# FISH FRIENDLY WATER RULES' IMPACT ON THE POWER GRID WITH HIGH VRE LEVELS

Thushara De Silva, Ph.D.
Researcher,
National Renewable Energy Laboratory

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Coauthors: Mike Swirsky[2] , Sanjeeve Joshi[2],
David Graves[2], Anthony Teixeira[1]
1 National Renewable Energy Laboratory
2 Columbia River Inter-Tribal fish Commission

# Columbia River Basin Fish Passages

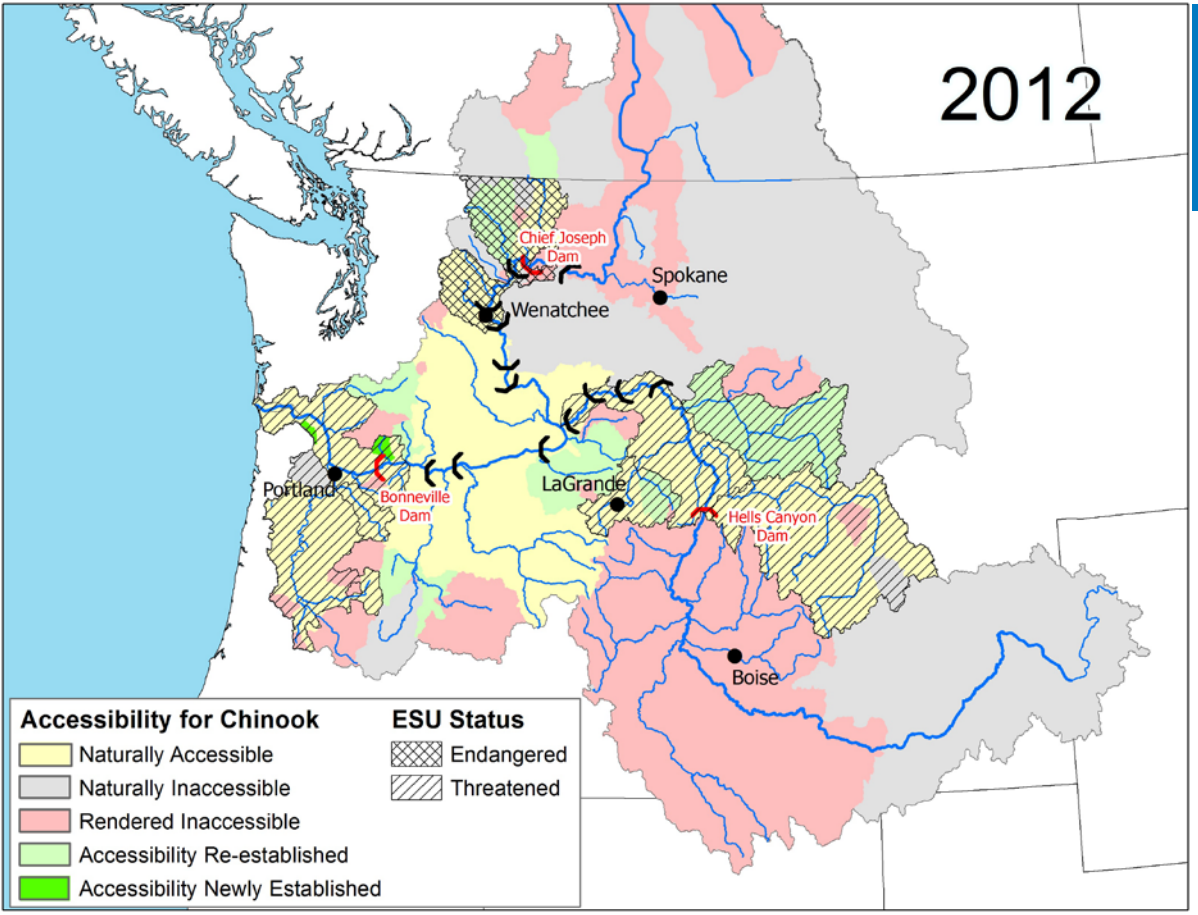



Fig: Year 2012 Chinook accessibility range analysis

- The Columbia River Treaty Tribes in the Pacific Northwest hold treaty-reserved fishing rights
- Accessible range for Chinook, salmon and steelhead species are after river flow augmented
- CRITFC energy vision includes recommendations to secure fish and treaty rights

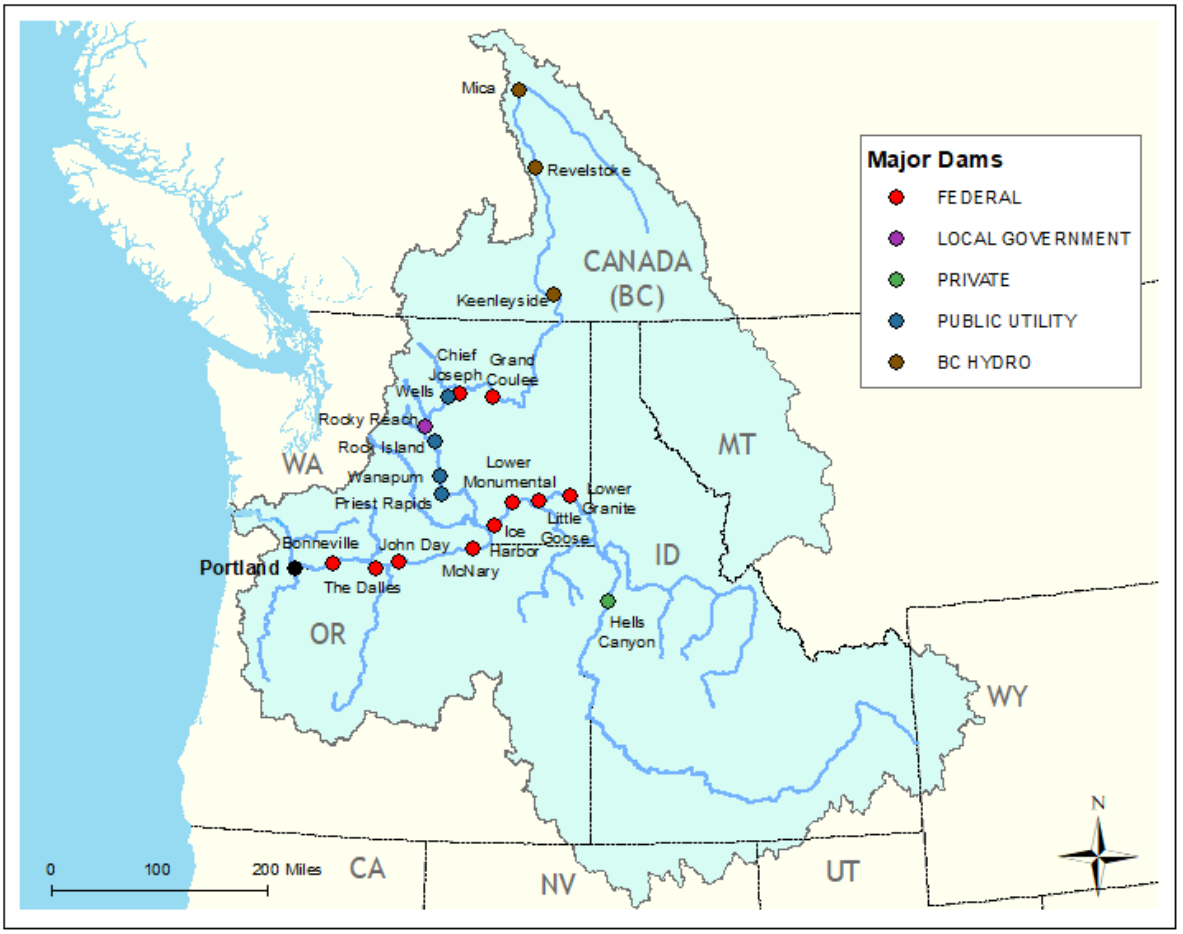
Ref: CRITFC and NOAA Northwest Fisheries Science Center, https://www.youtube.com/watch?v=KpDGDyDARFo

# What are the Grid Impacts of Reservoir Operating Water Rules

Questions addressed in this analysis:

- How would fish-friendly water rules impact total grid operations costs, local marginal prices (LMP), reliability, transmission congestion, reserve shortages, or dropped load (if any)?
- How would hydropower generation patterns change with a higher variable renewable energy (VRE) power grid?
- How would different weather patterns and water rules impact power grid operations?

# Columbia River Basin Hydropower



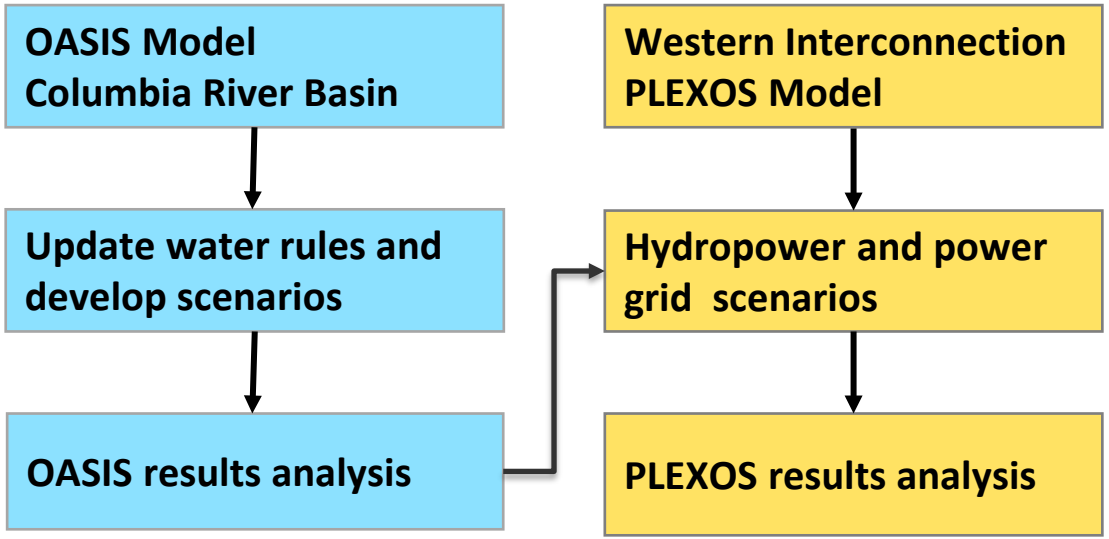

Our study consider

- **14 run of river dams (17684 MW)**
  - Revelstoke, Chief Joseph, Wells, Rocky Reach, Rock Island, Wanapum, Priest Rapids, McNary, John Day, The Dalles and Bonneville, Upper & Lower Bonnington, Kootney Canal, Brilliant
- **5 storage reservoirs (10207 MW)**
  - Mica, Arrow, Grand Coulee, Libby, Corra Linn

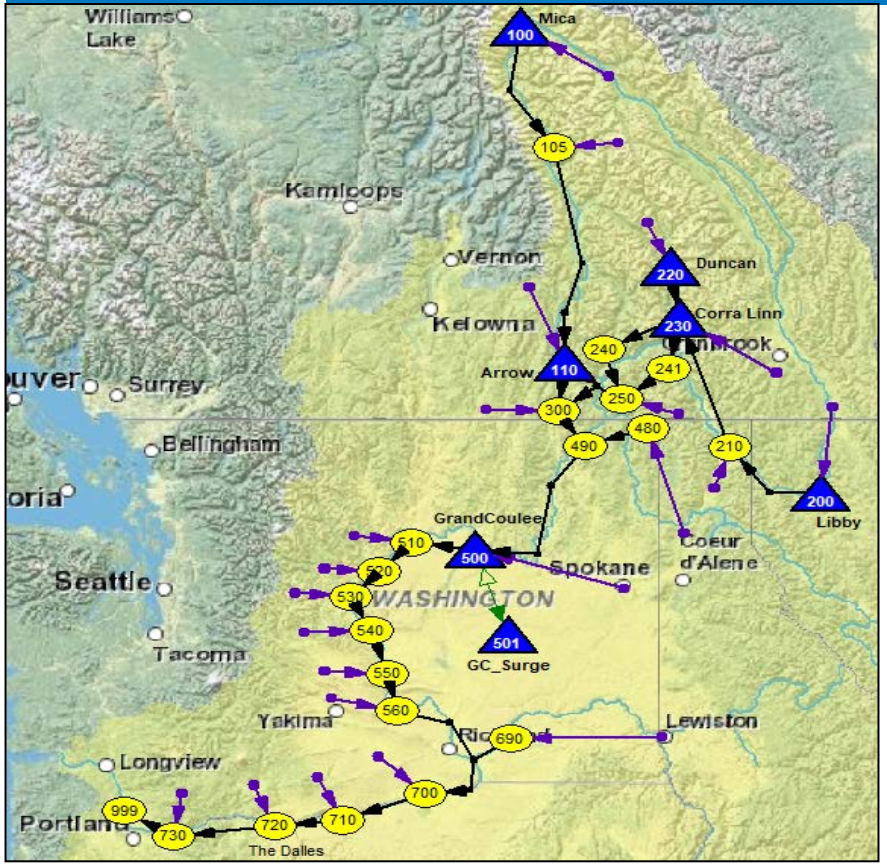
Ref: Columbia River Inter-Tribal fish Commission, https://critfc.org

# Integrated Modeling Approach

- An integrated water resource and power grid modeling approached was used
- CRITFC simulates Columbia River basin hydropower operations using a water resources planning tool, OASIS
- NREL simulates western interconnection grid operations using a production cost model, PLEXOS

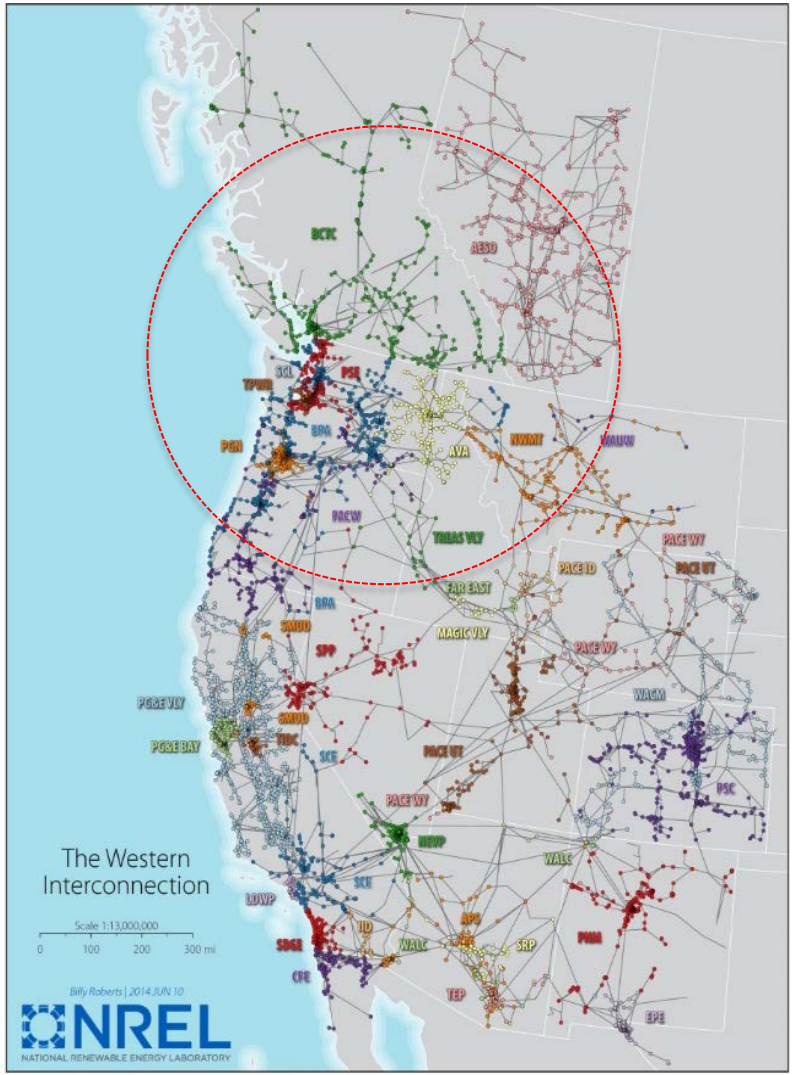


# Columbia River Operation Model (CROM)




- Columbia River and its major tributaries are simulated using OASIS (CROM)
- CROM balances daily flows and reservoir elevations through a set of model rules and weighted objectives applied at "nodes" and "arcs" throughout the system
- CROM was updated to use current operating rules, ESA required storage levels, spill requirements, and modified flows that simulate current irrigation depletions and river regulation

Ref: Columbia River Inter-Tribal fish Commission, https://critfc.org




# Western Interconnection power grid operation model

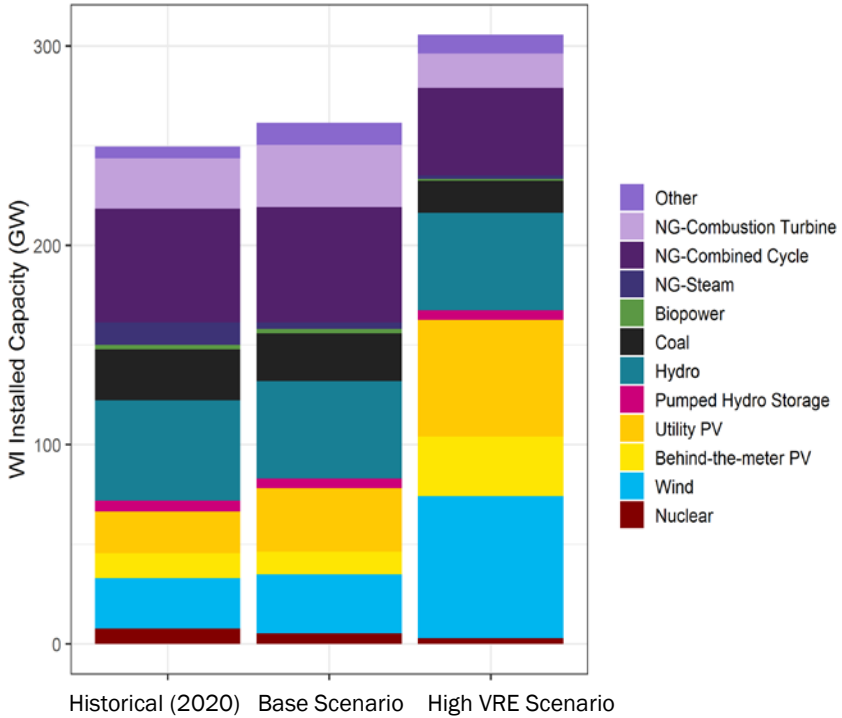
Western interconnection power grid operations are simulated with a production cost model, PLEXOS

- Hourly or subhourly chronological
- Commits and dispatches all generating units based on:
  - Electricity demand
  - Operating parameters of generators
  - Transmission grid parameters
  - Timeseries profiles of wind, solar, water
  - Operating reserve requirements
- Transmission modeling includes granular intraregional modeling for the Pacific Northwest and less granular interregional transmission modeling for other regions

# Study scenarios

- Current water rules and base grid
- Current water rules and HRE grid
- Ecosystem water rules and base grid
- Ecosystem water rules and HRE grid

Four scenarios are modeled with 2008-2013 weather years

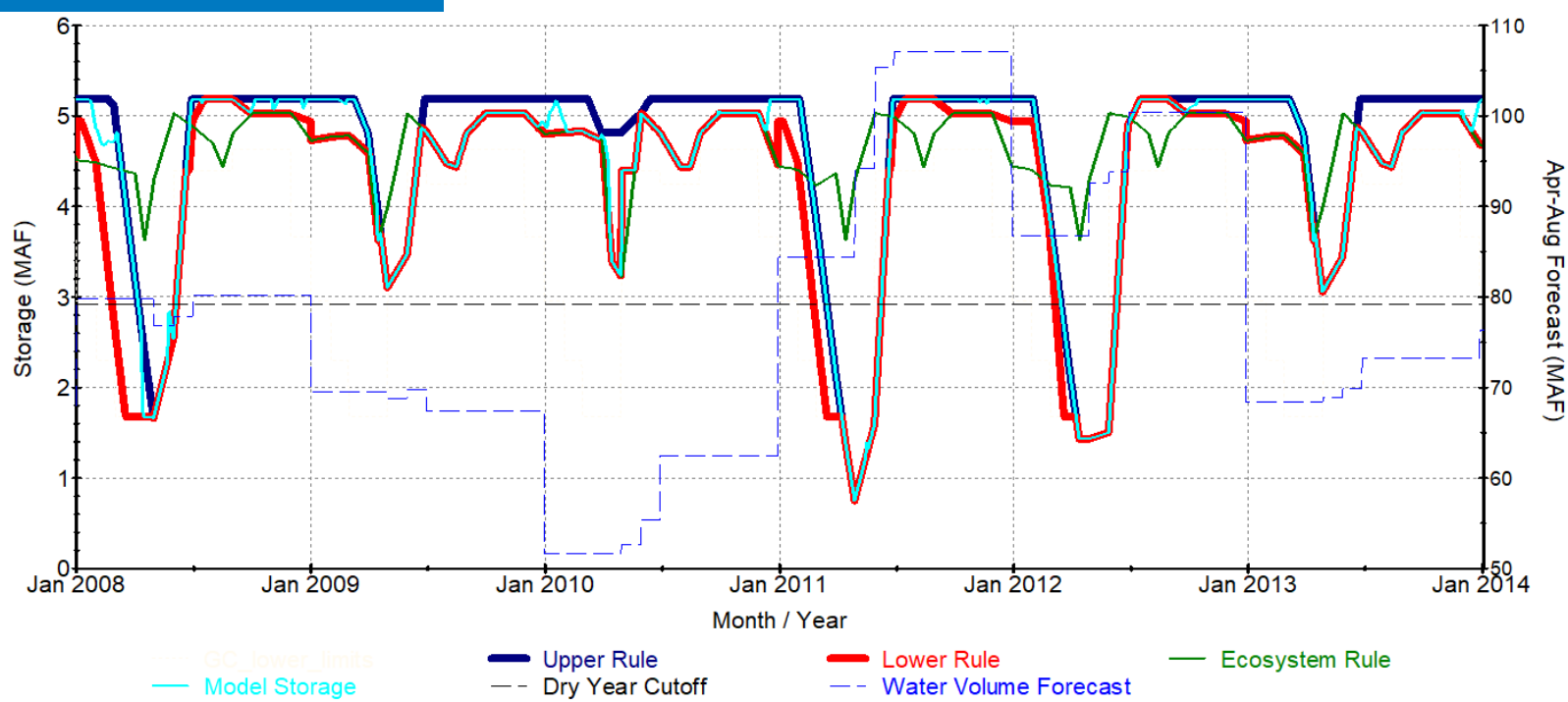



Capacity mix of grid scenarios

Wanapum Dam

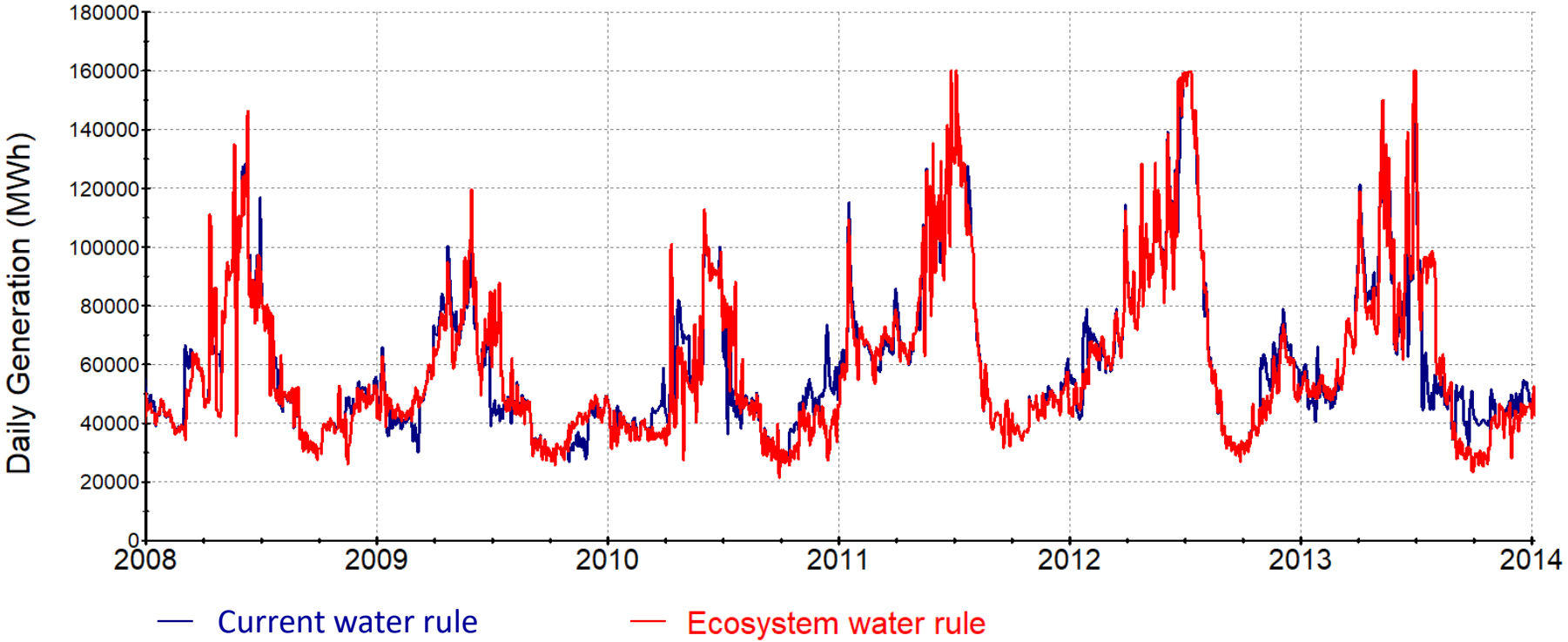
Photo credit: Grant County Public Utility District

# Water Rule Curves



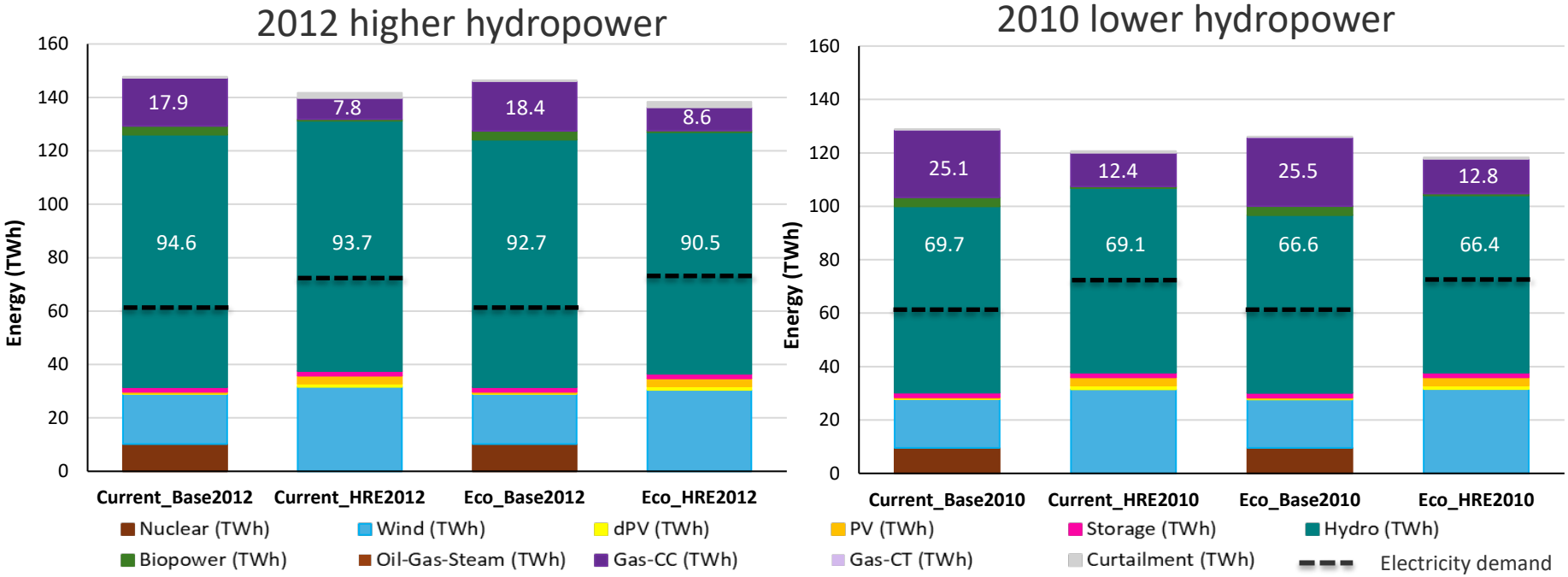

- Ecosystem rule curves are used in dry years
- Increased flow in late spring through summer
- Additional penalty applying for 4/15 – 7/31
- Lower dam water release during winter and early spring
- Maintain reservoir elevation levels for resident fish and water releases for fish passages

# How hydropower generation could be changed




- Ecosystem water rules increase spills and decrease flow through turbines for specific periods
- Difference of the hydropower generation of two water rule scenarios is less significant

# BPA generation mix

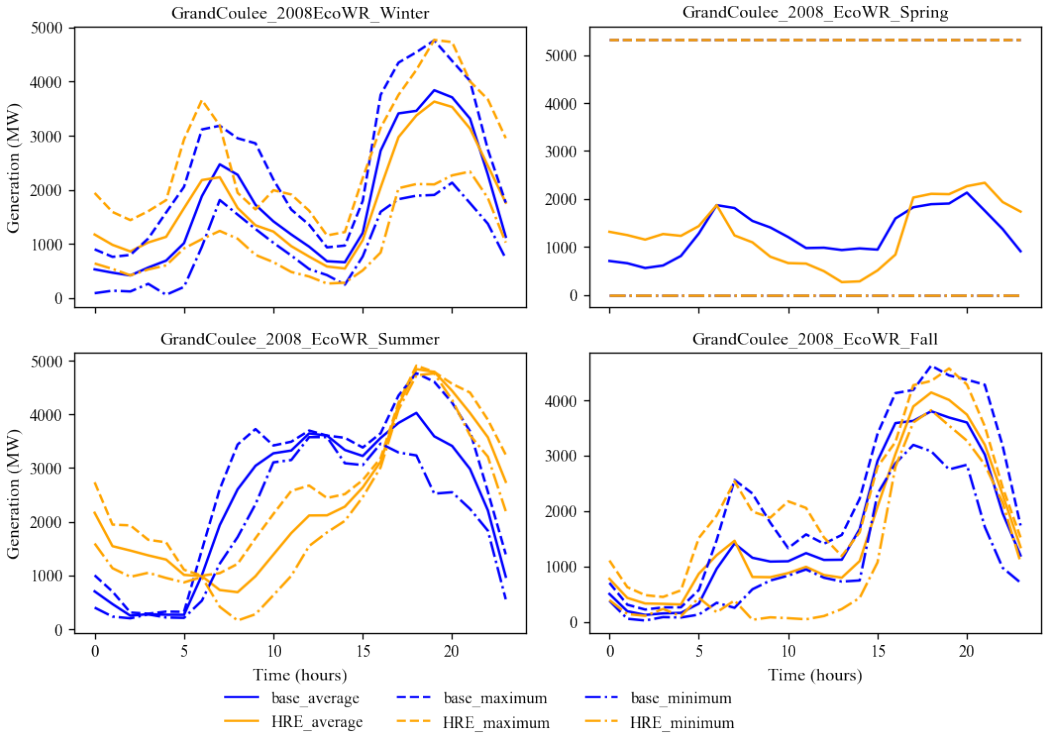



- BPA is a net importer, more than 50% generation imports
- Current and Ecosystem water rule scenarios have slight difference of total hydropower generation
- Low hydropower would increase gas CC generation and total generation cost

# Diurnal average generation dispatches

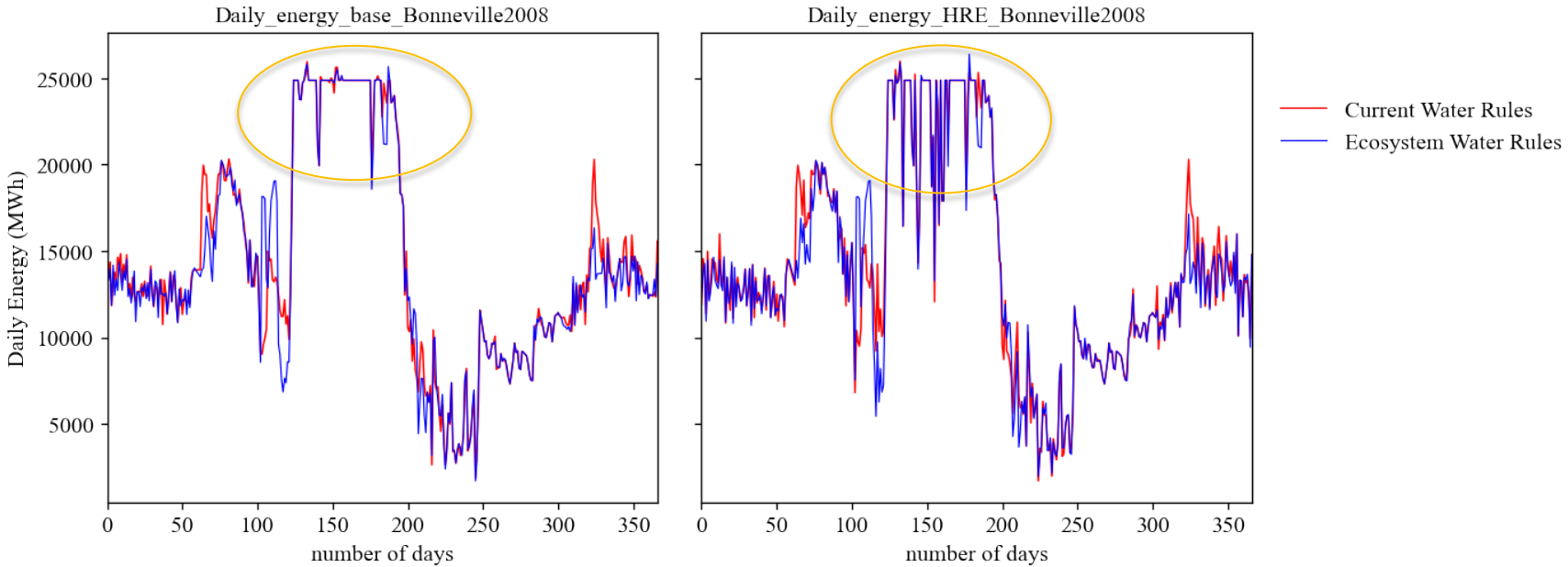
- Average diurnal hydropower dispatch shapes for four seasons, Grand Coulee plant
- Dispatch follows steep ramps during morning and evening peaks
- In the High VRE grid scenario, daytime hydropower dispatches would be decreased
- Flexibility for generators to dispatch between maximum and minimum capacities depend on downstream minimum flow requirements

## Grand Coulee dispatches



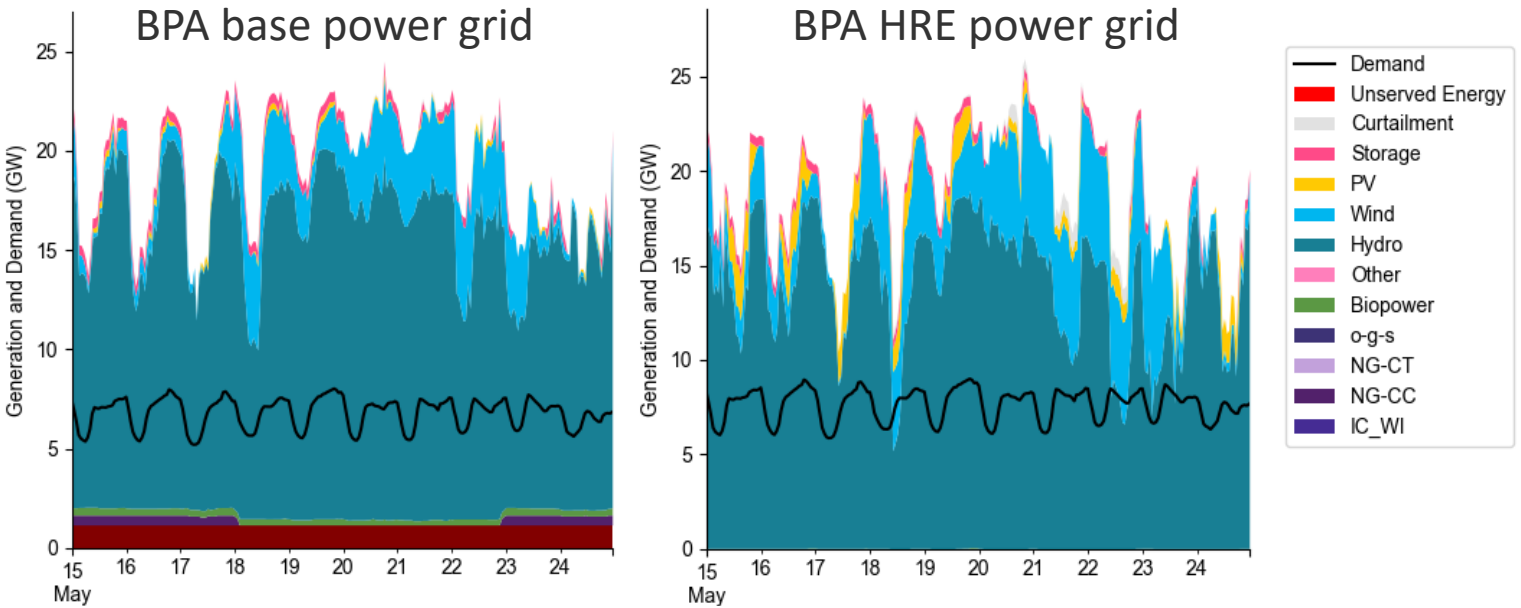

Seasons: Winter (Jan – April 15), Spring (April 16 – June 30), Summer (July – Sep), Fall (Oct – Dec)

# Impact on Daily Generation



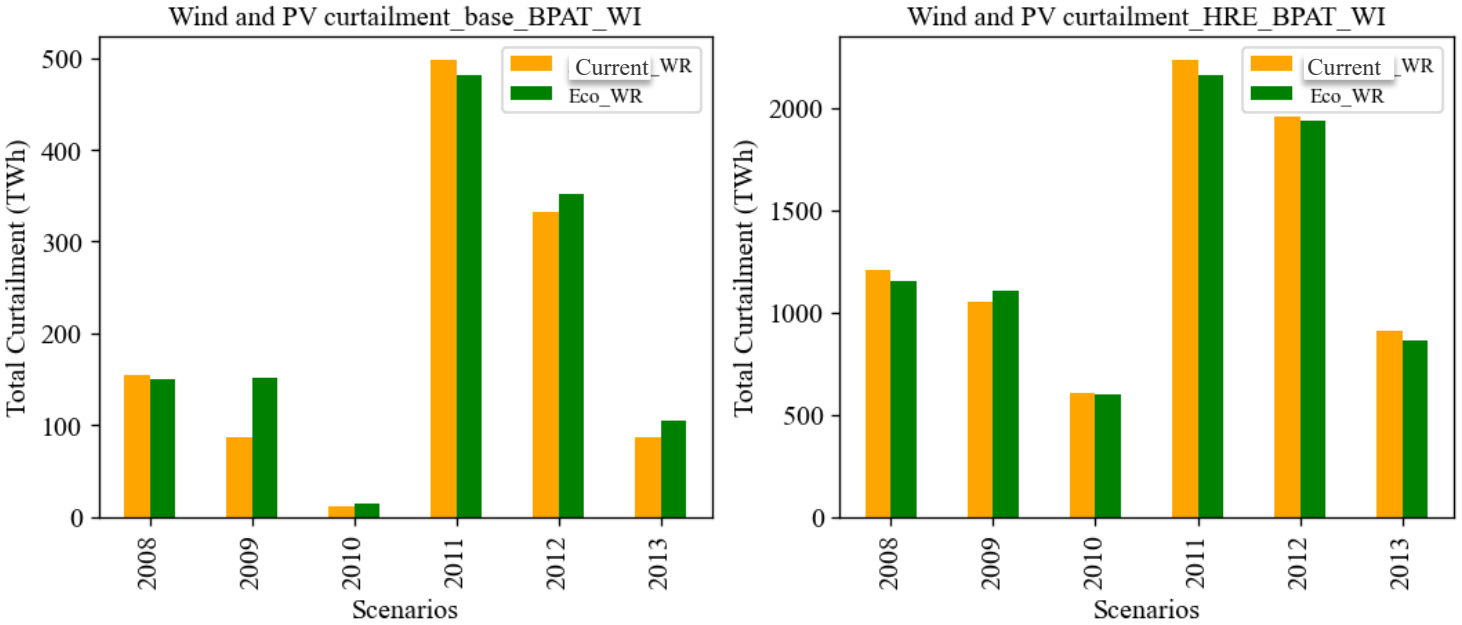

- Bonneville and some other hydropower plants daily generation show differences in late spring and early summer months, when generation is highest
- Hydropower plants have more flexibility to dispatch for grid requirement since downstream flow requirements are met by spills during this period

# Hydropower operation in high VRE power grid



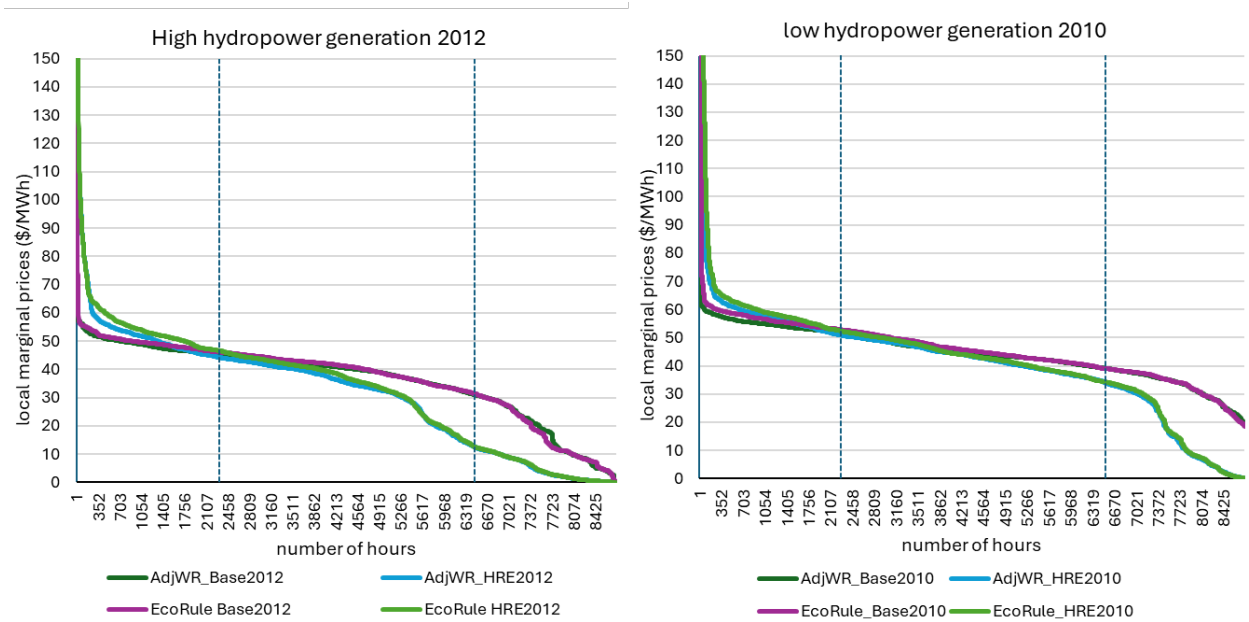

- Example of BPA hydropower dispatch for selected time window with generation differences for base and High VRE grid scenarios
- Hydropower balance wind and solar variability while meeting environmental constraints

# Wind and Solar curtailment




- Wind and PV curtailment are not directly related to water rule scenarios
- High hydropower generation years have higher wind and PV curtailment than low hydropower years
- High VRE grid scenario VRE curtailments are high (the y-axis scale for the right-side graphs are higher than for the left-side graphs)

# Impact on Electricity Prices




- Water rule scenarios impact prices, with prices varying between -2% - 4%
- For the High VRE scenario prices decrease by 7%-13%
- Lower hydropower years increase prices by 22% -32% compared to higher hydropower years

# Water rule impacts on grid operation

- Total operation cost varies -4% to 11% between current and Eco system rules
- No transmission congestion, dropped loads, or reserve violations
- Grid has higher hydropower dispatch flexibility during Spring
- Ecosystem rules increase June, July hydropower generation, which could increase renewable curtailment

# Summary

- Hydropower dispatch patterns vary for power grid and water rule scenarios and weather years
- Water rule scenarios do not change daily hydropower generation significantly
- Ecosystem rules' hydropower flexibility is not significantly different from today's rules.
- Hydropower dispatches in a grid with higher share of VRE would be different
- Hydrology and grid infrastructure buildouts would impact the grid operation more than fish-friendly water rules

References:


1. David Graves, Peter Galbreath, Kim Engie, Damon Holzer, Michelle McClure, Columbia River Inter-Tribal Fish Commission, NOAA/NW Fisheries Science Center, https://www.youtube.com/watch?v=KpDGDyDARFo
2. De Silva, T., Jorgenson, J., Macknick, J., Keohan, N., Miara, A., Jager, H., & Pracheil, B. (2022). Hydropower operation in future power grid with various renewable power integration. *Renewable Energy Focus*, *43*, 329-339.
3. Jager, H. I., De Silva, T., Uria-Martinez, R., Pracheil, B. M., & Macknick, J. (2022). Shifts in hydropower operation to balance wind and solar will modify effects on aquatic biota. *Water Biology and Security*, *1*(3), 100060.
4. Pracheil, Brenda, et al. *Designing Hydropower Flows to Balance Energy and Environmental Needs*. No. ORNL/SPR-2022/2596. Oak Ridge National Laboratory (ORNL), Oak Ridge, TN (United States), 2022.

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Thushara.DeSilva@nrel.gov

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