Washington State Academy of Sciences

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Commonly Used Power Supply Terms/Metrics

- **Energy**: power generated or conserved across a period of time (i.e., months, years) to serve system demands for electricity (a function of generation capability, available fuel and power demand).
- **Peaking Capacity**: capability of power generating resources to satisfy maximum system demands for electricity at a specific point in time.
- **Flexibility**: ability to continuously and reliably match generating and demand-side resources to system demands for electricity.

Three Different Time Dimensions

- **Energy**: provide service across periods much longer than an hour (e.g., months, years)
- **Peak Capacity**: provide service for an hour or for a limited number of hours
- **Flexibility**: on an ongoing basis, increase or decrease generation moment by moment to balance within-hour scheduling mismatches

In the Northwest, Peaking Capacity Has Several Important Sub-Timeframes

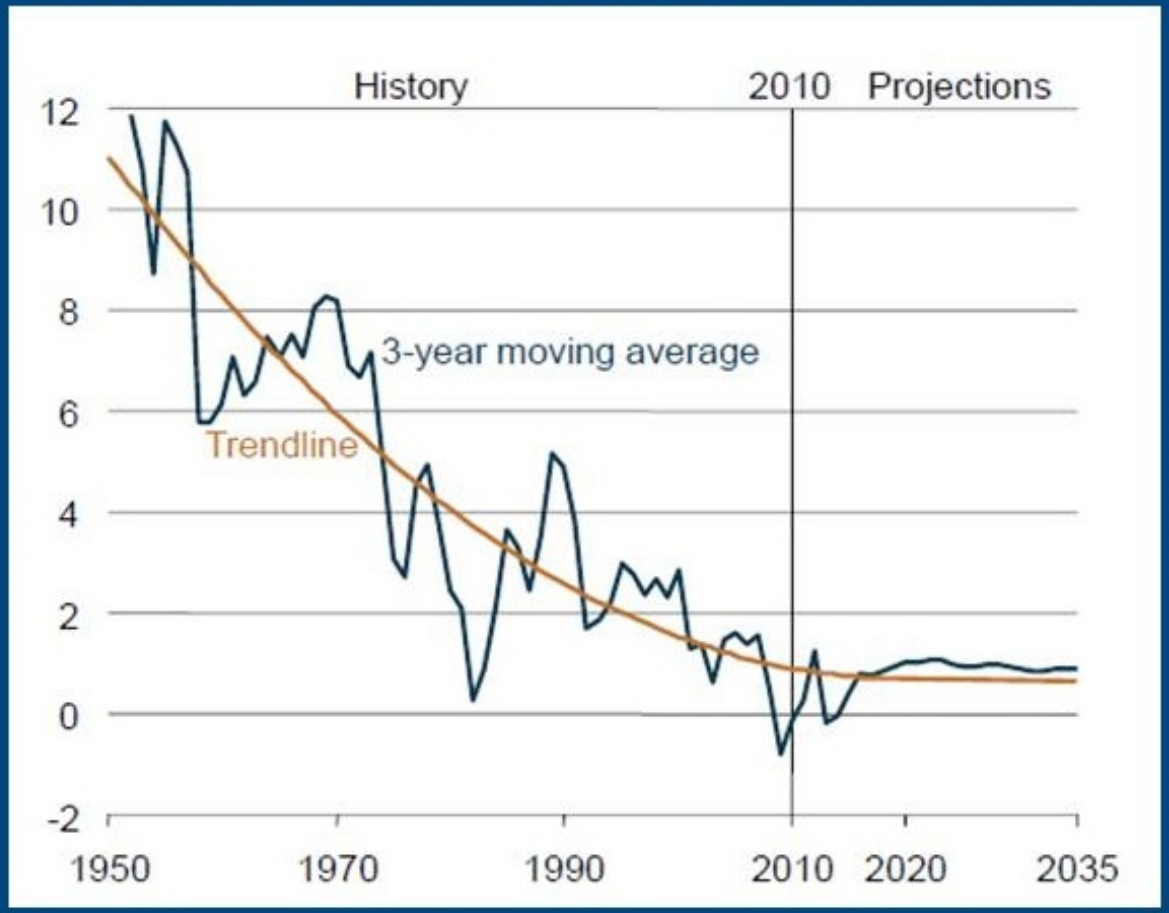
- **Single-Hour Peaking Capacity**: Maximum power system capability during the peak hour of demand
  - Typical metric used in other regions that rely on thermal generation
- **Sustained Peaking Capacity**: Maximum average power system capability during a limited number of heavy load hours for one or more days
  - Multiple metrics used in the Northwest due to limitations on our region's hydro storage
  - Single-hour hydro capacity is over 34,000 MW but cannot sustain that beyond a few hours
  - 120 hour capacity: indicative of ability to meet expected peak loads day after day over month (6 hours per day, 5 days per week, 4 weeks per month)
  - 18 hour capacity: indicative of ability to meet peak loads over 6 peak load hours for 3 consecutive days during 3-day extreme weather event

Each Type of Resource Can Provide Unique Mix of Energy, Capacity and Flexibility

Resource Type	Provides Energy	Can be Dispatched	Provides Add'l Peaking Capacity	Provides Flexibility
Hydro	Yes	Yes	Yes	Yes
Coal	Yes	Yes	Not normally	Not normally
Natural Gas	Yes	Yes	Yes	Not normally
Nuclear	Yes	Yes	No	No
Wind	Yes	No	No	No
Solar	Yes	No	No	No
Storage (e.g., battery)	No	Yes	Yes	Yes
Energy Efficiency	Yes	No	No	No
Demand Response	No	Yes	Yes	Yes

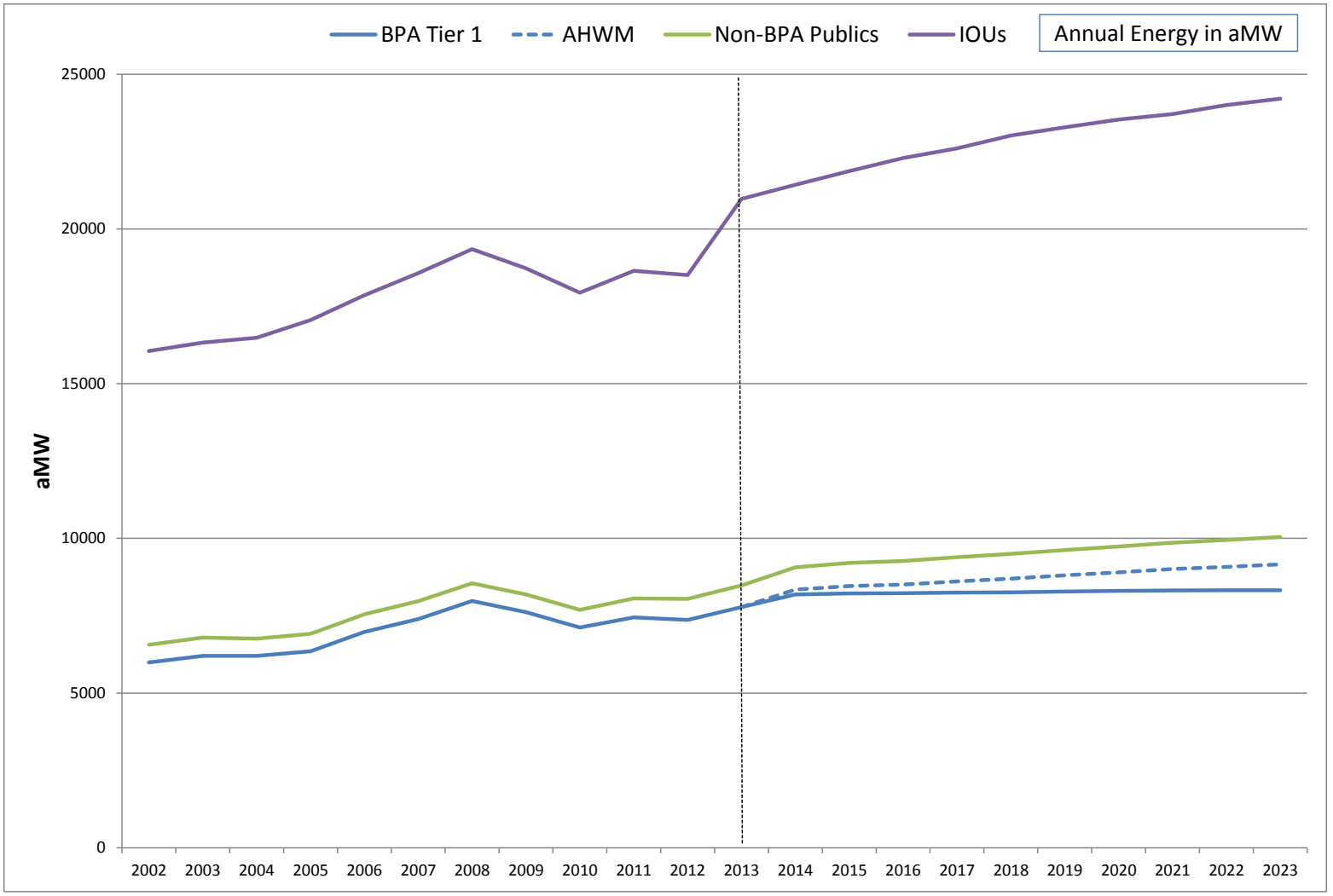
Northwest Power and Conservation Council

U.S. Electricity Demand Growth, 1950-2035 (percent, 3-year moving average)

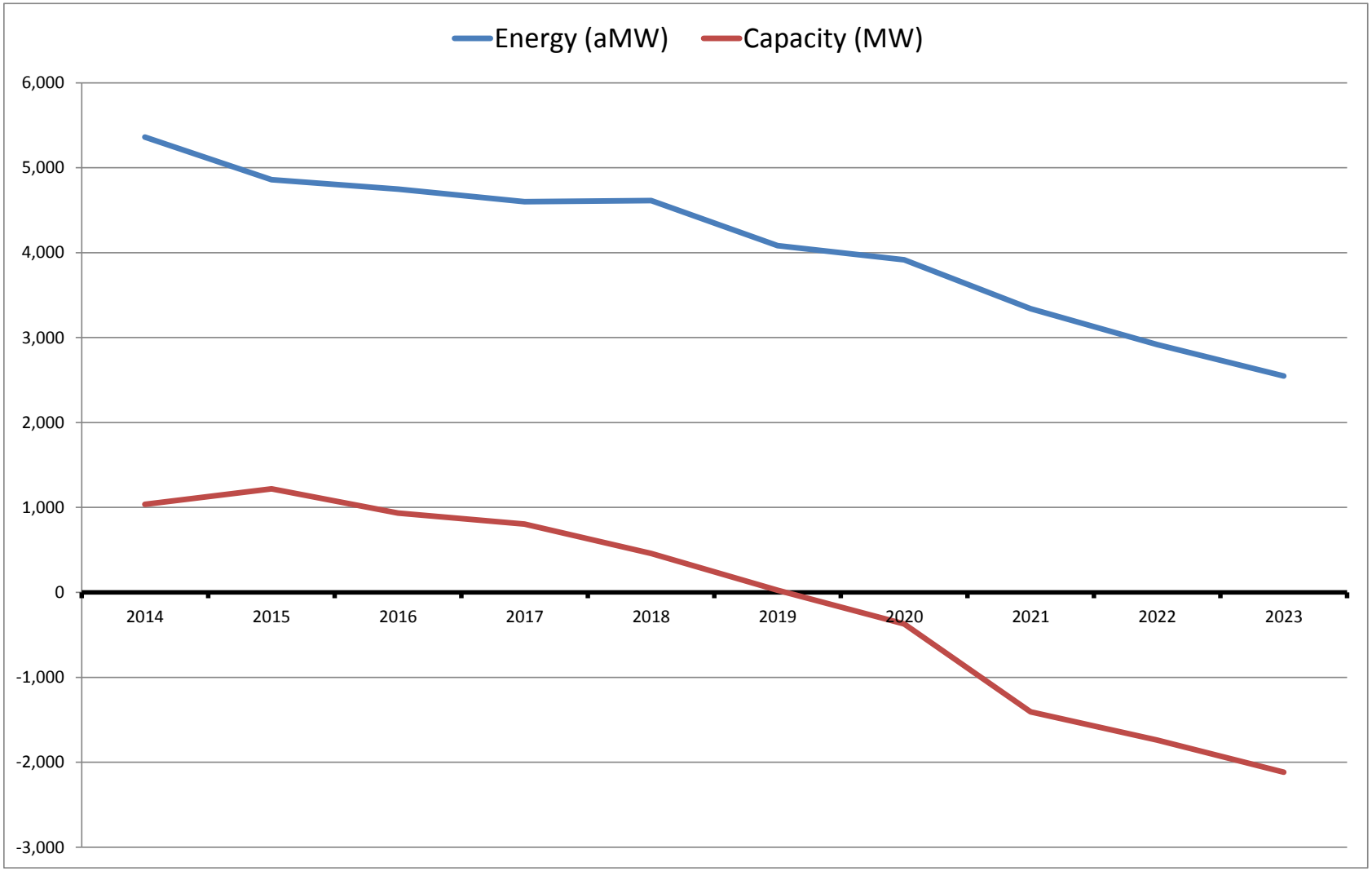


Source: EIA, 2012 Annual Energy Outlook

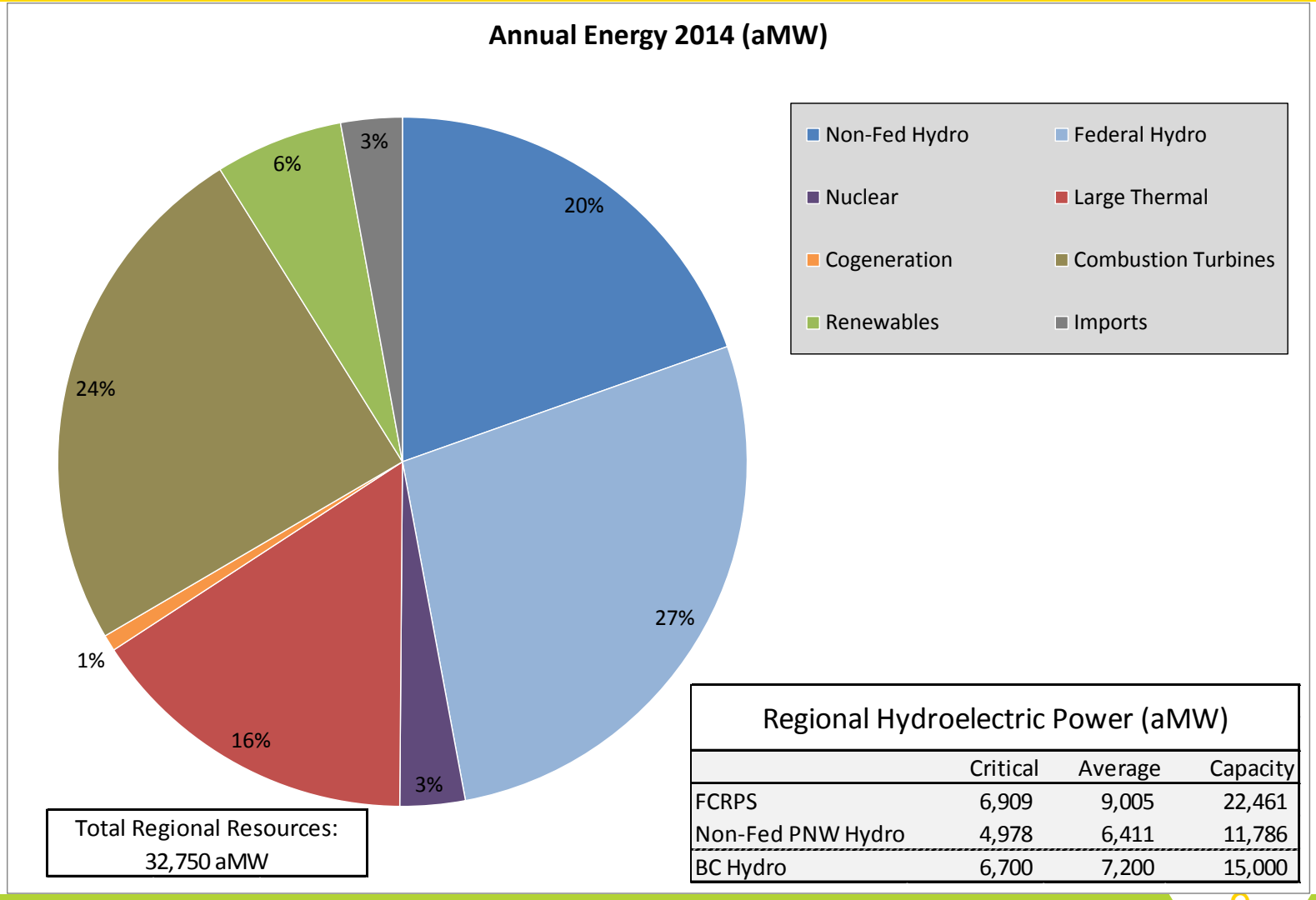
PNW Regional Loads



Regional Supply/Demand balance: Energy and Capacity



PNW Regional Generation



Total Regional Resources:
32,750 aMW

Regional Hydroelectric Power (aMW)			
	Critical	Average	Capacity
FCRPS	6,909	9,005	22,461
Non-Fed PNW Hydro	4,978	6,411	11,786
BC Hydro	6,700	7,200	15,000

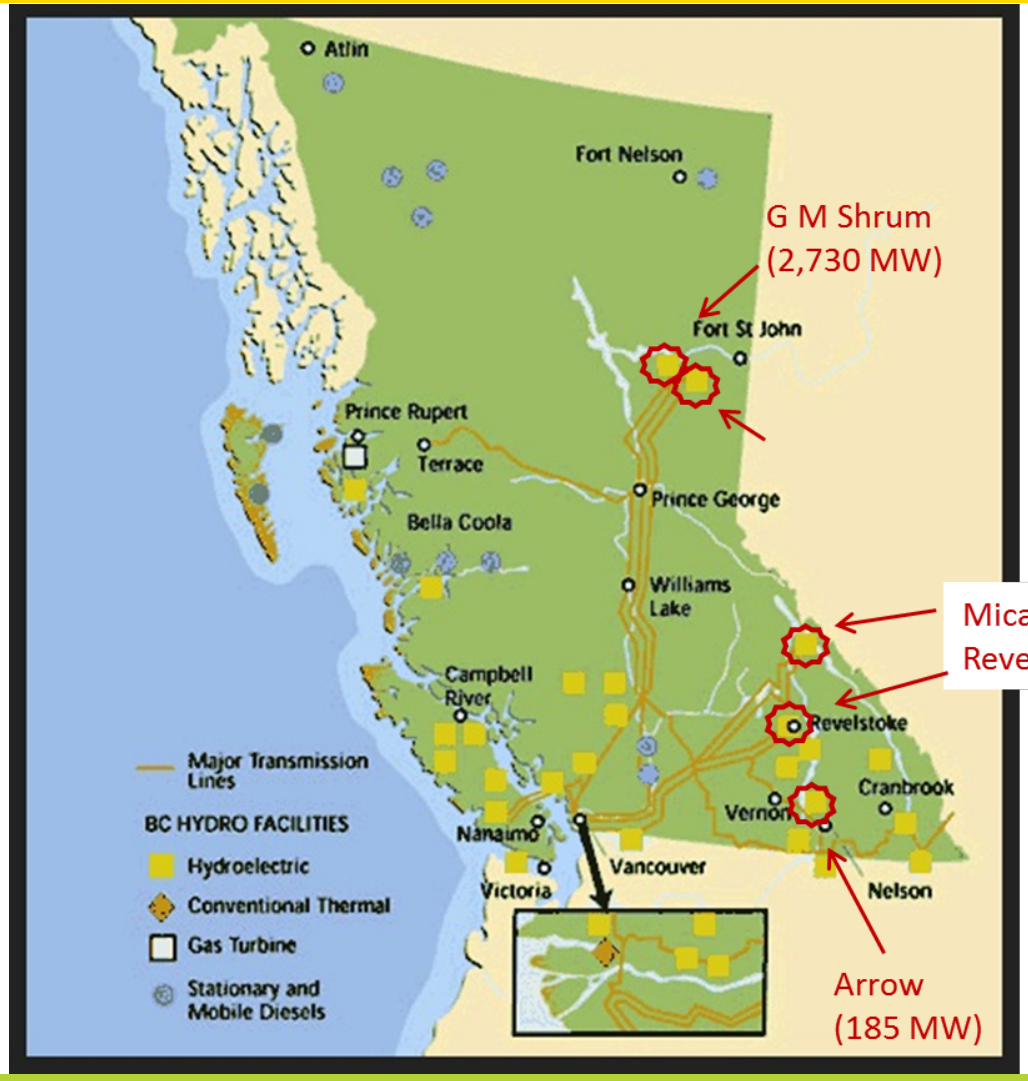
Federal Columbia River Power System

Columbia River Basin & BPA Service Area

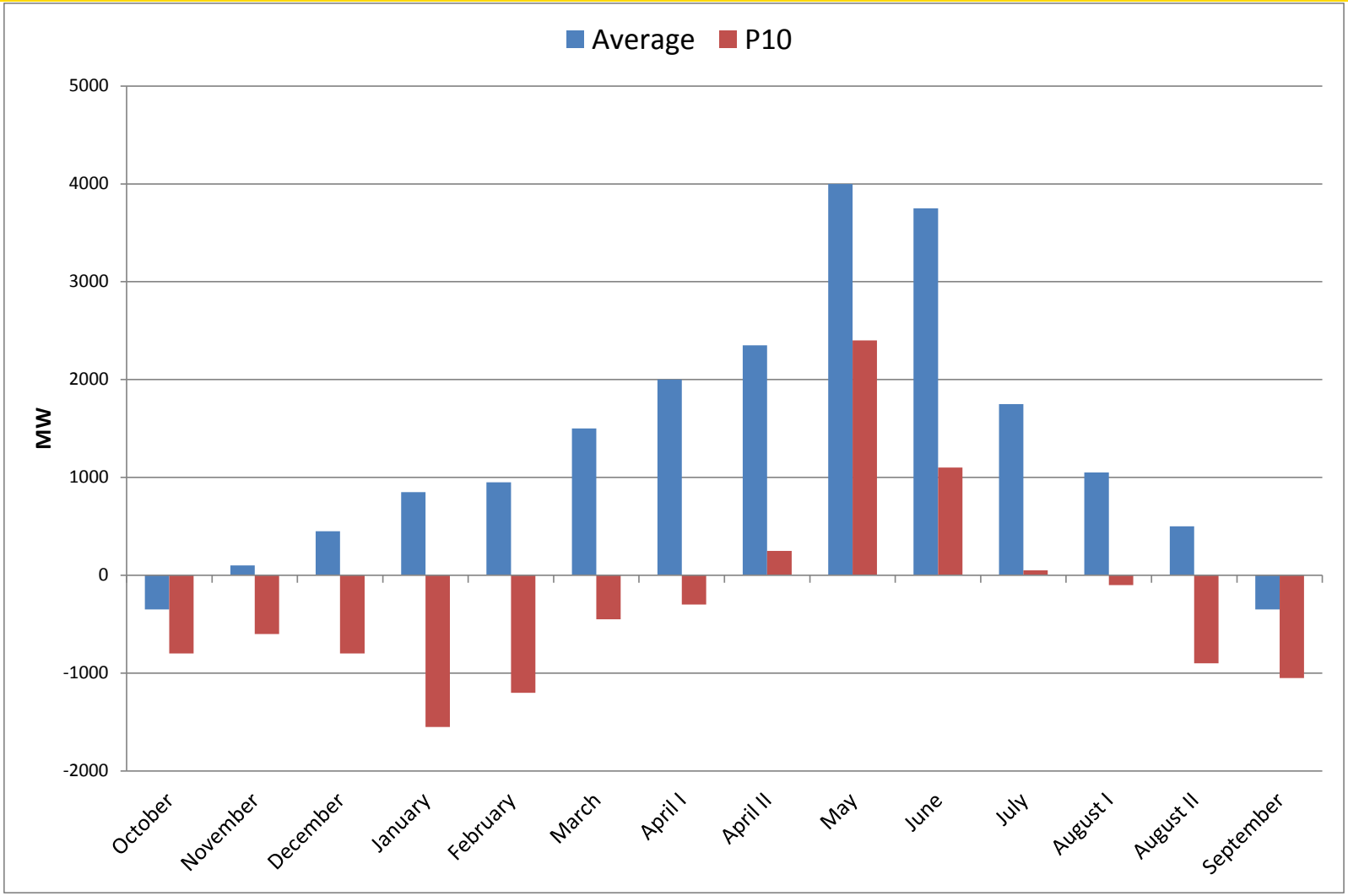
WHAT IS BPA?

- Self-funded federal agency within DOE. Sets rates to recover costs.
- Markets power at cost from 31 federal dams and 1 nuclear plant – over one-third of electricity used in PNW.
- Power is sold under long-term contracts to 135 public utilities, coops, and municipalities.
- Owns, operates, and markets transmission services for 75% of the regions high voltage transmission grid.
- Protects, mitigates & enhances fish & wildlife in the Columbia River Basin.
- $3.5 billion in annual revenues.
- Established in 1937.

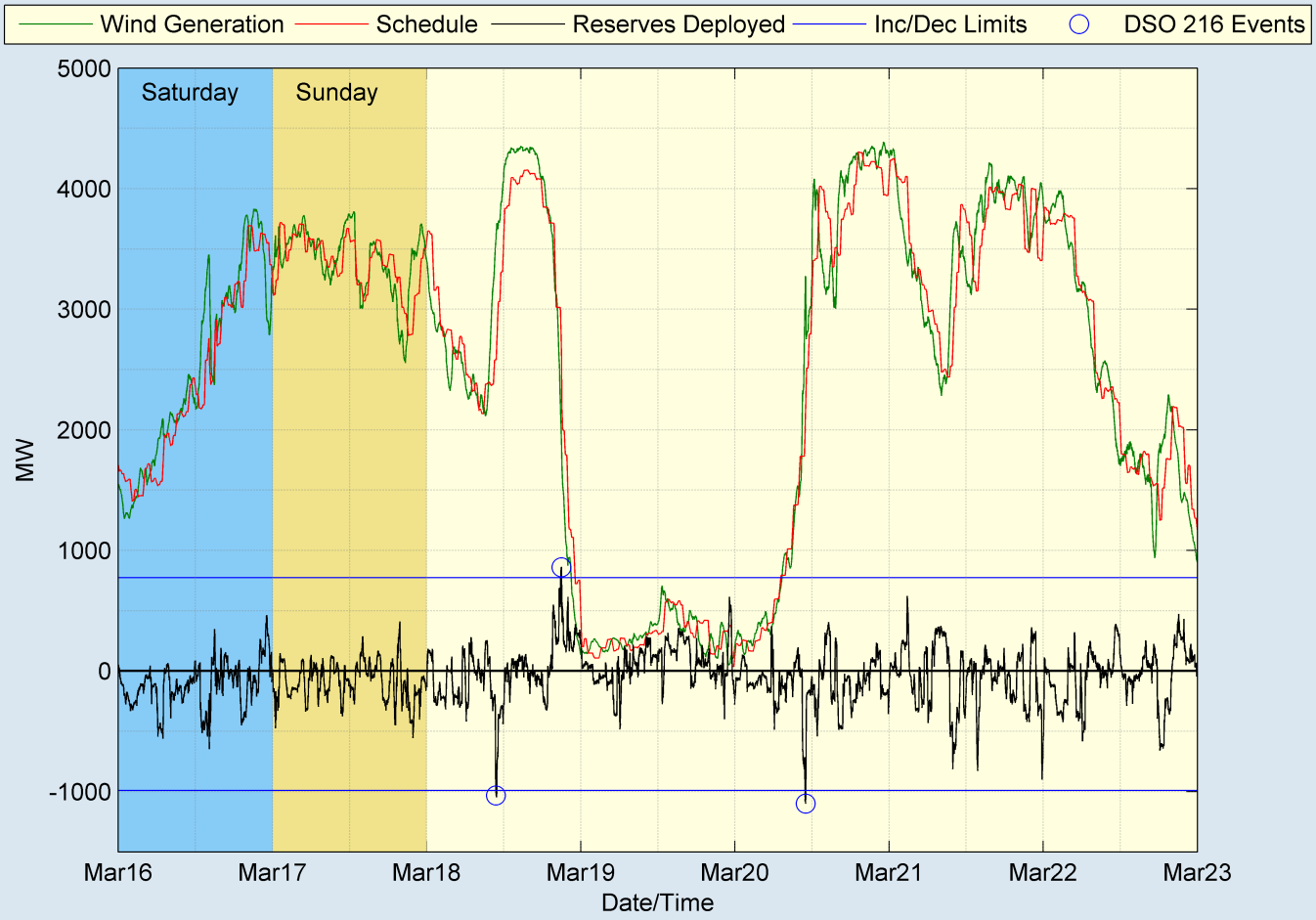
Major Dams on Peace and Columbia Rivers



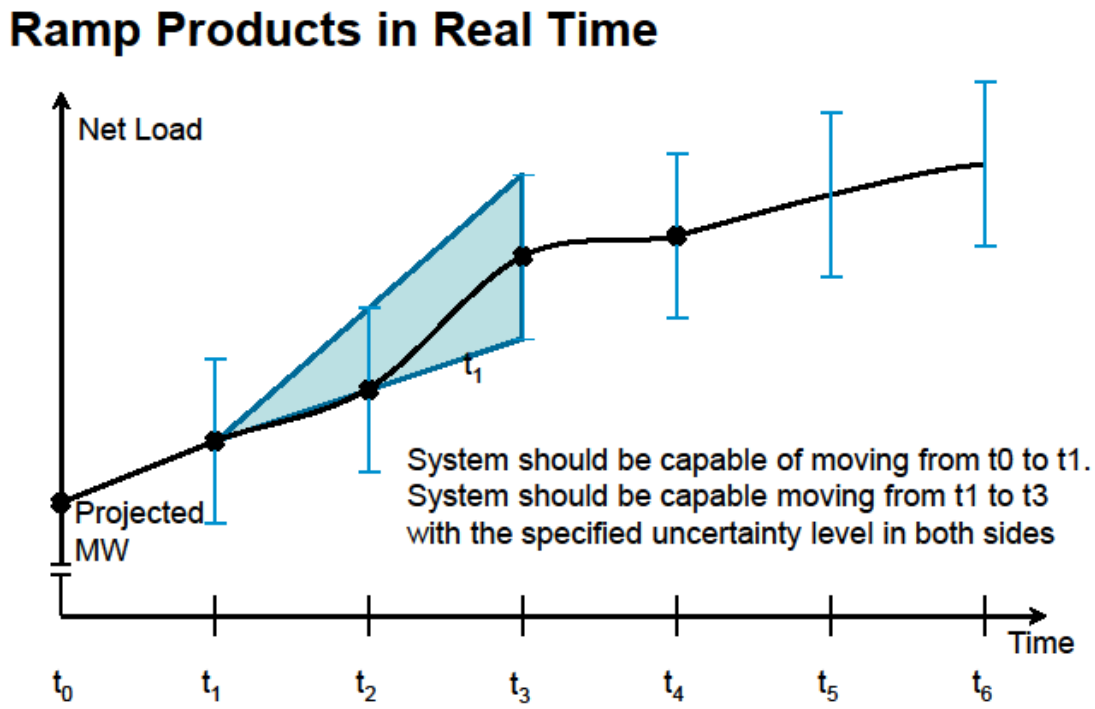
Variability of Hydro and BPA surplus/deficits in 2016



Balancing Reserves Example

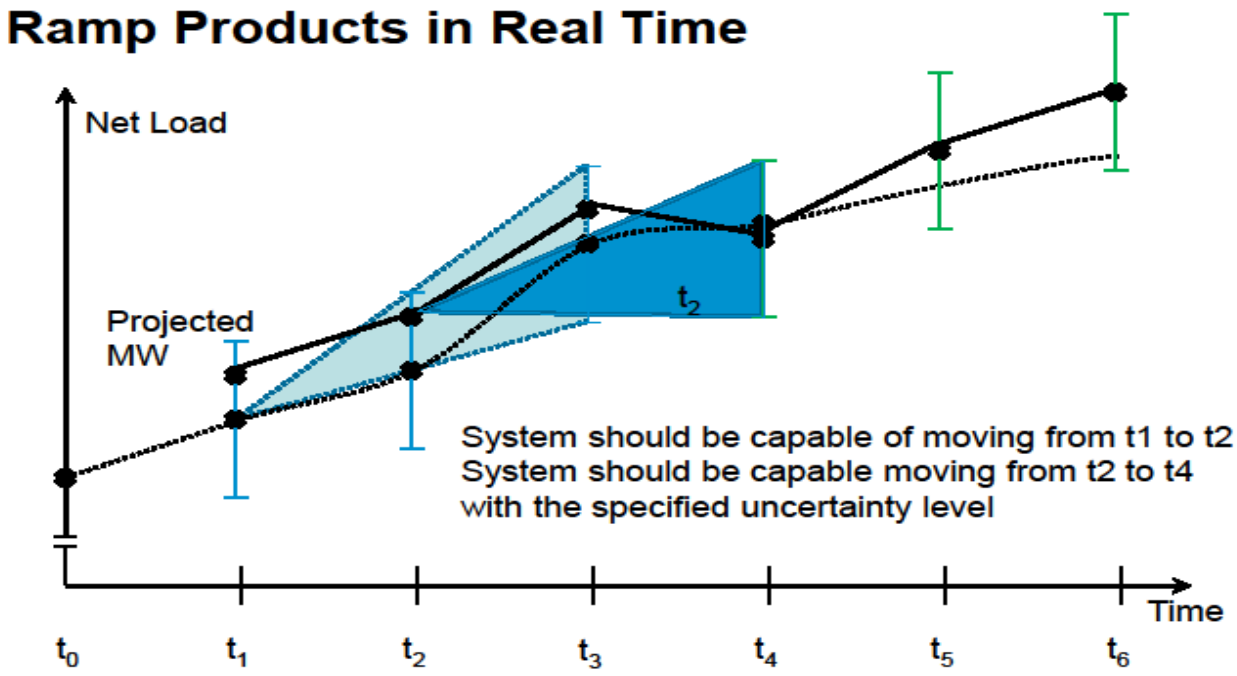


Flexibility in Action



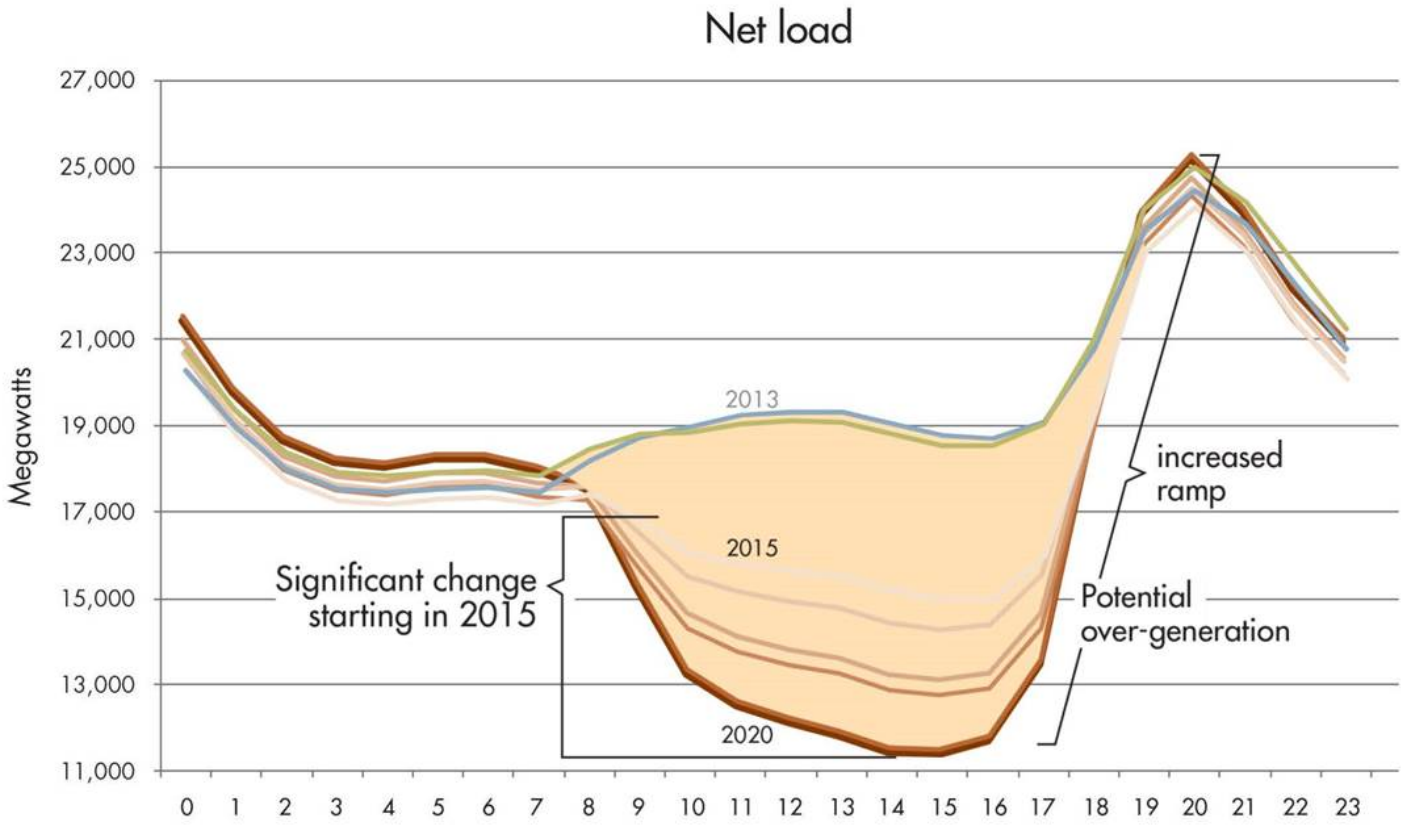
MISO

Flexibility in Action



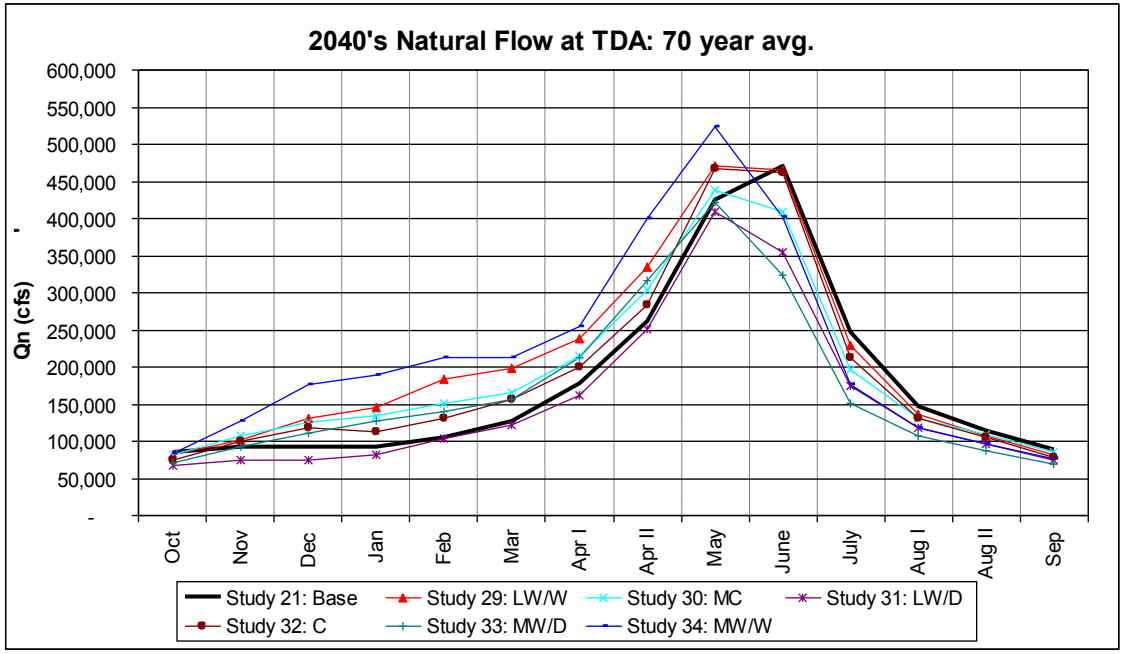
MISO

Growing need for flexibility starting 2015



Climate Change Study: River Management Joint Operating Committee

- Collaboration with University of Washington Climate Impacts Group, BPA, Corp of Engineers, Bureau of Reclamation
- Climate models from IPCC-4 (2007)
  - A1B (fairly aggressive) and B1 (modest) greenhouse gas scenarios
  - Temp and precip statistically downscaled to Columbia River Basin
  - Routed using a common hydrologic model (VIC)
  - Regulated using BPA and Corp hydraulic models, concentrating on the 2020s and 2040s
- Expected Regional Temperature Change:
  - 2020s: +0.7-1.6°C
  - 2040s: +1.3-2.8°C
- Regional Precip Change (reflecting large model uncertainty)
  - 2020s: -1.5% to +7.9%
  - 2040s: -7.9% to +14.2%
- Peer reviewed and collaborated with similar research by BC Hydro



Results:

- Higher winter flows/more generation
- Peak runoff shifting earlier in the spring
- Less summer flows/less generation, even in the wettest scenarios
- More winter precipitation falling as rain in parts of the US Columbia Basin
  - Increased winter flow volatility
  - Possible need for winter flood control