On the needs to evaluate power grid models' hydropower scheduling with a river operations model

Nathalie Voisin[1], Tim Magee[2], Sean Turner[1], Mitch Clement[2], Kostas Oikonomou[1], Edith Zagona[2]

[1]Pacific Northwest National Laboratory
[2]CADSWES

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Innovation in Hydropower Operations and Planning to integrate renewable energy sources and optimize the Water-Energy Nexus

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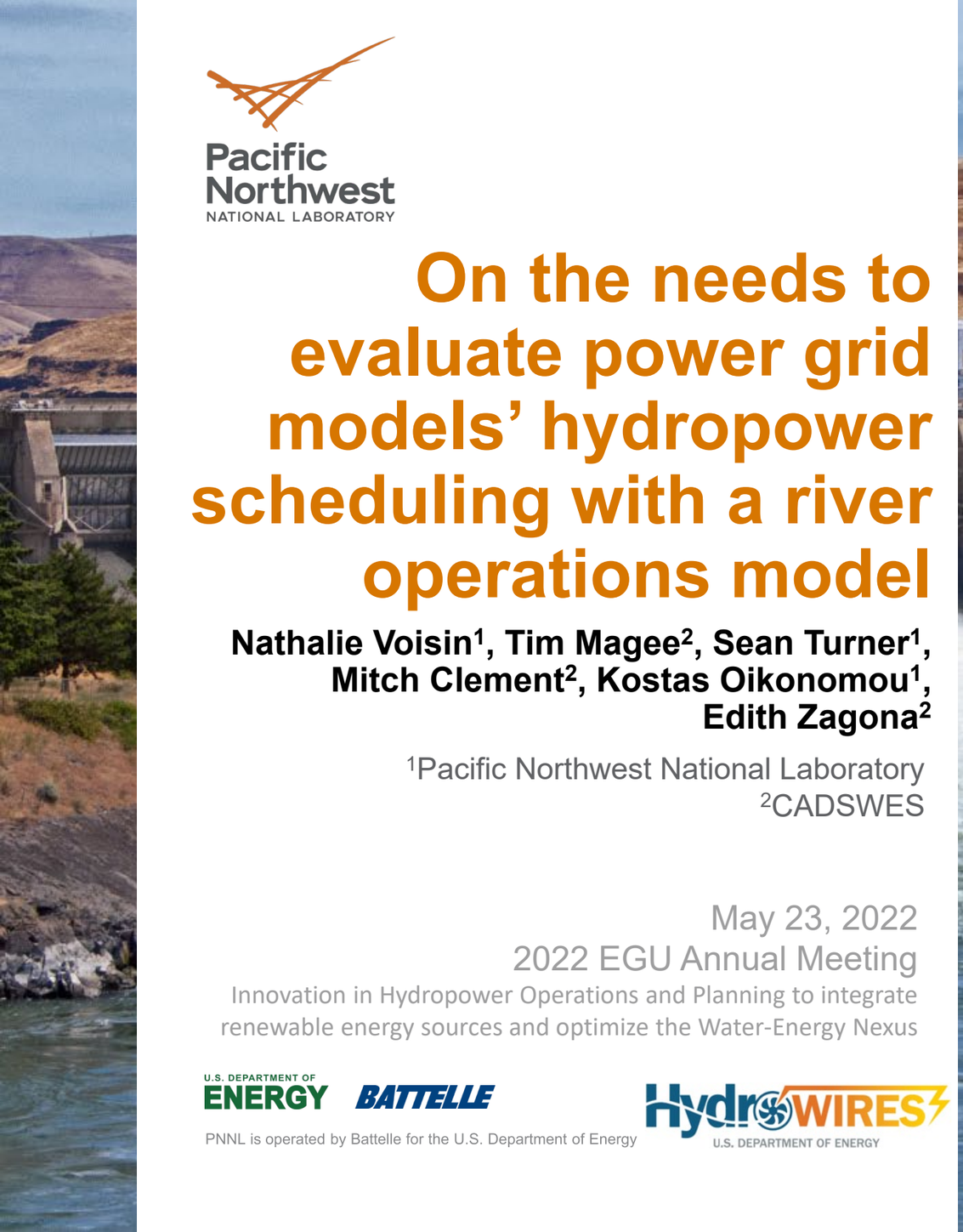


Hydropower scheduling is represented differently in each system

Hydropower scheduling by a water model

Multi-objective optimization to maximize generation or revenues as constrained by other water uses

Flow to energy factor

Inflows

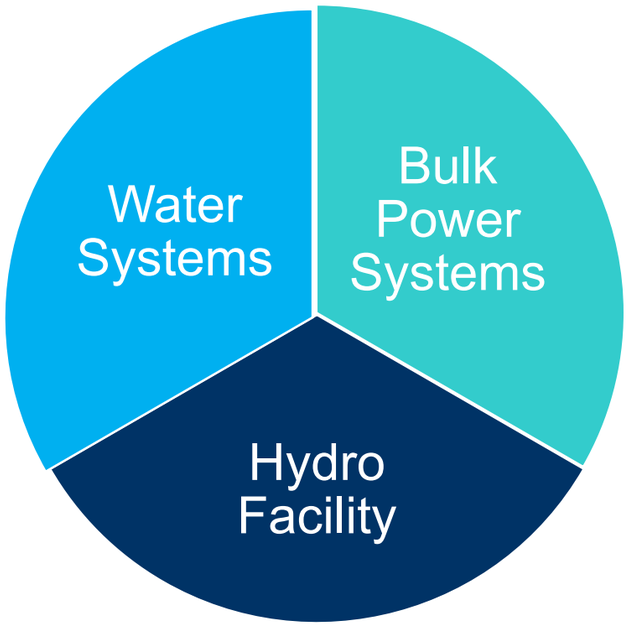
Hourly energy prices

Reservoir Release Optimization

hydropower

Hydropower **hourly** schedule

System scale



Asset scale

Hydropower scheduling by a bulk power model

Multi-objective optimization to minimize production cost

Monthly hydropower target

Hourly load

Ramping rates, Daily fluctuations, Mode of operation

Production cost

Unit Commitment (across all technologies)

Hydropower **hourly** schedule

Hydropower scheduling by a facility model

Multi-objective optimization to maximize revenues

(multi-) day release & storage targets

(Sub)hourly energy prices

Unit Loading Optimization

Hydropower **sub-hourly** schedule

Short-term planning: cross-system infeasibility is managed by iterating daily between power and water models

Hydropower scheduling by a water model

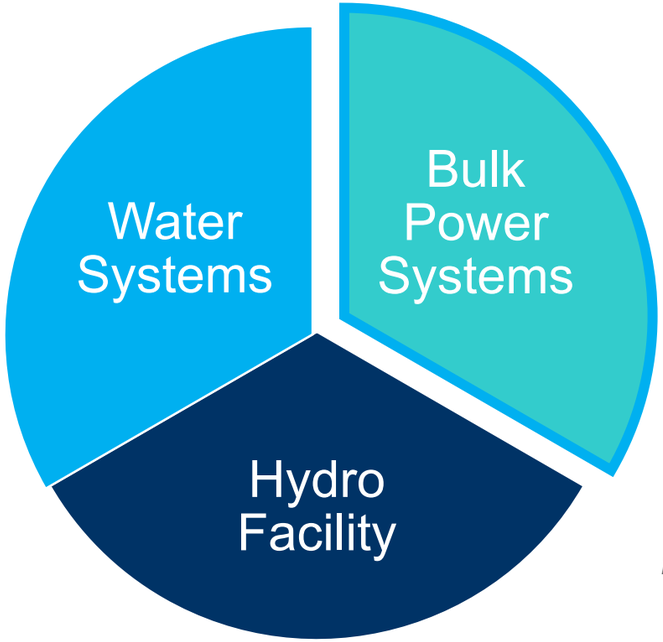
Multi-objective optimization to maximize generation or revenues as constrained by other water uses

Flow to energy factor | Inflows | Hourly energy prices

Reservoir Release Optimization

hydropower

Hydropower **hourly** schedule



Hydropower scheduling by a bulk power model

Multi-objective optimization to minimize production cost

Monthly hydropower target | Hourly load | Ramping rates, Daily fluctuations, Mode of operation

Unit Commitment (across all technologies)

Production cost

Hydropower **hourly** schedule

Input into the unit commitment

***Pros**: Feasible and Optimal for Water.*

***Cons:** not flexible for Power, errors in revenues*

Co-optimization

***Pros:** feasible and co-optimal*

***Cons**: curse of dimensions to converge.*

Needs from Power Grid

Pros: Optimal for Power

Cons: not feasible from water perspective

What about for resources adequacy under climate change and decarbonization infrastructure policies?

Computational cost of daily iterations can lead to a decoupling between water and power models in resources adequacy studies

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2009 observed generation by project

Monthly hydropower target

Hourly load

Ramping rates, Daily fluctuations, Mode of operation

Unit Commitment (across all technologies)

Western Interconnect Set Up, GridView model (2028 WECC ADS)

2009 daily observed

Inflows

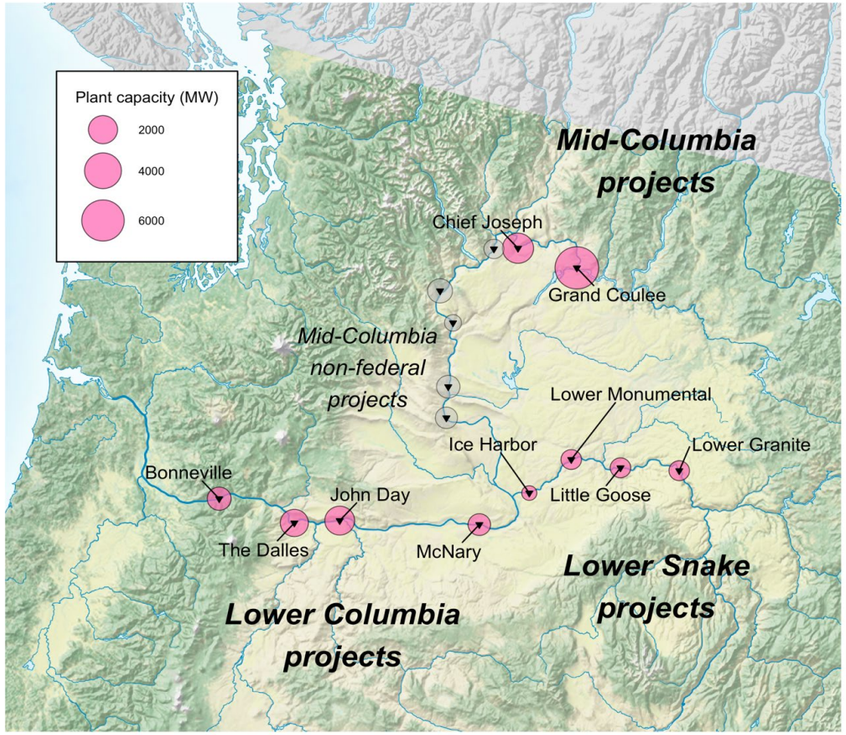
Hydropower **hourly** schedule

Flow to energy factor

Reservoir Release Optimization
REVERSE OPTIMIZATION – NEED TO MEET UCED HYDRO SCHEDULE

RiverWARE Big 10 Set Up – Core Mid Columbia River projects Include post 2009 new environmental regulation

Numerical Experiment to evaluate the hydro scheduling from a decoupled power model using a water model. What is the cost of decoupling to resources adequacy studies?



Δ generation = environmental regulation
+ inconsistency in representations

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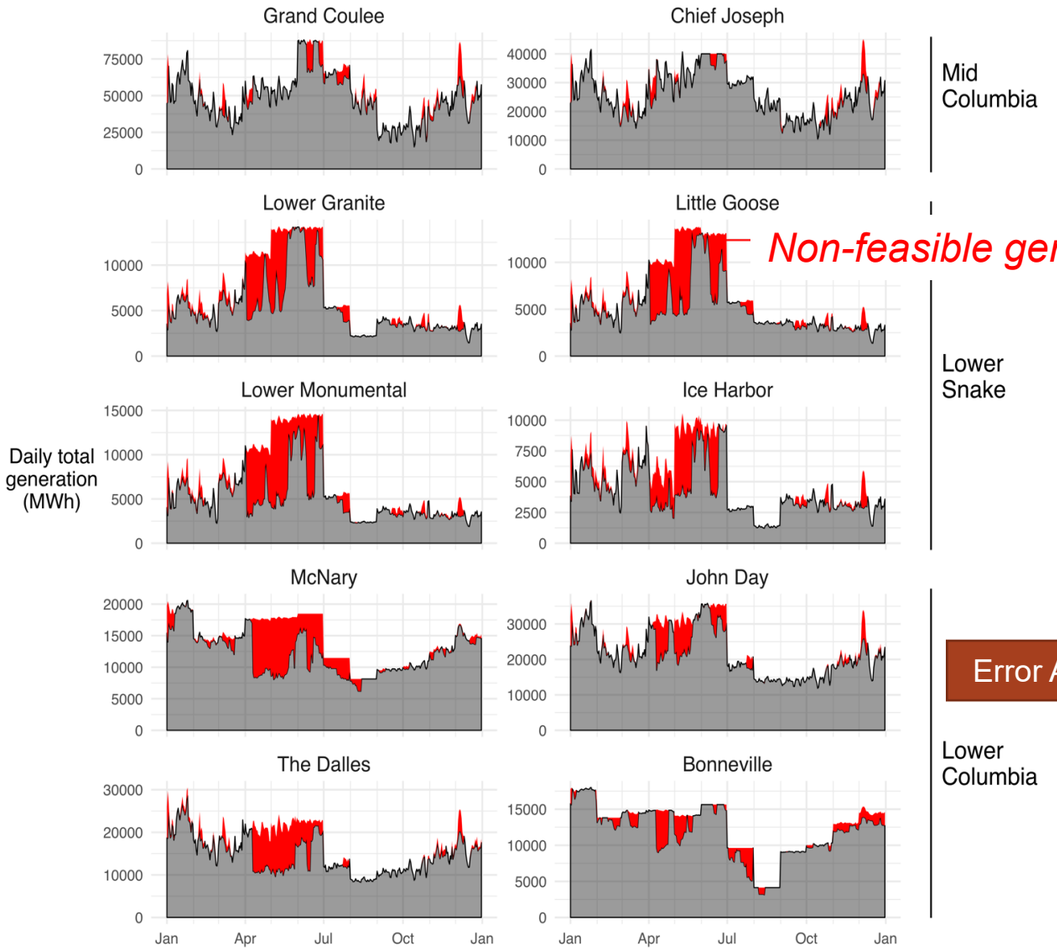
The water model could not match the power model hydro scheduling

9% of the annual hydropower generation infeasible,
2/3rd of it associated with contemporary environmental regulation
Estimates based on an average water year conditions



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Implications For Resources Adequacy Studies and Mid-Term Planning

- This work motivates the exploration of new hydropower representation in power system models for mid and long term planning when decoupled
- The errors quantified in this study also impact mid term energy planning (seasonal to multiple years)
- The suggested numerical approach can be used by water managers and system operators to agree on a time step for resources adequacy studies and mid-term planning, saving on computation cost while not compromising on reliability services provided by hydropower operations
- The use of observed water conditions and reservoir operations is still often preferred for resources adequacy studies however those do not represent evolving climate change, environmental regulations, etc
- Resources adequacy studies based on simulated flow with a reservoir optimization scheme more and more integrate climate change – changes in environmental regulation also need to be considered

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Thank you

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Nathalie.Voisin@pnnl.gov
Magee@colorado.edu