DE-EE0008941– HYDROPOWER FLEXIBILITY FRAMEWORK

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*Photo is meant to be as an example and does not represent the ultimate public interface

Project Overview

Project Summary

- This project intends develop an industry-recognized methodology and framework for calculating the flexibility that hydropower assets can provide, demonstrate the validity of the approaches and the viability of comprehensive application across the fleet, and establish a platform for future flexibility assessments. This quantification relies on, a systematic and detailed understanding of hydropower plants' capabilities and constraints, a directory of flexible services needed by the power system, and a model that capable of co-optimize a solution while account for these factors.

Intended Outcomes

- This project intends to develop a model that quantifies hydropower flexibility by considering asset characteristics, water schedules, and market signals to support hydropower owners/operators with decision making. The intended outcome is a public facing tool that provides hydropower flexibility assessments.

Project Information

Principal Investigator(s)

- Francisco Kuljevan, EPRI
- Robert Entriken, EPRI

Project Partners/Subs

- Patrick March, Consultant
- Dr. Paul Wolff, Consultant

Project Status

New

Project Duration

- 02/01/2020
- 02/28/2023

Total Costed (FY19–FY21)

$434,211.91

Project Objectives: Relevance

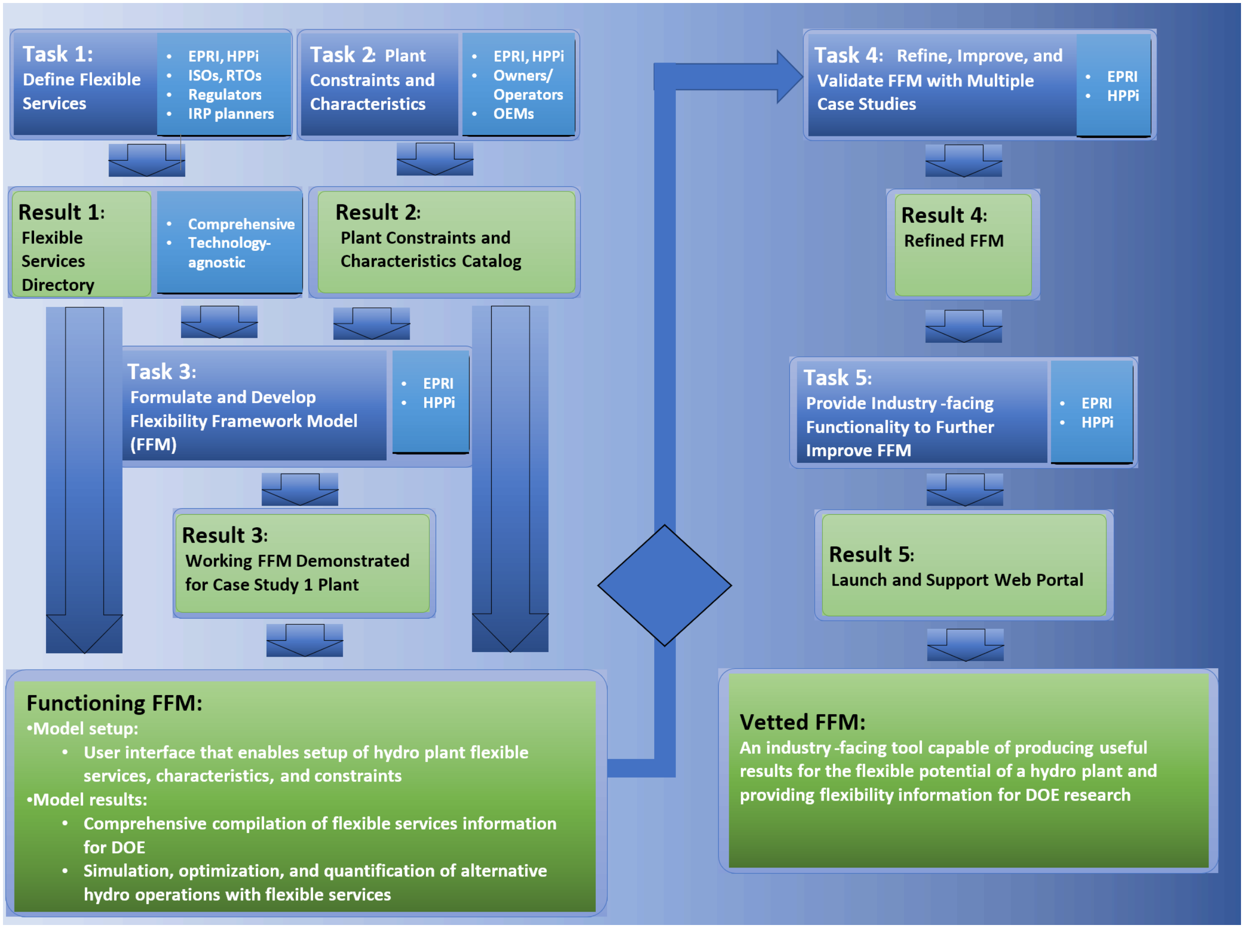
Relevance to Program Goals:

- The Hydropower Flexibility Framework project contributes WPTO's mission by conducting research to better understand and capitalize upon opportunities for hydroelectric power plants by integrating water schedules, energy generation, and ancillary services (regulation and spinning reserve), unit characteristics, reservoir characteristics, and minimum flow requirements to support hydropower owners and operators in making informed asset-level decisions.

Project Objectives: Approach

Approach:

- The Hydropower Flexibility Framework project's methodology recognizes the importance of integrating a series of hydropower innate characteristics including water, asset, and system operator indicators to optimize energy, regulation, and spinning reserve schedules



Project Objectives: Expected Outputs and Intended Outcomes

Outputs:

- A public User Interface (UI) that includes the Flexibility Framework Model to support its use by the hydropower industry. The UI intends to allow users to input hydropower plant parameters and constraints, plant operational data, and corresponding market data and then produce analyses and measures of flexibility potential for their plant.

Outcomes:

The project intends to provide an organizing framework to evaluate the effects of hydroelectric power plants capabilities and constraints on the various types of flexible operations and services that could potentially be supplied, along with the generation of clean energy, and to enable more appropriate decision making for investments in plant equipment.

Project Timeline

FY 2019

Not Applicable

FY 2020

Develop Model for Analysis of Potential Flexibility

Flexibility Literature Review

Industry and Stakeholder Engagement

Develop Plant Capabilities Taxonomy

Develop Constraints Catalog

FY 2021

Ensure Compatibility of Flexible Services Directory, Plant Capabilities and Constraints Catalog, and Flexibility Framework Model

Test Flexibility Framework Model with Initial Case Study

User Interface Development

Data Warehousing Process

Model Adaptation to modern coding standards

Project Budget

Total Project Budget – Award Information		
DOE	Cost-share	Total
$1,417,162.00	$354,301.00	$1,771,463.00

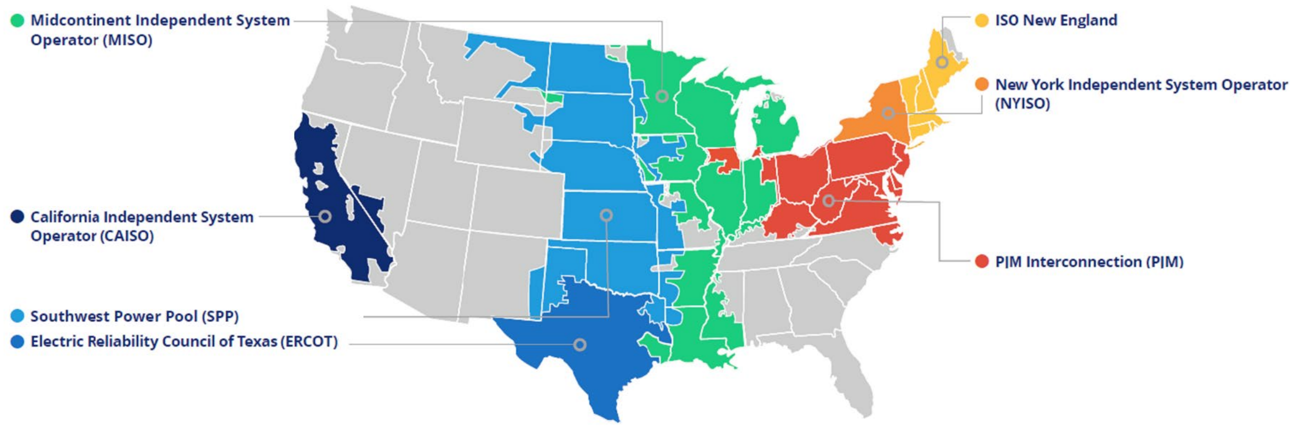
FY19	FY20	FY21	Total Actual Costs FY19–FY21
Costed	Costed	Costed	Total Costed
$Not Applicable	$55,210.01	$379,001.9	$434,211.91

End-User Engagement and Dissemination

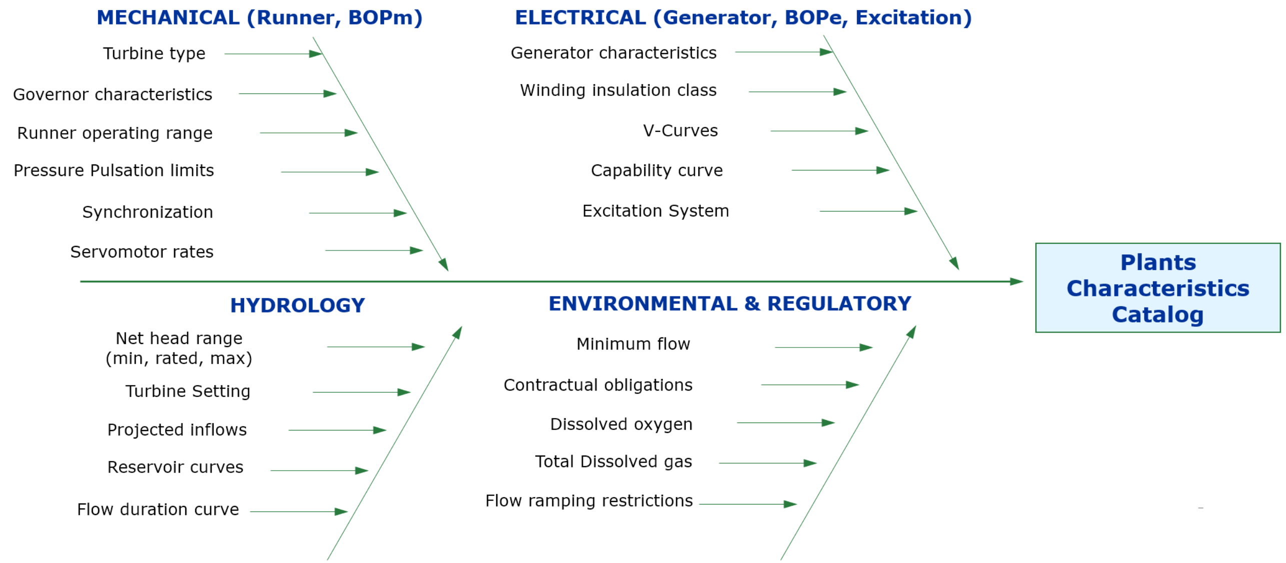
- The intent of the Hydropower Flexibility Framework project is to be used by hydropower industry stakeholders to perform flexibility analysis whether it is from a technology, operations, or planning perspective
- The project's team has developed a skilled and diverse technical advisory group comprised of independent system operators, utilities, research organizations, and technology developers who are actively guiding the technical approach to quantify hydropower's flexibility
- The rationale behind the technical advisory group was to address the different hydropower stakeholders that may have a need in the development of the public facing tool
- Project team has been engaged with personnel at Ameren's Osage hydroelectric power plant and performed several analysis as a test case

Performance: Accomplishments and Progress

- Defined and developed a technology agnostic Flexible Services Directory (FSD) that provides a robust definition of flexibility to provide grid reliability
- Development of a draft hydropower plant characterization matrix to facilitate the classification of plant capabilities and constraints

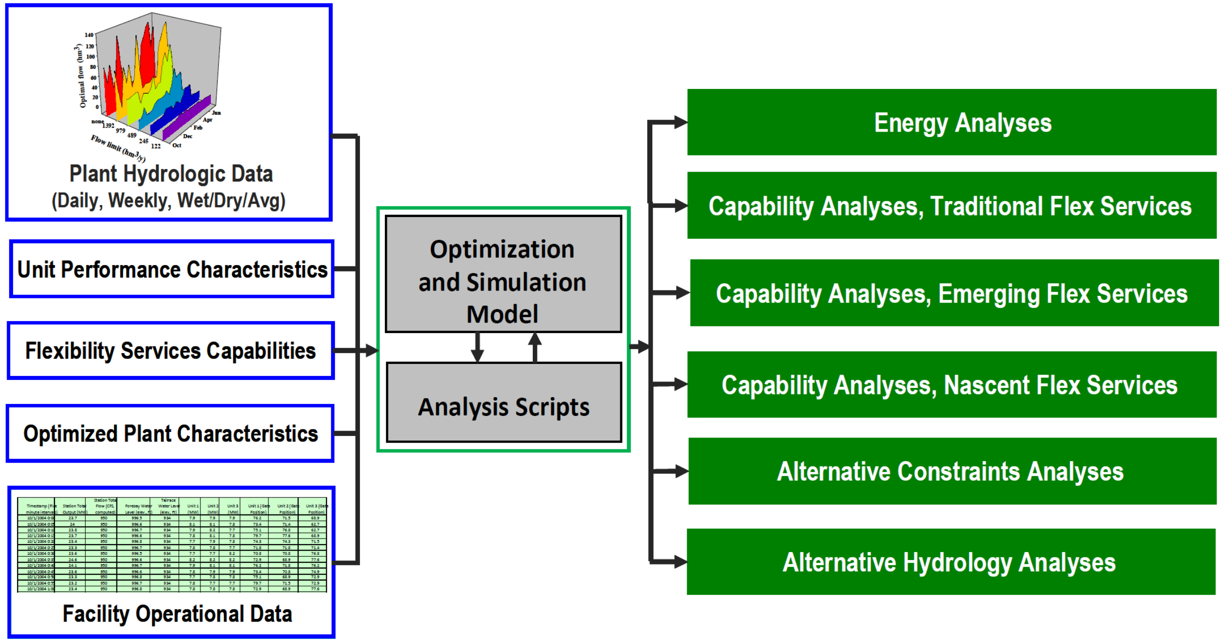


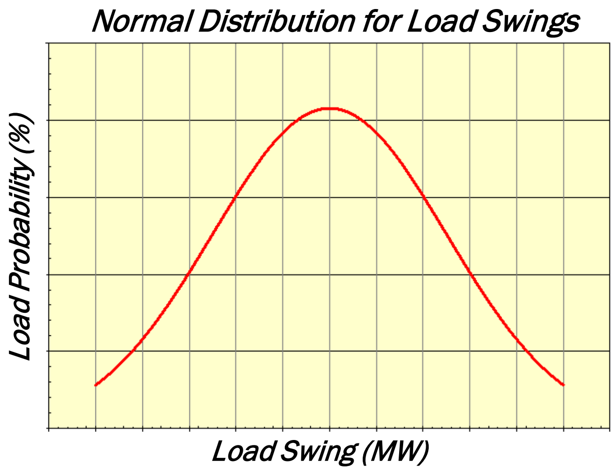
Source: Navigant, 2018

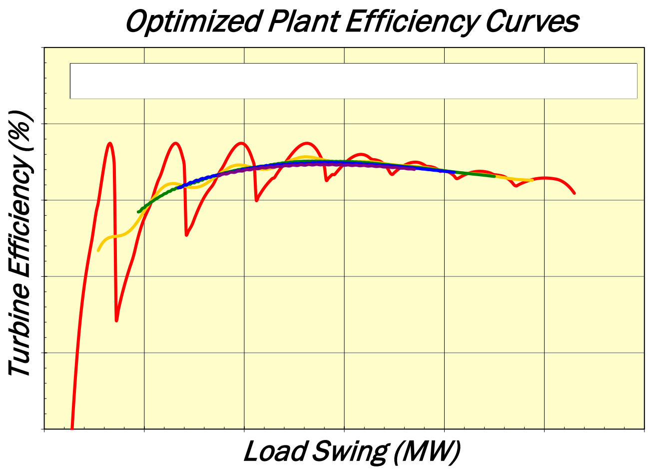


Performance: Accomplishments and Progress

- Development of a model that includes a calculation engine that co-optimizes energy, regulation, and spinning reserves. Currently model supports two modes:
  - Mode 1: Actual day ahead vs. co-optimized schedule
  - Mode 2: Energy, regulation and spinning reserves supply curves
- Development of model components, such as plant model, an associated reservoir curve, and the minimum flow or environmental flow characteristics.







Performance: Accomplishments and Progress – Test Case 1

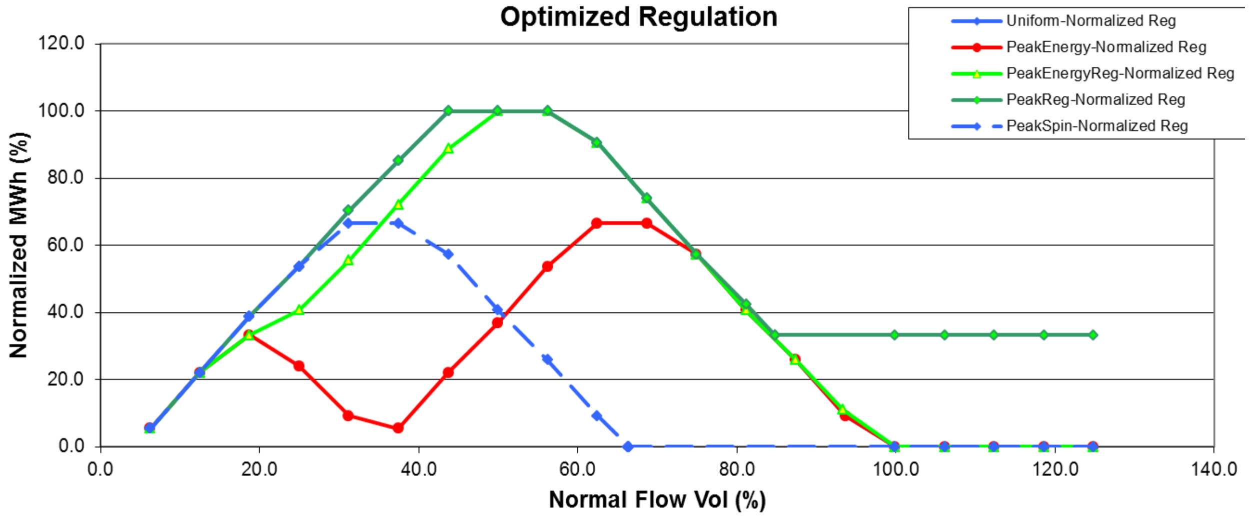
- Evaluated day ahead energy and ancillary service schedules by comparing the day ahead schedule (actual) created by the ISO to the co-optimized schedule computed by the model. Key results for test case 1 (8-unit 240MW plant, with three different designs) include:

  – The actual and optimized schedules were consistent. The schedules produced similar results for a high flow winter month. The optimized schedule produced 5.5% improvement for a low flow summer month.

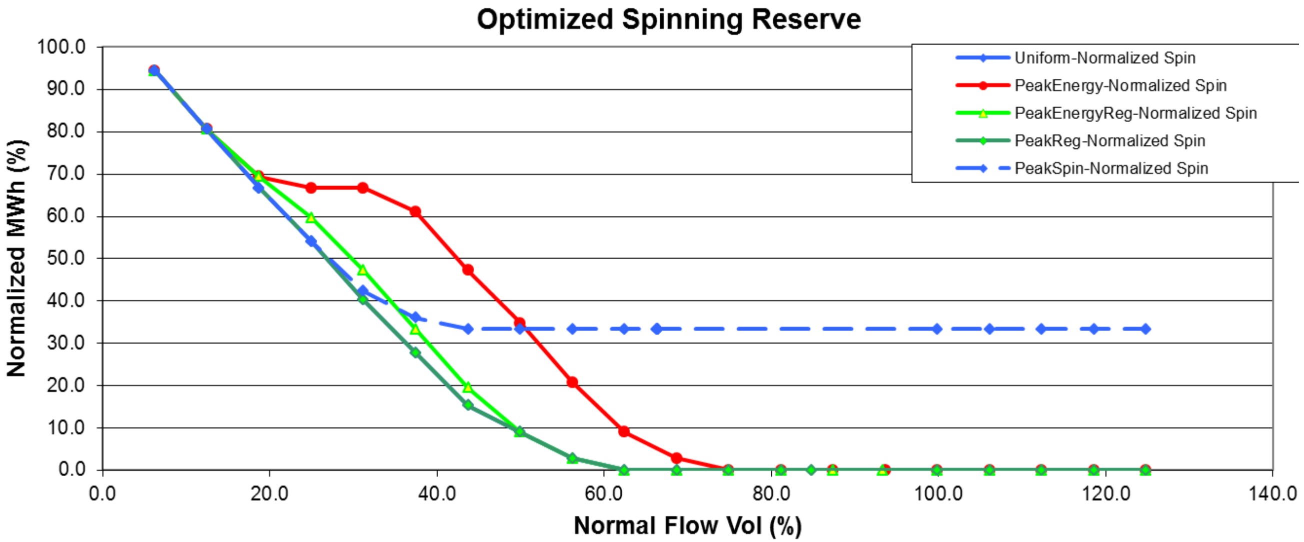
  – Forecast analyses were performed for various time spans into the future and were most beneficial during low flow time periods. These analyses distributed the water more uniformly over the multiple day interval which enabled the plant to generate in future time periods when hourly demand was higher

Performance: Accomplishments and Progress – Test Case 1

- For a series of price profiles, the quantity of regulation peaks when the plant outflow is approximately 50% of the maximum flow for a plant



- The quantity of spinning reserve available is highest at low plant flows and goes to zero as the plant outflow increases



Future Work

- Select and document of primary Use Case and Functional Requirements. Plant perspective of real-time availability, hourly available flexibility (given day-ahead schedule), planning upgrades (given production cost model price streams).

- Develop and Test primary Use Case based on Functional Requirements and user feedback.

- Repeat development and testing for additional Use Cases as feasible.

- Continue to request user’s feedback on prototype software.

Future Work

- Work with advisory committee and test case volunteers to continue exploring ways how products from this project will be used
- Continue graphical user interface development and ensure it is aligned with user requirements
- Continue validation of the Flexibility Framework Model (FFM)
  – Additional test cases will help clarify user requirements and provide scenarios to test the software and to modify as needed
  – Continue FFM conversion to a dynamic link library for use in a web-based application
- Present project results in upcoming Hydropower industry conferences.

Q&A