best available technology and implementation of best practices for operations and maintenance.

HAP Performance Levels & Assessment



Technical Approach – HAP Overview

HAP Process & Baseline Development

For each facility

- Standardized Asset Condition Assessment
- +
- Standardized Performance Assessment

→ Identify Asset Upgrades

Identify Process Improvements

x 10 Assessments

a validated, documented, standard methodology for quantifying and correlating condition, performance and improvement opportunities

HAP Standard Assessments

- Component, Unit, and Plant Condition Ratings
- Unit and Plant Performance Ratings
- Wide range of upgrade opportunities

QA/QC into HAP Condition and Performance Databases

- Extrapolation to US hydropower inventory yields fact-based estimate of additional MW and MWh
- Prioritization of upgrade opportunities and applicability to US inventory
- Documentation of barriers to upgrades

Technology and policy impact research of improvement opportunities

Technical Approach - Products

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The HAP will produce online documentation and tools to support the assessment process . . .

Hydropower Technology Taxonomy

Best Practices Catalog

Assessment Manual

- Process Guidance
- Component Rating Workbooks
- Component Rating Checklists
- Plant Performance Calculator

Assessment Reports

- Center Hill
- Rhodhiss
- Reclamation Facility
- 7 Facilities in FY12 by HAP Team
- Verify efficacy of assessment process
- Begin populating performance & condition databases
- Earlier identification of upgrade demo opportunities

. . . and reports that provide insight into the state of existing U.S. hydropower assets

Non-Public Business-Sensitive Assessment Report Archive – provide to the facility owners only

- Controlled by Non-Disclosure Agreements
- Individual Project Performance and Condition Ratings (provided only to facility management staff)
- Project and Component Condition Database
- Project Performance Database
- Flow and Generation Data

Public Reports of Multiple Assessments

- Project configuration and assessment summaries
- Overall and component-level trends in condition across many projects
- Trends in water-use efficiency, constraints across many projects
- Correlations between efficiency, condition, and production
- Summary of opportunities for and barriers to upgrade/improvement

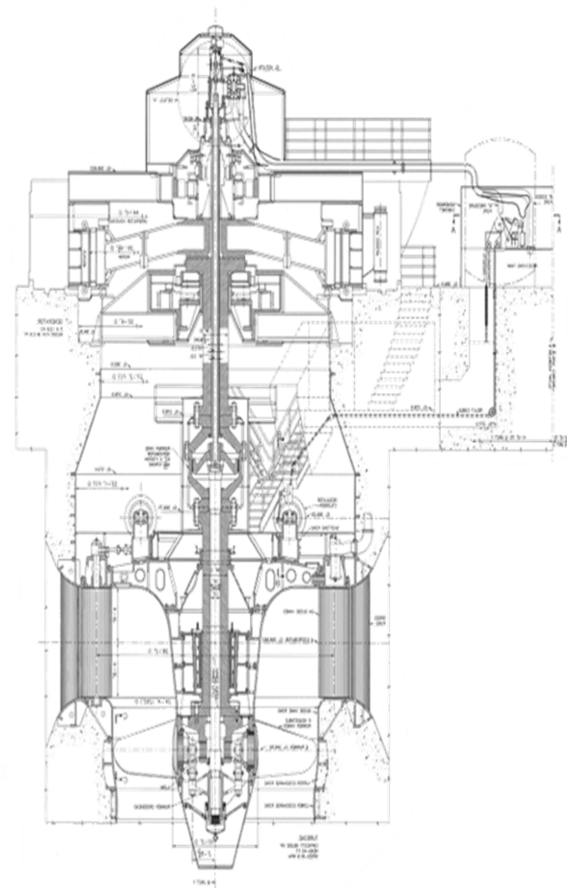
http://hydropower.ornl.gov/HAP

Technical Approach

Hydropower Technology Taxonomy

Hydropower Facility

- 1. Headwater/Reservoir
- 2. Dam/Weir
- 3. Water Conveyance
  - 3.1 Trash Racks
  - 3.2 Intakes
  - 3.3 Tunnels
  - 3.4 Penstocks
  - 3.5 Control/Shut-off Valves
  - 3.6 Surge Tanks/Air Chambers
  - 3.7 Flumes/Open Channels
  - 3.8 Draft Tube Gates
- 4. Powerhouse
  - 4.1 Power Train Equipment
    - 4.1.1 Turbine
      - 4.1.1(a) Francis Turbine
      - 4.1.1(b) Propeller/Kaplan Turbine
      - 4.1.1(c) Pelton Turbine
    - 4.1.2 Governor
    - 4.1.3 Generator
      - 4.1.3.1 Stator
      - 4.1.3.2 Rotor
      - 4.1.3.3 Ventilation & Cooling System
      - 4.1.3.4 Neutral Grounding
      - 4.1.3.5 Thrust Bearing & Cooling System
      - 4.1.3.6 Guide Bearing & Cooling System
      - 4.1.3.7 Generator Shaft
    - 4.1.4 Exciter
    - 4.1.5 Transformer
    - 4.1.6 Circuit Breakers
  - 4.2 Balance of Plant/Auxiliary Components
  - 4.3 Instruments & Controls
  - 4.4 Powerhouse Structures
- 5. Tail water
- 6. Switch Yard
- 7. Navigation Locks



Standardization of physical hierarchy is key to meaningful analyses and trending

- Provides physical and functional hierarchy for Best Practices, Ratings, and Component Condition Database
- Provides consistent nomenclature for facility characterization, reporting and team/assessor communication
- Enables detailed component level queries of component conditions across multiple projects
- Color-coded to indicate HAP coverage and Corps/Reclamation HydroAMP alignment

http://hydropower.ornl.gov/HAP

Technical Approach

Best Practices Catalog (BPC)

- Concepts
  - Functional requirements
  - Typical configurations for components
  - Efficiency role of components
  - Reliability role of components
  - Concise history of technological evolution
  - Summary of State-of-the-art technology
  - Typical O&M requirements
  - References to testing protocols
- Components covered
  - Turbines (Francis, Propeller, Pelton)
  - Generators
  - Water Conveyances
  - Main Transformers
  - Trash Racks & Intakes
  - Instrumentation and controls for condition monitoring
  - Instrumentation and controls for automation
- Special topics
  - Uncontrolled water leakage
  - Flow releases
  - Operational impacts of environmental mitigation systems

Condition Rating Workbooks

- Excel Workbook files
  - User (assessor) fields to enter part scoring
  - Predefined rating scales for ease of use and consistency among different assessors
  - Providing additional guidance for files and fields
- Components covered
  - Turbines (Francis, Propeller, Pelton)
  - Generators
  - Water Conveyances
  - Main Transformers
  - Trash Racks & Intakes
  - Instrumentation and Controls for Automation and Condition Monitoring
  - Instrumentation for Unit Performance Measurement
- Rating structure
  - Component specific weighting factors for parts (e.g. wicket gates, runner, shaft, …)
  - Weighted scores for Age, Physical Condition, Technology Level, Operating Impact, Maintenance Demands, and/or other specific metrics

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Condition Rating Process – Turbine Example

Francis Turbine Unit ____	Taxonomy ID	Physical Condition Score	Age Score	Installed Technology Score	Operating Restrictions Score	Maintenance Requirement Score	Data Quality Score	Weighting Factors for Parts
Spiral/Scroll Case	4.1.1.1							1.5
Stay Ring/Vanes	4.1.1.2							1.5
Wicket Gates Mechanism/Servomotors	4.1.1.3							3.0
Runner	4.1.1.4							5.0
Draft Tube	4.1.1.5							2.0
Main Shaft	4.1.1.6							1.0
Guide Bearings	4.1.1.7							1.5
Mechanical Seal/Packing	4.1.1.8							1.0
Head Cover	4.1.1.9							1.5
Vacuum Breaker/PRV	4.1.1.10							1.5
Aeration Devices	4.1.1.11							2.0
Bottom Ring	4.1.1.12							1.0
Weighting Factors for Condition Parameters		2.0	1.0	1.0	1.0	1.5	Data Quality -->	*0.00*
							Condition Indicator -->	***0.00***

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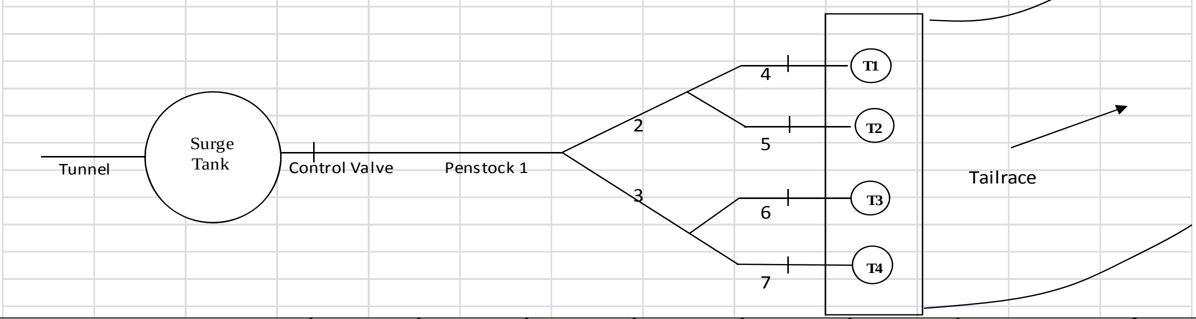
Condition Rating Scale – Turbine Example

Chart 1 Turbine Physical Condition Rating Criteria		
Physical Condition Description		Physical Condition Score
Excellent	No noticeable defects. Some aging or wear may be noticeable.	**9 – 10**
Very good	Only minor deterioration or defects are evident, and function is full.	**7 – 8**
Good	Some deterioration or defects are evident, but function is not significantly affected.	**5 – 6**
Fair	Moderate deterioration, function is still adequate, but the unit efficiency may be affected.	**3 – 4**
Poor	Serious deterioration in at least some portions, function is inadequate, unit efficiency or availability significantly affected.	**2**
Very poor	Extensive deterioration. Barely functional.	**1**
Failed	No longer functions, may cause failure of a major component.	**0**

- Physical Condition of turbine parts refers to those features that are observable or detected through measurement and testing. It includes surface roughness from erosion, corrosion or cavitation, cavitation pitting, cracking damage, clearances and leakage, vibrations and noises, oil loss, shaft runout, etc.

(References: USACE & MWH 2010 – HMI Final Report; USACE 2001 – Major Rehabilitation Evaluation Report for Center Hill Plant)

Condition Rating Process – Mapping the Parts of Water Conveyance for Each Unit



Pressurized Water Conveyance for Unit 1	Taxonomy ID	Physical Condition Score	Age Score	Installed Technology Score	Operating Restrictions Score	Maintenance Requirement Score	Data Quality Score	Weighting Factors for Parts
Tunnel	3.3							2.0
Penstock 1	3.4.1							3.0
Penstock 2	3.4.1							2.0
Penstock 4	3.4.1							2.0
Bifurcation 1	3.4.2							1.0
Bifurcation 2	3.4.2							1.0
Linings & Coatings	3.4.3							1.0
Foundation & Supports	3.4.4							1.0
Air Vent/Pressure Relief Valve	3.4.5							1.0
Joints & Coupling	3.4.6							1.0
Surge Tank	3.6							1.5
Weighting Factors for Condition Parameters		2.0	1.0	1.0	1.0	1.5	Data Quality -->	0.00
							Condition Indicator -->	0.00

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Condition Rating Process - Synthesis of Components Indicators to Unit Indicators – for X Hydropower Plant – Unit

Components	Component Code in Taxonomy	Weighting Factors *W* (*i*)	Condition Indicator *CI* (*i*) (0-10)	Data Quality Indicator *DI* (*i*) (0-10)
Trashracks and Intake	3.1/3.2	2.0		
Penstock/Tunnel/Surge Tank	3.3/3.4/3.6	1.5		
Control/Shut-off Valve	3.5	1.0		
Flume/Open Channel	3.7	1.0		
Draft Tube Gate	3.8	0.2		
Leakage and Release	2.1/2.2/2.3	1.5		
Turbine	4.1.1	2.0		
Governor	4.1.2	1.0		
Generator	4.1.3	3.0		
Exciter	4.1.4	1.0		
Transformer	4.1.5	2.5		
Circuit Breaker	4.1.6	0.5		
Surge Arrester	6.1	0.5		
Instruments & Controls	4.3	0.5		
Powerhouse Crane	4.2.1	0.5		
Station Power Service	4.2.2	0.5		
Compressed Air System	4.2.3	0.5		
Raw Water System	4.2.4	0.5		
Lubrication System	4.2.5	0.5		
Unit Indicators			***0.00***	***0.00***

Note: Circuit Breaker, Surge Arrester, Powerhouse Crane, Station Power Service and Compressed Air System will be considered for future additions.

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Aggregated Plant Condition Indicators

Components	Unit 1	Unit 2	Unit 3	Unit 4	Unit 5	Unit 6	Units Average
Trashracks and Intake							
Penstock/Tunnel/Surge Tank							
Control/Shut-off Valve							
Flume/Open Channel							
Draft Tube Gate							
Leakage and Release							
Turbine							
Governor							
Generator							
Exciter							
Transformer							
Circuit Breaker							
Surge Arrester							
Instruments & Controls							
Powerhouse Crane							
Station Power Service							
Compressed Air System							
Raw Water System							
Lubrication System							
Unit Condition Indicators (*UCI*)							
Plant Condition Indicators (*PCI*)							

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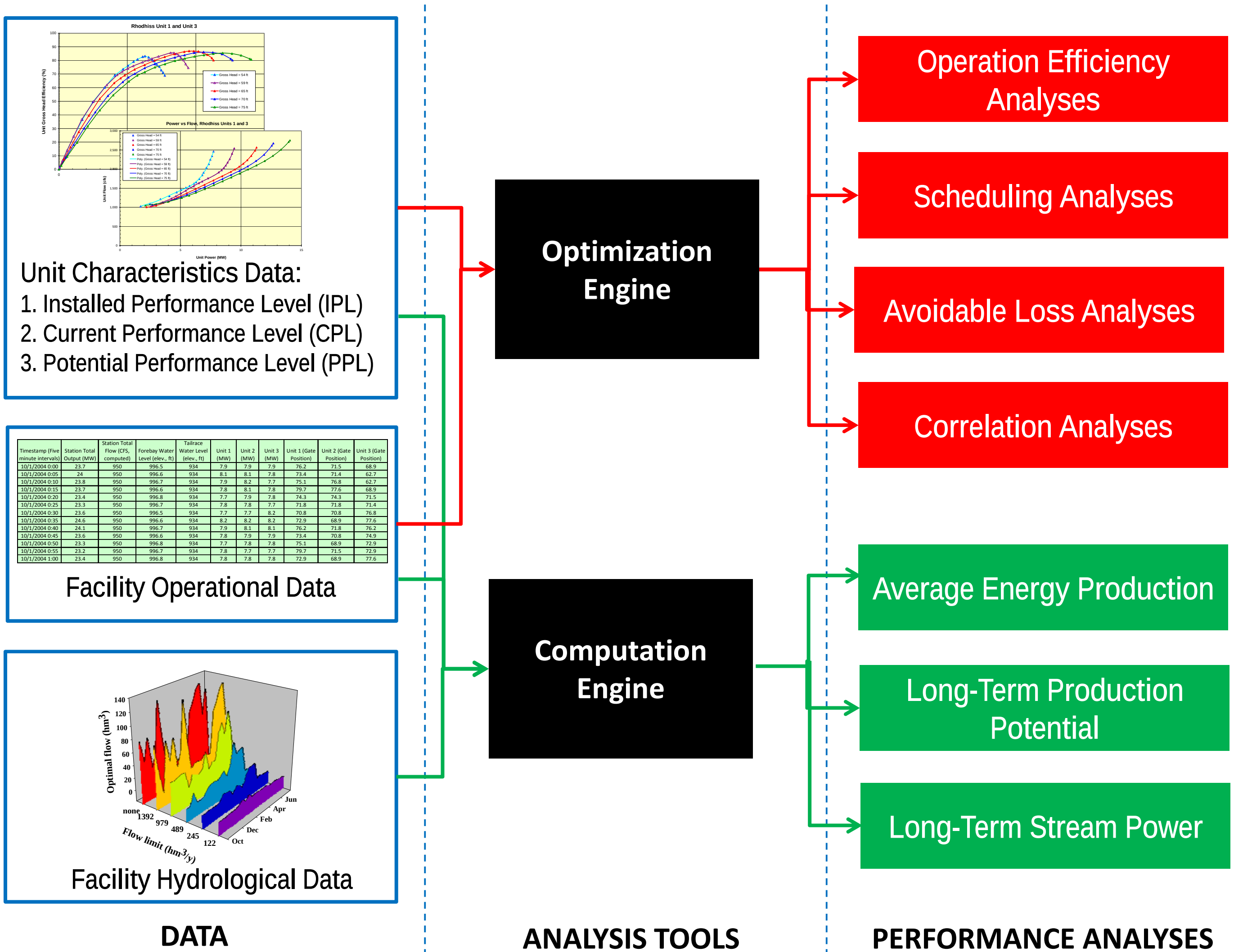
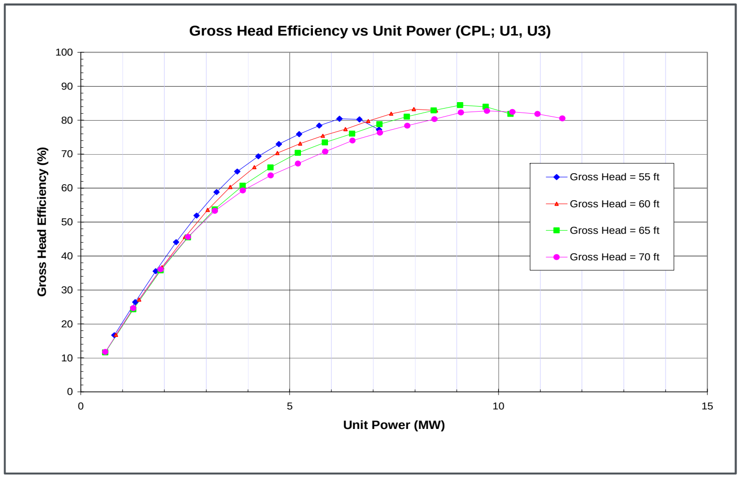
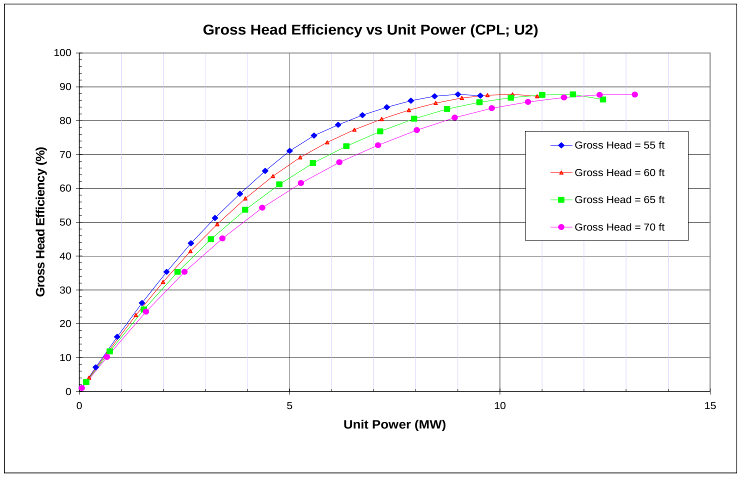
Overview of Performance Assessment

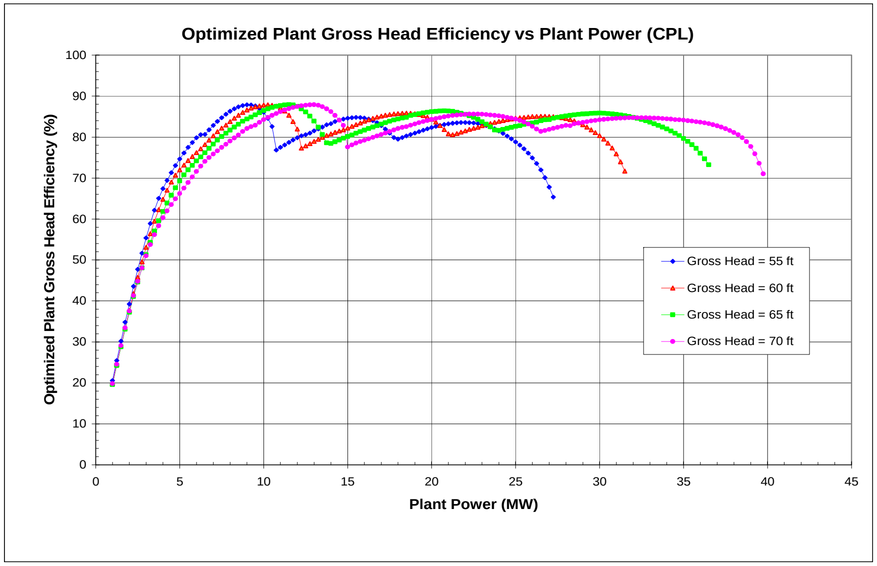


Technical Approach

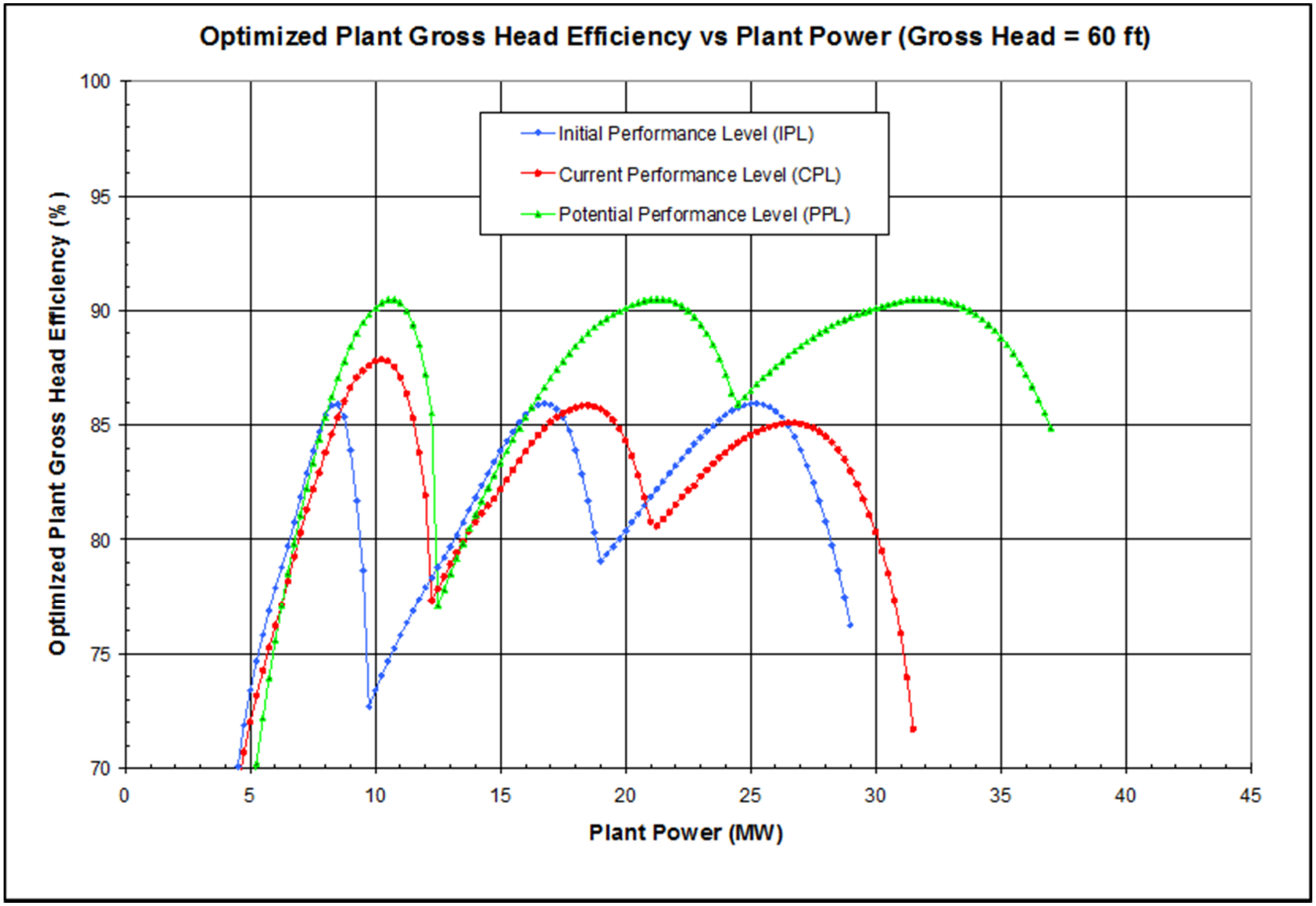




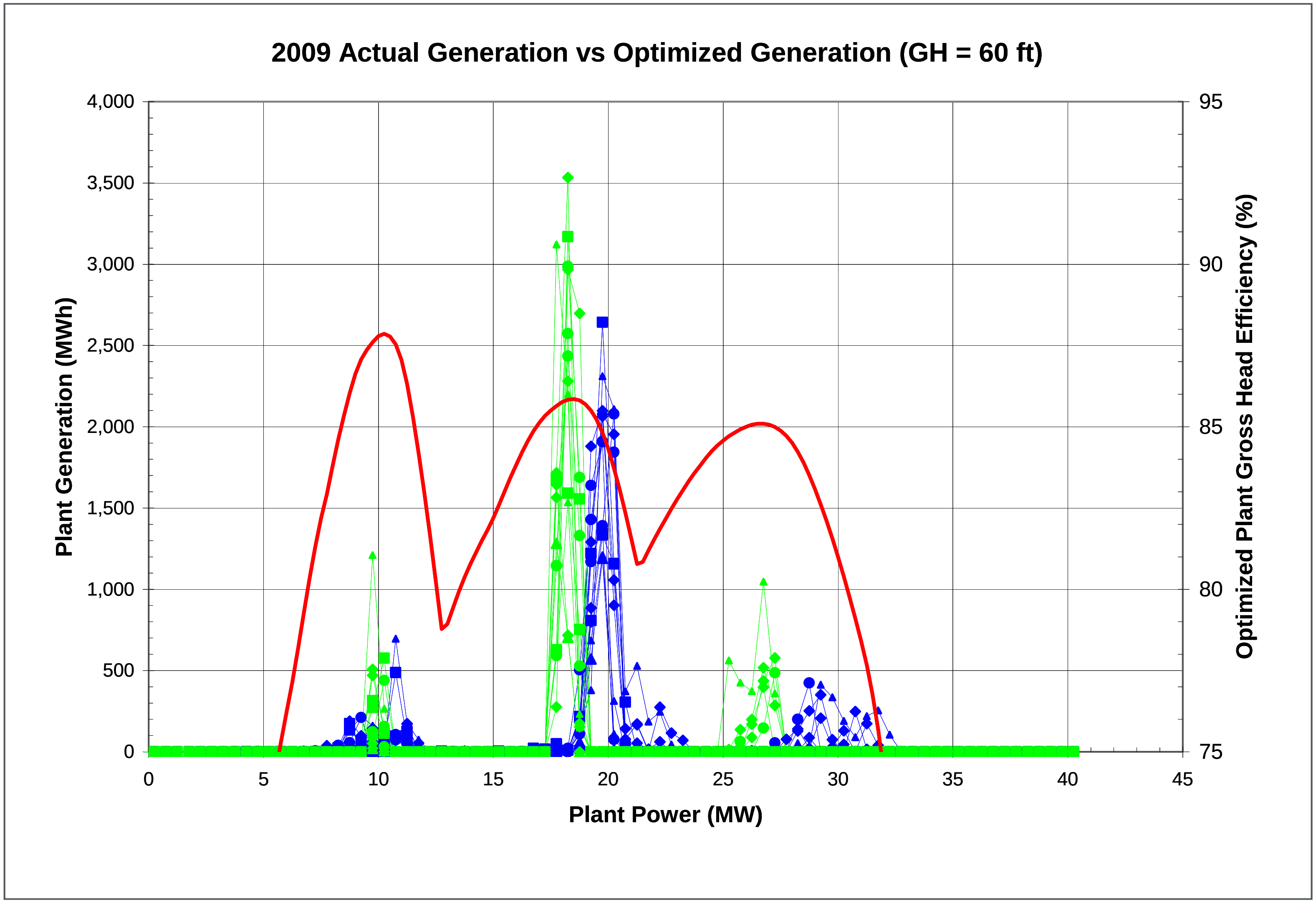
Opt. Plant Gross Head Efficiency vs Plant Power (CPL example)



Opt. Plant Gross Head Efficiency vs Plant Power (GH = 60 ft)



Typical Results from Scheduling Analyses (2009; GH = 60 ft)



Preliminary Results from Performance Assessments

CPL Results: Avg. Improvement = 4.7%

Year	Actual Annual Generation (MWh)	Optimized Annual Generation (CPL) (MWh)	Improvement (MWh)	Improvement (%)
2007	33,472	35,096	1,624	4.9
2008	35,313	36,389	1,076	3.1
2009	67,362	70,570	3,208	4.8
2010	63,291	67,071	3,781	6.0
2011	29,377	30,709	1,332	4.5

Notes:
1. The 2007 results only include generation from January 1, 2007, through June 30, 2007.
2. The 2011 results only include generation from January 1, 2011, through August 22, 2011.
3. The generation analyses show potential improvements while using the actual amount of water per hour.

PPL Results: Avg. Improvement = 9.8%

Year	Actual Annual Generation (MWh)	Optimized Annual Generation (PPL) (MWh)	Improvement (MWh)	Improvement (%)
2007	33,472	36,800	3,329	9.9
2008	35,313	38,344	3,031	8.6
2009	67,362	74,371	7,010	10.4
2010	63,291	70,243	6,952	11.0
2011	29,377	32,115	2,738	9.3

Notes:
1. The 2007 results only include generation from January 1, 2007, through June 30, 2007.
2. The 2011 results only include generation from January 1, 2011, through August 22, 2011.
3. The generation analyses show potential improvements while using the actual amount of water per hour.

Preliminary Outcomes

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Preliminary opportunities identified through condition assessment:

- Turbine runners with advanced hydraulic and aeration design
- Wicket Gate, stay vane, spiral case surface rehabilitation and re-profiling.
- Draft tube surfacing, shaping, and slot filler installation
- Generator air cooler and ventilation upgrades
- Shaft vibration sensing for improve bearing performance and reliability

Key concepts identified through owner-assessor interaction

- Asset owners/operators are primary sources of quantitative and qualitative information useful for assessments.
- Anonymous aggregated public reporting combined with site-specific feedback only to owners - enables individual facilities to compare their results to the collection of assessed facilities
- No ranking of hydropower facilities by DOE

Guidance for Response

Responses on both the **contents of the RFI** and the **HAP supporting documents** should be provided as an attachment (in Microsoft Word format) to an e-mail addressed to HAPHydroRFI@go.doe.gov

- Subject line of the email for RFI responses should read: "Response to Hydropower Advancement Project **Request for Information** (insert name-organization)."
- Subject line of the email for comments to the HAP documents should read "Response to **HAP Documents** (insert name-organization)."

Responses must be received no later than 11:59 PM EST on **February 6, 2012**. HAP Documents will continue to be available for review on hydropower.ornl.gov/HAP/ after the RFI comment period.