Value of flow forecast for power system analytics

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Abstract

Most hydropower utilities rely on flow forecasts to manage the water resources of their reservoir systems and to help marketers and schedulers make efficient use of power generating resources. Flow forecast providers and dam operators typically assess the value of flow forecasts by assessing the skill of the forecasts in a verification exercise. Although there are many flow forecasting approaches available—from physics-based approaches associated with statistical pre and post processors and data assimilation, to emerging machine-learning based approaches—there is little consensus on how to choose the best forecast product. Nor are there established methods for translating forecast skill—a summary statistic amalgamating multiple types of errors —to forecast value (benefits or avoided cost) as perceived by a marketer or scheduler. In this work we develop such an approach by combining a water resources management model with a power grid model. Flow forecasts are developed at 85 locations for a varying range of skills, from perfect, to persistent and in-between. Using reservoir and power grid simulations over the Western U.S., we propagate flow forecasts through the power grid model, mapping flow forecast skill to regional hydropower revenues, production costs and carbon emissions. We develop a deeper understanding of the influence of regional and seasonal differences in markets and hydrologic dynamics on forecast value. We discuss future research directions to integrate hydrologic forecasts into decision-making at the utility and wider system scale.

Pacific Northwest NATIONAL LABORATORY

HydroWIRES U.S. DEPARTMENT OF ENERGY

Value of Flow Forecast for Power System Analytics

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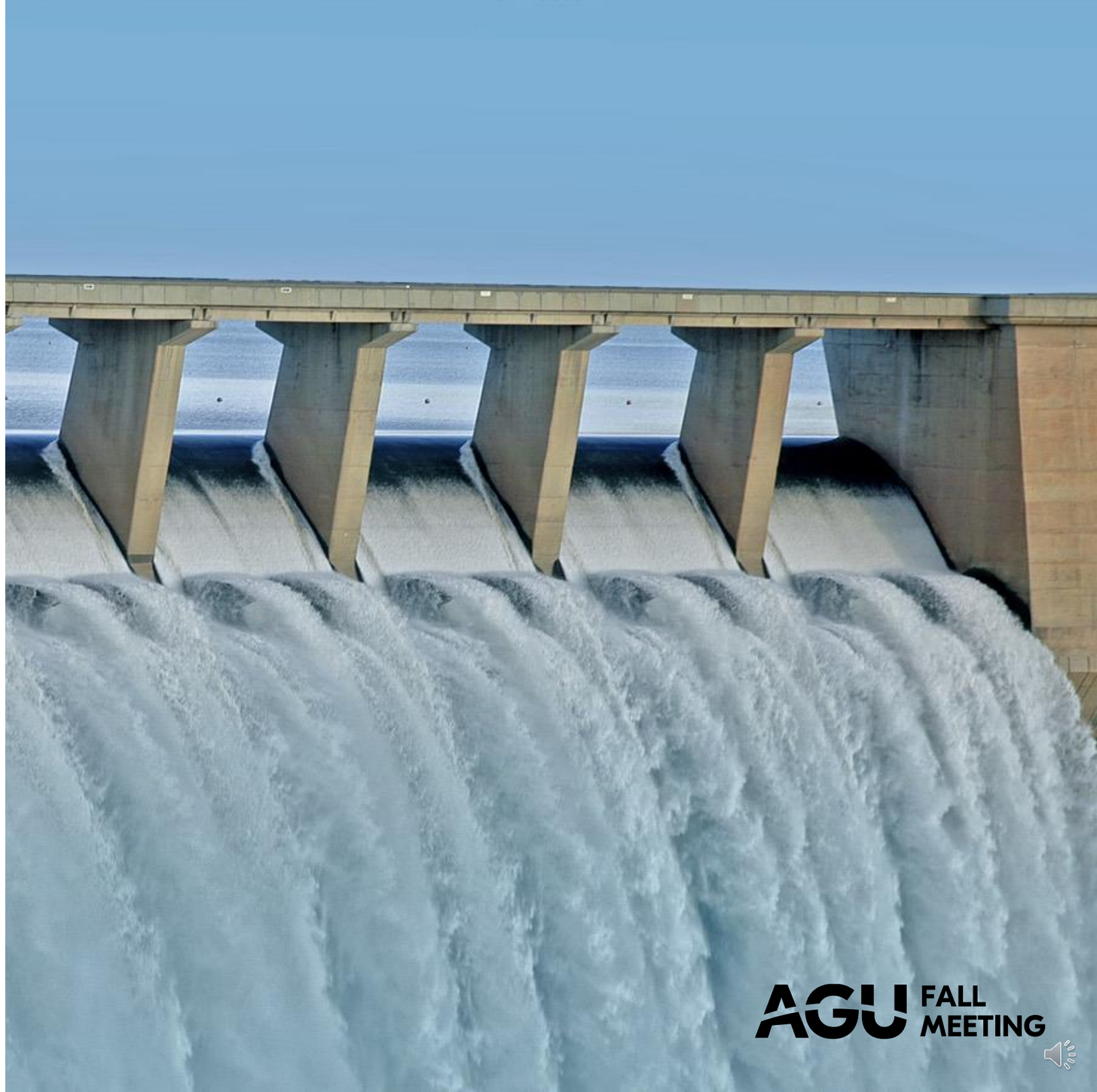
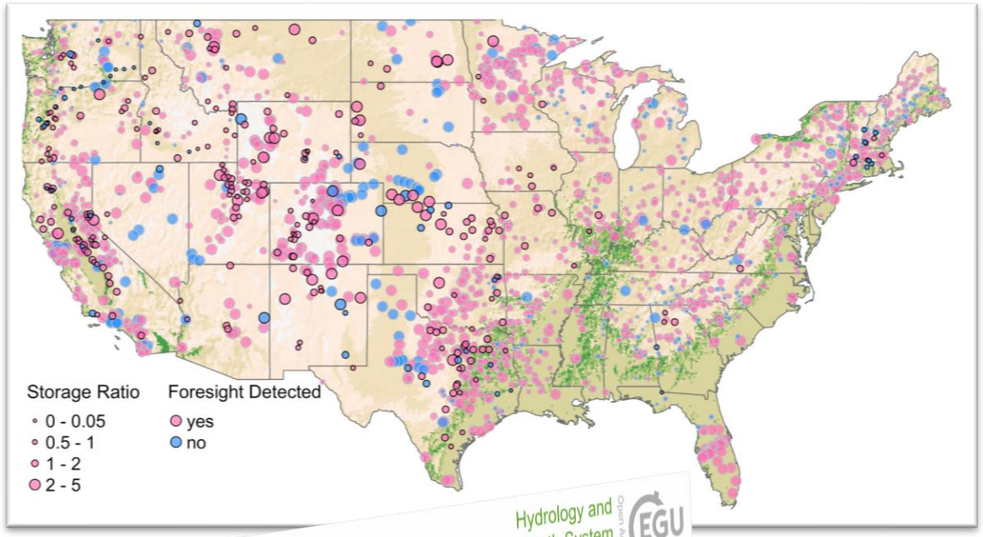
NCAR NC STATE UNIVERSITY INL Idaho National Laboratory



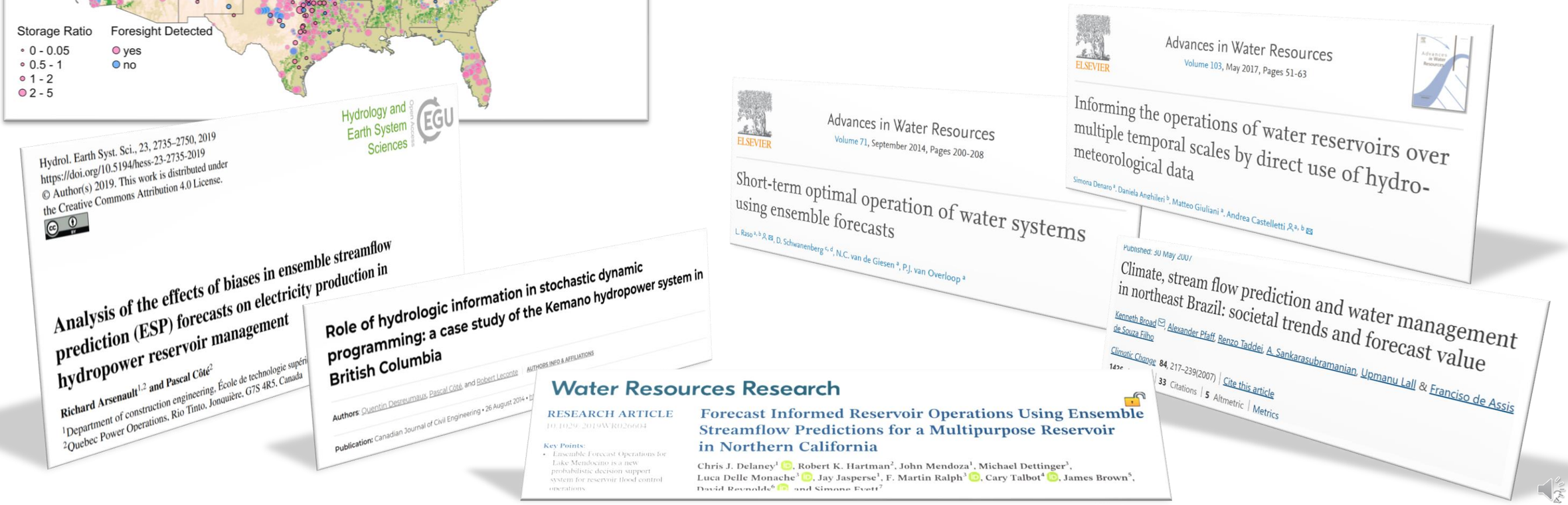
AGU FALL MEETING

Flow forecast value for water management has been demonstrated



Releases from a large majority of reservoirs are modified based on inflow forecasts.

Turner, S. W. D., Xu, W., & Voisin, N. (2020). Inferred inflow forecast horizons guiding reservoir release decisions across the United States. *Hydrol. Earth Syst. Sci., 24*(3), 1275-1291. doi:10.5194/hess-24-1275-2020



The valuation of flow forecasts is however limited to enhanced river services within a watershed

Flow Forecast

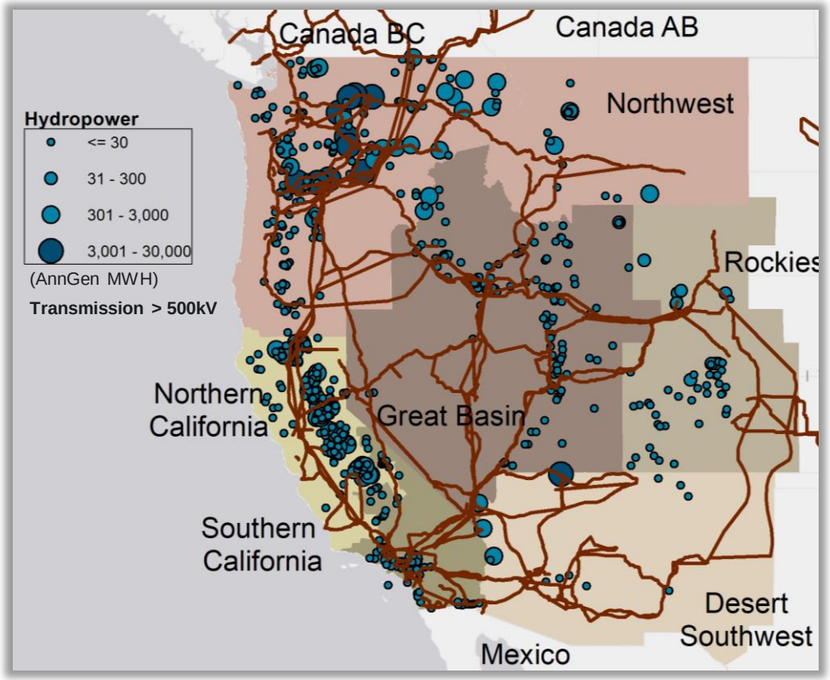
- Accuracy
- Reliability

Water Management / Decision Support System

- Reliability of river services
- Value of river services

Valuation mostly based on enhanced river services

- Hydropower generation & revenues
- Agriculture yield & revenues



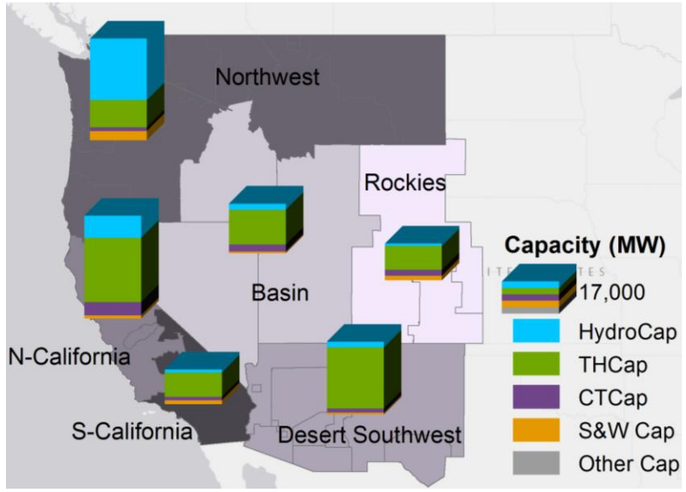
Hydropower rarely serves local load. Hydropower provides cost effective flexible operations (reserve, regulation, ramping, etc). What is the value of flow forecast for grid services?

Science questions

- What is the value of flow forecast for the power grid?
- What have we learned about how flow forecasts influence power systems models to:
  - ✓Guide the development of flow forecast products specific to grid services
  - ✓Advance science in hydropower and grid operations under forecast uncertainty?

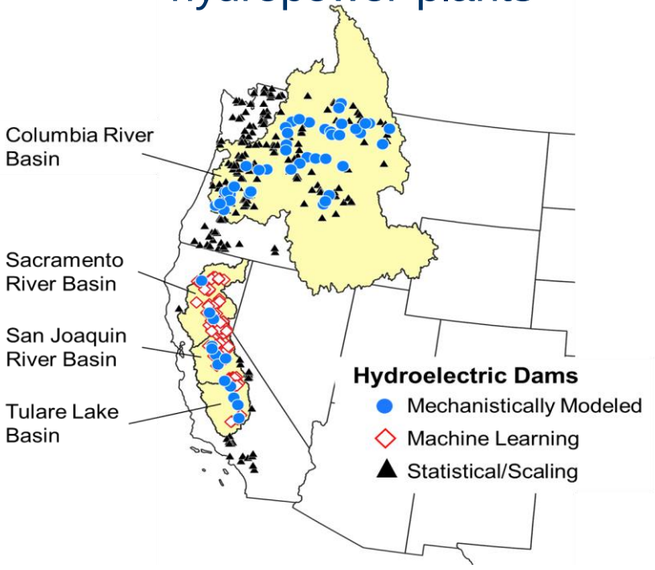
A Western U.S. Case Study & the CAPOW model

Contribution of hydropower to grid services might be regional



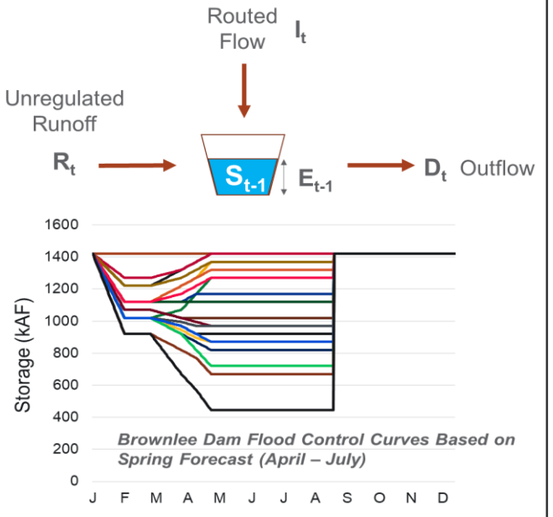
Installed generating capacity by regional and by technology

85 represented hydropower plants



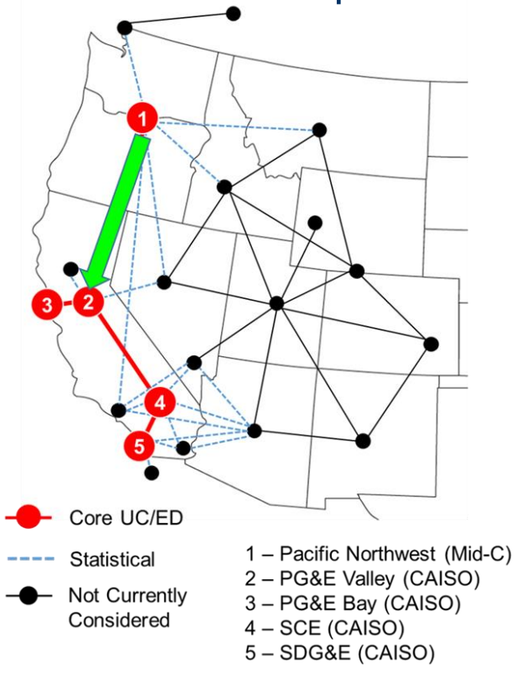
Focus on the Pacific Corridor

CAPOW
Explicit representation of reservoir operations



Rule curves

CAPOW
Zonal unit commitment economic dispatch



A zonal representation that supports 10,000s of runs

Su, Y., Kern, J. D., Denaro, S., Hill, J., Reed, P., Sun, Y., . . . Characklis, G. W. (2020). An open source model for quantifying risks in bulk electric power systems from spatially and temporally correlated hydrometeorological processes. *Environmental Modelling & Software, 126*, 104667. doi:https://doi.org/10.1016/j.envsoft.2020.104667

Experimental approach

2 book-ends in how hydropower is used (flexibility)

2 book-ends in forecast accuracy

Persistence

Yesterday flow repeated for 7 days

Perfect

Observed daily flow

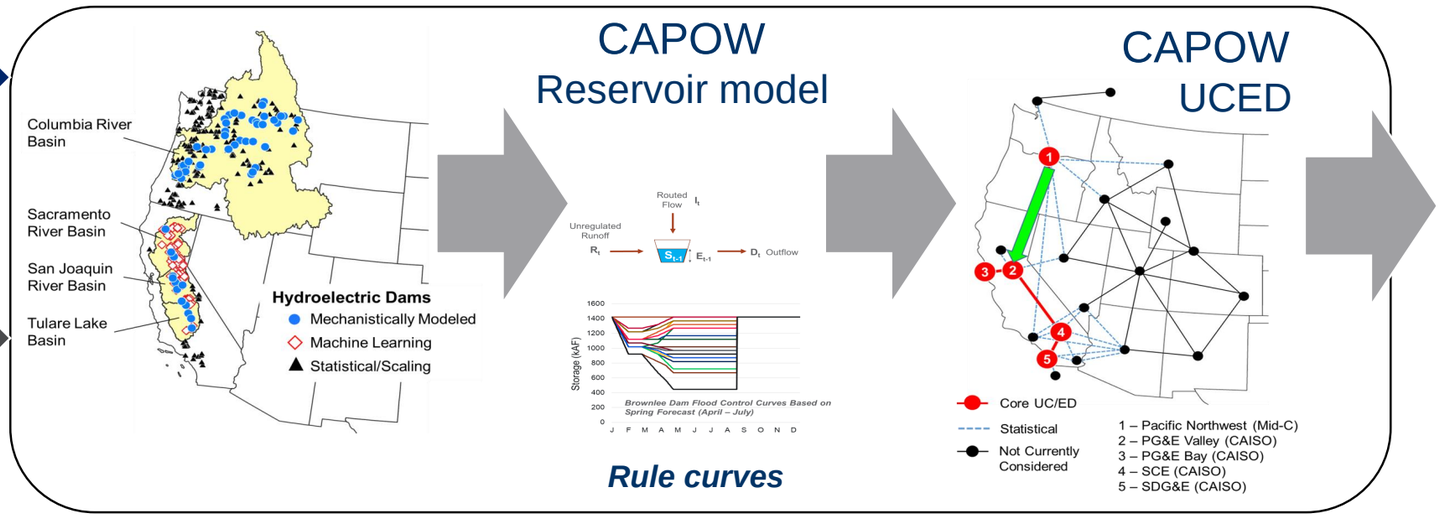
1995-2005 7-day daily flow forecast

Fixed Schedule

Daily must-take

Hydro-thermal coordination

7-day aggregation to be optimized



	Fixed Schedule *(follow daily rules)*	HTC Schedule *(flexible & foresight of grid needs)*
Persistence Fcst		
Perfect Fcst		

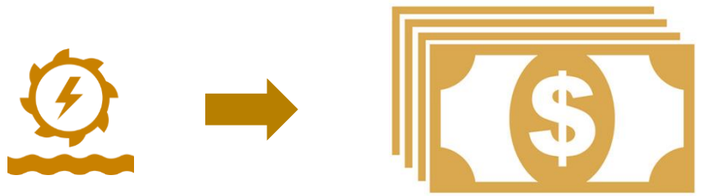
Metrics: Flow

Metrics: Generation

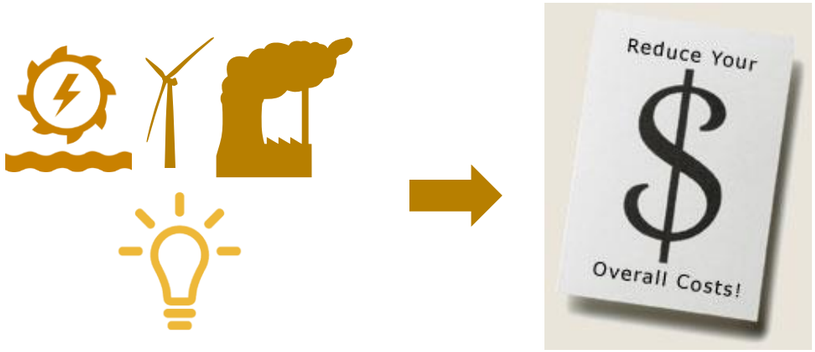
Metrics:
- Regional System Cost
- Regional Electricity Prices

Metrics

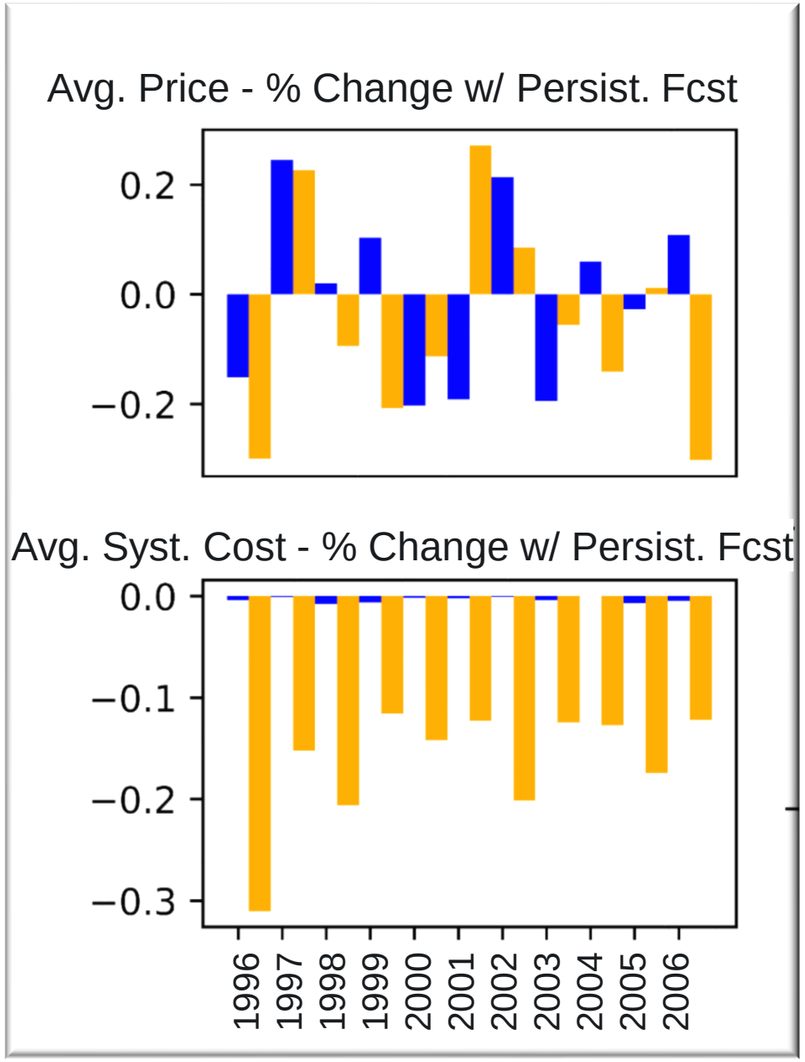
- Change in electricity prices
  - ~ changes in revenues
  - map with traditional flow forecast valuation approach for hydropower
  - capture any complex interactions between forecast skill and price variations



- Changes in system cost
  - ~ avoided cost
  - value to utilities with mixed generation portfolio and system operators



In California, the value of flow forecast propagates mostly into changes in revenue.



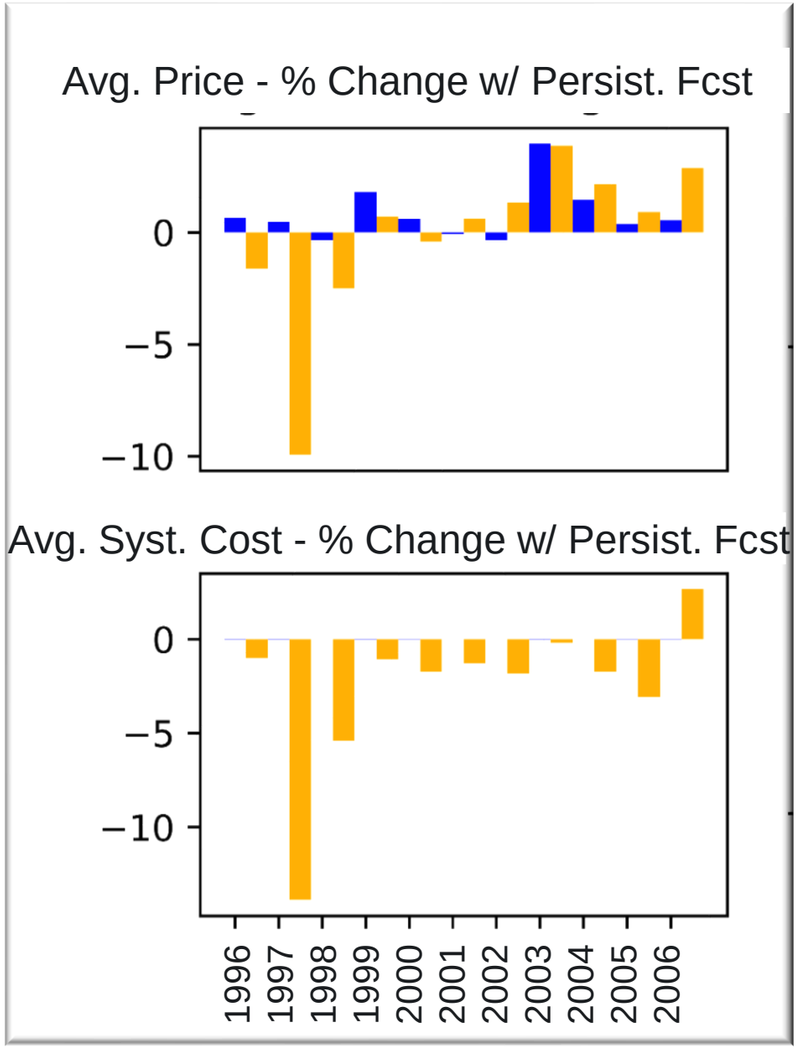
Large Regional Impact: *direct relationship between changes in generation and revenues.*

Low system-wide impact*: HTC enhances value of forecast by further decreasing the system cost (0.3%)*

Fixed schedule, Perfect wrt Persistence
HTC scheduling, Perfect wrt Persistence

In the Northwest, the value of flow forecast propagates mostly into changes in avoided cost.

And the type of unit commitment for hydropower plays a large role in this valuation process!



Conflicting regional impact: *prices are impacted by the forecast. An HTC scheduling enhances price fluctuations and potentially decrease revenues.*

High system-wide impact*:*
Combined with HTC, forecast reduce price volatility, system cost and CO2 emission significantly.

Fixed schedule, Perfect wrt Persistence
HTC scheduling, Perfect wrt Persistence

Conclusions

- The valuation of flow forecast for power systems requires a production cost model in some regions
  - Over California, the value of flow forecasts remains mostly regional measured in generation and revenues.
  - Over the Pacific Northwest, flow forecasts influence both regional and system-wide dynamics (revenues, prices, system-cost).
- For regions with system-wide impact, dual / coordinated optimization schemes can balance regional and system-wide benefits.
- The cost of errors remains a challenge to assess with existing tools.

Thank you
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