Keep Your Standards High: Increasing Unit Availability by Establishing a System of Excellence Anchored by Standardization

A Review and Analysis of Documentation-Based Standardization

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Abstract

When major hydro construction projects are planned or when unexpected failures occur, units are taken out of service, resulting in decreased revenue and increased expenses. This unfortunate but unavoidable facet of outage management is often exacerbated by a lack of standardized systems. Standardized systems bring repeatability, ease of understanding, and, ultimately, innovation to any business seeking to improve the cycle time of projects. This is particularly important in today's evolving, modern hydro industry, where public and private utilities and their vendors are under constant pressure to seek ever-greater quality management solutions and unit availability improvements.

By incorporating distinctive quality systems anchored by standardized documentation, such as ISO 9001, utilities can improve availability, increase mean time between failure (MTBF), decrease mean time to repair (MTTR), and improve business longevity and construction project cycle time. Hydro businesses that implement a system of excellence geared toward enhancing availability and reducing both planned and forced outage length will also benefit from improved training methods; quicker troubleshooting practices; faster startups; and more efficient system planning. Furthermore, as the hydro industry's workforce retires, standardized documentation provides a conduit for the knowledge left behind for a newer, greener generation who rely on extensive career development and training opportunities in order to get up to speed.

By evaluating the latest practices and methodologies, this paper will present various tools, software, and strategies for developing and delivering standardized systems to ultimately improve engineering, project management, production, installation, and startup performance. Additionally, this paper will assess the use and benefits of standardized documentation in knowledge retention and training in the changing hydro workforce and propose techniques for improving existing quality management systems.

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Introduction: The "S" Word

Imagine this scenario: an aging plant contacts a vendor to assess and upgrade its existing hydraulic equipment. The vendor requests drawings, graphs, and other specifications for their existing equipment in order to understand how the plant works. However, this plant is over fifty years old and can only supply bits and pieces of documentation that has been saved; the rest is tribal knowledge or has been lost to time and employee turnover – if it ever existed at all. Because of this, the plant now has to spend money and the vendor has to take time to travel to site to evaluate the plant and its functionality in order to design the upgraded equipment. More than that, because the plant is a major energy provider in the area, its blackout dates are set in stone. Now the vendor has to rush to complete the upgrade with limited knowledge of how the plant works, potentially costing more money and time.

Here is another, simpler scenario: a new operator is hired to replace one that is retiring in a few months. The new operator is very green in the hydropower industry but is ready and willing to learn. However, no existing standards or documentation exist for training this new operator. The retiring operator does his best to educate and bring the operator up to speed, but two months is far from enough time to impart all of his knowledge. The new operator is ultimately left alone to manage plant operations.

What do these two scenarios have in common? A lack of standardization.

According to IEEE, the world's largest technical professional organization, standards are "designed to ensure the reliability of the materials, products, methods, and/or services people use every day. Standards address a range of issues, including but not limited to various protocols that help ensure product functionality and compatibility, facilitate interoperability, and support consumer safety and public health"[2]. Standardization, then, is fundamentally all about increasing efficiency by prescribing a set of universal requirements that enable sustained improvements and innovation. More simply, standardization is a way of conducting essential tasks in a way that is repeatable, useful, easy to understand, and measurable. Standardization fosters order and usability.

To add to that, more often than not, a lack of standardization means a lack of documentation. A standard many in the hydro industry – in most industries, really – will have heard of is ISO 9001. ISO 9001 is an international quality management system (QMS) standard established by the International Organization for Standardization (ISO) that has been gaining traction in

[2] Beyond Standards. 2011. "What are Standards? Why are They Important?" Accessed 15 April 2019. https://beyondstandards.ieee.org/general-news/what-are-standards-why-are-they-important/

manufacturing and other industries since the publication of its first iteration in 1987[3]. The standard presents fundamental management and quality assurance practices for any organization in any industry. The standard also places heavy evidence on documentation as a means of process management and, subsequently, adherence to the quality standard. I reference the ISO 9001 standard because standardization is vital in creating and sustaining quality outputs, which this paper (and all hydro businesses, assuredly) is most concerned with. In that knowledge, documentation and standardization go together. In fact, for the purposes of this paper, I may use the terms interchangeably at certain junctures.

In short, standardization is a key business practice. This is not a revelation. So why do so few companies do it? And why is it so important in the hydropower industry? This paper seeks to make an argument for standardization, present case studies, and deliver and evaluate methodologies and strategies for developing and delivering standardized systems to ultimately improve engineering, project management, production, installation, and startup performance. Additionally, this paper will assess the use and benefits of standardized documentation in knowledge retention and training in the changing hydro workforce.

Case Studies

A customer in the southeast United States contracted American Governor Company to conduct a digital governor upgrade following a previous upgrade to their analog equipment almost two decades prior to contracting with American Governor. As with most equipment upgrades conducted by American Governor, the goal of the project was to develop new equipment and governor operational control logic that met or exceeded the current governor and plant control logic, without impacting the performance of the generating units. However, the project immediately hit a snag when it became apparent that the customer did not have documented cam curves which are utilized to program into the governor for unit control. In fact, there was very little documentation on the previous equipment upgrades, which ended up being an issue when American Governor agreed to assess the customer's equipment in order to recreate the curves. At their own expense, the customer shipped their equipment to American Governor. We assigned a co-op engineer to develop software that would read their equipment and pull from them the necessary cam curves, a process that took about a week. At this point, the customer realized that of the three units up for governor conversion, they had sent equipment that was not programmed with the original settings needed for the digital upgrade. This led to a second shipment of equipment and another round of testing before the correct cam curves were finally available.

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[3] International Organization of Standardization. 2019. "The ISO Story." Accessed 30 April 2019. https://www.iso.org/the-iso-story.html

A second customer located in the southeast United States had previously hired a large hydro equipment producer to upgrade their governor controls equipment at one of their plants. However, once the vendor had upgraded the controls, they were unable to make the newly installed programmable logic controllers (PLCs) communicate with the existing HMI system, which was installed in the early nineties. American Governor was then contracted to examine and test the equipment to see if we could connect the new system with the old. The issue was further impaired by a lack of documentation on the software code contained within the new PLCs – the customer was unable to troubleshoot or read their PLC code because the software had been updated by the vendor multiple times without documentation of the updates. In the end, American Governor was able to download and translate the PLC code designed by the vendor, update it to be able to speak to the existing HMIs, and, ultimately, create a standardized and well-documented code throughout the customer plants that the customer is able to read, troubleshoot, and update as necessary.

As before, these two scenarios have a glaring commonality: a lack of standardized processes. These are two real-life examples of the need for standardization in business generally, and in the hydropower industry in particular.

A Case for Standardization: Where Does the Industry Fail?

It cannot be overstated that hydro is a significant source of renewable energy around the world. According to the World Energy Council, "Hydropower is the leading renewable source for electricity generation globally, supplying 71% of all renewable electricity. Reaching 1,064 GW of installed capacity in 2016, it generated 16.4% of the world's electricity from all sources"[4]. The longevity and supportability of hydro plants is therefore paramount; this is where standardization becomes a noteworthy topic of discussion.

Hydro as an industry suffers from disparate issues related to waste and variability. Many plants have technical and institutional issues of concern, such as disorganized and incomplete project files or information, as seen in our second case study above. The lack of information, and any standardized information at that, hindered the accessibility and troubleshooting capacity of not only a contracted expert but the customer itself. Other plants are simply so old that documentation has been misplaced or lost over time, and operators have moved on, taking their tribal knowledge with them, as seen in our first case study above.

Hydro is specifically found wanting as an aging industry in several areas: equipment, people, and quality. Occasional upgrade or rehabilitation of hydro equipment is necessary due to deterioration,

[4] World Energy Council. 2019. "Energy Resources > Hydropower." Accessed 15 April 2019. https://www.worldenergy.org/data/resources/resource/hydropower/

changing technical standards, improved techniques, better understanding of the area's precipitation conditions, and changes in downstream populations or land use, according to a 2019 update of a report from the Association of State Dam Safety Officials (ASDSO)[5]. When new equipment upgrades are called for to ensure the continued reliable operation of a plant, a lack of documentation of how original equipment was configured or built can be a detriment to any project, leading to longer outages and more expensive project cycles.

In the coming decades, as the developing world's population continues to expand and tits subsequent energy demands increase, it is estimated that the hydropower workforce is going to expand commensurately – perhaps as much as 2-3x or more[6]. With the influx of manufacturers, construction workers, plant operators, maintenance workers, and others, comes the inevitable discussion of how to train them, and quickly. The workforce is a revolving door, and as a newer, greener generation arises, the older generation of the hydro industry retires, taking with them knowledge and experience that may not be properly recorded and set down for future generations. Many technology systems found in hydro plants and other utilities, as well as health and safety or other policies, require a certain amount of training, and many employees rely on work instructions, tip sheets, guidelines, and other pieces of documentation as a point of reference. New employees, particularly as they move from different industries into hydro, require training on industry regulations and policies, and a record of these trainings, in addition to the documented training materials themselves, is an important best practice, particularly in light of audits conducted by regulators, vendors, and customers.

Moreover, in today's evolving, modern hydro industry, public and private utilities and their vendors alike are under constant pressure to seek ever-greater quality management solutions. With great power comes great responsibility; because of the importance placed on plants and their output, it is crucial that hydro businesses from all walks of life are able to meet the quality demands of customers. This includes better outage management and unit availability, increased mean time between failure (MTBF), and decreased mean time to repair (MTTR).

What this essentially means is that hydro can benefit from a push for standardization. Without it, the hydropower industry is hard-pressed to continue to meet ever-growing energy demands, especially as technologies evolve and the hydro workforce changes.

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[5] Association of State Dam Safety Officials. Updated 2019. "The Cost of Rehabilitating our Nation's Dams: A Methodology, Estimate, and Proposed Funding Mechanisms." Accessed 1 May 2019. https://damsafety-prod.s3.amazonaws.com/s3fs-public/files/Cost%20of%20Rehab%20Report-2019%20Update.pdf

[6] National Hydropower Association. 2019. "Hydropower is creating jobs." Accessed 1 May 2019. https://www.hydro.org/waterpower/why-hydro/job-creation/

Building a System of Success: What are the Benefits of Standardization?

Standardization has brought order to many other industries. For instance, as one article points out, it has guaranteed interoperability between different equipment and electricity outlets, or machines and other machines[7]. Standardization has ensured that that we all obey traffic lights and rules of the road the same way. Homogenous, time-tested, and consistent standardized systems have been established that govern our lives in a variety of ways.

The benefits of standardization are many. An engineering firm that has standardized design practices has fewer specifications, cleaner drawings, and reduced variability of design practices. Original equipment manufacturers (OEMs) have lower costs, better quality projects, and more effective training. Operational improvements through standardization can increase performance of a hydro plant and raise revenue for operators[8].

How does this happen? Firstly, standardization brings less ambiguity to a process, which in turn improves repeatability and reliability. A standard way of doing something eliminates confusion; a documented standard way of doing something ensures that arbitrary use is not engendered by a lack of knowledge of the system.

If a business has a standard way of responding to issues, response time is increased, leading to greater supportability of customers. Moreover, a standardized system is easy to support and maintain – changes or updates made to one aspect generally flow outward, to anywhere else in the system that the update is applicable.

A standardized system is generally associated with greater quality control, the best way to spot an issue is to notice deviations from the standard best practice. When employees use a standard system

Benefits

- Standardization provides decision-makers with a means for comparing outcomes.
- Standardization enables top management to assess the efficacy of existing processes.
- Through standardization, employees across plants as well as old and new employees alike can relate to one another through the homogeneity of tools and terms used.
- Standardization of technology and devices increases the likelihood of user familiarity across plant locations.
- Standardization invites continual improvement, as employees can provide new ideas on how to address problems based on what has and has not worked.
- Standardization allows employees to more easily learn from one another.

[7] Christoph U. Lehmann & Marlene R. Miller. 2004. "Standardization and the Practice of Medicine." Accessed 20 May 2019. https://www.nature.com/articles/7211060

[8] Adam James. 2013. "Three Ways to Increase Hydropower Efficiency and Revenues." Accessed 20 May 2019. https://www.renewableenergyworld.com/articles/2013/05/three-ways-to-increase-hydropower-efficiency-and-revenues.html

of quality control review, they produce products or services of consistent quality. This in turn leads to increased customer service, as customers learn to associate a business with consistent quality output. Moreover, standardized processes invite continuous improvement of management and design – they are easy to maintain and build upon as time goes on.

Standards further enable the dissemination of knowledge. When processes and procedures are standardized and documented, it is easier to pass the knowledge of that process and procedure along to a new hire or a transfer to a department. Everyone knows how a task should be completed, and it is easier to spot abnormalities. Experiments and improvements can also be better leveraged across standardized practices.

Standardization is also cost-effective and has been shown to reduce manufacturing costs by almost 50%[9]. By standardizing the tools used or the features of products, companies can cut down on time spent on guesswork or hunting down how products for a customer were previously designed.

Equally important, standards enable top management to assess the efficacy of existing processes. ISO heavily emphasizes the measurability of objectives, processes, and procedures, generally in the form of recordkeeping requirements. Evaluation of the performance of a particular process or procedure is made easier when they are standardized and documented, and evaluation criteria allows a plant owner or other business manager to identify training and development opportunities.

Incorporating Distinctive Quality Systems: Operational Improvements and Plant Optimization

As has been shown, having standardized processes and procedures in place for any business's tasks ranging from the mundane to the operational improves the quality of output of that business's project. In the case of hydro, these benefits are immediately shown: a plant that has a standardized procedure in place for reacting to a unit that has suddenly islanded after having been connected to the Bulk Electrical System (BES) ensures that the nearby town that depends on that plant for power is not severely affected if the islanding event is unexpected. An engineering design firm with documented design standards means that fewer manufacturing and quality problems will be found when three different engineers work on a project due to turnover, retirement, or interdepartmental changeover.

[9] Business Automation Specialists of Minnesota. 2019. "Using Standardization to Reduce Manufacturing Costs – Types of Standardization." Accessed 1 May 2019. https://bautomation.com/using-standardization-to-reduce-manufacturing-costs-types-of-standardization/

When major hydro construction projects are planned or when unexpected failures occur, units are taken out of service, resulting in decreased revenue and increased expenses. This unfortunate but unavoidable facet of outage management is often worsened by a lack of standardized systems. As has been stated, a lack of standardized systems leads to a deficiency of response in the event of an unexpected failure. Firms that must spend time "recreating the wheel" in search of information on handling planned projects lose money, time, and customer trust when deliverables cannot be handed over within the contractually agreed-upon timeframe.

Standardized systems bring repeatability and ease of understanding to the hydro industry. When an unexpected outage occurs or a planned project leads to an outage, operators are trained and knowledgeable, and engineers and technicians can utilize well-proven design methods to deliver projects in a timely manner. Moreover, auditors and outside vendors seeking to understand a plant's processes are better equipped to perform their audits if a plant's processes are standardized. Nothing is muddled or inexplicable, and any deficiencies can quickly and accurately be identified and resolved. This in turn enables management to identify innovative ways to do things and continually improve the organization. ISO 9001:2015 prescribes an entire section of its standard to continual improvement, stating that an organization "shall continually improve the suitability, adequacy, and effectiveness of the quality management system" [10].

A design firm that has standardized processes sees speedier completion and management of proposals, contracts, projects, project engineering, procurement, production, and closeout. This in turn leads to a faster response time when customers request work. Similarly, standardization leads to faster response time for original equipment manufacturers (OEMs) that do not have to be concerned with unnecessary procedures or a lack of industry knowledge due to turnover. Employees are more efficient when they can respond in a "by the numbers" way. Requiring standardized systems of documentation or methodology or otherwise increases supportability in the event that engineers leave a company (leading to a loss of expertise) or companies go under. The more detail on how something was done enables more fruitful actions later.

Standardized systems mean that plant technicians, operators, and the like have a quicker, more efficient response time, which in turn means increased MTBF and decreased MTTR. A design firm that has standard designs and components, and their system would place a greater emphasis on reliability during the component selection process. For critical plant locations, MTBF and MTTR become key indicators of performance, directly tied to customer service.

[10] International Standards Organization. (2015). *ISO 9001:2015*.

A further note of interest is the ability of hydro businesses that implement a system of excellence anchored by quality standards to improve their training methods. Training for new and inexperienced operators, technicians, engineers, or other staff is streamlined and faster when a standard way of training and standard training documents exist. Plants that do little or no internal training specifically can benefit from this. Even something as small as having a standard employee manual can help new staff get up to speed on how a plant functions. A 2018 HydroVision paper, "Enabling People: The Methods and Costs of Training Hydropower Professionals," stipulated a systematic approach to training in order to address the issue of workforce planning in the hydro industry – "systemic" being the key word. Standardized training is about "teaching people to perform efficiently and safely in their job role"[11].

Lastly, in an industry where hydro stations pose significant safety risks, a robust standardized safety system is key to preventing workplace injuries and death[12]. Safety within plants and other hydro firms improves when standardized systems are in place, leading to reductions in injuries and stress and a subsequent increase in employee productivity and wellness.

Concerns with Standardization

In spite of its many benefits, many may have concerns with standardizing systems. Standardization means monotony, boredom, and uniformity. But with standardization comes the ability to establish measurable metrics, which in turn can be used by employees and managers alike to evaluate performance and productivity.

Some argue that standardization hinders employee innovation but at its core the standardization of systems is meant to eliminate inefficient and conflictual alternatives to a process or procedure. Engineers do not have to spend needless amounts of time tracking down projects similar to a new one they have been assigned; by knowing how a standard project is completed, they can simply follow the standard. Employees are free to focus on developing innovative ideas in other areas. A third concern with standardization is the cost.

As we will discuss in the next session, the cost of implementing standardized systems can vary, but often there is a high cost in both time and money. However, there is a greater cost in not standardizing, which leads to waste of time and money, loss of customers due to a lack of quality, and so on.

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[11] Cherie Ferrari. 2018. "Enabling People: The Methods and Costs of Training Hydropower Professionals." Paper presented at the annual HydroVision International Conference, Charlotte, North Carolina, June 26-28.

[12] Ambrose Canning. 2015. "Seven ways to make a hydropower station a safer workplace." Accessed 1 May 2019. https://www.hydropower.org/blog/seven-ways-to-make-a-hydropower-station-a-safer-workplace

Methods and Best Practices

There are several methods and best practices for standardizing systems. Indeed, many standards exist which prescribe methodologies and systematic approaches to creating a standardized infrastructure.

ISO 9001:2015 is the first standard that comes to mind, which, according to the ISO website, was founded with the idea of answering a fundamental question: "what's the best way of doing this?" Because ISO is an internationally recognized organization, businesses that obtain this certification have improved credibility and image. The standard invites organizations to adopt a quality management system (QMS) to help "improve its overall performance and provide a sound basis for sustainable development initiatives"[13]. The standard itself lists the many potential benefits to an organization, including consistently provide products and services that meet customer requirements; facilitating opportunities to enhance customer satisfaction; addressing risks and opportunities; and demonstrating conformity to quality requirements, to name a few. Therefore ISO 9001:2015 is a good starting point for standardizing systems.

In addition to committing to the adoption of a quality standard, documentation in generation is a once-and-future best practice for creating standardized work. In large part, standardization as a means of improving availability by ensuring repeatability and understanding hearkens back to a lack of documentation. In fact, in many ways, one cannot have standardization without good documentation. One of the cornerstones of quality management standards such as ISO 9001 is "write what you do and do what you write." Documentation of processes and procedures gives substances to any business's activities, quality management actions, legal matters, historical records, and, most importantly, standardization efforts. Furthermore, written processes help to decrease ambiguity, guarantee quality control of products and operations, and ultimately boost productivity and clarity.

When upgrades occur, a deficiency in standardized documentation (or, as is so often the case, any documentation at all) belabors the process of gathering information to accurately design and engineer needed equipment, particularly when in discussions to upgrade old equipment in the midst of plants changing hands, engineers and operators changing jobs, and tribal knowledge being lost.

Additionally, exploring the applicability of documentation in any workplace, let alone one staunchly set in the hydropower industry, offers a compelling argument for the importance of

[13] Cherie Ferrari. 2018. "Enabling People: The Methods and Costs of Training Hydropower Professionals." Paper presented at the annual HydroVision International Conference, Charlotte, North Carolina, June 26-28.

recordkeeping and quality management. Engineers, software developers, and many in the science, technology, engineering, and mathematics, or STEM, fields are notorious for skimping on design and operational documentation, often electing to eschew it altogether in favor of the next big project; documentation is an impediment to their fast-paced world. This trend leads to projects that span years due to a lack of documentation and therefore incomplete closeout.

Many may balk at the idea of writing, but documentation does not necessarily have to exist in a written format. We live in an age where documentation does not have to be printed. Nowadays, businesses use documenting tools like flowcharting, training videos, phone and tablet applications, gamification, and interactive troubleshooting guides to convey information to end-users. As technology evolves and the "Internet of Things" becomes more sophisticated – by 2020, the international research firm Gartner estimates that there will be 25 billion smart devices transmitting data throughout the world[14] – the way we experience "documentation" is going to change significantly.

Furthermore, as the hydro industry's workforce retires, standardized documentation provides a conduit for the knowledge left behind for a newer, greener generation who rely on extensive career development and training opportunities, as well as multi-functional means of obtaining that information, in order to get up to speed.

Another best practice for creating standardized hydro systems is to explore and potentially invest in enterprise resource planning (ERP) systems and other ancillary technologies. ERP systems are used to make the use of standardized systems easier for end-users on a day-to-day basis. These systems communicate with one another and support process adherence by saving time and defining business processes in an easy-to-understand format. By collecting an organization's shared transactional data from multiple sources (accounting, procurement, project management, risk management and compliance, etc.), ERP systems eliminate data duplication and provide data integrity[15]. For example, a company that manufactures governors would have an ERP system that tracks the requisition of parts and supplies, ensuring that each component across the procurement process uses uniform and clean data connected to integrated enterprise workflows, business processes, and reporting with analytics[16]. Some examples of tried-and-tested ERP systems include NetSuite and IQMS. SharePoint is a good alternative system which has been proven successful in document management and as means of disseminating information as a company internet platform.

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[14] Alec Scott. 2019. "8 ways the Internet of things will change the way we live and work." Accessed 1 May 2019. https://www.theglobeandmail.com/report-on-business/rob-magazine/the-future-is-smart/article24586994/

[15] Mindstream Analytics. "What is Enterprise Resource Planning?" Accessed 1 May 2019. https://www.mindstreamanalytics.com/articles/what-is-enterprise-resource-planning.html

[16] Oracle. "What is ERP?" Accessed 1 May 2019. https://www.oracle.com/applications/erp/what-is-erp.html

Conclusion

In order to optimize operational processes within hydo plants, which in turn improves unit availability, increases MTBR, decreases MTTR, and ultimately improves construction project cycle time and customer service, it is compelling for hydro managers to consider incorporating distinctive quality systems anchored by standardized documentation and ERP software. Hydro businesses that implement a system of standardized excellence, far removed from simply ensuring the conformity of processes, can enhance unit reliability and reduce planned and forced outage length as well as improve training methods.

Author Biography

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