Performance Assessment Manual

Appendix 2.01 - Discussion of Best Practices for Unit and Plant Performance Processes

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Prepared by
HYDRO PERFORMANCE PROCESSES, INC.
Doylestown, PA 18901

and

OAK RIDGE NATIONAL LABORATORY
Oak Ridge, Tennessee 37831-6283
managed by
UT-BATTELLE, LLC
for the
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DISCUSSION OF BEST PRACTICES FOR UNIT AND PLANT PERFORMANCE PROCESSES

Data, Utilization, and Integration - For single unit and multi-unit efficiency characteristics to provide maximum benefit, the data-driven performance information, such as the unit and plant characteristics summarized previously in Figures 2 and 3, must be effectively incorporated into the load planning, dispatching, and other processes to optimize generation for the plant or power system.

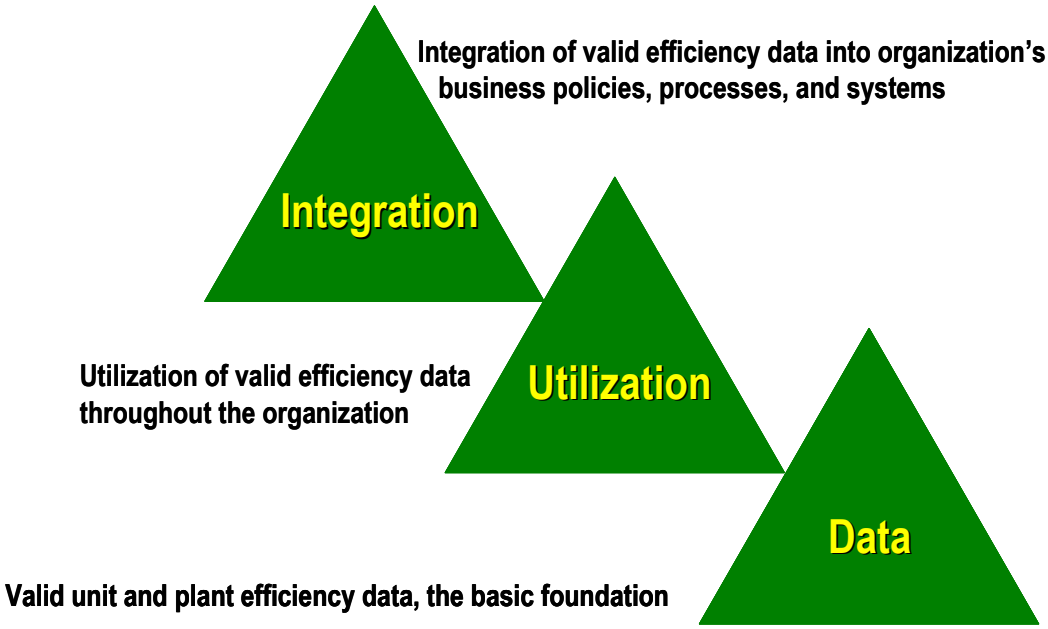

Figure 2.01-1: Conceptual Diagram of Best Practices for Unit and Plant Performance Processes

Figure 2.01-1 is presented as a useful way to consider efficiency-related processes in the context of the Best Practices for Unit and Plant Performance Processes, which is described in this appendix and provided in detail in Appendix 2.02. Figure 2.01-1 shows that valid unit and plant performance data form the basic foundation for effective performance processes, but the performance data must be widely available in useful form, such as unit and plant efficiency characteristics. The efficiency data must be incorporated into operator-based or automation-based optimization systems at the unit, plant, and system levels and at a variety of time scales

ranging from real-time to a year or longer and utilized appropriately throughout the organization. And, for effective performance processes, all of the relevant performance-related data, information, and analyses must be fully integrated into the organization's business policies, processes, and systems.

These three process components, data, utilization, and integration, are discussed in more detail in the following sections.

Valid Unit Efficiency Data, the Basic Foundation - The hydroturbine and generator together constitute a hydro unit. Unit efficiency characteristics consistent with current international and/or national standards should be available for each generating unit over the entire range of operating heads. Efficiency-related data consistent with relevant international and/or national standards [ASME, 2011], including power, headwater elevation, tailwater elevation, flow rate, water temperature, gate opening, trash rack differential, and blade angle (where appropriate) should be continually measured and readily available for each generating unit.

In addition, adequate personnel, budgets, systems, processes, and procedures should be in place for the following activities:

- Properly manage and maintain efficiency-related instrumentation, including obsolescence management for hardware and software and succession planning for personnel;
- Periodically compare expected performance characteristics for each unit with measured performance characteristics;
- Periodically evaluate and train relevant personnel; and
- Take timely and appropriate action when necessary.

Organizational Utilization of Appropriate Performance Results - Unit efficiency characteristics and past efficiency test results should be readily available to appropriate personnel (e.g., operations, maintenance, engineering, power management, water management, environmental management) and systems (e.g., monitoring system, automation system, optimization system, maintenance management system, environmental management system) within the organization. The efficiency information should be used in the long-term, medium-term, short-term, and real-time optimization of unit/plant and system operations for relevant operational modes (e.g., specific power, specific flow, most efficient power, most efficient power within a range, conventional AGC, optimization-based AGC).

Real-time and archival efficiency-related data, as well as supplementary efficiency-related information (e.g., unit operational data; electrical, mechanical, and hydraulic operational limits; power/energy and ancillary services rates versus time; operational scheduling information such as unit status and schedule request;) should be securely stored, appropriately backed-up, and readily available to appropriate personnel and systems within the organization. Systems, processes, and procedures should be in place to periodically compare expected efficiency data for each unit with real-time and archival efficiency-related data and supplementary efficiency-related information to ensure that improvements and corrections to unit characteristics are incorporated in a timely fashion into all appropriate optimization systems and related procedures, such as operator guidelines.

Adequate personnel, budgets, systems, processes, and procedures should be in place to properly manage and maintain performance-related communications infrastructure, archival software with appropriate data compression settings, operator-based and/or automation-based optimization infrastructure and software, including training, obsolescence management for hardware and software, and succession planning for relevant personnel.

Integration of Efficiency Results with Business Policies, Processes, and Systems - Unit performance characteristics should be used in the evaluation and quantification of economic losses associated with optimization systems, instrumentation, avoidable losses, unit/plant scheduling, environmental operations, and operational impacts on maintenance (e.g., AGC operation, exceeding cavitation limits, rough zone operation). Systems, processes, and procedures should be in place to compute quantitative performance metrics which ensure that relevant economic results are available for establishing maintenance priorities, developing capital equipment priorities, and evaluating operational policies, such as:

- Timely comparison of actual operations to optimized operations under the same conditions;
- Timely comparison of expected (i.e., historical) performance data for each unit with real-time and/or archival performance-related data to ensure that improvements and corrections to performance characteristics and instrumentation are incorporated in a timely fashion;
- Timely evaluation of avoidable energy losses (e.g., trash rack fouling, penstock/tunnel fouling, penstock/tunnel degradation); and
- Timely evaluation of unit/plant scheduling.

Adequate personnel, budgets, systems, processes, and procedures should also be in place to properly manage and maintain the infrastructure and software for integrating performance-related data and related information into the organization's business policies, processes, and systems; to periodically evaluate and train relevant personnel; and to take timely and appropriate action when necessary.

Best Practices Protocol for Unit and Plant Performance Processes - The Best Practices Protocol for Unit and Plant Performance Processes addresses three aspects related to the operational performance of hydropower units and plants, namely data, utilization, and integration. The protocol and the three appraisal aspects are inspired by, and, in part, derived from, the International Hydropower Association's *Sustainability Guidelines* [IHA, 2004] and *Sustainability Assessment Protocol* [IHA, 2006]. The protocol was developed from decades of experience with the Tennessee Valley Authority's integrated, multi-purpose power and water system and experience with additional hydropower systems in the United States, Canada, New Zealand, and Brazil. The protocol was initially presented in draft form at the World Renewable Energy Conference in 2004 [March, 2004]. The current protocol is derived from a similar protocol presented at Waterpower XIII in 2005, published in the conference proceedings [March et al., 2005], and submitted as an "Annex on Best Practice for Hydropower Performance" to the International Energy Agency.

The protocol is useful for assessing the overall operational performance of hydropower units, plants, and systems; comparing the relative performance of units and plants within a system; and providing guidance for allocating capital and maintenance resources and for prioritizing upgrades and improvements. Implementation of comprehensive unit and plant performance processes is important for the successful implementation of more efficient turbines and generators, improved automation and control systems, and advanced optimization systems. Improved performance can provide increased generation, increased revenue, additional water supply, and reduced maintenance costs.

Scoring for the Best Practices Protocol for Unit and Plant Performance Processes is based on the following system:

- 5 for each aspect where the hydro plant meets all of the relevant criteria;
- 3 where most of the criteria are met;
- 1 where only some of the criteria are met;
- 0 where none of the criteria is met.

In the protocol, Aspect P1 relates to unit efficiency data; Aspect P2 relates to organizational utilization of efficiency data for multiple purposes, including optimization; and Aspect P3 relates to integration of efficiency data and related information with business policies, processes, and systems.

Appendix 2.02 provides the complete protocol, including specific guidance on scoring for each aspect.

For overall questions
please contact:

Brennan T. Smith, Ph.D., P.E.
Water Power Program Manager
Oak Ridge National Laboratory
865-241-5160
smithbt@ornl.gov

or

Qin Fen (Katherine) Zhang, Ph. D., P.E.
Hydropower Engineer
Oak Ridge National Laboratory
865-576-2921
zhangq1@ornl.gov