Pacific Northwest NATIONAL LABORATORY

Idaho National Laboratory

NREL Transforming ENERGY

HydroWIRES

U.S. DEPARTMENT OF ENERGY

Introduction- Modeling Gaps in Hydrogeneration Representation

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U.S. DEPARTMENT OF ENERGY

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Problem Statement

Hydro generation not adequately and inaccurately represented in planning and operation studies:

- Water availability not updated seasonally or modeled in basecases
- No interdependencies between resources, environmental constraints ignored

The six-turbine Edward Hyatt Power Plant was taken offline after the water level in the Oroville Dam reservoir that feeds it sank to an historic low

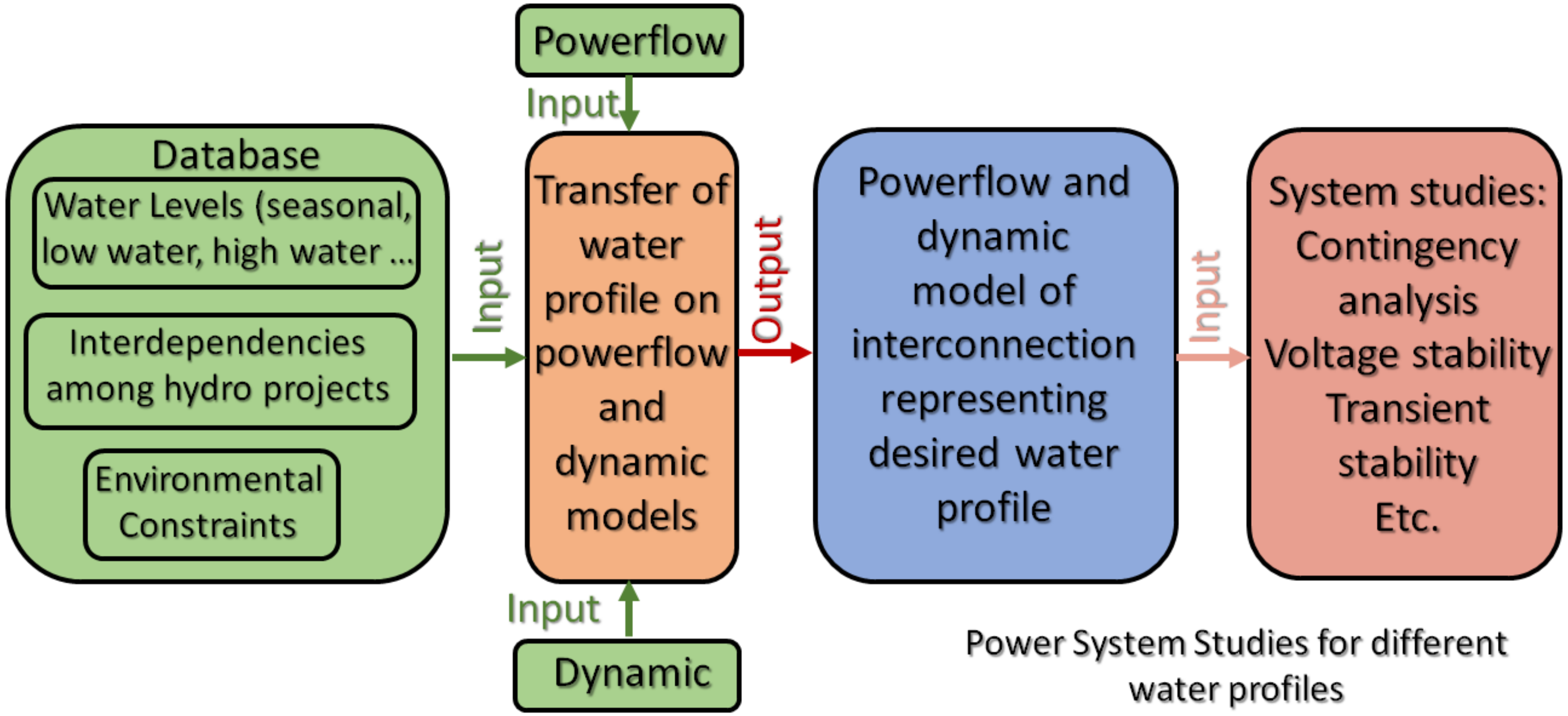
https://www.cnbc.com/2021/08/06/california-shuts-down-major-hydroelectric-plant-amid-severe-drought.html

As the river's biggest reservoirs, Lakes Powell and Mead, fall to one-third of their capacity, the dwindling flow threatens electricity generation.

https://insideclimatenews.org/news/08082021/colorado-river-water-power/#:~:text=The%20Colorado%20River%20is%20tapped,government%20will%20declare%20a%20shortage.

Software

The software updates the existing steady state and dynamic model based on desired historical hydro conditions, allow modification while respecting interdependences and impose desired hydro profile, including dispatch constraints on hydro plants, as illustrated in Figure below:



Power System Studies for different water profiles

Mitigation of Modeling Gaps

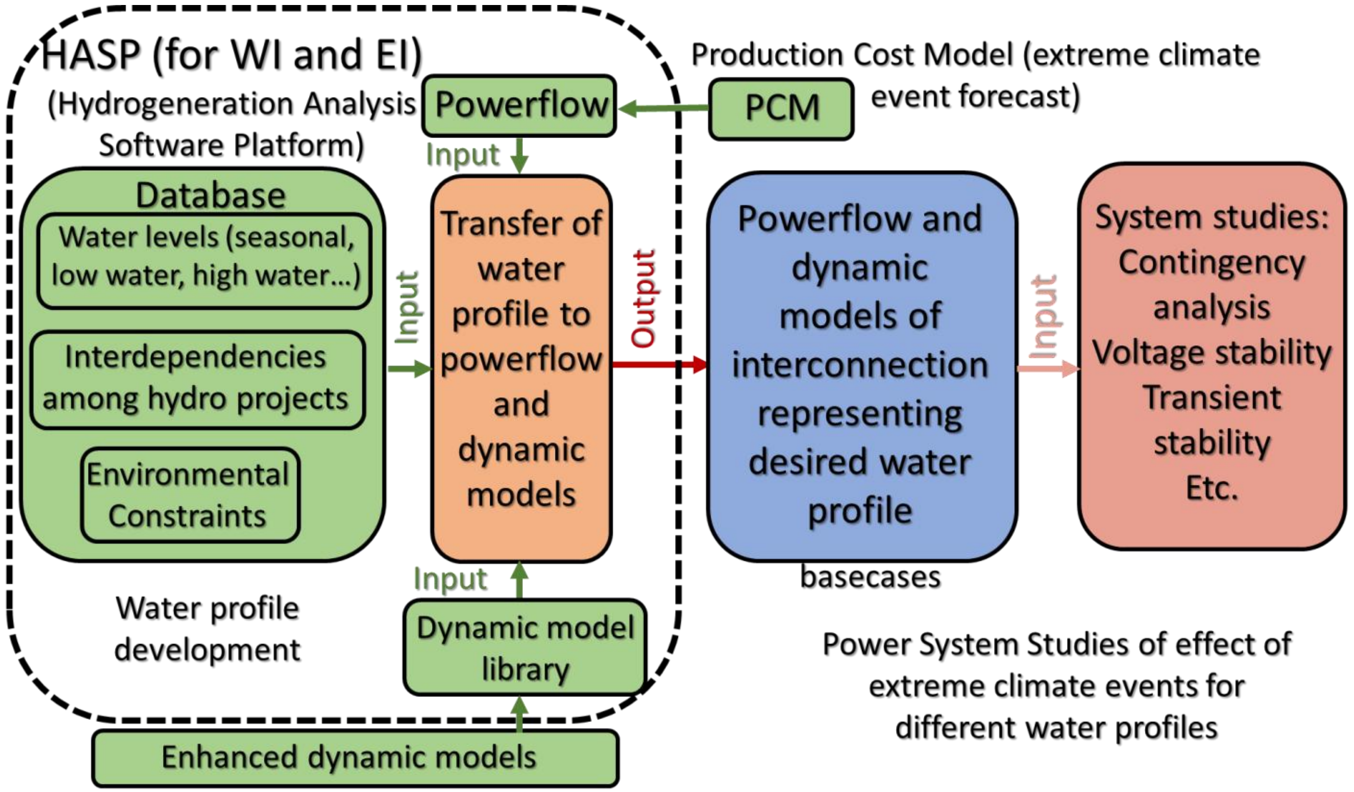
Within Modeling Gaps project, PNNL has developed the Hydrogeneration Analysis Software Platform (HASP). HASP is a software/database and tool that bridges the gap in between hydrological and electrical power system model, brings hydrological data into the electrical model of power grid allowing realistic hydrological representation in the base cases (powerflow and dynamic model).

Next steps:

- Expand HASP to Eastern Interconnection (EI) - currently it contains only WI data.
- Interdependency model development -Modeling interdependences among the cascading plants. The current model in Hy-DAT is a statistical model. In this task we shall develop model-based approach to interdependences and validate it against historical data and the statistical model for a set of cascading plants. This will allow to use model-based approaches for the cases statistical data are not available (ANL)
- Improve dynamic models:
  - Develop advanced pump storage model and implement the model with major software vendors (NREL).
  - Develop generic hydro turbine governor model that would eliminate modeling gaps outlined within ongoing Modeling Gaps project and implement the model with major software vendors (INL).

Mitigation of Modeling Gaps

- Make HASP a public tools so that power system planners, operation engineers, regulators and academia can use the tool to be able to have more robust and updated scenarios for utility planning and operational studies by incorporating accurate hydrological conditions and constraints and develop basecases that reflect the required hydro conditions (PNNL).
- Use HASP to develop basecases to study the role and impact of hydro under normal and extreme climate events (e.g., extreme heat, extreme cold.) and other conditions (e.g., high DER) in ensuring grid reliability and resilience using the modified models with accurate hydrological conditions (PNNL).

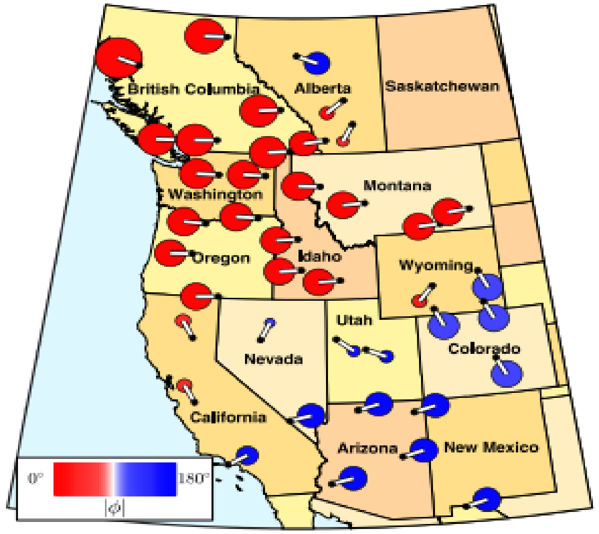


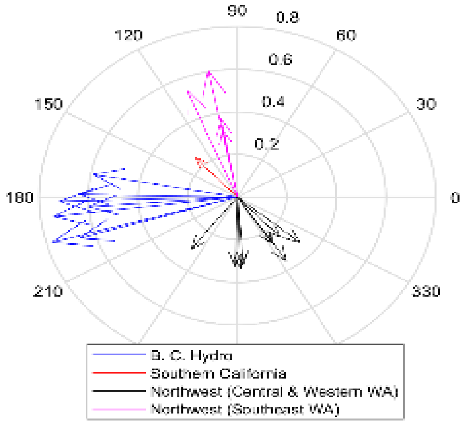
Impact: Mitigation of hydropower modeling gaps leads to more accurate evaluations of the value of hydropower under rapidly evolving power system conditions, evaluates hydropower constraints, helps operation and planning, and support overall larger DOE goal to improve reliability and resiliency of the National Power System.

Grid Oscillations and Dynamics Assessment Considering Hydro Generation, Hydrological Conditions and High Penetration of Inverter-based Resources – Collaboration with Norway

Hydropower generators may be the only significant source of rotational inertia in future grids dominated by inverter-based resources (IBR), hence playing a critical role in ensuring grid stability. This project will employ model-based and data-driven techniques in support of Hydro Fleet and Grid Monitoring and Control Technologies, to analyze evolving oscillations in the Nordic grid as IBRs displace rotating machines, and to formulate strategies to utilize hydropower generators to damp inter-area oscillations, and to detect ultra-low frequency oscillations in hydrogenator clusters. New insights and lesson learned from Nordic grid oscillations and dynamics study, will also benefit U.S. researchers and grid operators, inspire collaborative solutions showing unparallel value of hydro fleet.

Western U.S.



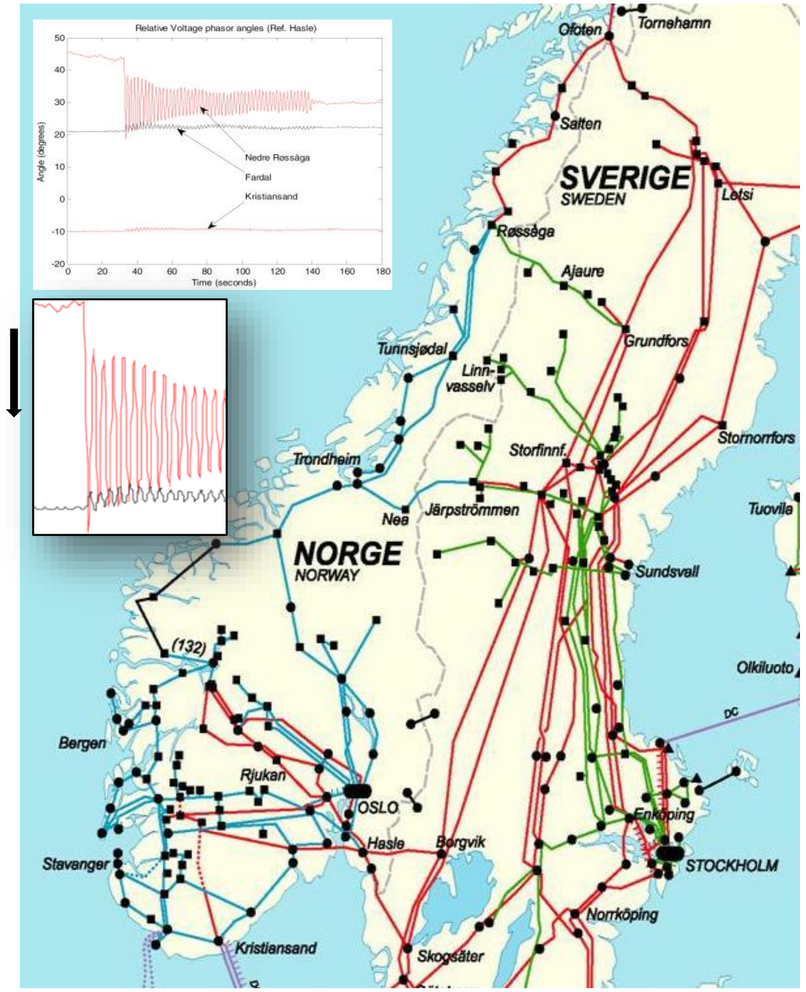


Modelling high fidelity hydro plants & high penetration of IBRs

Better stability More damping by Hydro & IBRs

New findings and innovations by collaborating on data, model, analytics, and control designs.

Nordic Grid in Norway



The objectives:

(a) Informe about changing grid oscillatory behaviors under varying weather/fuel-mix scenarios;

(b) Assessment of potential Impact of hydrological conditions on interarea modes

(c) advancing understandings of control interactions among hydro- and IBR plants, formulate monitoring & control strategies;

(d) assessing hydro & IBRs frequency dynamic characteristics in new grid paradigm.