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HydroWIRES

U.S. DEPARTMENT OF ENERGY

Intro and Hydrogeneration Modeling Gaps

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Workshop on Hydrogeneration , September 26th 2023 SLC

U.S. DEPARTMENT OF ENERGY BATTELLE

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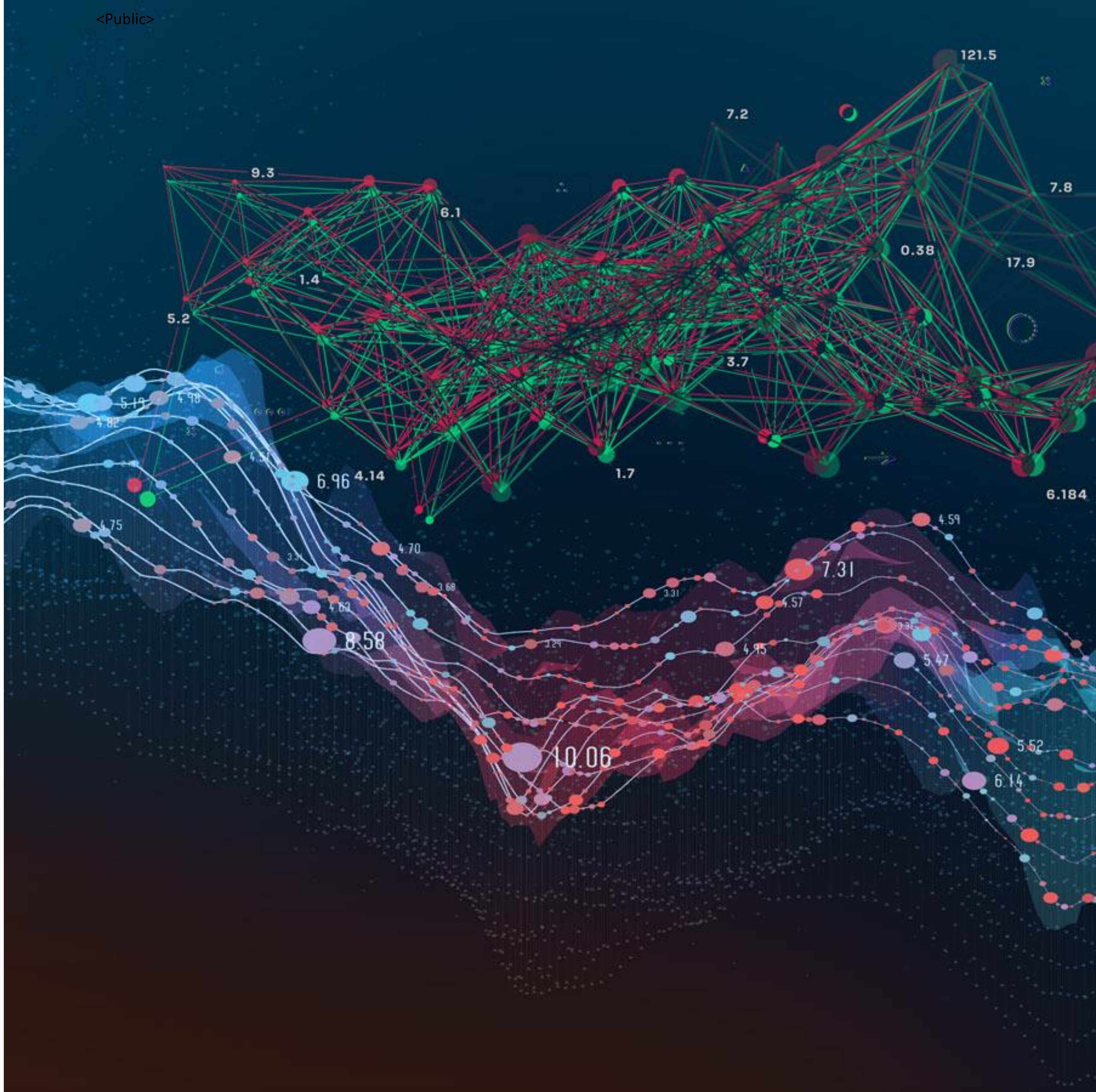


Water Availability

Key Industry Comments:

- “It’s a good idea to vary head parameter in dynamic models and observe the effect on studies”
- “For power system simulation programs, we should propose to build a new section ... to specify seasonal water flow condition on rivers, head information and ... to adjust steady state and dynamic model data accurately”

Source: Insight Climate News

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

Recommendations:

- To collect water data for different river basins for low and high-water conditions
- To establish water profiles for different water conditions for different river basins.
- Dependence among parameters (dynamic model)
- Many dynamic models do not allow to change water head
- To develop a tool that automatically impose water conditions on each river basins separately in steady state and dynamic models.

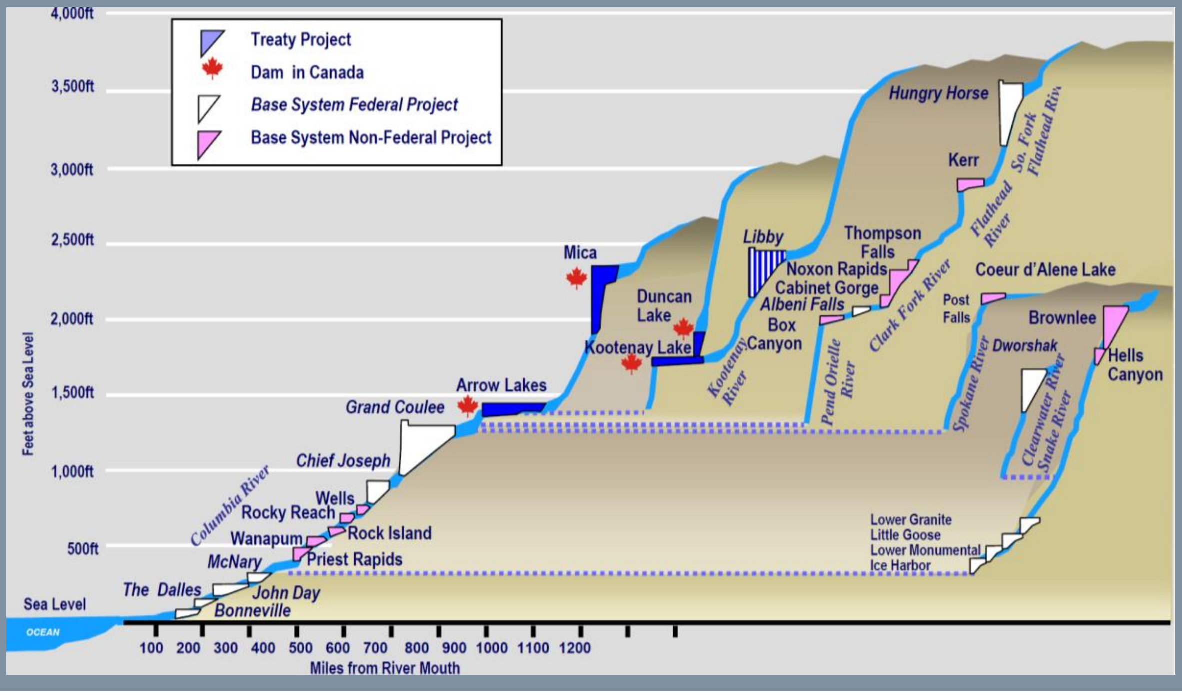
Interdependences and Constraints

Key Industry Comments:

- "Study engineers need to be educated on the river flow operations and the model data exchange between PCM and planning case need to be checked"
- "Not an urgent requirement for the transmission planners – need to educate the engineers to make sure errors are not made…"
- "It's more important in long term simulations and critical for run of river plants"

Recommendations:

- To collect rules on how water can be shifted from project to project including environmental rules
- To develop tool implementing coupling among plants and impose restriction on generation dispatch on powerflow.



Source: Scott Winner, BPA, "Winter Operations: A Hydro System Perspective"

Dynamic Models

Key Industry Comments:

- “Some of the models developed late 60s and early 70s”
- On some model water head cannot be changed”

Recommendations:

- The models with linear water/turbine models have been superseded, and are now subsets of better models
  - ieeeg3 -> hygov4
  - gpwscc -> hyg3
  - g2wscc -> hyg3
  - pidgov -> hyg3*

*more discussion necessary

- Need to convert parameters from old to new, some studies are needed to check on effect
- About 200 models needs to be updated/substituted

A Framework for Addressing Hydropower Modeling Gaps in Planning and Operational Large-Scale Grid Studies

Problem Statement:

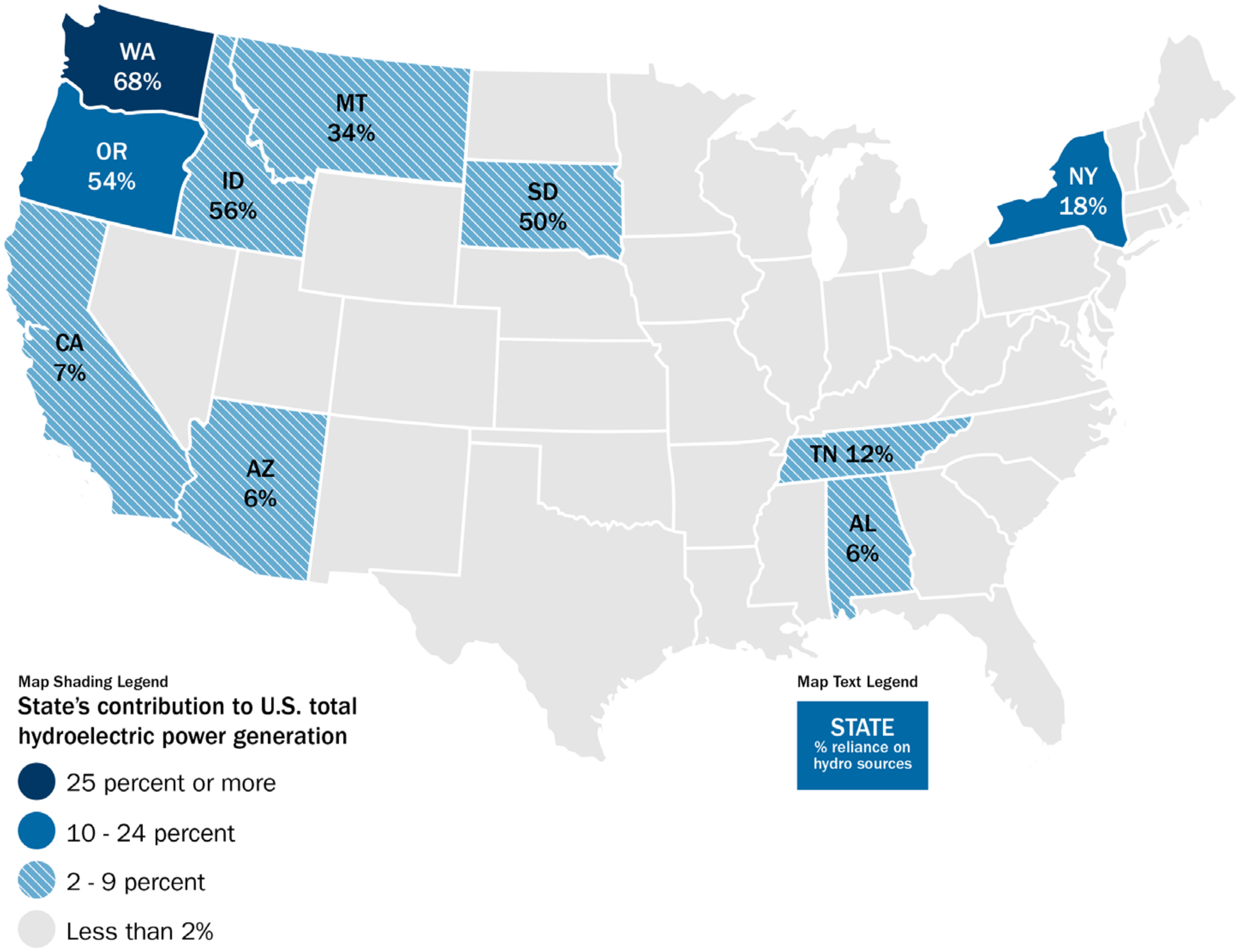
Hydro generation not adequately represented in planning and operation studies:

- Water availability not updated seasonally or modeled in basecases
- No interdependencies between resources, environmental constraints ignored
- Dynamic models need to be updated

Consequence: Over/under estimation of hydropower response in planning and operations studies

Objective: Improve hydro generation representation in power system studies (operation and planning)

Why it is Important for WECC



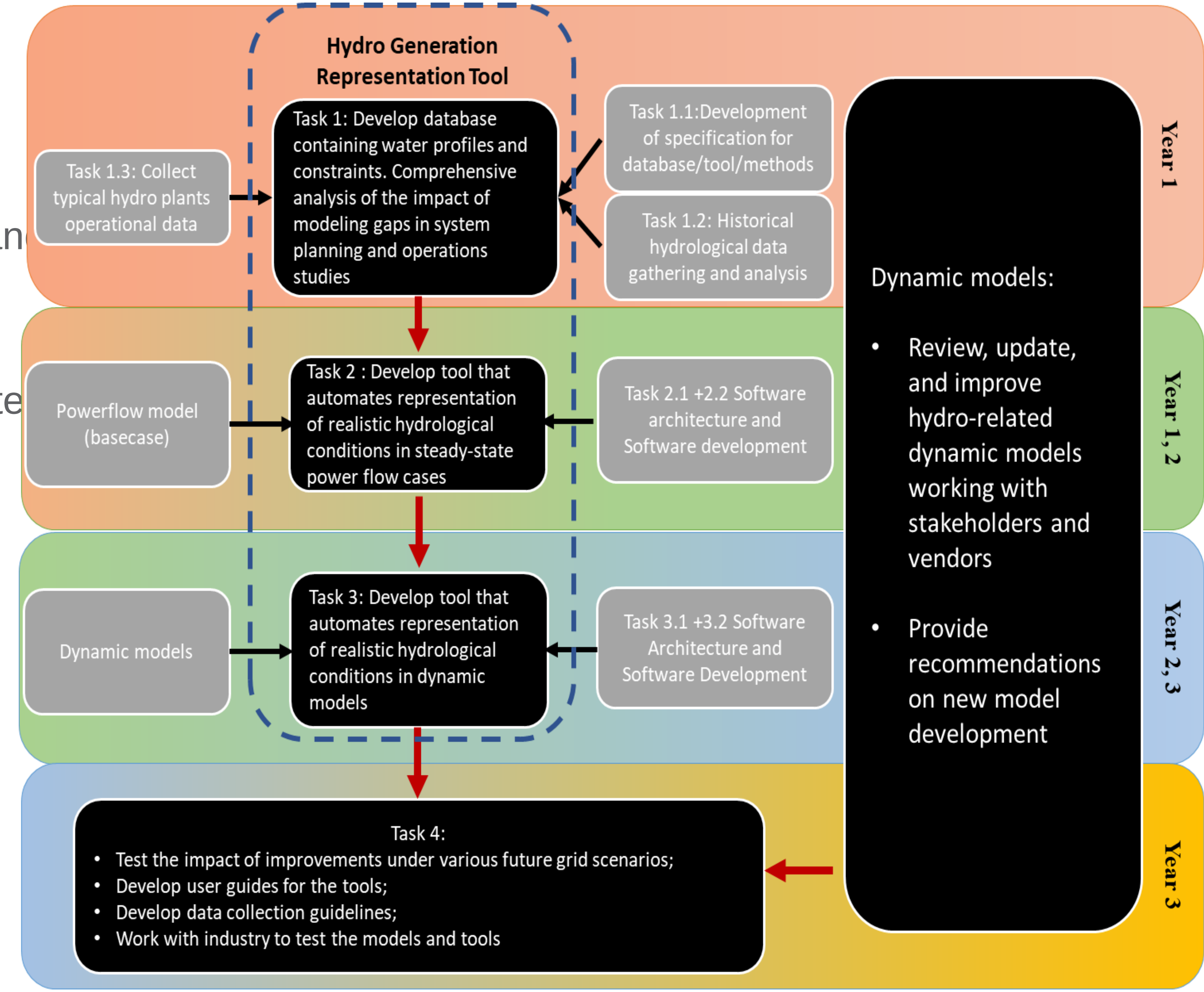
The 10 highlighted States together produced about 79 percent of the Nation's total hydroelectric power. The numeric values represent each State's dependence on hydro sources for electricity generation. For example, Washington State produced the highest level of hydropower, contributing to 30 percent of the total hydropower in the United States and 68 percent of total electricity generation in the State of Washington

Project Objectives and Approach

- Develop software tools that will update system models to account for steady state and dynamic water availability, interdependences between cascading systems, and rough zones in planning an operations models.
- Review, update, and develop dynamic models,
- Stakeholder engagement to collect and disseminate information and data, validation of methodologies, and testing of the tools

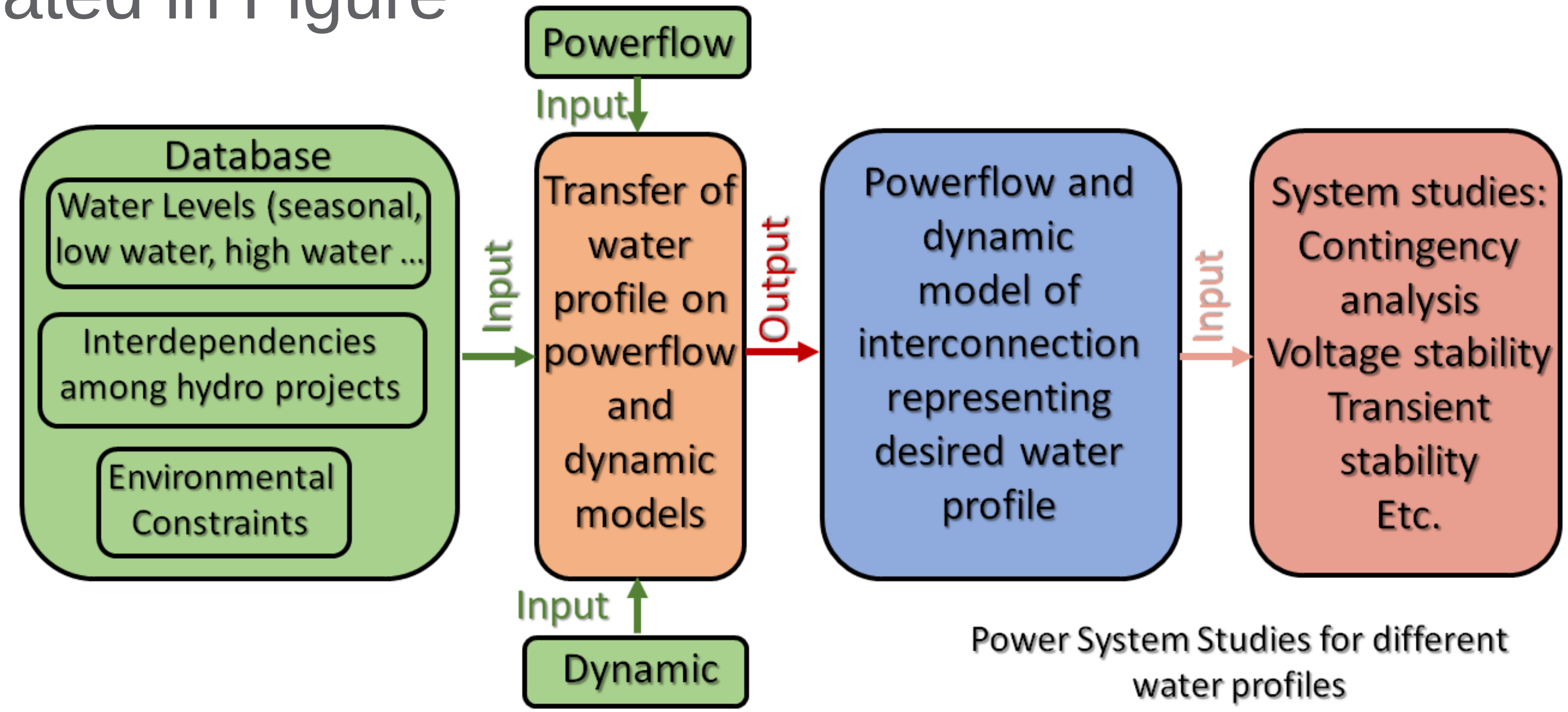
Project Outcomes

- Improved representation of hydro generation, constraints, and updated/improved dynamic models in operation and planning studies
- Knowledge exchange with the industry in the form of data, methodologies, and tools for improved planning and operations studies



Software Specifications

The software will update the existing steady state and dynamic model based on desired historical hydro conditions and impose desired hydro profile, including dispatch constraints on hydro plants, as illustrated in Figure



Power System Studies for different water profiles

Software Specifications

The software tool developed under this project will consist of the following four modules.

1. **Database:** The objective is to store and couple historical hydro data with the electrical models for steady-state and dynamic model update tools. The database will also contain specific nonchanging hydro project data.
2. **Steady-State Model Update and Hydrogeneration Dispatch Tool:** The objective is to transfer desired hydro conditions to a steady-state electrical model and dispatch hydro-based generation realistically, taking into consideration various hydro constraints.
3. **Dynamic Model Update Tool:** The objective is to update dynamic models based on water conditions and hydro profile/capability imposed in 2.
4. **Integration:** With commercial software for operation and planning studies.

Dynamic Models

GE PSLF	PTI PSS/E*	Number of the models in WECC case	Model Description
ieeeg3	IEEEG3	119	IEEE hydro turbine/governor model. Represents plants with straightforward penstock configurations and hydraulic-dashpot governors.
gpwscc	WSHYGP	47	PID governor and turbine.
g2wscc	WSHYDD	4	Double derivative hydro governor and turbine.
pidgov	PIDGOV	48	Hydro turbine and governor. Represents plants with straightforward penstock configurations and "three term" electro-hydraulic governors (i.e., Woodard electronic).
hygov	HYGOV	168	Hydro turbine and governor. Represents plants with straightforward penstock configurations and electro-hydraulic governors that mimic the permanent/temporary droop characteristics of traditional dashpot-type hydraulic governors.
hygovr	HYGOVR	25	Fourth order lead-lag governor and hydro turbine.
hyg3	HYG3U1	372	PID governor, double derivative governor and turbine.
hygov4	IEEEG3	174	Hydro turbine and governor. Represents plants with straightforward penstock configurations and hydraulic governors of traditional 'dashpot' type.
h6e	H6EU1	2	Hydro Turbine with American Governor Company controller.
hypid		0	Hydro turbine and governor. Represents plants with straightforward penstock configurations and proportional-integral-derivative governor. Includes capability to represent blade angle adjustment of Kaplan and diagonal flow turbines.
hyst1		0	Hydro turbine with Woodward Electrohydraulic PID Governor, Penstock, Surge Tank, and Inlet Tunnel.
hygov8		0	Hydro Governor Model for Up to 4 Units on Common Penstock.

Dynamic Models

- Perform comprehensive analysis on the dynamic models used for hydropower plants in WI and identify model limitations
- Develop a white paper on suggested changes for these models
- Use the white paper for outreach with MVS for further discussion on a path forward for dynamic model improvements

Workshop

Agenda:

- **S. Kincic (PNNL)** – Intro and hydro generation modeling gaps: 10 mins.
- **J. Undrill** – Overview of hydro generation representation and what is missing: 45 mins.
  - 5 min Q&A
- **S. Datta (PNNL)** – Presentation and Demo of hydro generation steady state and dynamic representation tool: 40 mins
  - Other presenters: **Sameer Nekkalapu, Dewei Wang, Bhaskar Mitra**
  - 5 mins Q&A
- **M. Vaiman (V&R Energy), T. Hussain (INL), and K. Sedzro (NREL)** – Integration of hydro generation tool with POM, demo, and preliminary study results: 40 mins
  - 5 min Q&A
- **S. Patterson (USBR)** "Hydro Governor Response": 30 mins
- Discussion and Q&A