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Addressing Hydropower Modeling Gaps with Hy-DAT

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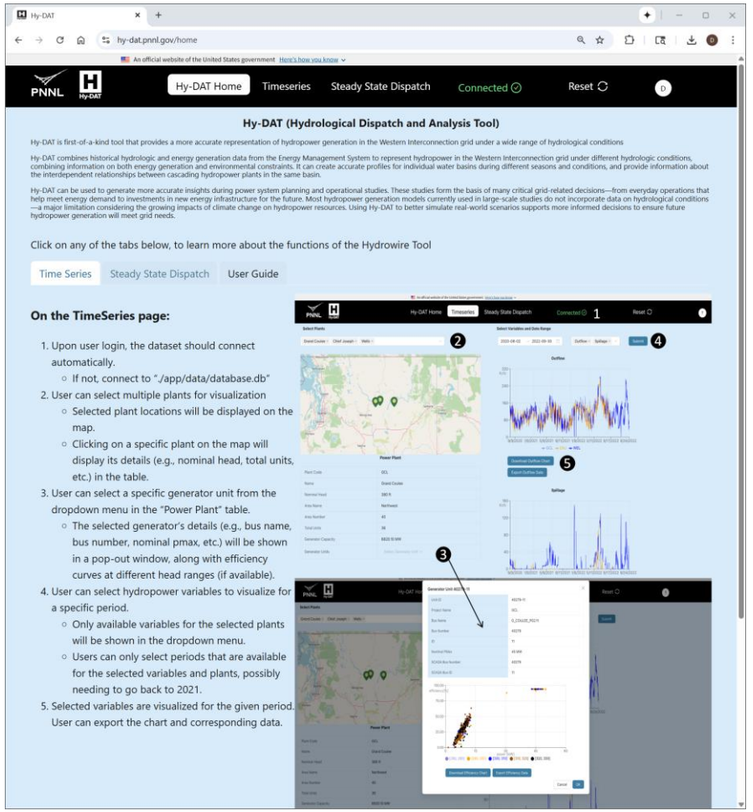
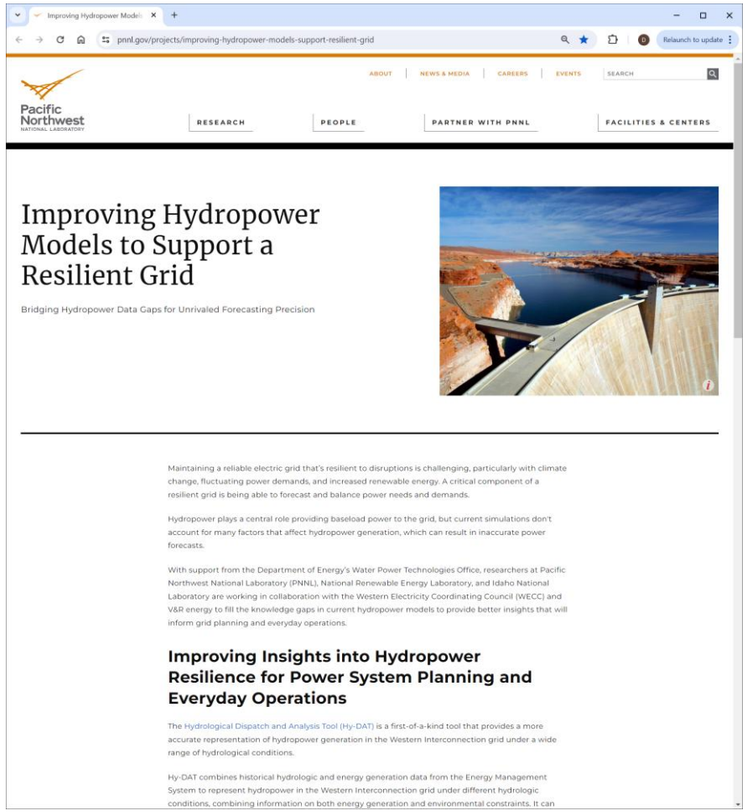
Hydrological Dispatch and Analysis Tool (Hy-DAT)

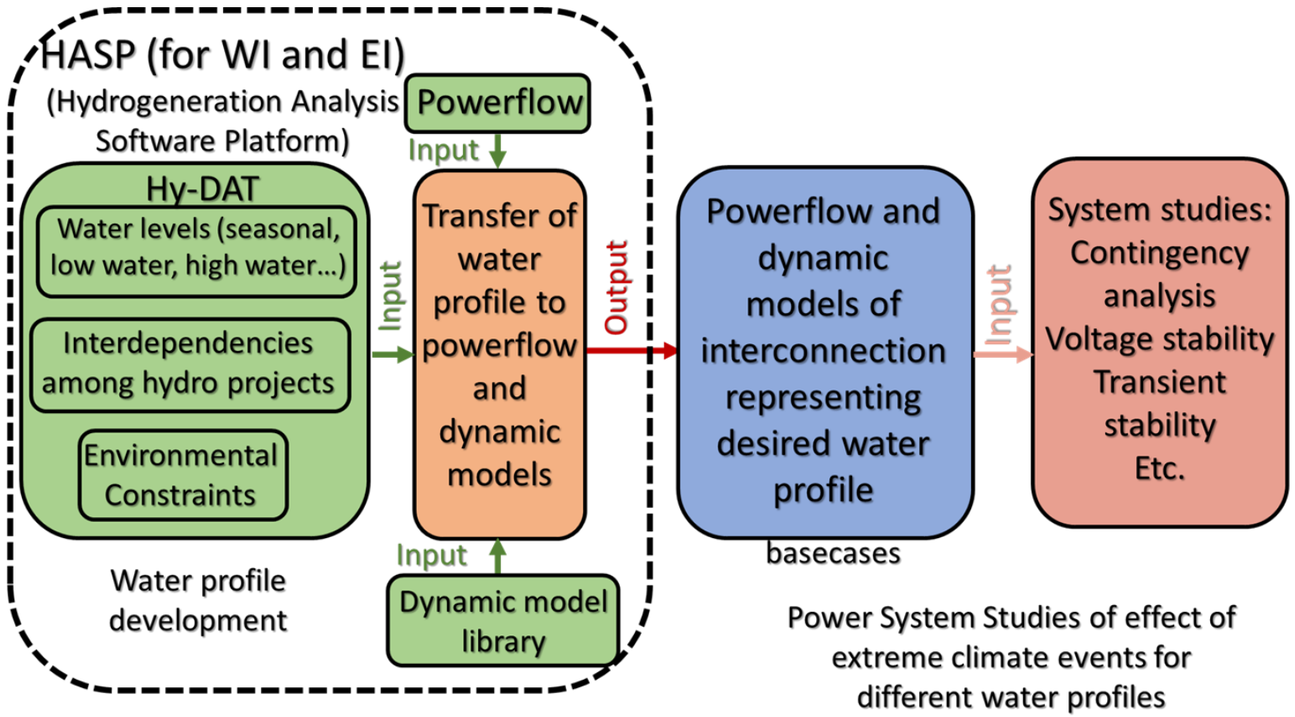
- **Status of Hy-DAT:**
  - The tool is externally accessible: https://hy-dat.pnnl.gov
    - ✓ Invite-only access (email required)
  - Overview of the tool and project:
    - ✓ https://www.pnnl.gov/projects/improving-hydropower-models-support-resilient-grid





Hydrological Dispatch and Analysis Tool (Hy-DAT)

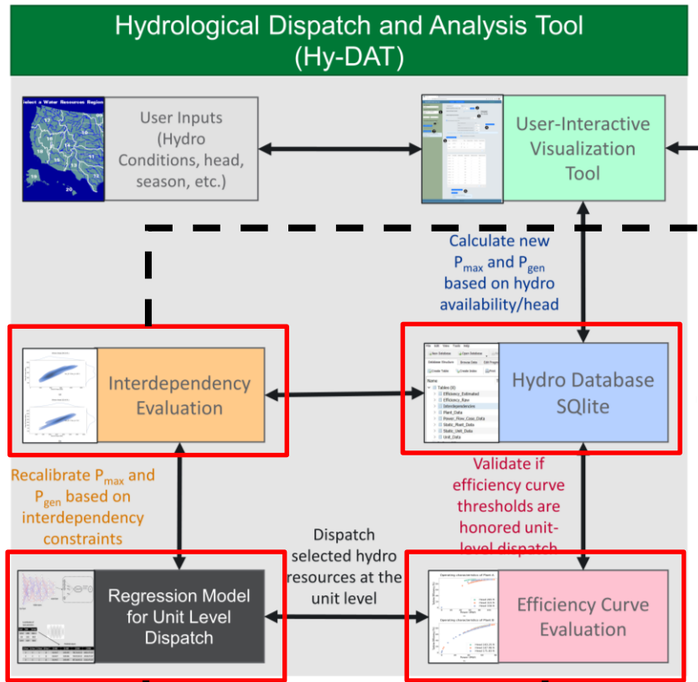
- Hy-DAT is a tool to update the existing steady state and dynamic model using **Interdependency**, **Efficiency Curves**, and **Unit Dispatch Models**.



- Hy-DAT in HASP: Generate Accurate **Representative Model** for Power System Simulation

Hydrological Dispatch and Analysis Tool (Hy-DAT)

- How does Hy-DAT work:



- **Interdependency**
  - This module uses seasonal hydrological information from upstream plant to limit the output of the plants downstream below the allowable limit.
- **SQL based database**
  - Static Hydro data containing plant information like nominal head, turbine rating, # of units, etc.
  - Historical Hydrology data containing plant head, flow, MW output, spillage, etc.
  - SCADA output – hydro unit level generation data from actual operations
- **Regression Model**
  - Merges SCADA data and hydrological data
  - An ML technique is used to learn the historical unit-level dispatch of hydro resources based on available head, flow, season, etc.
- **Efficiency Curve**
  - The tool uses historical hydrology data to generate a database for efficiency curves for various hydro units.
  - This is used when dispatching an unit based on user inputs making sure efficiency threshold is met.

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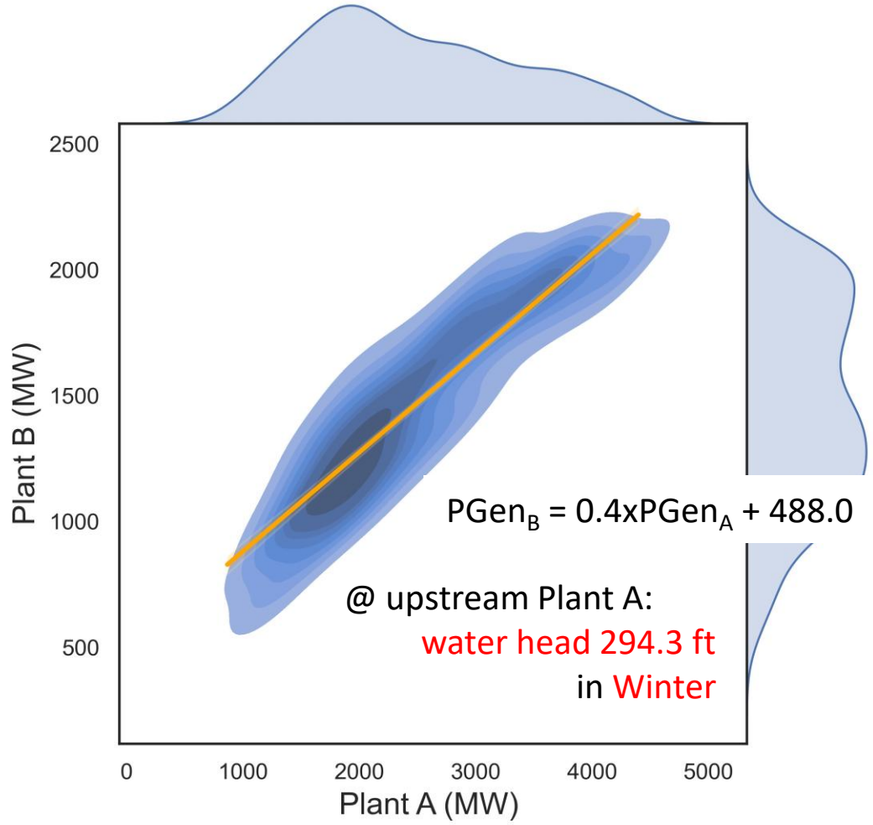
SQL Based Database

- **The Database contains three major sections:**
  - **Plant-level data:**
    - ✓ Timeseries and Generic hydrological data
    - ✓ Released: 23 WI plants, 10 years of data (2013-2023)
    - ✓ Upcoming: 14 EI plants, 3 years of data (2022-2025)
  - **Unit-level data:**
    - ✓ Timeseries and Static electrical data, Planning cases
    - ✓ Released: 27 WI plants
    - ✓ Upcoming: 13 EI plants
  - Others:
    - ✓ **Efficiency curves**: calculated efficiencies of individual generators
    - ✓ **Interdependency**: correlate the generation patterns of the upstream and downstream rivers
    - ✓ **Dispatch models**: relationship between the hydrological and electric data

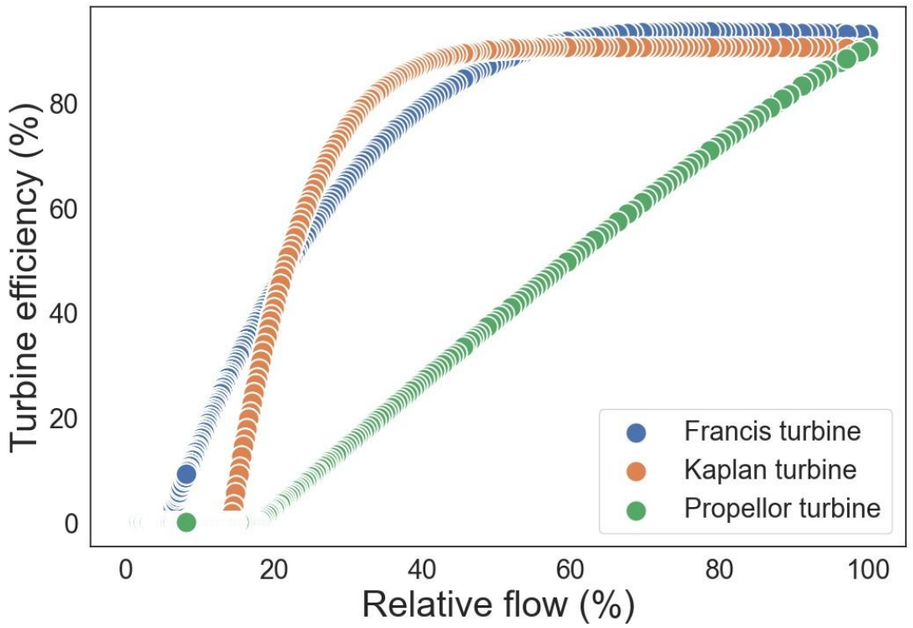
Interdependency (Data-Driven)

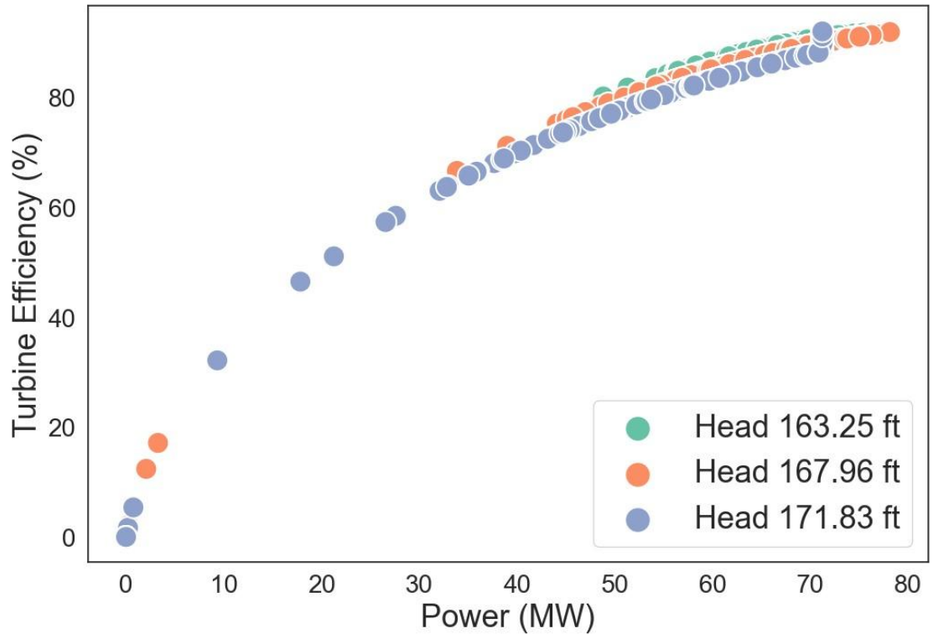
- **Train: Build a time correlation between streamflow data**
  - Evaluate overall correlation between upstream and downstream plants
  - Divide power outputs into four seasons and piecewise head ranges
  - Build linear regression correlations for each head range and season
- **Apply:**
  - When conducting dispatching, check the restriction from the upstream plant on the power output



Efficiency Curve

- **Efficiency Curve Evaluation:**
  - Efficiency curves for different turbines and different head conditions were estimated with HydroGenerate.
- **Apply:** dispatch results will be validated with online units' efficiency curves





Regression Model

- DNN-based regression models were built to correlate water head, total power output, water storage with individual generator's status and power output.

1. Group Units

number of each category

power outputs of each category

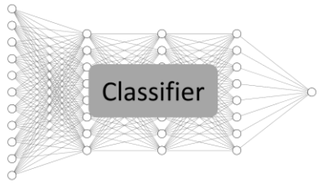
timestamp	C0-Num	C1-Num	C2-Num	C3-Num	C0-MW	C1-MW	C2-MW	C3-MW
1514786400	0	1	0	15	0.0	168.960	0.0	1586.76
...								
1533096000	0	2	1	14	0.0	1131.74	612.58	1335.02
1533099600	0	2	1	14	0.0	963.30	626.58	901.30
1533103200	0	0	1	14	0.0	0.0	625.47	1217.45

2. Train Group-based

Model inputs

power	head	storage
2086	326.8	8802.12
1852	328	8809.95
1829	328.9	8809.95

Step 1:



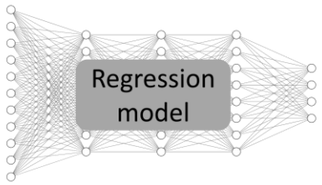
Model outputs

C1-Exist	C1-MW	C1-unitMW
0	0	0
1	12	4
1	28.43	14.215

Model inputs

power	head	storage
2086	326.8	8802.12
1852	328	8809.95
1829	328.9	8809.95

Step 2:



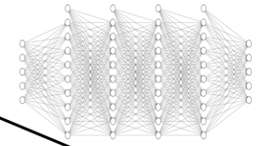
Model outputs

C1-Exist	C1-MW	C1-unitMW
0	0	0
1	12	4
1	28.43	14.215

3. Predict Group-based

A combination of input parameters

head	MW	storage
326.8	2086	8802.1
328	1852	8810
328.9	1829	8810



Predicted outputs

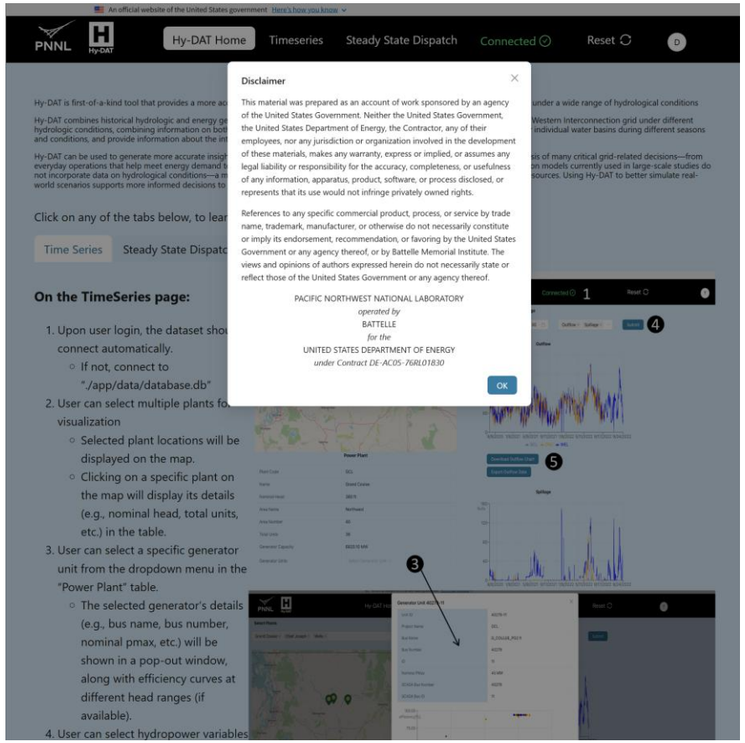
C0-Num	C1-Num	C2-Num	C3-Num	C0-MW	C1-MW	C2-MW	C3-MW
0	0	2	15	0±8.4417	0±90.696	780.72±240.32	1468.1±79.287
0	0	2	15	0±8.4417	0±90.696	749.07±240.32	1459.8±79.287
0	0	2	15	0±8.4417	0±90.696	807.18±240.32	1518.2±79.287

4. Break Groups into Units

Project	Unit ID	Head (ft)	P_{max} (MW)	Dispatch Status	$P_{gen\ calculated}$ (MW)	$P_{max,available}$ (MW)
Plant A	1-1	307.1	707	1	361	513.65
Plant A	2-1	307.1	707	1	361	513.65
Plant A	3-1	307.1	707	1	361	513.65
Plant A	4-1	307.1	825.7	0	0	599.88
Plant A	5-1	307.1	825.7	1	553.97	599.88
Plant A	6-1	307.1	825.7	1	553.97	599.88
Plant A	7-1	307.1	125	1	79.48	90.81
Plant A	7-2	307.1	125	1	79.48	90.81
Plant A	7-3	307.1	125	1	79.48	90.81

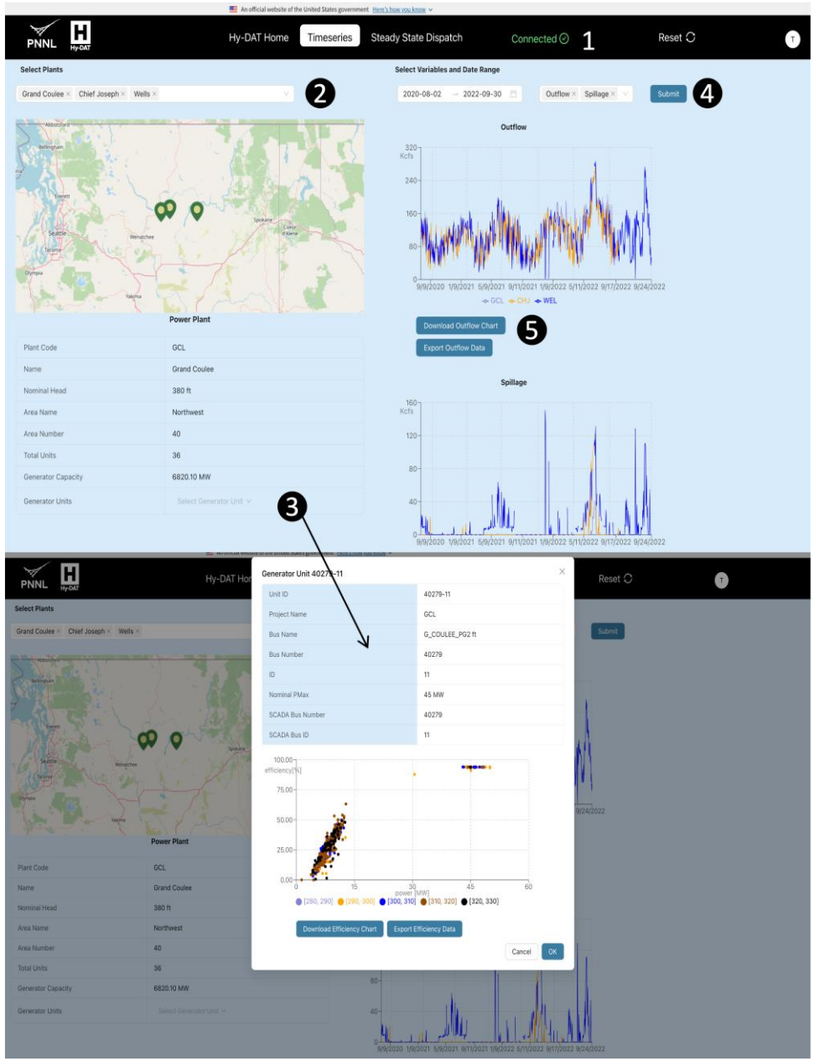
Hydrological Dispatch and Analysis Tool (Hy-DAT)

- **Functions of Hy-DAT:**
  - Landing page (https://hy-dat.pnnl.gov/home):
    - ✓ Provides quick instructions and a detailed User Guide (PDF)
  - Visualization (https://hy-dat.pnnl.gov/timeseries):
    - ✓ View general information about hydro plants and generators
    - ✓ Visualize historical hydropower data for a selected time period
  - Dispatching (https://hy-dat.pnnl.gov/steadystatedispatch):
    - ✓ Perform dispatching of one or more hydro plants based on user-defined inputs (e.g., water head, dispatch threshold, season, storage)
    - ✓ Results are “dispatch status” and “unit-level power”, can be exported for further analysis
    - ✓ There are one-click “Dispatch All” and “Export All” buttons allow fast analysis across many plants



On the "TimeSeries" Page, users can:

- **1. Select multiple plants**
  - visualize their location
  - display plant-level generic information
- **2. Select specific unit/generator**
  - display its nominal power, etc.
  - visualize its efficiency curve
- **3. Select multiple hydrological parameters and date range**
  - visualize and export historical recordings of each hydro-power variable



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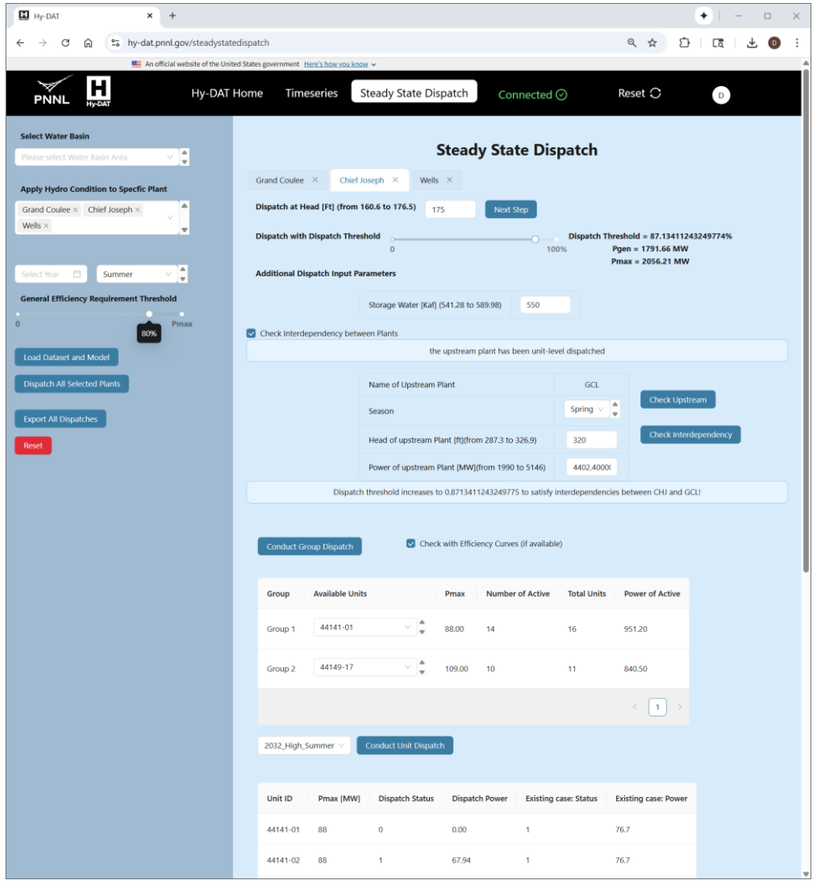
On the “Steady State Dispatch" Page, users can:

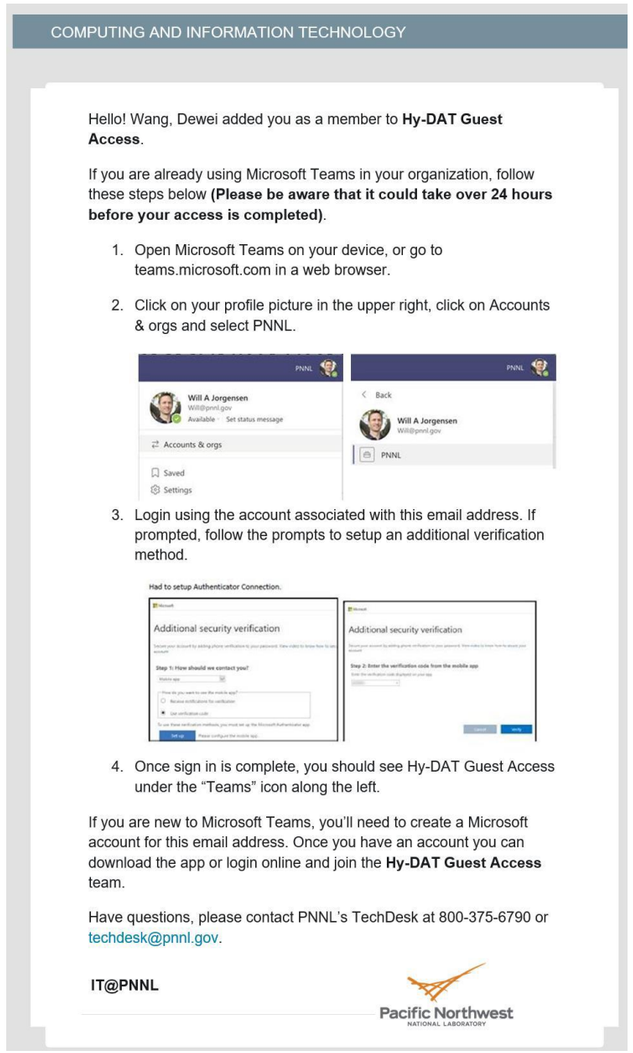
- **1. Select plants to be dispatched**
  - specify year, season and general dispatch threshold (reference and valid ranges provided)
- **2. Check interdependency**
  - adjust dispatch threshold accordingly
- **3. Conduct dispatching**
  - predict group-based dispatch results
- **4. Check with efficiency curves**
  - adjust results to satisfy generators' efficiency curves
- **5. Distribute within groups**
  - randomly distribute dispatch power to individual units
- **6. Quick analysis:** "Dispatch All", "Export All"



Hydrological Dispatch and Analysis Tool (Hy-DAT)

- **Accessing Hy-DAT (https://hy-dat.pnnl.gov):**
  - Guest provides the owner (dewei.wang@pnnl.gov) with an email (must be registered with Microsoft Teams)
  - Owner sends an invitation (see instructions on the right)
  - Guest follows the registration steps provided in the invitation email
  - With Microsoft Teams running in the background, the guest should be able to access the Hy-DAT tool

Note. A more detailed instruction PDF is attached for reference.



COMPUTING AND INFORMATION TECHNOLOGY

Hello! Wang, Dewei added you as a member to **Hy-DAT Guest Access**.

If you are already using Microsoft Teams in your organization, follow these steps below **(Please be aware that it could take over 24 hours before your access is completed)**.

1. Open Microsoft Teams on your device, or go to teams.microsoft.com in a web browser.
2. Click on your profile picture in the upper right, click on Accounts & orgs and select PNNL.

3. Login using the account associated with this email address. If prompted, follow the prompts to setup an additional verification method.

4. Once sign in is complete, you should see Hy-DAT Guest Access under the "Teams" icon along the left.

If you are new to Microsoft Teams, you'll need to create a Microsoft account for this email address. Once you have an account you can download the app or login online and join the **Hy-DAT Guest Access** team.

Have questions, please contact PNNL's TechDesk at 800-375-6790 or techdesk@pnnl.gov.

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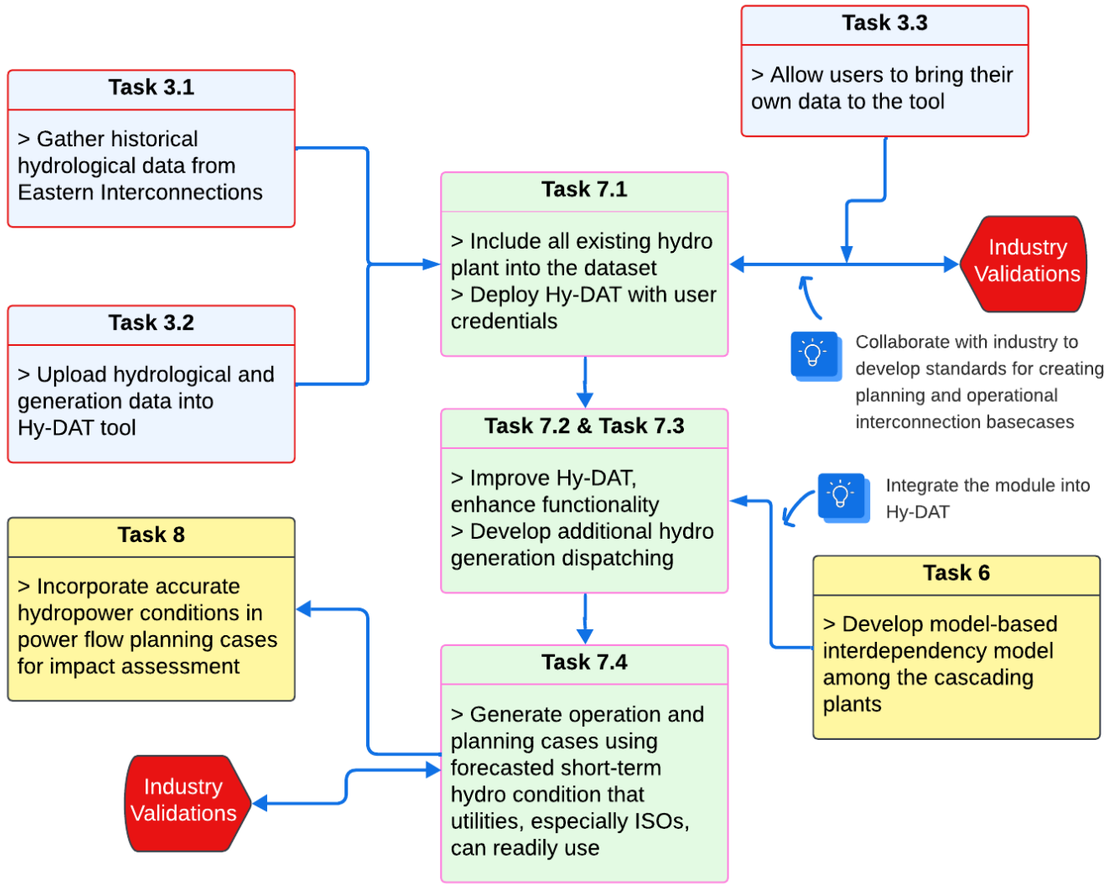
Hydrological Dispatch and Analysis Tool (Hy-DAT)

- **How will Hy-DAT be improved in FY26 and FY27:**



Upcoming Changes in FY26 and FY27

- Eastern interconnection data has been collected, will be analyzed and added to Hy-DAT.
- Users will be able to upload and use their own data in the tool