ASSET MANAGEMENT: AGING ASSETS AND BALANCING RISK

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ABSTRACT

Electric utilities are increasingly faced with aging infrastructure, more stringent operating requirements, and insufficient human and financial resources. Asset management programs can comprehensively address these challenges, but one approach does not fit all utilities. Asset management is ultimately designed to inform and spur action; although adhering to an overly complex program can encumber resources, without leading to clear action plans for high-value assets. Drawing upon PAS 55 principals, Black & Veatch has employed a hydro-specific process that targets three main focus areas that ultimately determine the form of the Asset Management program. This paper first outlines the defining characteristics of power assets and how it fits into the typical lifecycle model. Then the primary activities of asset management are defined around 3 focus areas that encapsulate the needs and objectives of a utility. Finally, several examples are given of asset management experiences at two hydropower utilities, each varying in size, objectives, and constraints.

The first utility (PG&E), with a large and diverse hydroelectric capacity, embedded asset managers within the organization to drive long-term change, yet retained a significant role in the prioritization. This required an emphasis on quantitative condition and risk assessment, project justification, altering procedures and guidelines, and communicating change throughout the organization. The second utility (Hetch Hetch Water & Power) was a medium-sized power producer with a few large powerhouses whose primary responsibility was the delivery of water. The utility needed to prioritize a number of key capital improvement projects using a risk-based probabilistic net present value comparison that also satisfied a range of non-financial impacts.

INTRODUCTION

Originally published by the Institute for Asset Management in 2004, the Publicly Available Specification No. 55 (PAS 55) quickly became popular across the asset management community. It was later expanded upon in 2008 and became a 3-part ISO standard in 2014 (ISO 55000, ISO 55001, ISO 55002). This standard serves well as a checklist for understanding the complete range of capabilities and responsibilities of a generalized asset management system, yet the document is too broad to be practically applied to hydropower utilities. Thus, the first step in customizing the process was to understand the unique characteristics of the hydropower industry, as it applies to asset management in the United States. This will in turn highlight its needs such that a more focused process can be derived that specifically applies to hydro.

<u>Capital Intensive</u>. Most of the hydropower assets were built in the first half of the 1900's, with a trend towards building larger, more efficient units over time. The initial construction is very capital intensive, with long payback times, as is reflected by the lengthy FERC licensure. The remoteness and inaccessibility of the assets often exacerbate these costs.

<u>Additional Operating Constraints</u>. Over time, new requirements have been placed upon existing powerhouses in order to satisfy environmental, safety, reliability, flow delivery, and recreational requirements. These non-financial factors can carry a very high risk, yet the risks often remain uncalibrated against other similar assets within the system or against industry benchmarks. As in any engineered system, operating outside of the design intent either requires modifications to the system or results in sub-optimal performance.

Unidentified Acceptance Criteria. With the vast majority of hydro assets in the United States being built prior to the age of electronic communication, there comes a dearth of readily accessible documents that identify the design and performance criteria for the powerhouse components. This problem is further compounded by a string of modifications, improvements, or changes in ownership.

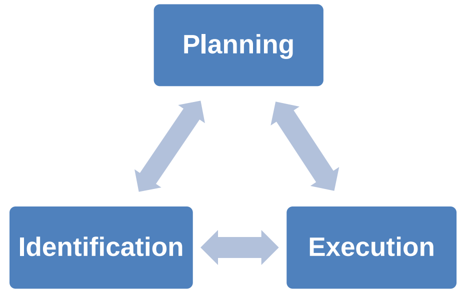
Permanence. Large infrastructure projects play an influential role with the surrounding community, with certain long-term rights and agreements made between affected parties. Likewise, a long payback period is assumed in order to recoup the high capital costs of construction. Additionally, in the United States, the prevailing assumption is that the majority of the large hydro capacity has already been installed. These three factors, while restraining large, new developments from occurring at this time, also promotes permanency among the existing facilities.

THE PROCESS

The typical life cycle of an asset often follows a particular sequence, from creation to retirement, as shown in the figure below. In light of the above characteristics, hydro asset management in the United States tends to focus on the latter half of an asset's life cycle, although all steps are vital to shaping that asset's plan.

While the life cycle steps are fairly uniform across all assets, the needs of particular utilities are not. These needs have been categorized into three focus areas, Planning, Identification, and Execution. Each focus area has an output or goal that typically encompasses a suite of asset management services that exhibit the core needs of the organization. Each focus area assists with a portion of the life cycle activities and is meant to produce a key deliverable.

Planning.
The goal of this facet is to establish a future plan of action, such as a Capital Improvement Plan. Other activities include establishing the asset management framework within the organization, defining its roles, objectives, and measures of progress. This activity ultimately involves incorporating the plan into the existing budget, gaining stakeholder support, and optimizing the schedule. This category would also include any recommendations to retire/divest the asset.



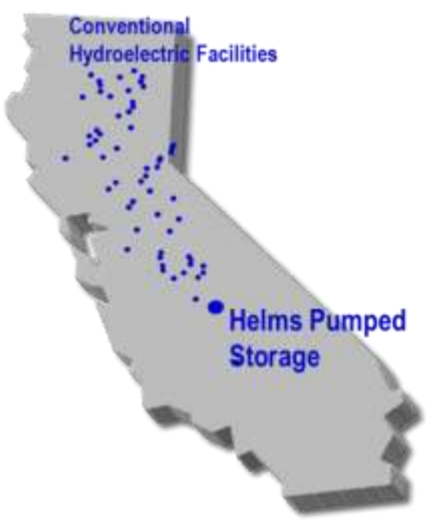
Identification.
The goal of this facet is to understand the probability of failure of individual assets, understand their basic characteristics, consequences of failure, and interrelations among different assets. This work typically culminates into a summary report that determines the existing and target value of the asset. Like assets are systematically compared using standardized ranking system that ideally accounts for financial and non-financial consequences.

Execution.
The goal of this facet is to produce targeted improvements towards improving the portfolio of assets. Typically this amounts to capital projects, shorter-term maintenance remedies, or restricted operations, yet it might include more hands-on changes to maintenance practices, better capture of tribal knowledge, updating design guidelines, or initiating training.

The following section will demonstrate these different activities as they apply to three different utilities for which Black & Veatch provided asset management services.

Example 1: Pacific Gas & Electric (PG&E)

Overview
Founded in 1905, PG&E is an investor-owned gas and electric utility with a large and diverse hydroelectric capacity, spread across a large geographic area and dating back to the late 1800's. The primary purpose of the hydropower assets is to supply electricity to the greater transmission and distribution system, also owned by the utility.



PG&E Hydroelectric System Highlights

- 3,896 MW
- 16 River Basins
- 68 Powerhouses
- 109 Units
- 140,000 acres of land
- 171 dams
- 98 reservoirs
- 173 miles of canals
- 132 miles of tunnels
- 43 miles of flumes
- 65 miles of penstocks, siphons, low head pipe

The Need

As shown above, PG&E had a significant number of aging assets that were approaching the end of their lifecycle. Decisions on improving assets were often guided by local personnel intimately involved with the equipment, yet this expertise was getting shorter in supply due to retirements, competition, etc. Limited budgets for aging components, tighter requirements for relicensing, and a need for systematic improvements led to the creation of an Asset Management team within the Power Generation division. By 2010, PG&E had established a core team, a framework and objective for the program with the support of senior management. The prioritization and sequencing of these projects were handled by this core team as well.

The quantity of assets was large and their condition was often not known. Likewise, the modes and the consequences of failure for lower value assets were not entirely understood. In addition, the utility wished to initiate capital and non-capital improvements in order to reduce the greatest amount of risk, yet the non-capital improvements prove difficult to carry out across a previously decentralized system. Likewise, the projects needed to be tracked and their solutions improved upon with other similar projects. Ultimately, all of these needs would fall onto the asset management program.

The Solution

Given the number of assets, the centralized process, and the technical role required, the assets were grouped together within programs, delineated along equipment class lines. Hence, all of the turbines, generators, penstocks, etc., were each placed within individual "Asset Programs". Each program was led by an Asset Program Lead (APL) who would direct program activities and use program budget and/or extra personnel for program tasks. Rather than dictating the asset management efforts directly, the core team relied on the individual asset programs to satisfy the needs described above (Identification and Execution), allowing the core team to focus on the Planning aspect. Black and Veatch led programs for the Turbines, Governors, Bearings, Shutoff Valves, Penstocks, and Oil Spill Prevention, and provided support for the Dam Safety, Water Conveyance, and Pressure Boundaries programs.

Typically, upon inception, the asset program would quickly verify the program's scope, schedule, available resources, and gain stakeholder buy-in. Then the program spends a significant amount of time on the Identification focus area, first flushing out the inventory across the entire fleet of assets and understanding its range of consequences. This provides the program with a broad understanding of the number of assets along with their key characteristics, configurations, and importance. The inventory is later used throughout to understand the magnitude of effort that a proposed change/policy would produce. Similarly, after conducting condition assessments, the information can be analyzed to determine if a certain correlation occurs between a specific characteristic and worsening conditions. The consequence of an asset's failure was ascertained across multiple categories, which included Financial, Safety, Compliance, Reliability, and Environmental. The core team provided guidance on equating the level of impacts across different categories. The Health and Consequence Scores were later combined together to produce a risk score for which the core team prioritized capital improvements.

For assessing the condition of the assets, Black & Veatch used a two-step process that optimized program resources while gaining system-wide information. The first step, Tier 1, had the operating personnel fill out a 1-page questionnaire on each asset. The questions were basic and easily observed, such as "number of cycles per year" and "packing leakage". Although subjective in nature, this allowed the program to quickly obtain a system-wide assessment using tribal knowledge. The responses were reviewed in-person with

local operating personnel to verify the observations and provide clarifications, as necessary. Based on this, and combination with existing information residing in the maintenance history logs, incident reports, and past condition reports, a Tier 1 Health Score is assigned to the asset. For poor or unknown Tier 1 Health Scores that correspond to high consequence assets, a Tier 2 Inspection is initiated. The Tier 2 Inspection typically is performed by an outside expert who travels to the site, collects qualitative data on the asset, and documents the findings in a report. This information, which ultimately leads to a Tier 2 Health Score, which supersedes the Tier 1 Health Score.

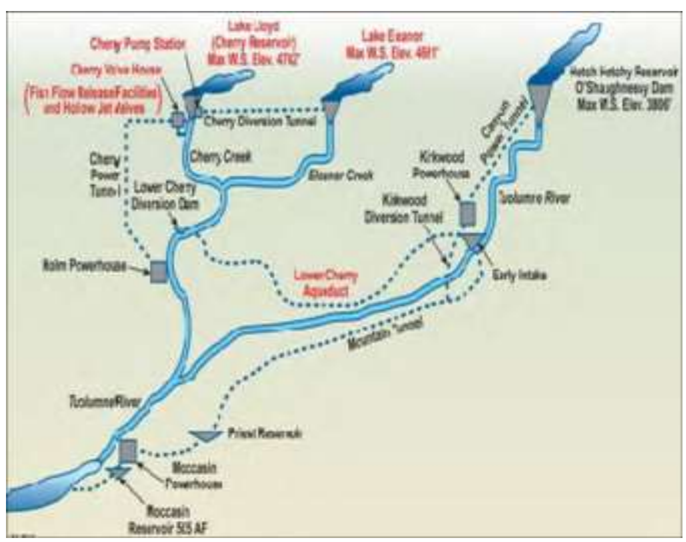
With the high risk assets now identified, the program then focuses on the Execution tasks that mitigate this risk. For large or complex issues, the asset program tends to propose a formal capital project or, if the solution is unknown, the program initiates a study to determine the concept. The proposed projects draw upon the experiences of similar past projects, as well as drawing upon the feedback of in-house technical experts and operating personnel. The program is responsible for providing the initial scope, schedule, and cost estimate, and to assist the assigned project team during project kickoff. For smaller, simpler issues, the program may instead communicate the risk directly to the area personnel and then track progress.

Beyond directly initiating fixes for the asset, the program takes indirect action to mitigate risk by proposing to adjust the operating procedures to reduce the risk. This might take the form of restricted run zones, increased oil filtering, more periodic walk downs, etc. The program also advises changes to existing design criteria/guidelines, which reduces the risk for future installations.

<u>Summary</u>
In this particular case, the shear quantity of assets justified creating individual asset programs, each managed semi autonomously, that reported back to a core team. Delineating the programs along equipment type allowed the program to specialize, creating a more effective process capable of broader “apples-to-apples” risk comparisons. The utility had established a strong Planning focus area, advantaged by directives from senior management, yet needed assistant in assessing the risk and transmitting the necessary corrective actions throughout the organization, i.e. Identification and Execution. With the assistance of consultants embedded within the program’s staff, the PG&E was able to provide a more complete hydro asset management program.

Example 2: Hetch Hetchy Water & Power

<u>Overview</u>
Hetch Hetchy Water and Power (HHWP) is the division within the San Francisco Public Utilities Commission (SFPUC) Water Enterprise responsible for operating, managing, and maintaining the Hetch Hetchy Water and Power Project. The HHWP combined water storage/delivery and electric power generation/transmission system was built in the mid 1920’s with later additions placed into service in the mid 1980’s. In general, this includes water and power facilities from Hetch Hetchy Reservoir down to Alameda East. The system is highly critical providing approximately 85 percent of the water needs of the San Francisco bay area. The HHWP Division operates, manages and maintains three impoundment reservoirs, two regulating reservoirs, four powerhouses (~400 MW of capacity), three switchyards, 170 miles of pipelines and tunnels, 250 miles of roads, 240 miles of transmission/distribution line, watershed land and right-of-way property. The



objectives of the HHWP Division are to provide responsible management of the SFPUC natural resources, to assure reliable water supplies and clean hydroelectric energy.

The Need

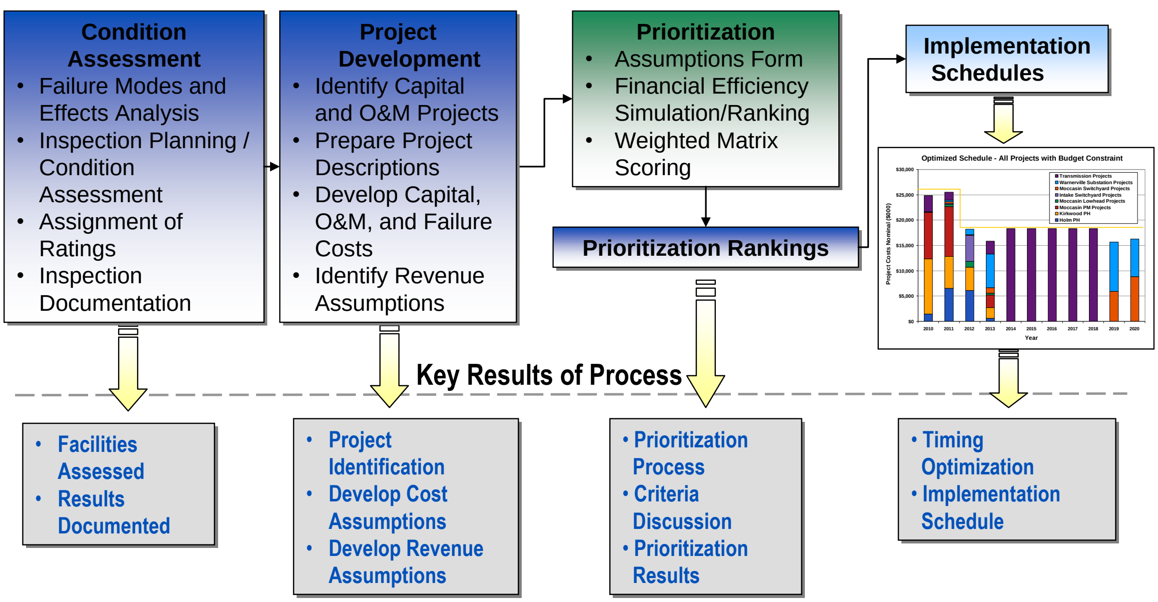
The Hetch Hetchy system has provided reliable service for an extended period with relatively little capital investment needs, however, due to the system criticality and age of the Hetch Hetchy system's key components, like many older complex infrastructure systems still in service today, there exists an increasing potential uncontrolled failures of significant frequency and/or magnitude that may result in the system's ability to meet it's obligation to serve their customers with potable water and inexpensive, clean, electric power.

As a response to potential significant service interruptions and the threat of uncontrolled operating cost risks, SFPUC and the HHWP Agency committed to the assessment and remediation of the key components of the Hetch Hetchy system. Additionally, given the current challenging economic conditions where budget constraints are ever more stringent, HHWP desired a balanced approach to optimize system performance, cost, and risk.

Black & Veatch was engaged to provide expertise and manpower to both perform and assist HHWP in the condition assessment and economic analysis of the electric power generation, transmission assets (powerhouses, substations and transmission lines), and storage assets (dams) to create a baseline Master Plan that balanced performance, cost, and risk.

The Solution

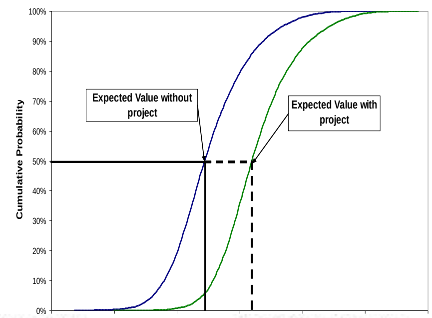
Black & Veatch leveraged its deep technical background in hydro-electric assets and its Capital Prioritization & Optimization process and tools in the development of the baseline Master Plan. The figure below shows the high level tasks performed.



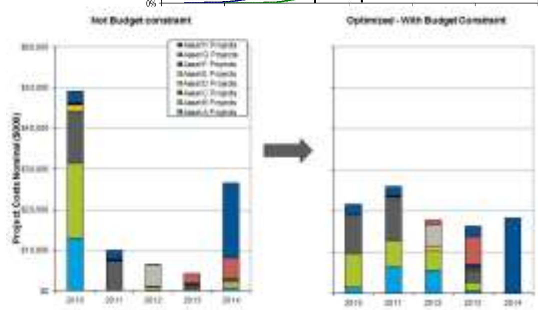
The condition assessment is an important step to ensure that the actual condition of the system components being evaluated is realized in the prioritization process. Black & Veatch engineering experts visited all powerhouse and transmission assets for HHWP for the condition assessment. From the condition assessment, projects are identified to reduce failure risk.

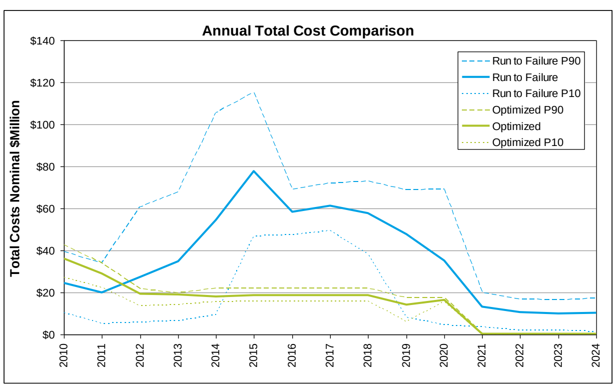
At the completion of the condition assessment and project identification, a review of the necessity, risks and economics for each project is made. The assumptions around each project's economics are captured in an assumptions form. The assumptions form consistently and transparently documents assumptions for each project. The form includes areas to input all qualitative and quantitative assumptions for each project. Qualitative assumptions within the HHWP process include regulatory, safety, and criticality (planning criteria) rankings (1 to 10). Quantitative assumptions include capital costs, O&M costs, growth rates, potential revenues (if any), failure costs (including lost revenue), and failure probability curves. Assumptions were developed using the results of condition assessments and through obtaining feedback from HHWP staff during a series of assumptions form workshops. Additionally, since this is a planning process, distributions for all key assumptions were developed.

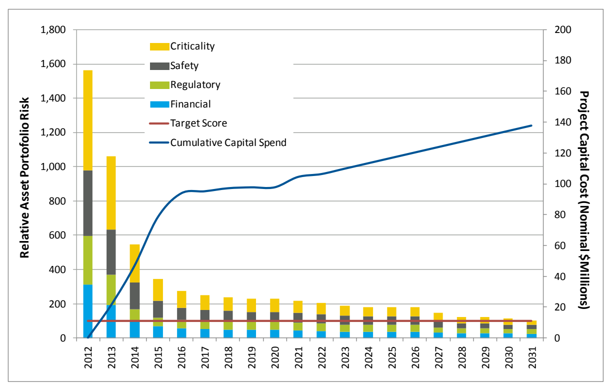
Each project assumptions form automatically populates a financial template. The financial template uses Monte Carlo simulation to calculate the range of net present value (NPV) cost for cases with and without the project. The difference between the two cases is the financial value of executing the project. The adjacent figure graphically show this value. The probabilistic results generated Monte Carlo simulation form the basis for prioritizing the financial efficiency and cost effectiveness of the projects. Additionally, the prioritization includes the qualitative evaluation to rank projects on a balanced scorecard approach.



Following the project ranking an optimized Capital Improvement Plan (CIP) is developed that incorporates utility budget constraint to schedule projects to maximize portfolio NPV benefits. The following charts show the financial forecast and balanced scorecard risk reduction forecast based on the optimized schedule.







The figure to the left above shows significant failure cost risk in a 'Run to Failure' strategy of over $40 million per year above an 'Optimized CIP' strategy for a significant period of time. This equates to triple the capital outlay than with the planned 'Optimized' spend profile. From a qualitative basis, the results show budget spending going to the projects with the highest balanced score risk. Additionally, the condition assessment combined with the financial evaluation identified a few key assets that posed significant risk to HHWP that previously were thought as mid-risky assets. HHWP was able to quickly react and develop a mitigation plan to decrease the likelihood and consequence of failure.

CONCLUSION

There is no easy solution to aging assets and good Asset Management. Each organization must evaluate the culture, commitment and value to develop the best approach. The previous discussion has demonstrated how Asset Management for power varies depending on the utility and its ultimate objective.

This objective, if depicted in terms of focus areas, allows one to better target the utility's primary intent. A newly rolled out asset management system receives significant attention at the beginning, increasing the need to have a firm direction at the onset rather than undergoing iterative adjustments. It's also important to understand and communicate the limitations of the asset management system, as it avoids duplicative work and scope misunderstandings.

An outside viewpoint with multi-client experience is highly beneficial for evaluating these 3 focus areas (i.e. consultant has an advantage). The benefits of Asset Management cross the entire lifecycle of the assets, and getting started on the journey with a path the best meets the needs of each organization will produce results.

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Ms. Forte is a Director in Black & Veatch Management Consulting and leads asset management, operations excellence, economic and financial analysis, risk management, and market analysis studies for energy and water utilities. With over 20 years of experience in the utility industry, her experience has included leading fleet-wide implementation of asset management improvement initiatives, implementation of a de-centralized operations excellence organization, performance and reliability improvement initiatives, risk and economic analysis engagements, and project management for several multi-million dollar capital projects and large utility systems.

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