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Water Management and Hydropower in the USA

December 9, 2019

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EIA Hydropower Annex IX & XII workshop
Hydropower Services and Climate Change:
Adaptation Resilience and
Valuation of Climate Change Services

Rio de Janeiro - Brazil

U.S. DEPARTMENT OF ENERGY BATTELLE

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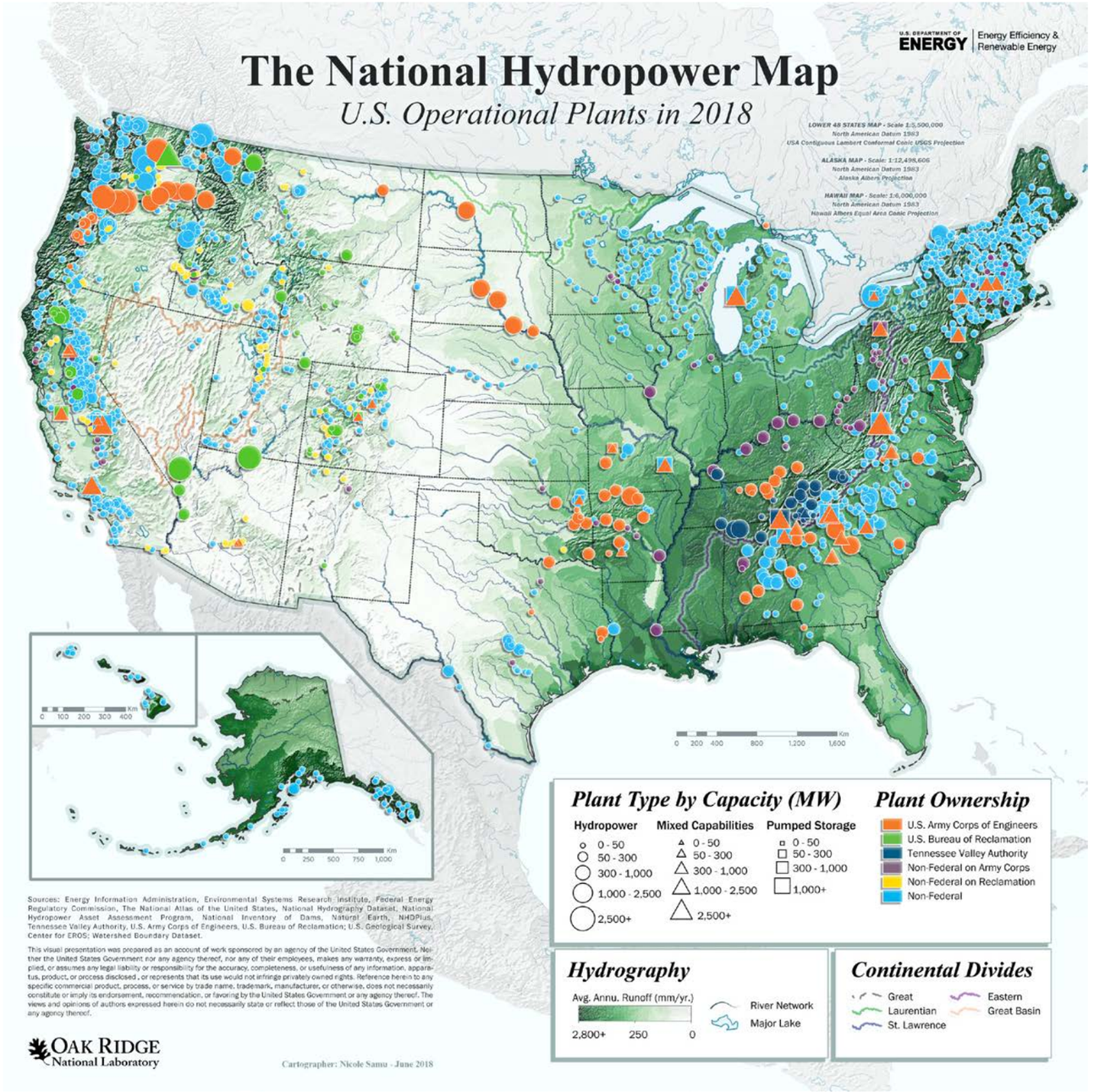
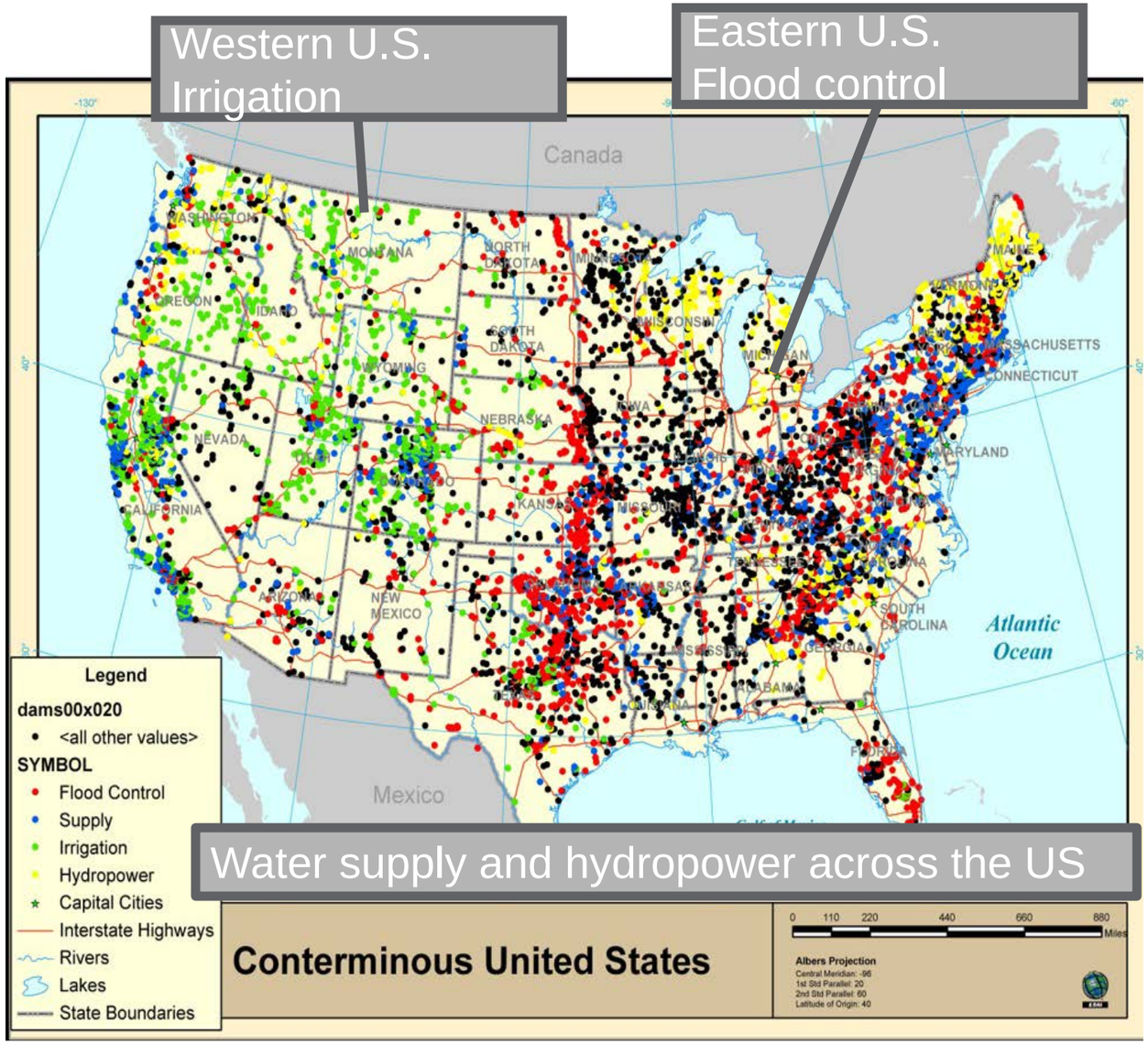
Hydropower in the USA

- Over 2,000 hydropower plants
- 7% of annual electricity generation
- ~25% of generation capacity of the Western USA
- ~half of total hydropower generation is produced by 132 US federal plants



Water management in the USA

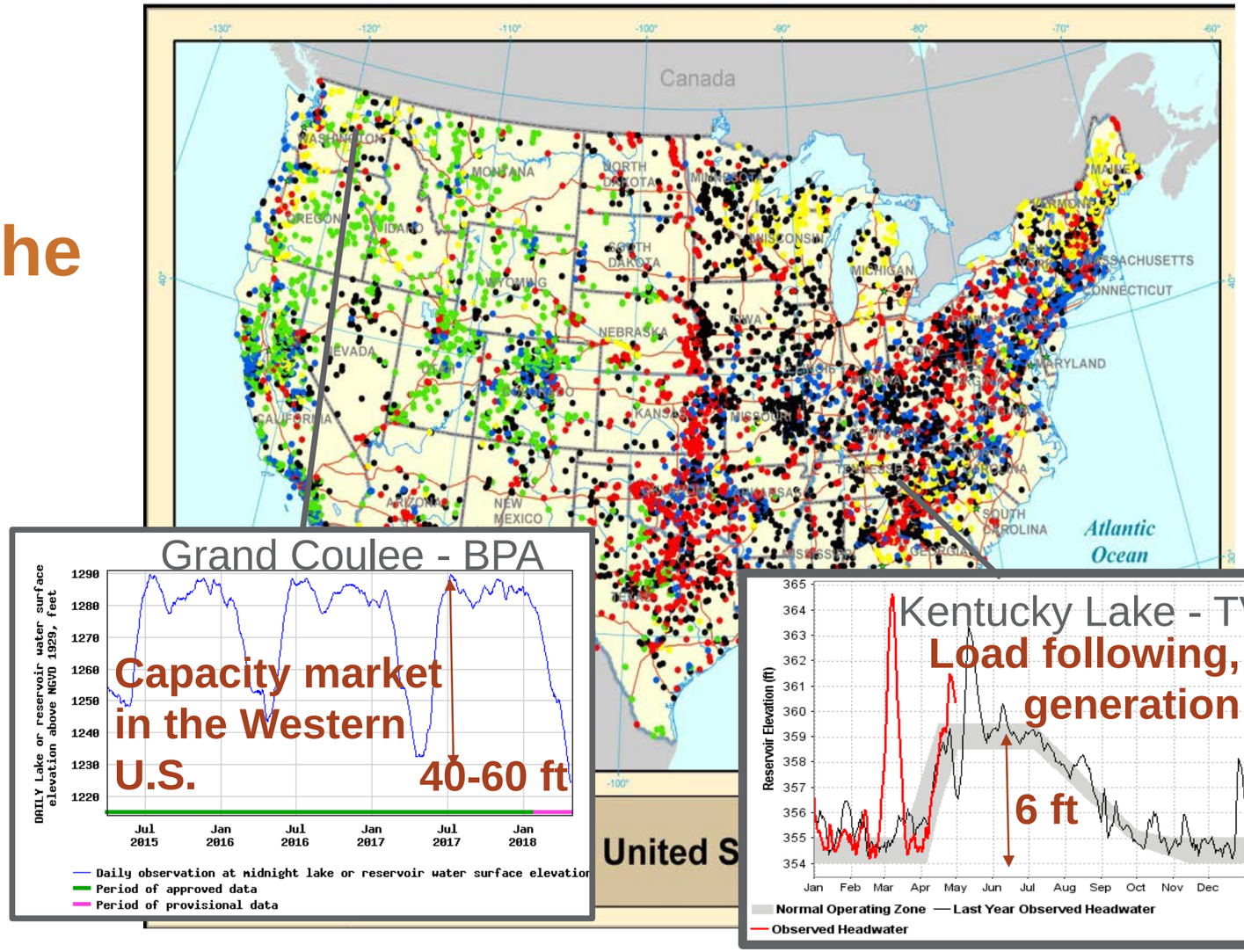
- Over 8000 major dams
- Flood control
- Irrigation,
- Water supply,
- Hydropower
- Recreation
- Environmental regulation (incl. water quality)



Water supply and hydropower across the US

Water management in the USA

- Over 50% of powered dams operated for multiple objectives
- Multiple institutions co-manage reservoir operations



Rule curves support dam operators in managing river systems and dam operations according to regional water laws, regulation and priority in water uses

Couple questions to be addressed

- How does water management support hydropower operations?
- How will water management keep supporting hydropower operations?
- What is the value of hydropower to environmental services? (Annex XII)
- What is the value of hydropower to grid services? (Link with Annex IX)

Water management under uncertainty

Rule curves are constantly challenged by the scientific research

Climate Change
- High uncertainty in precipitation projections
- Changes in extreme events
- Earlier snowmelt

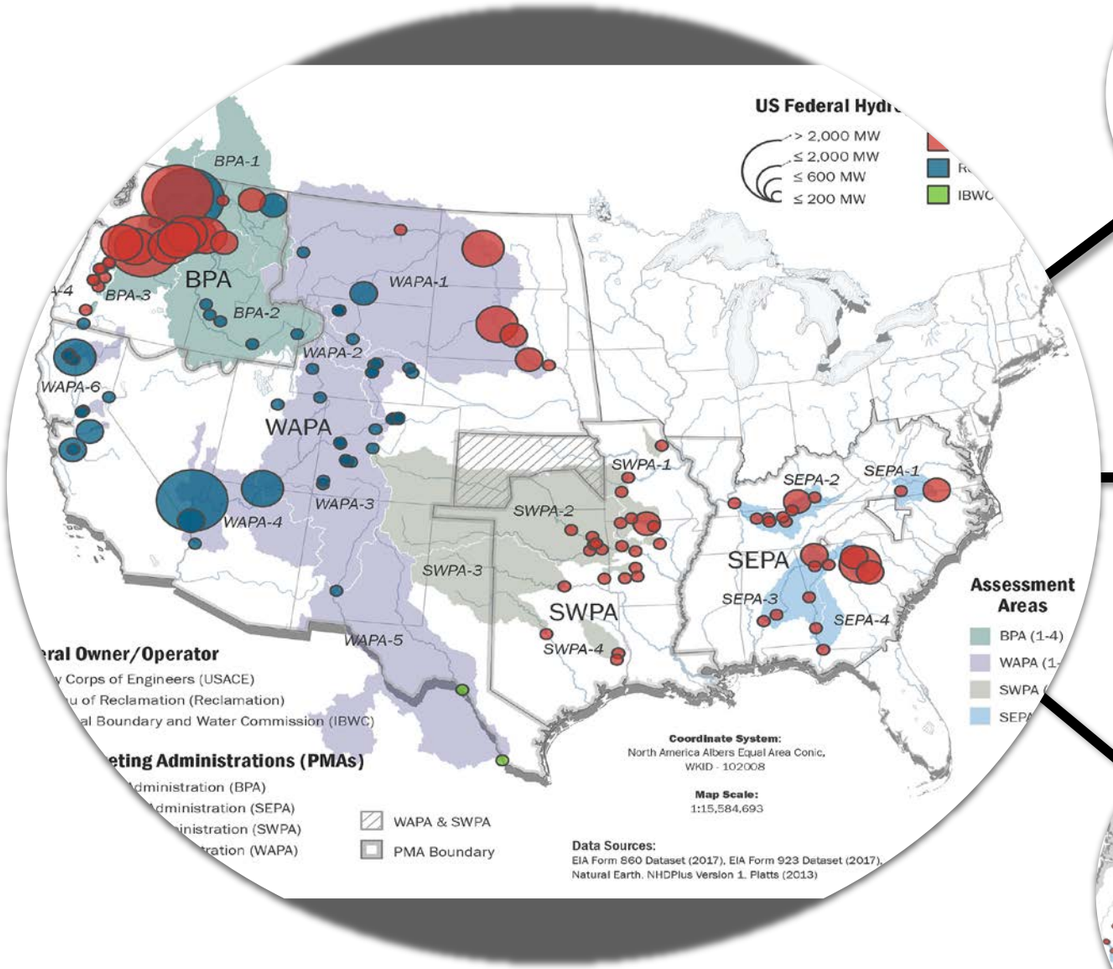
Technology Innovation
- Irrigation modernization
- Fish and wildlife science
- Seasonal to short term hydro-climate forecasts

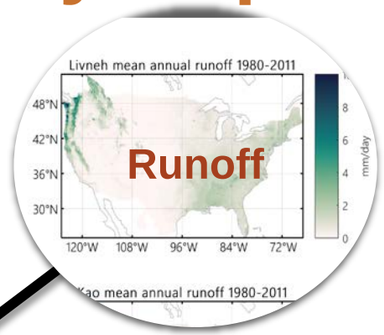
Water Uses
- Increase in population
- Food security
- Groundwater-surface water conjunctive uses

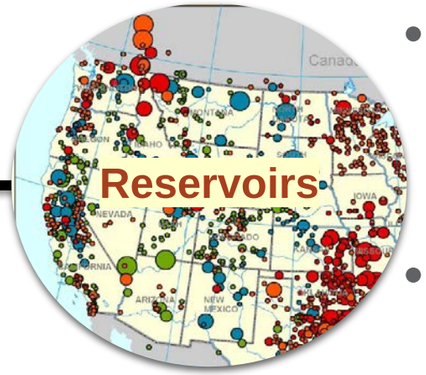
Public Awareness
- Water laws
- Environmental regulations

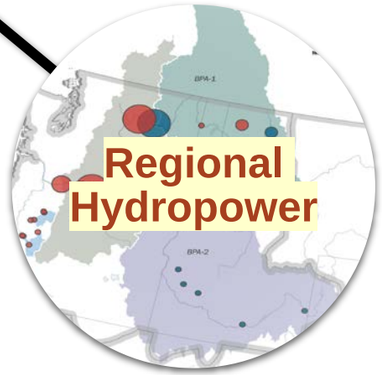
More coordination needed between applied, fundamental, and social sciences

Climate change, water management and hydropower









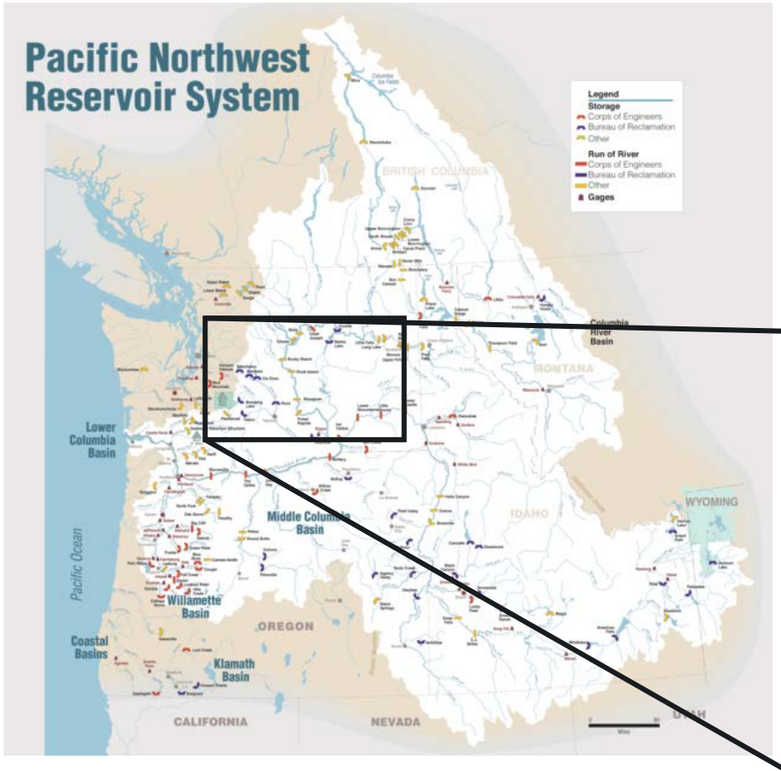
- High spatial resolution climate and hydrological simulations throughout CONUS
- Range of reservoir operations models, from watershed to regional scales
- PMF for reservoir operations design
- Statistical and process based hydropower models

Secure Water Act (S-C Kao), Climate change & stream temperature (M. Wigmosta), CEATI HOPIG, USACE, DHS, etc

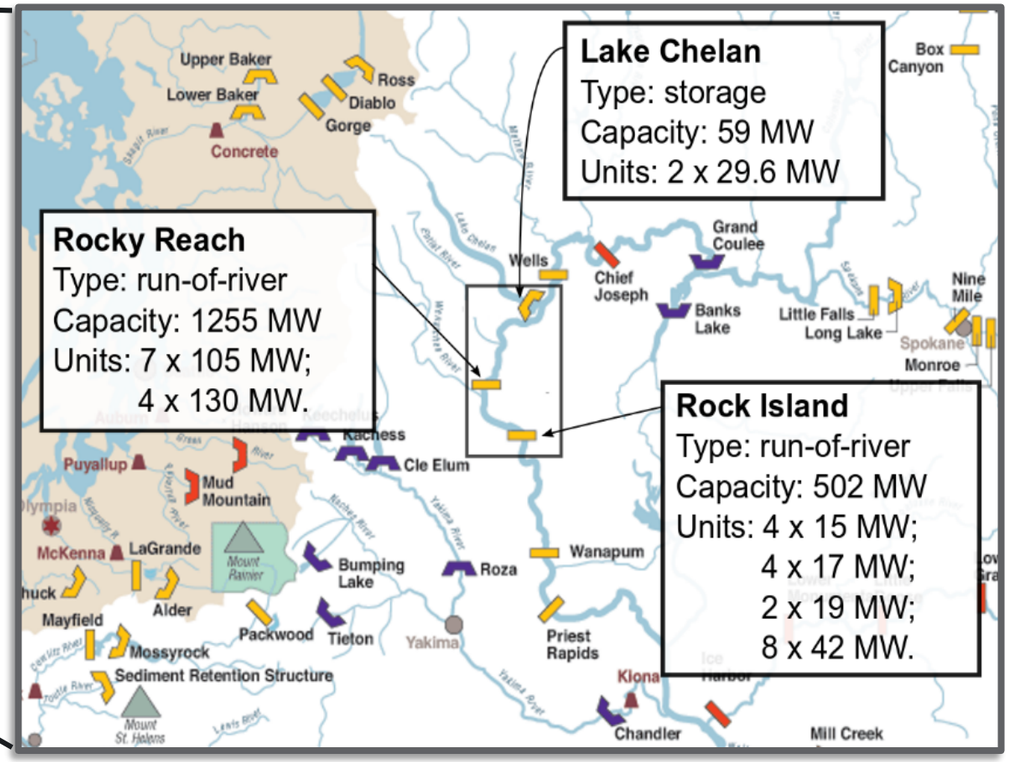
How will water management continue to support hydropower operations?

- **Climate Change**
  - High uncertainty in precipitation projections
  - Changes in extreme events
  - Earlier snowmelt
- **Technology Innovation**
  - Irrigation modernization
  - Fish and wildlife science
  - Seasonal to short term hydro-climate forecasts
- **Water Uses**
  - Increase in population
  - Food security
  - Groundwater-surface water conjunctive uses
- **Public Awareness**
  - Water laws
  - Environmental regulations
- **Market Prices**

Chelan PUD Case Study – Hydropower Value Study

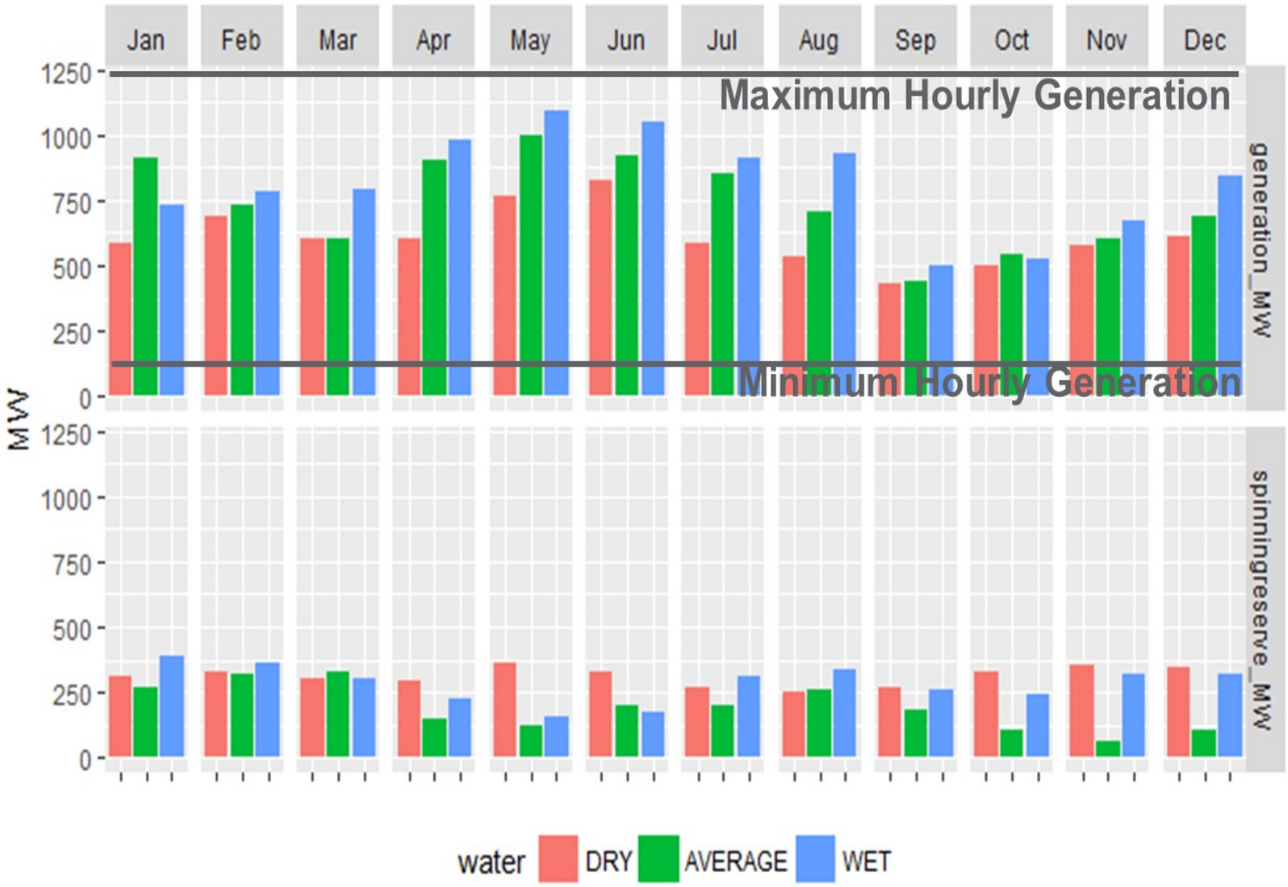


- 2 run of the river projects on the Columbia River main stem downstream of Grand Coulee
- 1 storage project on a tributary
- 100% hydro, 1648 MW operational capacity



Chelan PUD Case Study

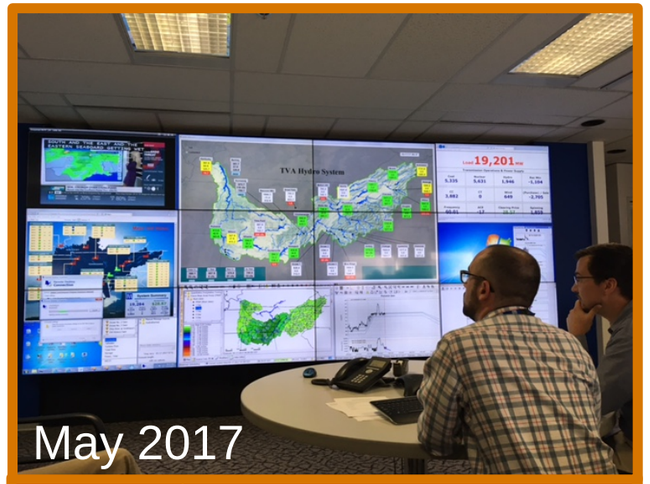
- Despite variations in water availability, hydropower provides consistent services
- Flexibility in the combination of services may vary based on water availability
- Typically a river-routing reservoir operations model is used to optimize utility-scale benefit under varying market prices and water availability conditions

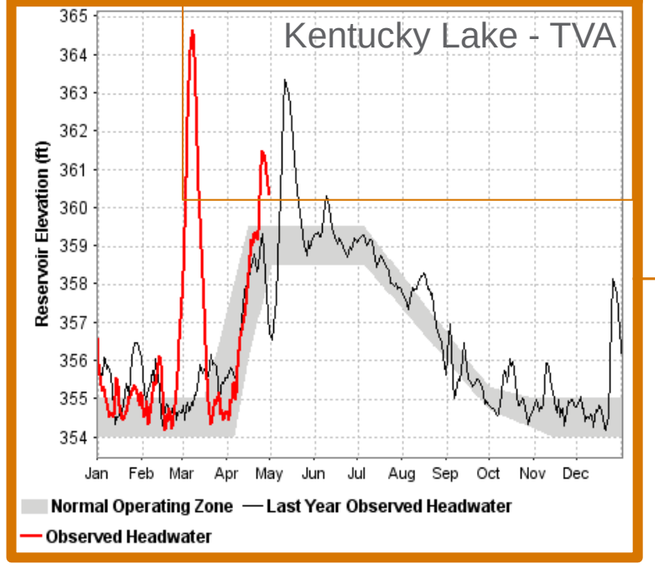


Average Rocky Reach generation and spinning reserve at 8 a.m. across all months and dry, average, and wet years. Note that units were in maintenance during the average year in the Fall

Valuation of hydropower to environmental services – TVA Case Study

Hydropower contributes to reduce the generation cost and ancillary services





Water management perspective

Water Use	Annual Value ($M)
Flood Control (property damage savings)	$X
Recreation	$X
Hydropower Generation	**$X**
Navigation	$X
Water Supply (Need more evaluation)	$X
Water quality (remediation)	

Seasonally and daily optimized for multi-use

Grid service perspective

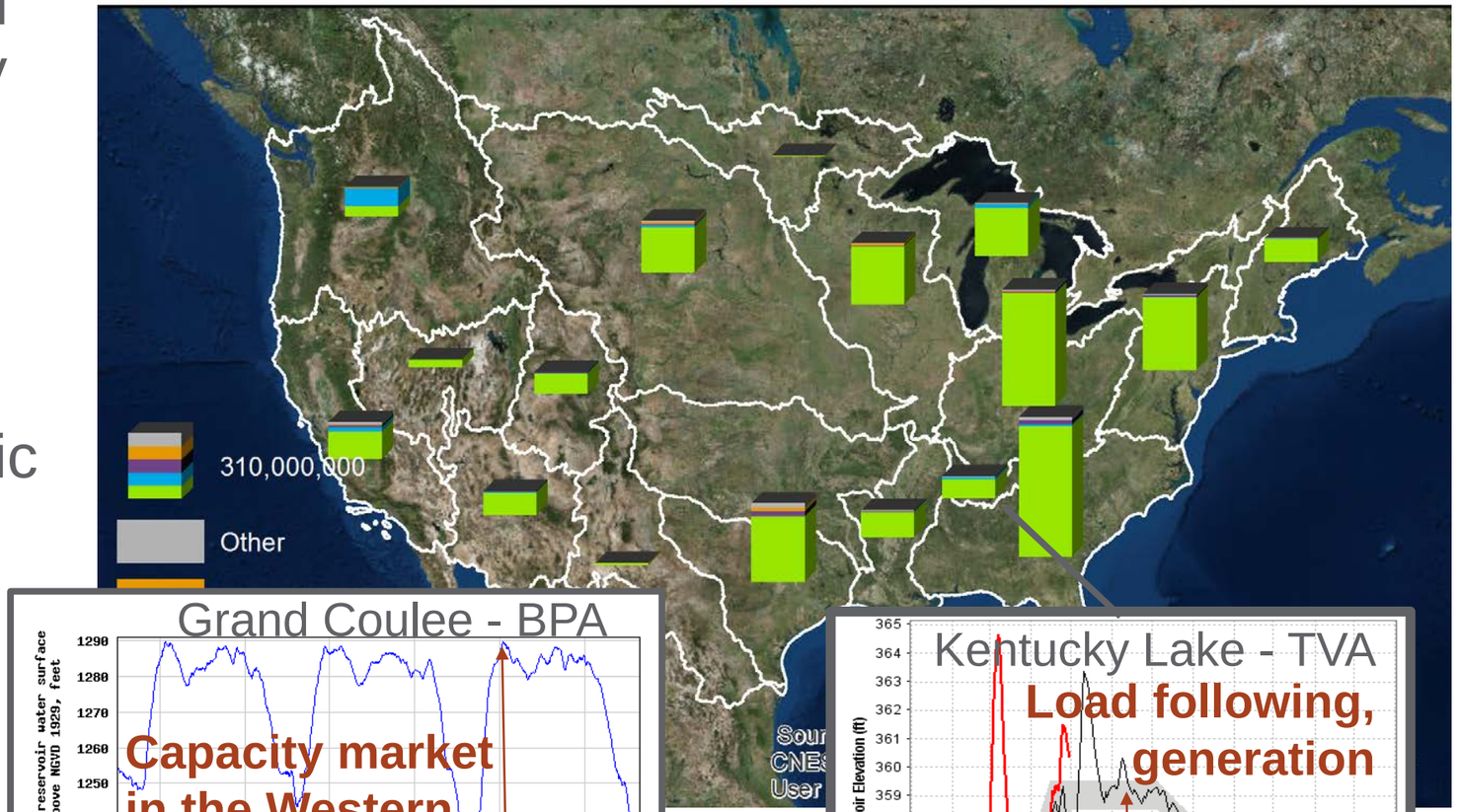
Ancillary service	Seasonal value
Generation	
Load following	Ancillary
Capacity Reserve	services
Frequency regulation	valuation
Black Start	
?	

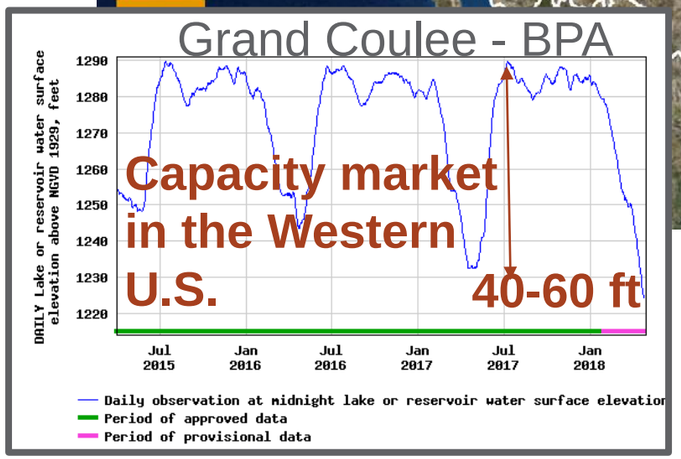
Sub-hourly optimized for grid services

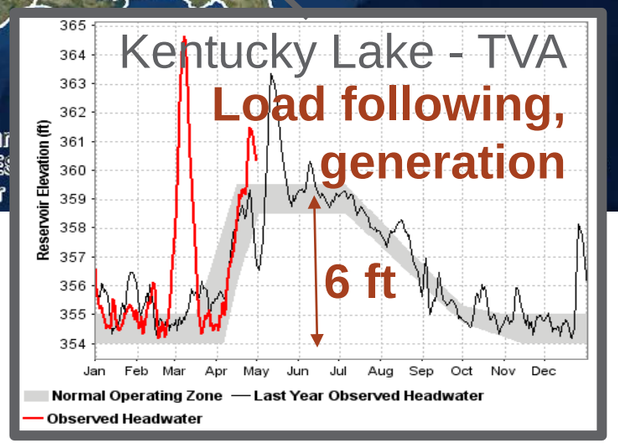
Value of hydropower to environmental services – expansion to other projects

Magnitude and frequency of hydropower operations vary regionally, and by utility, market, reservoir characteristics, etc.

Challenge of using economic metrics with water management.



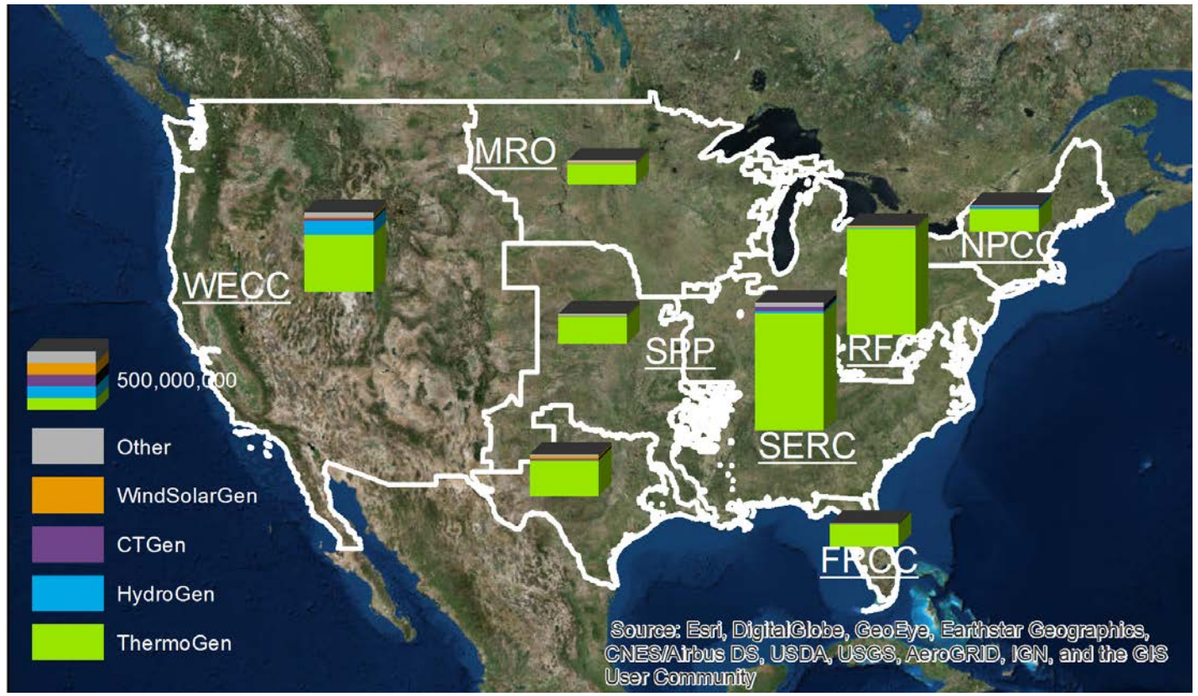




Regional variations in hydropower contribution to grid services

Regional variations in services to the grid:

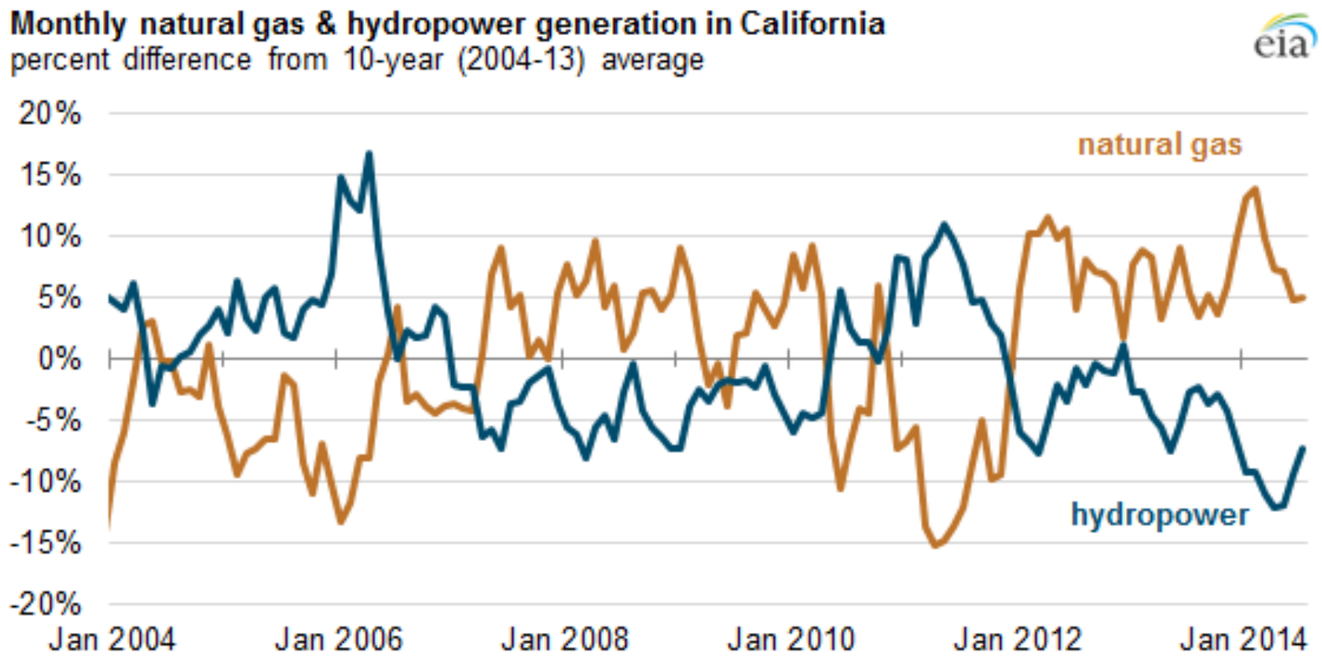
- Peak hours in most regions
- And baseload in the Pacific Northwest



Derived from Platts 2011

Hydropower significantly contributes to limiting high electricity production prices

- Hydropower generation is negatively correlated with natural gas electricity generation.
- If hydropower is available, use hydropower for generation and especially when electricity prices are high
- Hydropower also provides ancillary services to the power grid
- Large regional variations in those relationships



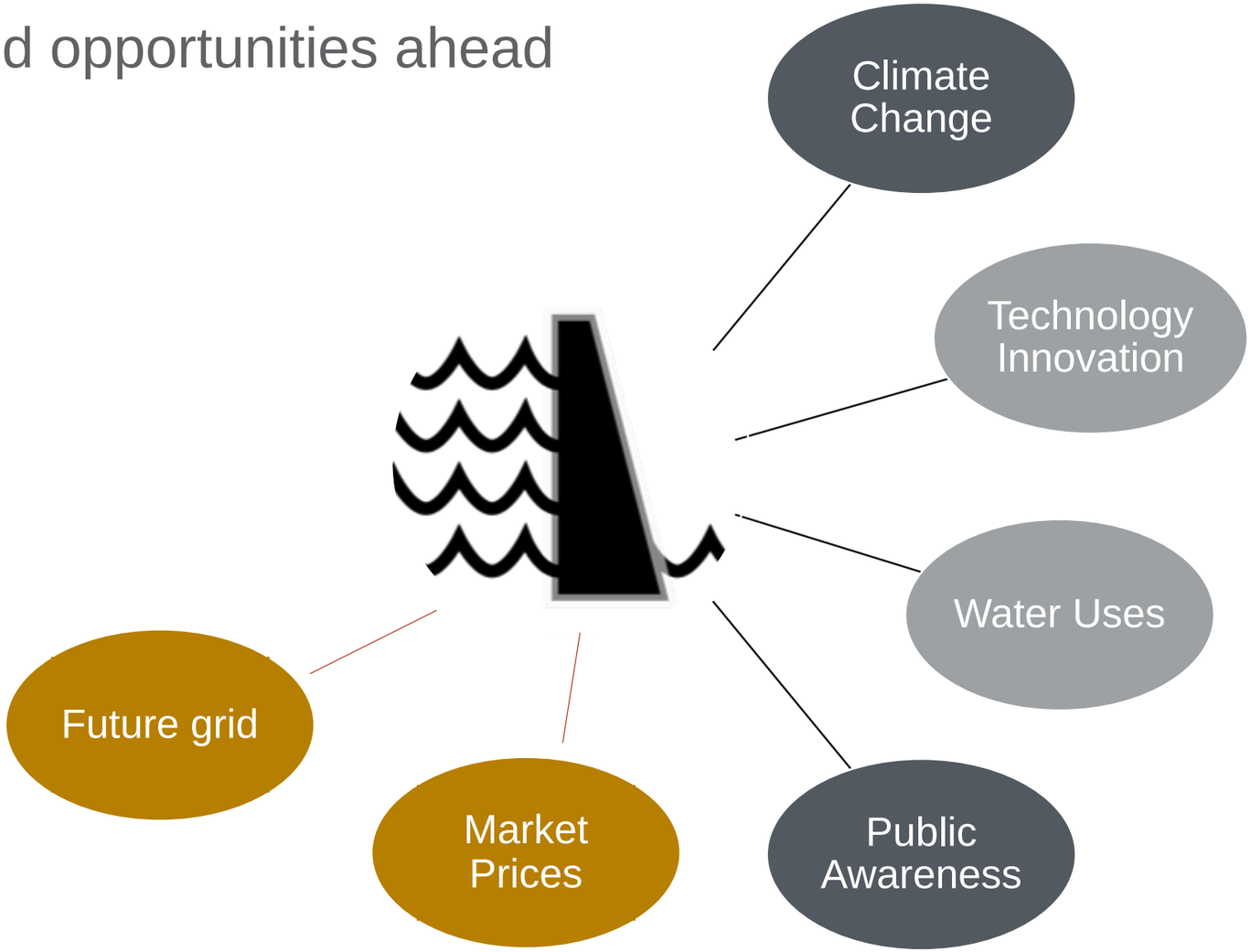
Valuation of hydropower for economics and resilience - HydroWIRES

HydroWIRES projects
Provide hydropower scenarios for electricity grid long term reliability studies
Value of hydropower forecast to grid analytics
Improve representation of hydropower in power system models
Catalog hydro-power plant physical and regulatory bounds in operations
Contribution of hydropower to electricity grid resilience

https://www.energy.gov/eere/water/hydrowires-initiative

Concluding thoughts

Challenges and opportunities ahead



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Thank you

The many futures of hydropower

Power grid changing

- Integration of renewables
- Batteries & demand response
- Deep electrification
- Distributed generation
- New market structures
- Fuel prices
- Increasing electricity demand
- Retiring power plants

Water management is uncertain

- Water availability (Climate Change)
- Water uses (C
- Environmental regulation
- Public perception

How can hydropower contribute to maintain resilience and ensure sustainably economic operations?