Outage Analysis and Maintenance Strategies in Hydroelectric Production

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INTRODUCTION

The implementation of major equipment within an existing electrical system necessitates a thorough comprehension of environmental policies, integrated planning, and organizational interaction in the sphere of the endeavor. In a hydroelectric energy system integration methodology, there are various optional processes and detailed analysis encountered throughout the execution. The selection of a turbine generator, for example, requires several layers of evaluation to assess the boundaries of the technology within the existing electrical system. Moreover, the decision-makers must understand the effects of the capital project upgrade as well as maintenance program implementations and utilize system thinking throughout the entire process (LaLiberte, 2013). The principle of the system boundary examines the interaction and issues of importance regardless of the organizational demarcation (Senge, 2006). This boundary principle espouses organizational interaction beyond the limiting constraints and requirements of the venture where one solution creates another problem.

In a learning organization where advance technology is proposed, key personnel must comprehend the invisible fabrics of interrelated activities. The renewable energy implementation requires overall system observations – from planning of the technology to the plant-in-service phase and beyond (Martino, 2013). The comprehensive management mechanism is designed specifically for organizational sustainability (Figge, 2002). The tool involves several layers and domains to include performance measurement, cost management, environmental quality, and strategic management, to provide an integrated approach to model and evaluate important areas.

The overall objective of the maintenance study examined the financial expenditures associated with generation outages. Specifically, these outages were based on the frequency of maintenance within a five-year period. Forced outages as well as the planned outage data were compiled for the evaluation. Ultimately, the focus of the analysis was based on the fundamental aspects of the intentional outages – planned, maintenance, scheduled, and extensions to sustain the integrity of the system. The hydroelectric generator maintenance program, its related costs, and frequency of the maintenance, was the impetus of the evaluation. The key expenditure of the entire process involved the Lost Opportunity Cost created by the forced and planned outages of generating units. It is a singular value utilized to assess the lost generation as it relates to the energy market prices to replace the diminished megawatt-hours (MWh). Moreover, the approach utilized several utility databases to properly assess the value, time-of-day, and operational condition of the hydroelectric generator before it experiences an outage. The evaluation also included a thirty percent reduction in outages for the Larie, Sembola, and Dosi Power Plants in the Mahalia Facility[1] electrical footprint. Consequently, the forecast targets of these decreased outage percentages must equate to lower lost MWhrs and hence reduce maintenance costs.

Most organizations are faced with a plethora of information with little or no structures to properly manage its key elements. The components generally reflect patterns of vulnerabilities (too much variability) within certain business units of an organization. The utilization of system mechanisms is designed to assist personnel with the visualization of patterns to frame strategic change options (i.e. reduce variability, re-modification of measures, re-creating interaction patterns) to obtain ideas from intricate theory (Axelrod, 2000). When a new technology is proposed, the alternatives are thoroughly vetted and evaluated within the organizational structure. The innate ability of systems thinking is the drive for humans to learn (Hall, 2007). The model to administer and lead change in an organization is dif-

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ficult. Nevertheless, a business that is willing to adopt new technologies and work together as a whole can achieve its desired goals. These specific goals must not erode over time where gaps are allowed to creep in between the current situation. Consequently, the goals are lowered (or abandoned) with the two sets of demands, and creates a *shifting the burden* situation. However, by exploiting the gap between the vision and current reality – called *creative tension* – the incisive decision-maker can channel it as a source of energy instead of a *sea of hopelessness*. The only options are to resolve the tension (pull the reality toward the vision) or release it (pull the vision toward the reality). When a tidal wave turbine generator is proposed for implementation, for example, the traditional fossil-fuel culture is forced to strategically think on the renewable energy system level. The control, maintenance, and adaptability of the new technology in the current infrastructure will have a steep learning curve in specific regions of the electrical footprint. Even so, in order to maintain the vision, the creative tension cannot be associated with discouragement, hopelessness, or other negative emotions. Astute decision-makers will escape the emotional tensions to diminish the gap and bring the reality closer to the vision, especially in the maintenance envelope. Experienced decision-makers typically rely on perceptive analogies, the ability to recognize patterns, and parallels to other seemingly disparate situations (Agor, 1984). Systems thinkingSystems thinking integrate reason (linear logic) and intuition with an emphasis on the cause-and-effect paradigm. Decision-makers with enhanced intuition have the ability to determine how obvious solutions to complex systems will produce additional impairment than high-quality resolutions, and temporary modifications generate lasting problems. These same leaders can sense the eroding goals in an organization and provide the necessary reinforcement mechanisms to maintain the standards. Conversely, if the project team is focusing on simply deliberate signs of performance and disguise deeper tribulations, it may further exacerbate the conditions (Chang, 2013). The incorrect indicators will generate alternatives to produce enhanced results within the organization.

The utility planner, for example, is deeply involved in power supply issues and future electric demand inside the region (Billiton, 2000). The utilization of scenario analysis as a practical planning tool is essential for renewable energy implementation within the current infrastructure. The methodology employs extensive use of substitute evaluations as well as generalizations about the characteristics of the electrical footprint. The development of these scenarios, equally applied to maintenance programs, is designed to assist decision-makers with a metal image of the proposed reality based on future assumptions (Wack, 1985). However, most of the identified assumptions are usually utopian by nature. If the decision-makers believe their views are facts instead of sets of postulations, the openness to challenge these views are non-existent. The *leaps of abstract* concept exploit substitution for simplicity in an object for details, which limits learning. These same decision-makers and systems planners are encouraged to incorporate practicing reflection methodologies in the strategy sessions and be conscientious of the leap of abstract concept in the systems thinking paradigm. Well-established mental models will prevent changes derived from systems thinking.

BACKGROUND

The four major maintenance strategies utilized today are Preventive Maintenance (PM), Predictive Maintenance (PdM) – synonymous with Condition-Based Maintenance (CBM), Reactive Maintenance (RM), and Proactive-Centered Maintenance (PCM). Oftentimes, multiple strategies are applied to a single asset. Nevertheless, the strategies elected for an asset must be a function of its criticality, its failure modes, and the related consequences. Most failure modes do have technologies that can detect problems early in the malfunction cycle (Doganaksoy, 2013). The Potential to Actual Failure (P-F) curve is illustrated in Figure 1.

The intent is to manage the assets at the crown of the curve. However, most plants manage the assets in the reactive mode – continually reacting to equipment approaching functional failure without warning. This situation oftentimes results in spare part shortages primarily because of inadequate planning time, increased overtime/callouts, and inferior quality repairs. Consequently, a plant is inhibited from having the time and resources to complete the gamut of maintenance routines and migrate towards a more predictive mode of maintenance. The *Best-in-Class* maintenance and reliability performers typically manage the majority of assets as far up the P-F curve as possible as a direct result of strong planning and scheduling programs. The

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