CIGRE Grid of the Future (GOTF) Symposium 2023

Hydropower Resilience Database for Assessing Microgrid Formation Capability and Enhancing Power Grid Resilience

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Idaho National Laboratory

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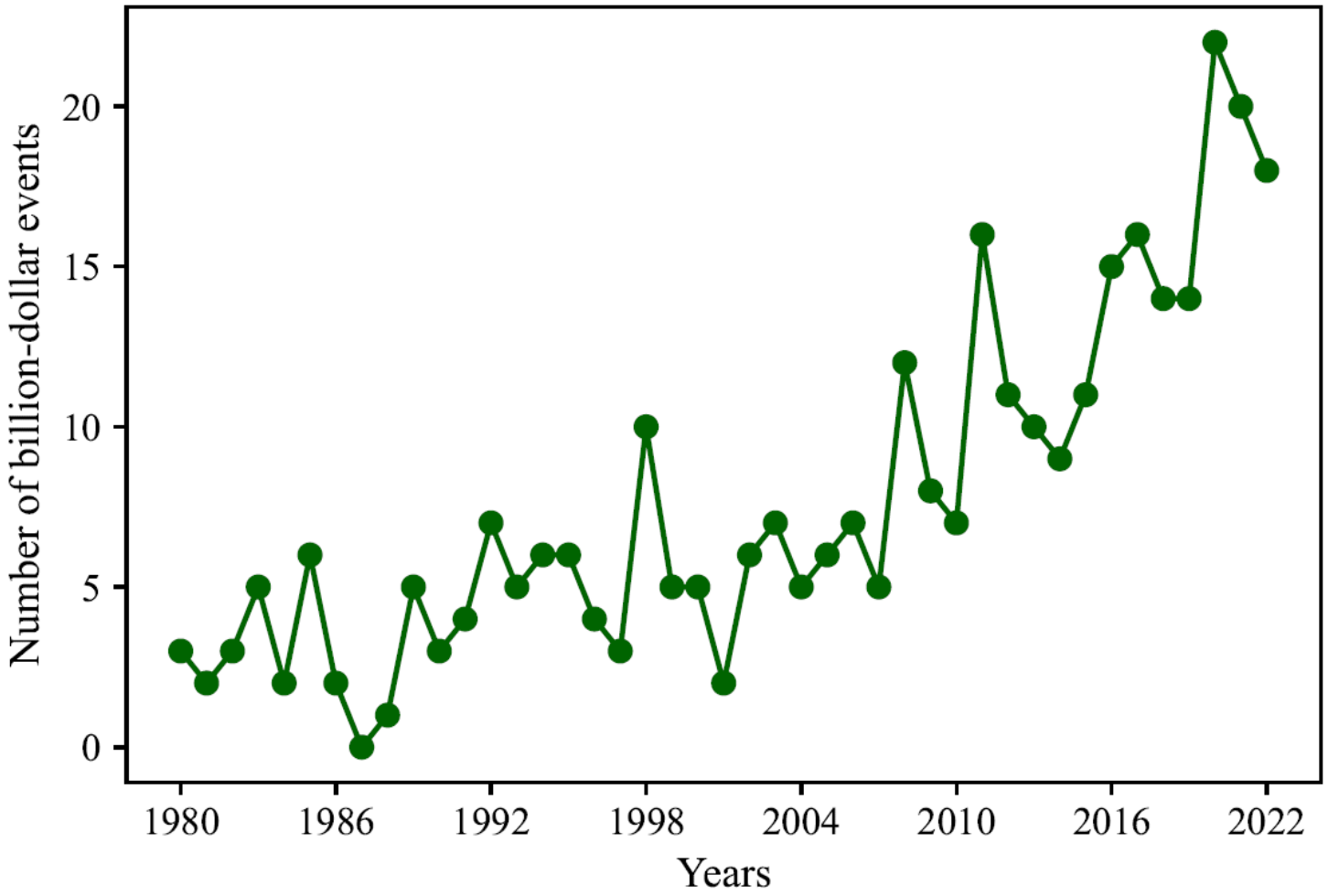
Introduction

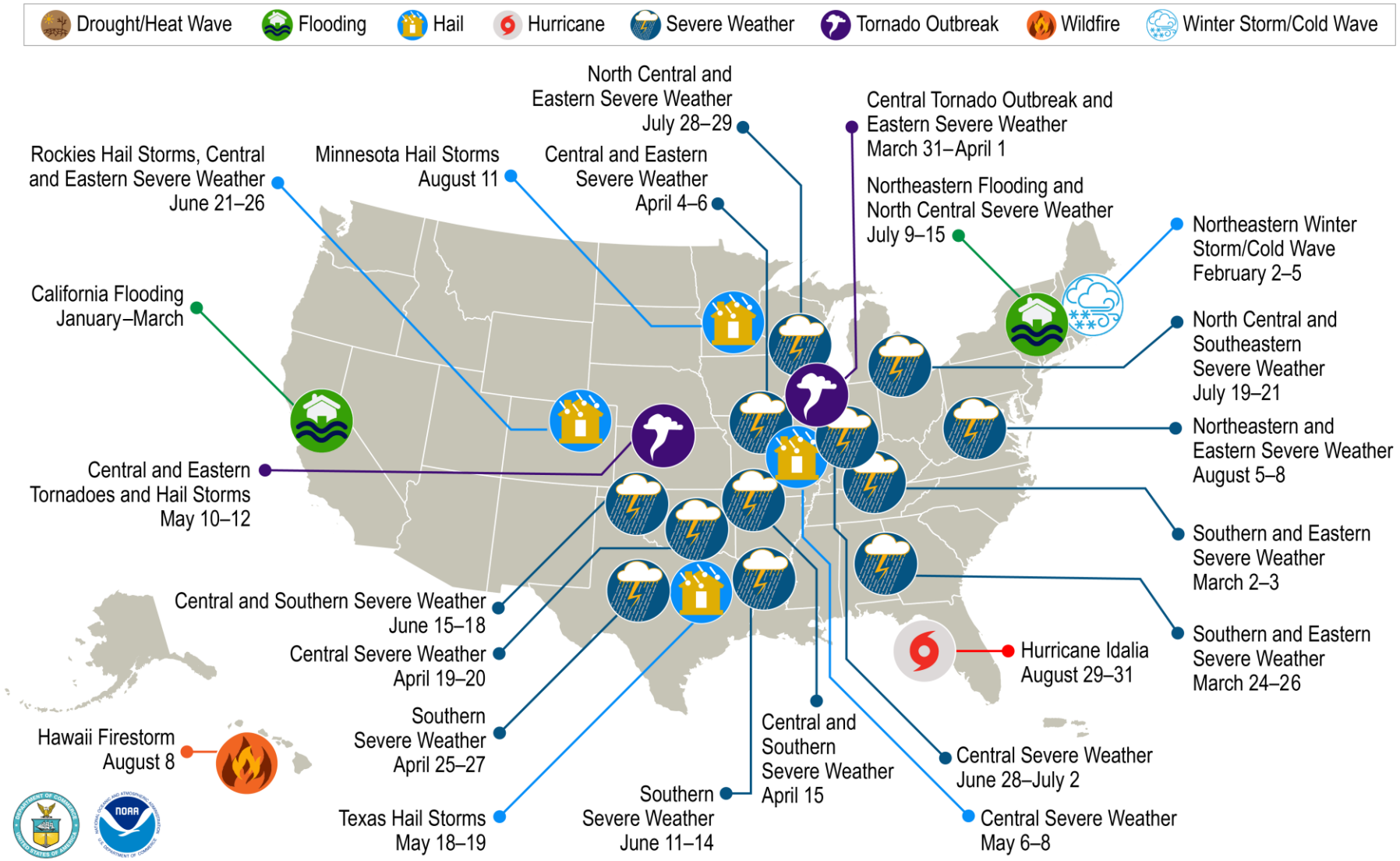
- In recent years, modern power systems have encountered significant challenges in maintaining reliable electricity access and availability in the face of extreme weather events and other high-impact low-probability disruptions.
- These events have caused damages to major power system equipment resulting in system wide prolonged outages.
- Catastrophic weather events and subsequent outages have jeopardized the electric utilities' objective of providing reliable and resilient electricity services to its customer.

Frequency of Weather Induced Disasters



Source: Gautam, Mukesh. "Distribution System Resilience Enhancement Using Movable Energy Resources." PhD diss., 2022.

U.S. 2023 Billion-Dollar Weather and Climate Disasters



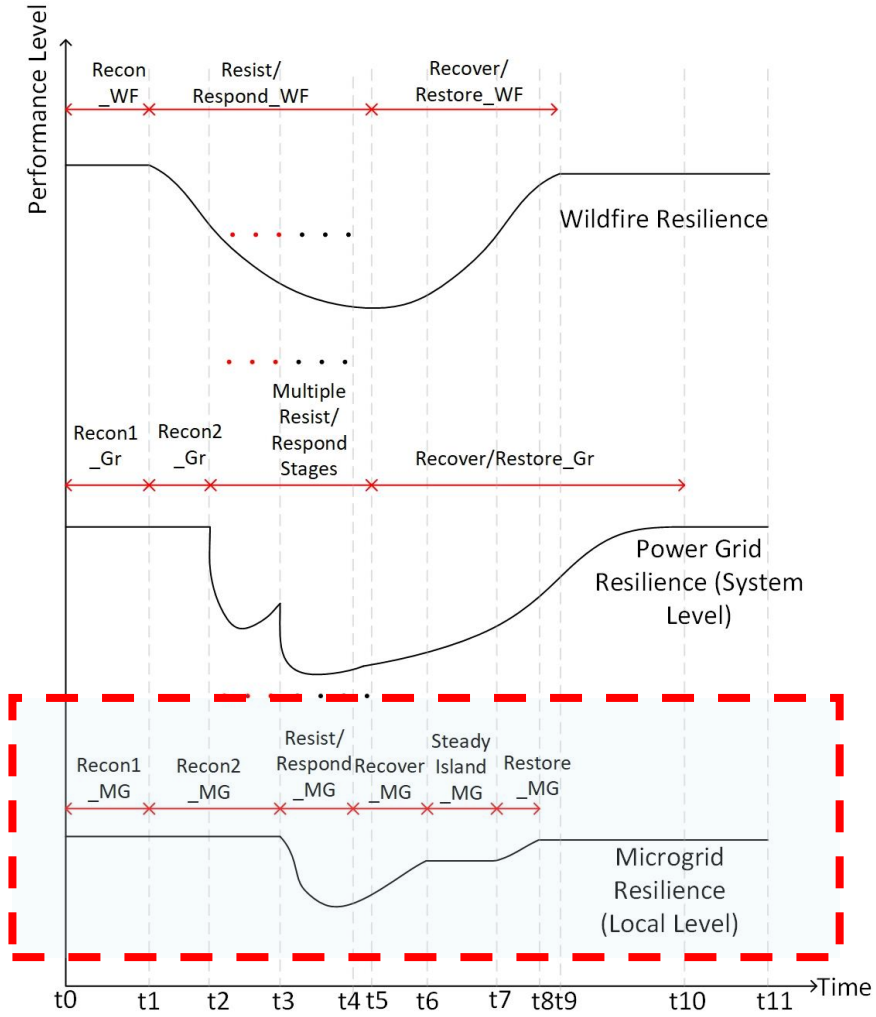
This map denotes the approximate location for each of the ***23 separate billion-dollar weather and climate disasters that impacted the United States through August 2023.***

Source: https://www.ncdc.noaa.gov/billions/

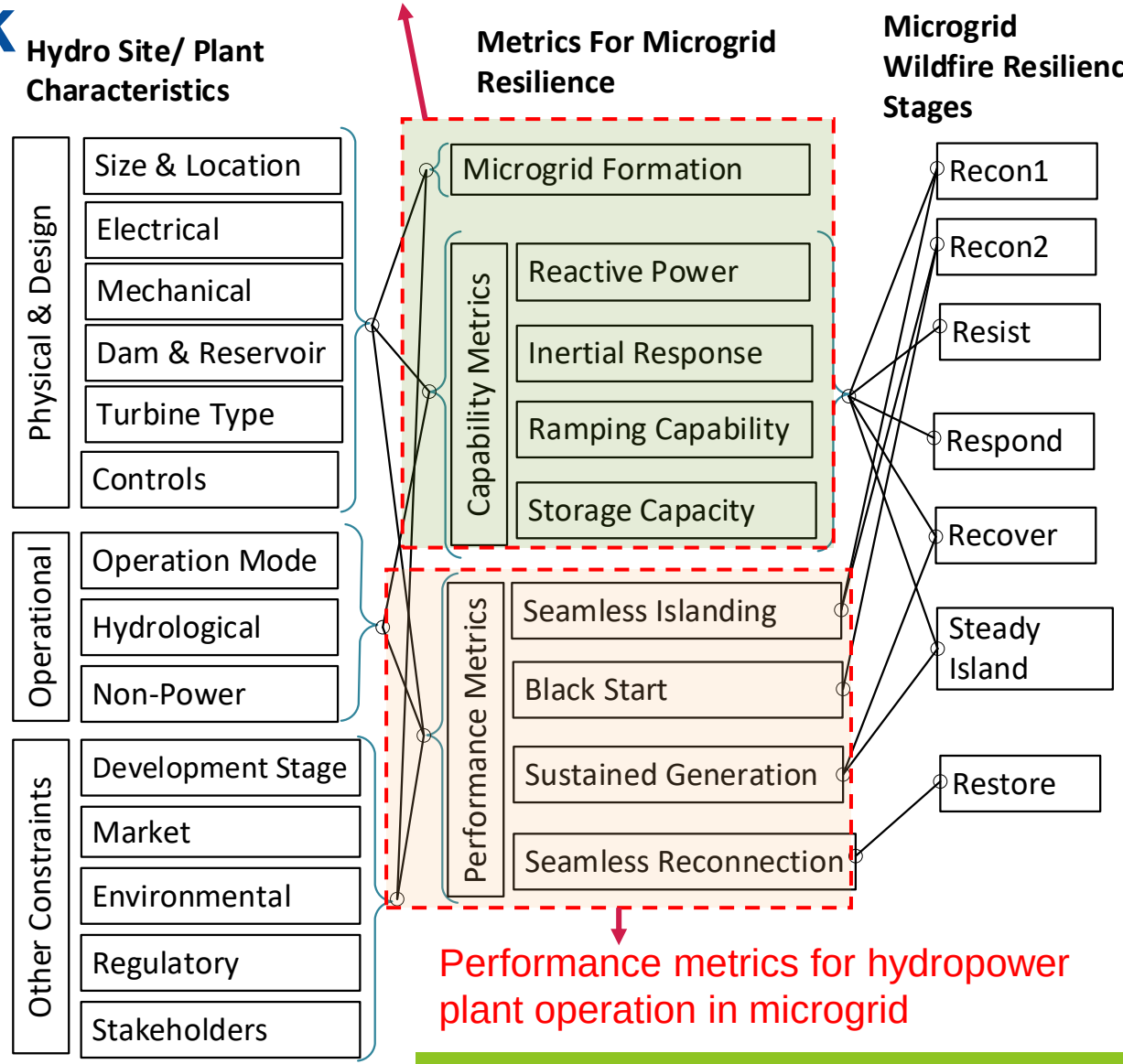
Introduction (contd..)

- In response to the extreme events, there is a pressing need to explore innovative approaches to enhance the resilience and reliability of energy infrastructure in vulnerable regions.
- Distributed Energy Resources (DERs) and microgrids with hydropower plants have emerged as potential solutions for withstanding and recovering from the catastrophic effects of weather-related disasters like wildfires.
- Understanding the capabilities and limitations of hydropower plants is essential for evaluating their suitability in forming resilient microgrid.
- Therefore, this research paper presents the development of the Hydropower Resilience Database (HRD), leveraging data from reputable sources, to assess microgrid formation capability of hydropower plants and their potential contributions in enhancing resilience.

Hydropower Resilience Characterization Framework



Screening and Capability Metrics for hydropower plant characterization



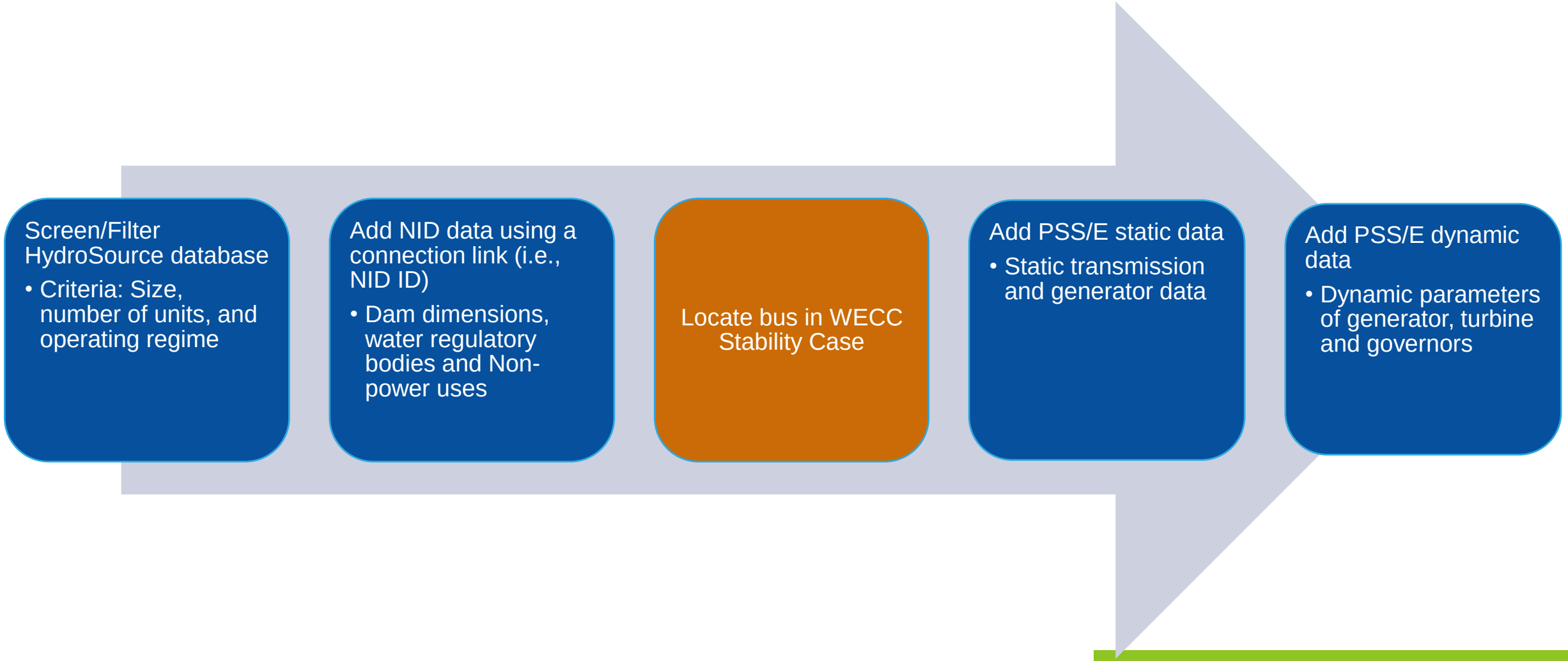
Performance metrics for hydropower plant operation in microgrid

1. B. Poudel, S. M. S. Alam, A. Medam, F. Gallego-Dias, and T. McJunkin, "Hydropower Evaluation Framework for Wildfire Resilient Microgrids." 2023 IEEE Power & Energy Society General Meeting (PESGM), Orlando, FL, USA.(Also presented in HydroVision International 2023)

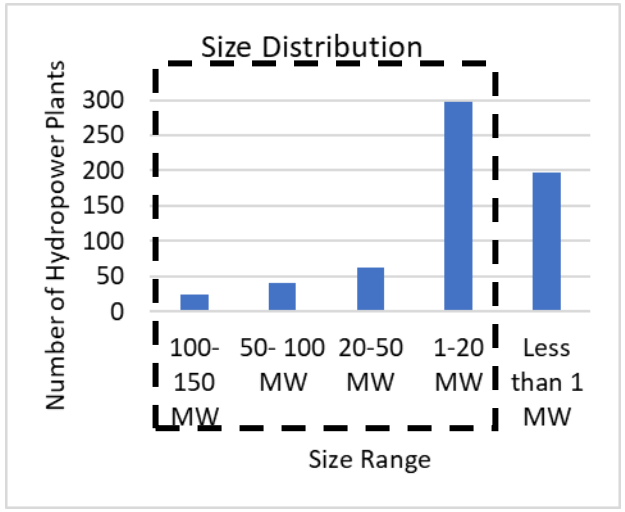
Hydropower Resilience Database

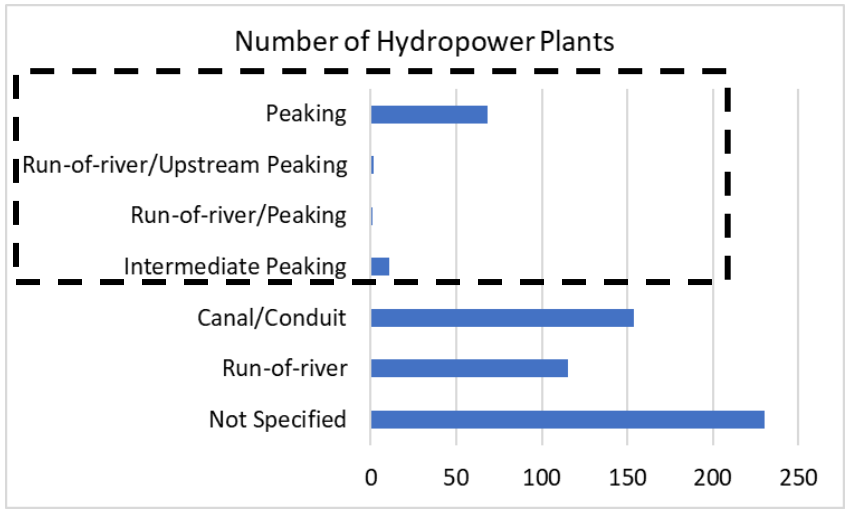
- Oakridge National Laboratory (ORNL) HydroSource provides valuable information on hydropower plants, but it lacks specific details necessary for evaluating their capability and performance to support resilience functions in microgrids.
- The Hydropower Resilience Database (HRD) is developed using power plant, dam infrastructure, water body and the connected utility grid information from various sources, including ORNL HydroSource, National Inventory of Dams (NID) database, and WECC Stability cases.
- The hydropower characterization metrics are scored and integrated as a part of HRD. These metrics can inform hydropower plant owners, utilities, communities and microgrid planners the feasibility of using given hydropower resource in resilience-focused microgrids.
- HRD provides necessary parameters to model hydropower plant in grid simulation and microgrid planning tools to carry out the impact analysis.
- HRD also offers a database for evaluating and designing hydro-based microgrids for resilience events other than wildfires (e.g., flood, snowstorm).

Hydropower Resilience Database Development



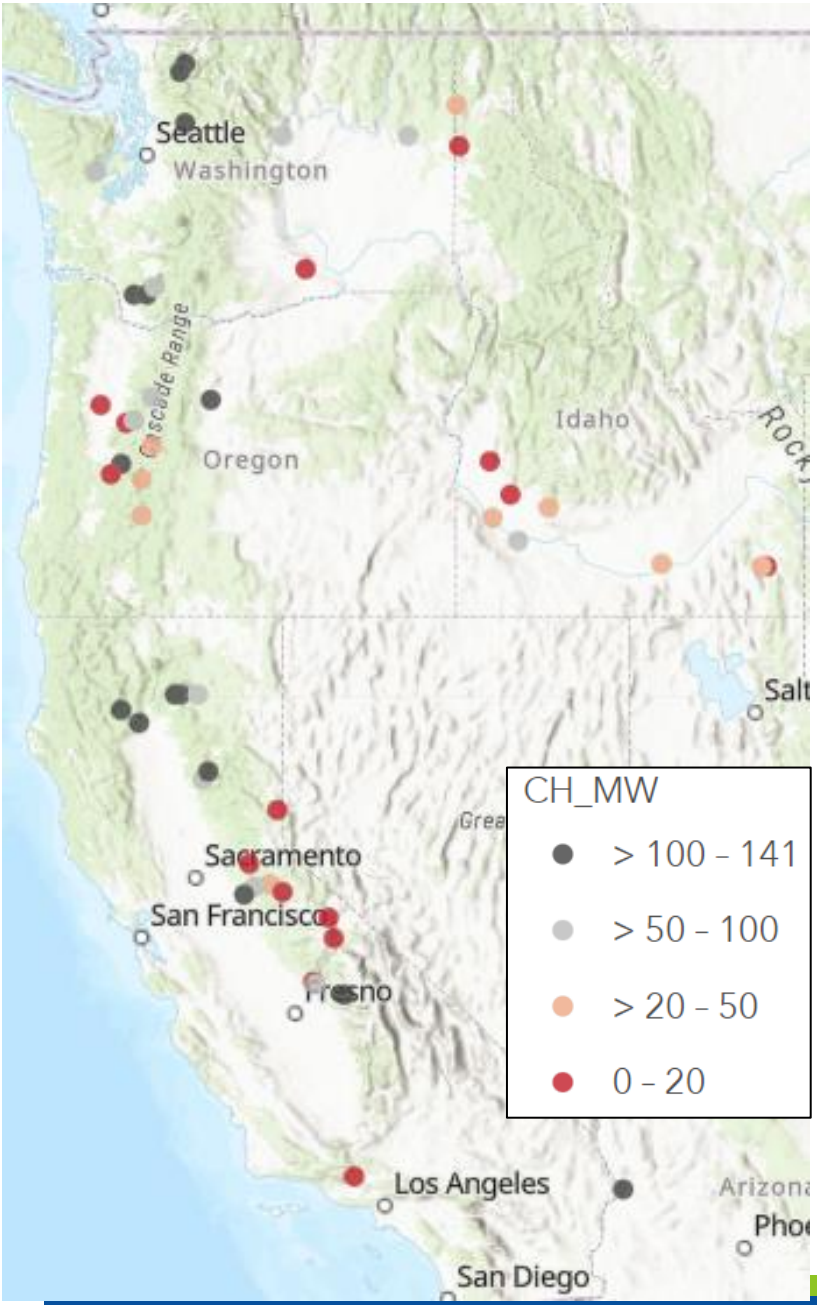
Hydropower Resilience Database



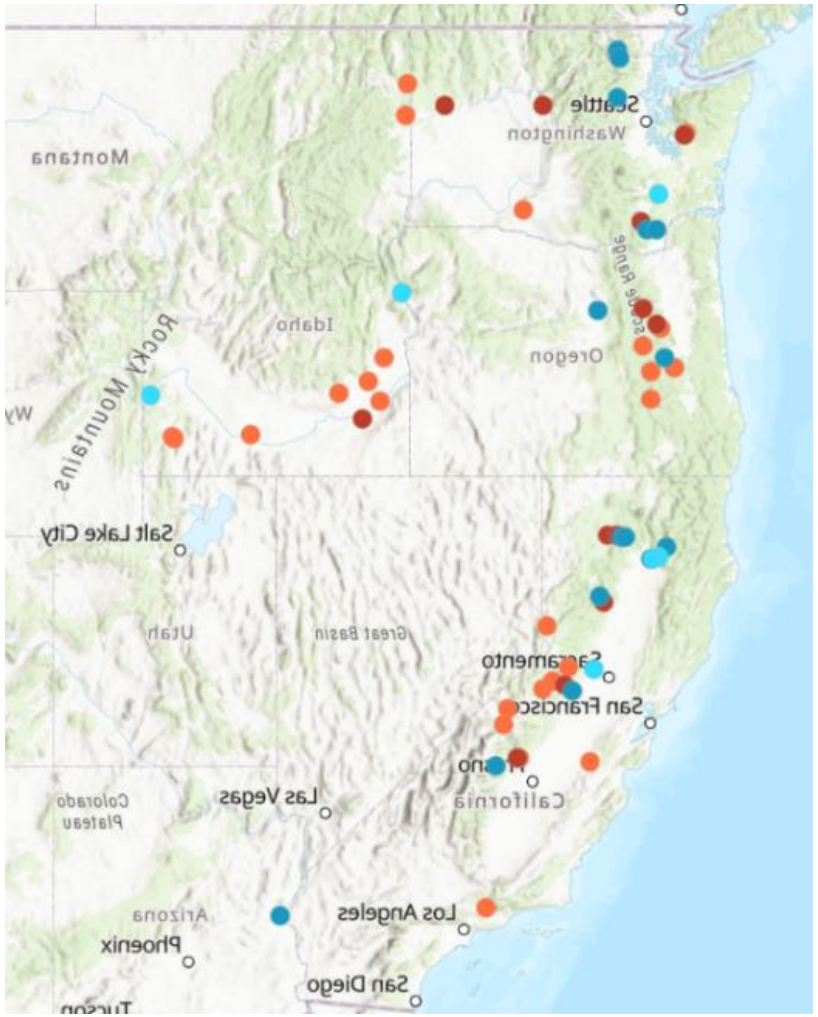


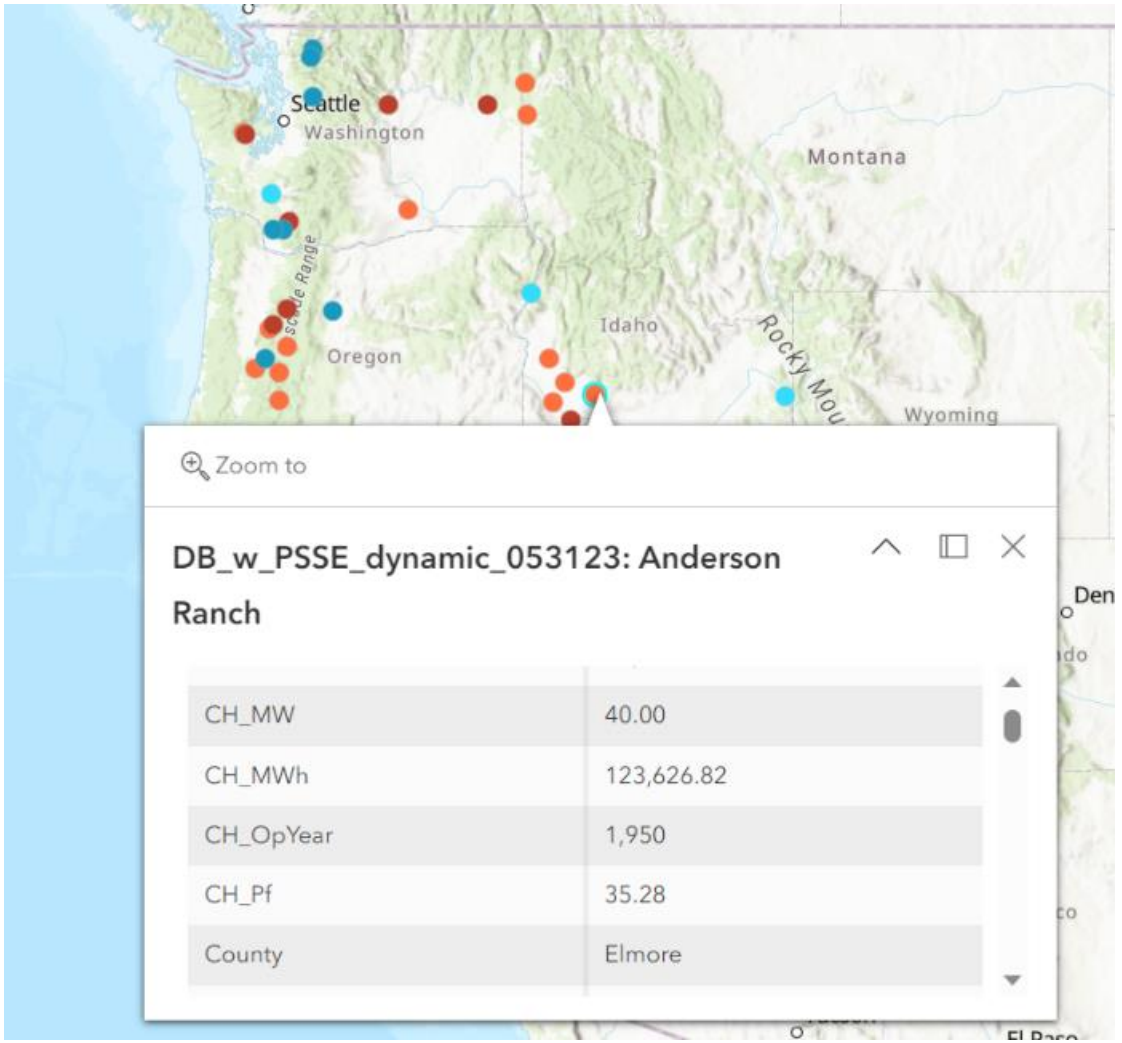
Parameters	Data Type
Plant Identifier	*int*
Name	*string*
Plant Type	*str*
Plant Size	*float*
Number of Units	*int*
Plant ownership	*str*
Operating Mode	*[str]*
Turbine Type	*str*
Inertia Constant	*float*
Gov Time Constant	*float*
Gate Rate Limit	*[float]*
Speed Droop	*float*
Reactive Power	*[float]*
Transmission Ownership	*str*
Reservoir Size/Dimension	*[float]*
Non-power Applications	*[str]*
Hydraulic Head	*float*
Water Regulatory	*[str]*

Data source: ORNL Hydrosource, WECC Stability cases, National Inventory of Dams.



Database Visualization using ArcGIS Interactive Map





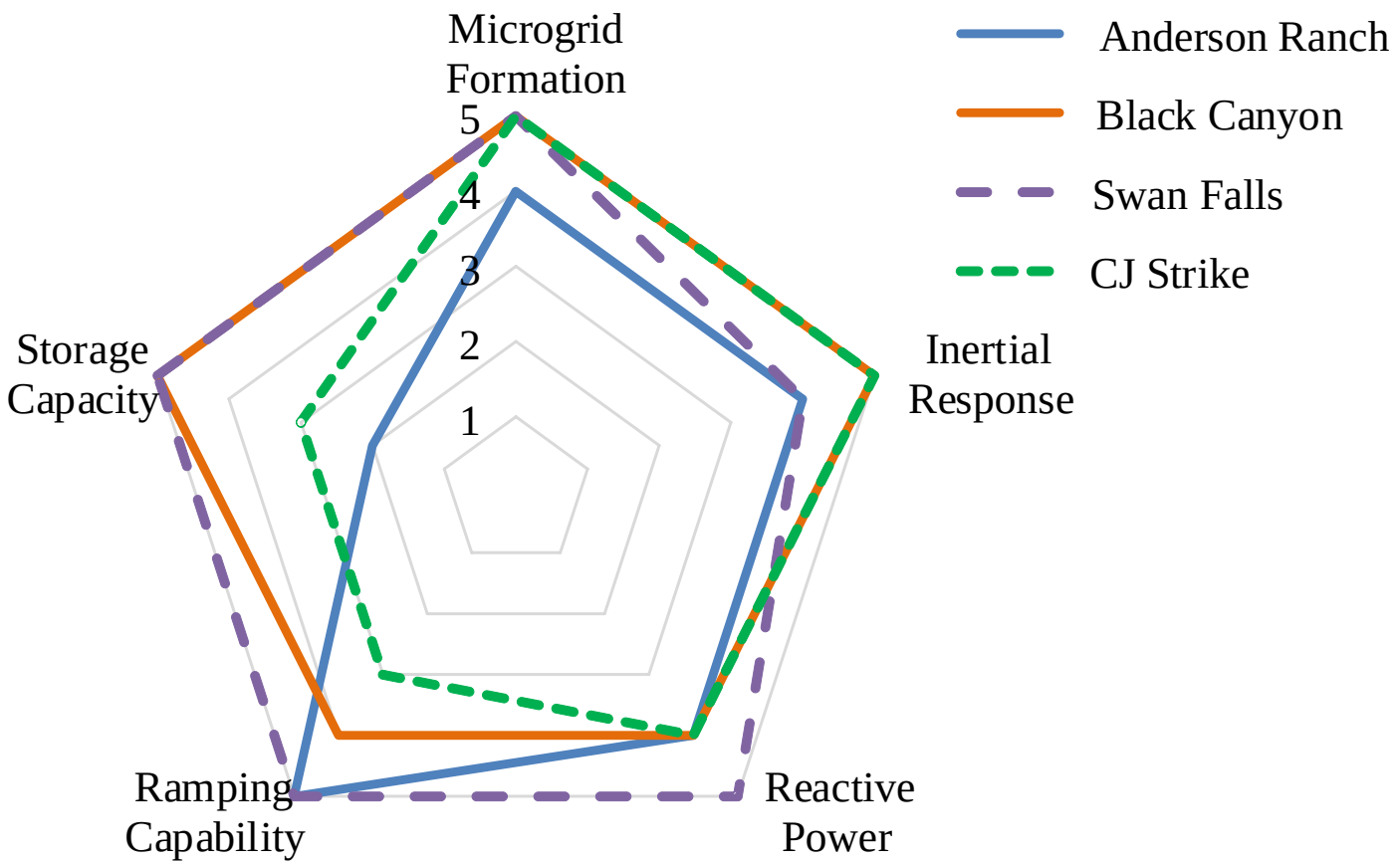
Hydropower Characterization Metrics

- **Microgrid formation:**
  - Qualitative screening considering technical and regulatory constraints.
- **Storage capacity:**
  - Determines the ability to provide continuous power during extended outages.
- **Reactive power capability:**
  - Supports efficient distribution of active power to end-users.
- **Inertial response:**
  - Critical for stabilizing frequency during microgrid operation.
- **Ramping capability:**
  - Essential for adapting to changing load conditions or power output changes.

Hydropower Characterization Metrics Scoring

- **Microgrid formation (0-5):**
  - Dam ownership (0-1), primary purpose (0-1), Sector (0-1), plant ownership (0-1), age (0-1).
- **Storage capacity (0-5):**
  - Duration served at rated capacity when full (0-5)
- **Reactive power (0-5):**
  - Reactive power increase limit (0-2.5), reactive power decrease limit (0-2.5)
- **Inertial response (0-5):**
  - Inertia constant (0-5)
- **Ramping capability (0-5):**
  - Ramping delay (0-1), ramping up rate limit (0-1), ramping down rate limit (0-1), permanent droop (0-1), temporary droop (0-1).

Hydropower Characterization Metric Scores



Conclusion

- In this paper, a framework for the development of a comprehensive Hydropower Resilience Database (HRD) and visualization tool to assess hydropower plants' potential in forming microgrids and strengthening grid resilience.
- The HRD possesses the following characteristics:
  - informs stakeholders of hydropower candidates suitable for forming microgrids in wildfire-prone areas,
  - provides database necessary to perform performance analysis
  - provides scores on different capabilities identifying strength and weaknesses requiring investment.
- Although the study centered on hydropower plants in wildfire-prone regions, the proposed approach and developed database is equally relevant to enhancing grid resilience in other contexts as well.

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