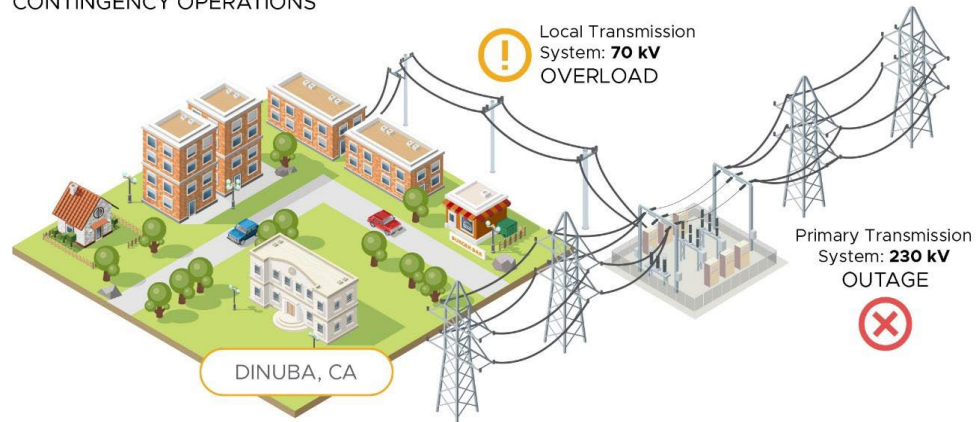
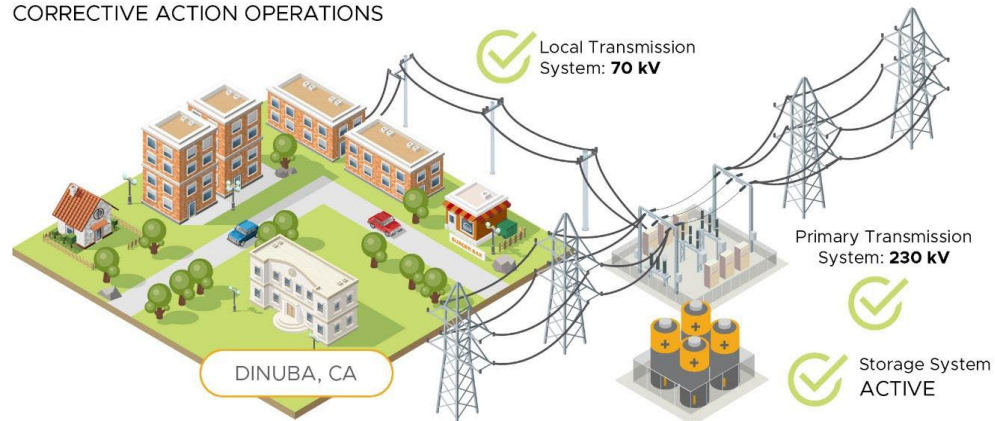


1.2.3.602: Pumped Storage Hydro as a Transmission Asset

CONTINGENCY OPERATIONS



CORRECTIVE ACTION OPERATIONS



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7/28/2002

Project Overview

Project Summary

- FERC issued a policy statement in 2017 that would allow PSH and other energy storage assets to provide both regulated transmission and competitive market functions, but regional market operators have struggled to implement enabling regulations. This project seeks to objectively inform regulatory proceedings on dual-use energy storage by developing a participation framework for dual-use storage assets and quantifying their potential value to the grid.

Intended Outcomes

- The intended outcome of this project is to identify the regulatory and operational challenges that impede the usage of storage for regulated transmission and competitive market function, potential solutions to those challenges, and the value of dual-use storage assets on the grid. We will achieve those outcomes through open source models and publications:
 - Transmission/Storage Equivalence Model (open source models, journal publication)
 - Participation Framework (open source models, technical report)
 - Dual-use PSH Valuation (technical report)

Project Information

Principal Investigator(s)

- Jeremy Twitchell, PNNL
- Zhi Zhou, ANL

Project Partners/Subs

- N/A

Project Status

Ongoing

Project Duration

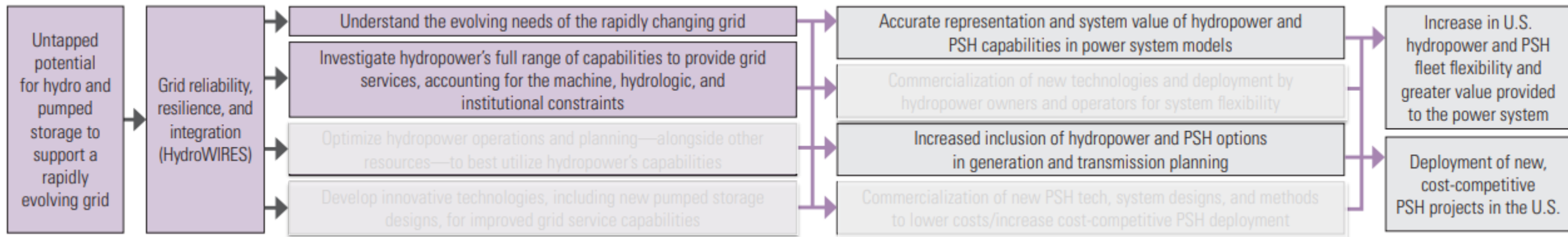
- 10/1/2019
- 9/30/2022

Total Costed (FY19–FY21)

\$600,000

Project Objectives: Relevance

Relevance to Hydropower Program Goals



Enabling dual-use PSH will result in:

- Recognition of additional services that PSH can provide to the grid
- Improved representation of PSH in models used for transmission planning and market dispatch
- Increased grid flexibility at reduced cost
- Construction of new PSH projects

Project Objectives: Approach

Key points:

- **Approach the question of dual-use storage through the lens of PSH**
 - PSH has the size necessary to support high-voltage transmission applications
 - FERC's policy statement motivated in part by a proposed dual-use PSH project
- **Identify a flexible participation framework that prioritizes reliability**
 - ISO practices vary by region; a one-size-fits-all approach is not practical
 - Market participation must not interfere with the asset's ability to meet its reliability obligations
- **Provide an example of technical pathway for implementation**
 - Identify an optimal storage-based solution (capacity, duration, and location) to address a transmission upgrade need
 - Design a market participation framework with its transmission service obligation as constraints.
 - Techno-economic analysis based on the implemented dual-use framework

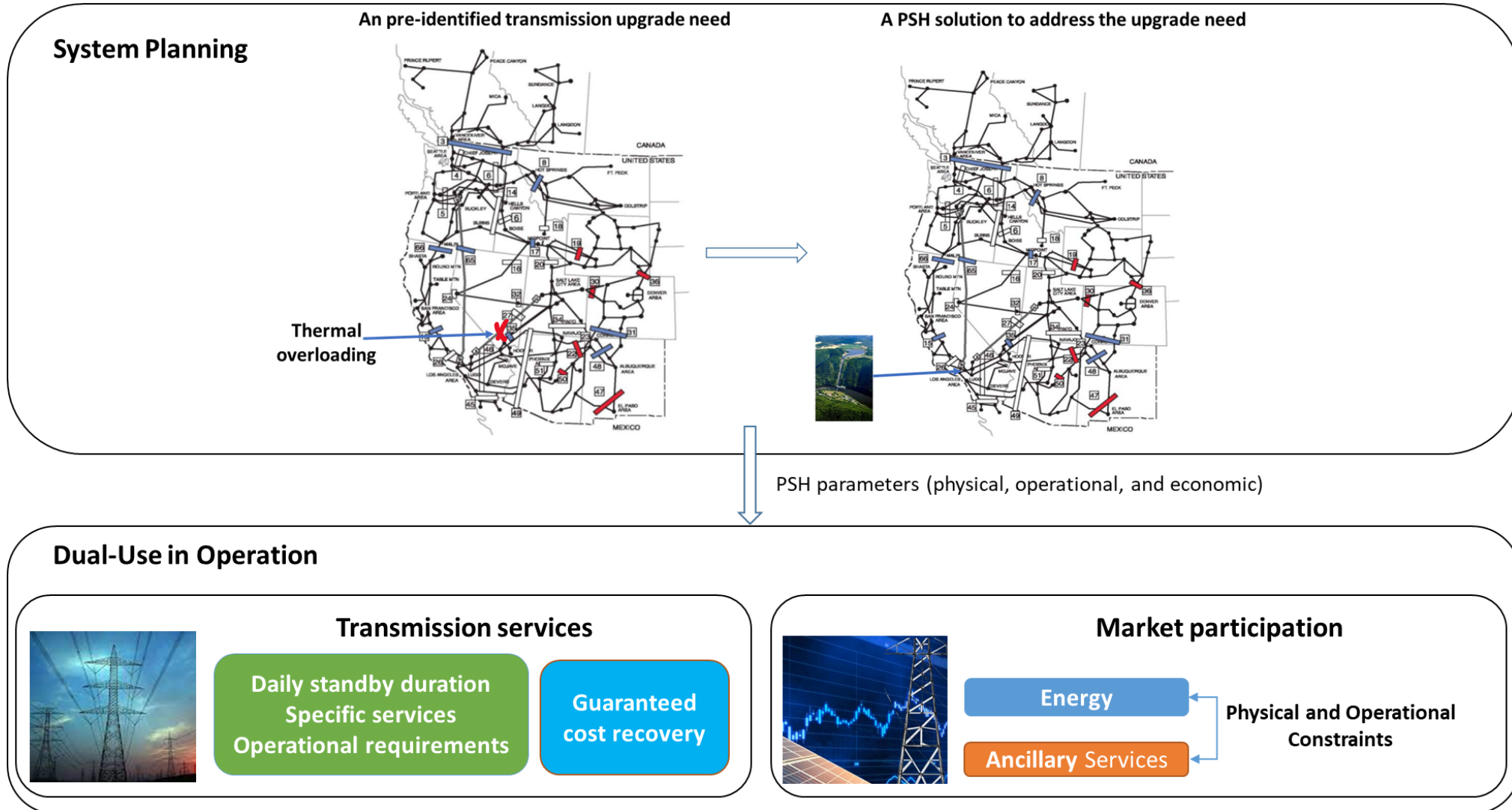
Project Objectives: Approach

A Participation Framework for Dual-Use Energy Storage Requires Adaptation in Transmission Planning and Market Operations:

- **Transmission Planning**
 - Establish transparent processes for how and when storage alternatives will be considered
 - Prepare a reasonable forecast of market revenues and account for it in cost assumptions
- **Market Operations**
 - Determine **when** a dual-use asset be able to participate in the market, subject to reliability obligations, in advance to allow for participation in day-ahead markets
 - Define **how** a dual-use asset will participate in the market through resource definitions and market products, ensuring flexible, no-fault dispatch as needed by the grid
 - Establish **where** a dual-use asset will recover its costs, maintaining a price signal for market participation while balancing competing priorities

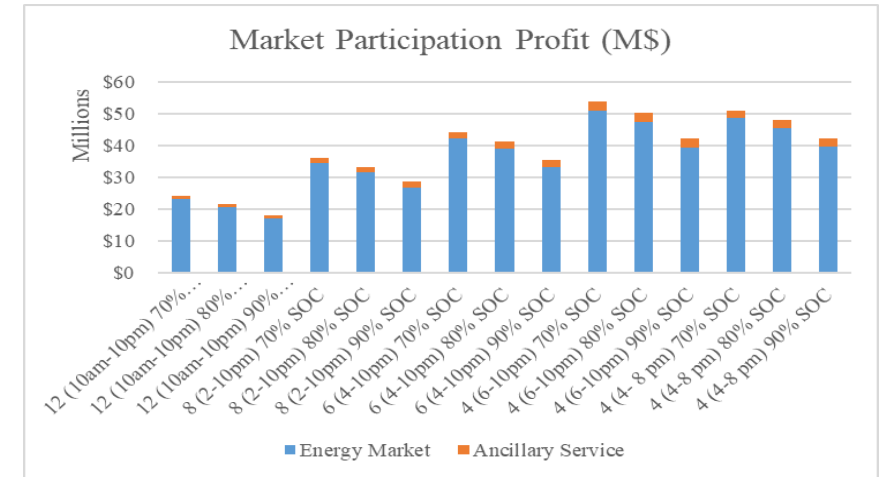
Project Objectives: Approach

- Workflow of PSH Participations to Transmission Planning and Dual-Use in Operation

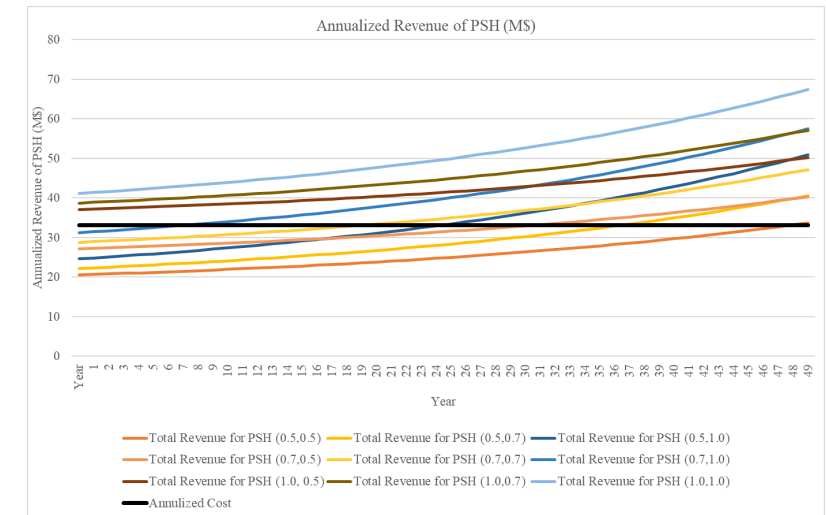


Project Objectives: Approach

- **Energy Storage for Transmission Planning (ES4TP)**
 - Determine an optimal PSH solution that addresses a known transmission upgrade need
 - Considering location, capacity, duration of a PSH solution.
- **Pumped Storage Hydropower Market Analysis Tool (PMAT)**
 - Optimization model that improves the market participation strategy for a PSH plant to maximize its potential revenue by providing various grid services
 - Considering restriction (e.g. market participation period, state-of-charge requirement) from transmission service requirements
- **Economic Analysis Module**
 - Cost benefit analysis
 - Considering investment cost, cost recovery from ratepayer, and market revenue payback mechanism



Breakdown of revenue from energy market and ancillary service participation for various TSPs and SOC requirements: Groups of cases with shorter TSP (e.g. 4-hour (6-10pm) and 4-hour (4-8)) have higher profits. Within each group, cases with higher SOC (e.g. 90%) have less profits.



Annualized revenue of PSH under various cost recovery mechanisms for 8-hour TSP and 80% minimum SOC requirement scenario

Project Objectives: Expected Outputs and Intended Outcomes

Outputs:

- Storage/Transmission Equivalence Model (software and journal article)
- Participation Framework for Dual-Use Energy Storage (software and technical report)
- Dual-Use PSH Asset Valuation (technical report)
- Engagement: Industrial stakeholders, including PSH developers (e.g. LEAPS), RTOs, state regulators, and industrial consortiums.
- Presentations at relevant conferences and webinars, e.g. Energy Storage Grand Challenge Community of Practice Webinar.

Outcomes:

- The expected outcome of this project is to inform future proceedings on dual-use energy storage by helping regulators, grid operators, and stakeholders understand the barriers to dual-use storage, options for overcoming those barriers, and the values that can be achieved by enabling dual-use storage.

Project Timeline

FY 2020

Develop storage/transmission equivalence model

Summarize regional transmission planning processes

FY 2021

Develop dual-use participation model

Final Report: Dual-Use Participation Framework

Final Report: Dual-Use PSH Asset Valuation

Project Budget

| FY19 | FY20 | FY21 | Total Actual Costs FY19–FY21 |
|--------|--------|--------|---------------------------------|
| Costed | Costed | Costed | Total Costed |
| \$0K | \$350K | \$250K | \$520K |

Unused funds of about \$80k were leveraged for additional, follow-on work that will be discussed later.

End-User Engagement and Dissemination

- Audience

- Grid operators (ISO/RTO), regulators (state and federal), developers, other stakeholders

- Engagement

- Modeling advisory group consisting of developers (e.g. LEAPS), industry organizations (e.g. EPRI), and ISO staff (e.g. MISO)
- Informal discussion and engagement with industry (National Hydropower Association, Energy Storage Association, transmission developers, energy storage developers)
- Stakeholders were briefed on the project's objectives and the team's thinking, and asked for their feedback and suggestions

- Dissemination

- This project has been presented in workshops for state regulators in approximately 12 states in partnership with the Office of Electricity Energy Storage Program and at eight industry conferences
- Three publications; relevant publications have been directly shared with participants in MISO's re-initiated proceeding on dual-use storage

Performance: Accomplishments and Progress

- Energy Storage For Transmission Planning (ES4TP) Framework
 - Developed a modeling tool that optimally sizes energy storage alternatives to an identified transmission need
 - Model and framework documented in a forthcoming publication
- Dual-Use Participation Framework
 - Identified the key issues that a dual-use participation model must resolve and flexible approaches to resolving them
 - Documented in a [technical report](#)

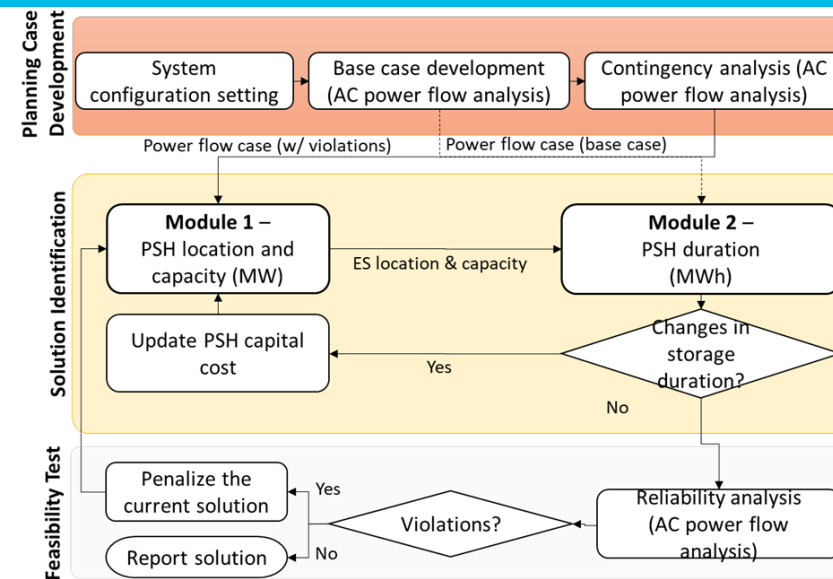
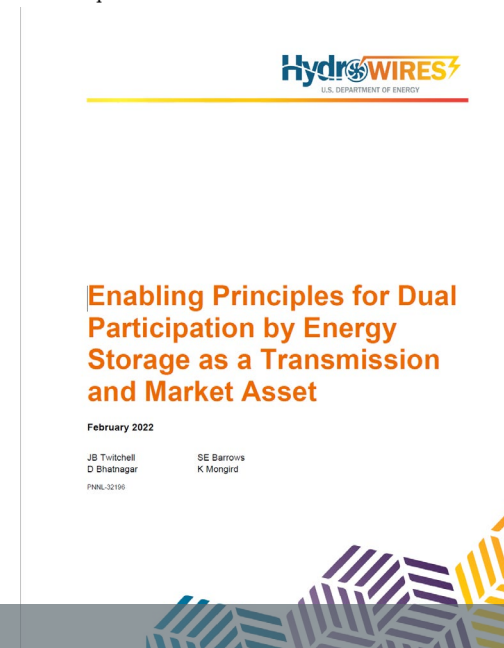


Figure: ES4TP three-process workflow for PSH solution identification and validation



Performance: Accomplishments and Progress – Cont.

- Dual-Use Computational Framework
 - Developed a participation model for PSH projects that strategically provide market services (energy/ancillary services) in addition to transmission services.
 - Applies the dual-use participation framework to quantify the market benefits of a theoretical PSH asset using the IEEE WECC 240-bus system
 - Documented in a technical report

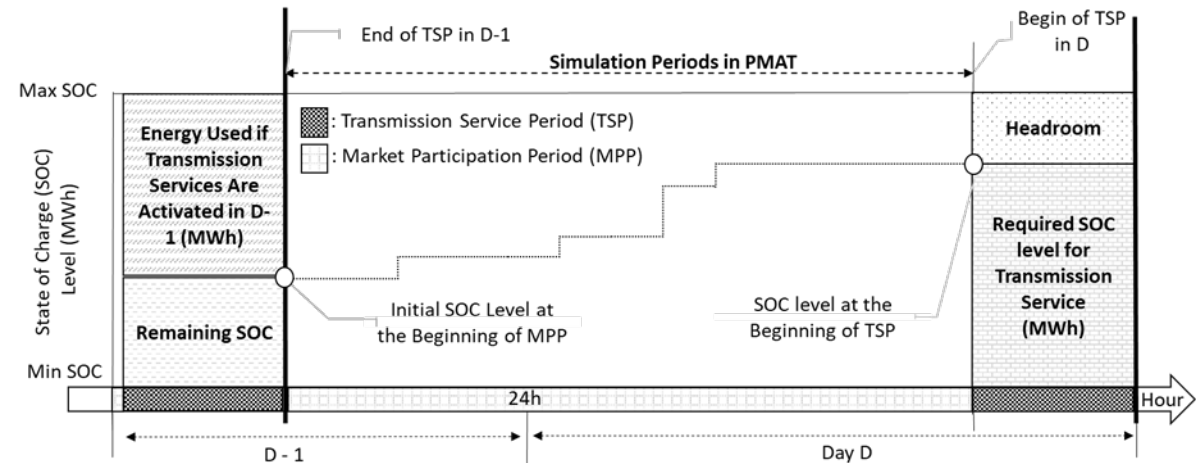


Figure: Timeline of a dual-use PSH project engaged in transmission service and market participation (Day D/D-1: An arbitrary day and the day before; Headroom: reserved capacity for ancillary services; PMAT: PSH Market Analysis Tool for market participation simulation)

Future Work

- Leveraging the unspent funding and combining it with additional, new funding, the project was extended to provide four additional deliverables in FY22:
 - Exploring financial incentive structures to support PSH (technical report)
 - Lake Elsinore Advanced Pumped Storage (LEAPS) project study: Diving into the details of what has impeded development of the first proposed dual-use PSH facility (technical report)
 - Mapping potential PSH sites: Identify sites suitable for PSH development in California that overlap with grid conditions that would benefit from large-scale energy storage deployment (technical report)
 - Model extension: Improve the ES4TP's model ability to forecast day-ahead reliability needs from transmission services and create more accurate forecasts of market revenues (improved model and publication)

Q&A

