Climate Adaptation Increases the Cost of Decarbonization:

A case study that informs community engagement on *model linkages*

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U.S. Department of Energy | Office of Science
HYPERFACETS
A Framework for Improving Analysis and Modeling of Earth System and Intersectoral Dynamics at Regional Scales

NCAR
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HyperFACETS
Cross-Cutting Engagement Themes

Guidance on use of model hierarchies / linkages

What are model *“hierarchies”*?

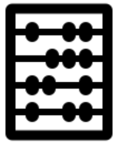
- The linkage of **climate models and data** with **impact/management models** to assess the impacts of climate change on human systems.
- Since we are not talking about actual hierarchies, we might want to rename the title to *model linkages?*

What is the goal of this work?

- Use HyperFACETS and other examples to co-produce a common set of challenges and guidance for addressing climate and impact model and data linkages

Synthesis of working group discussions to-date

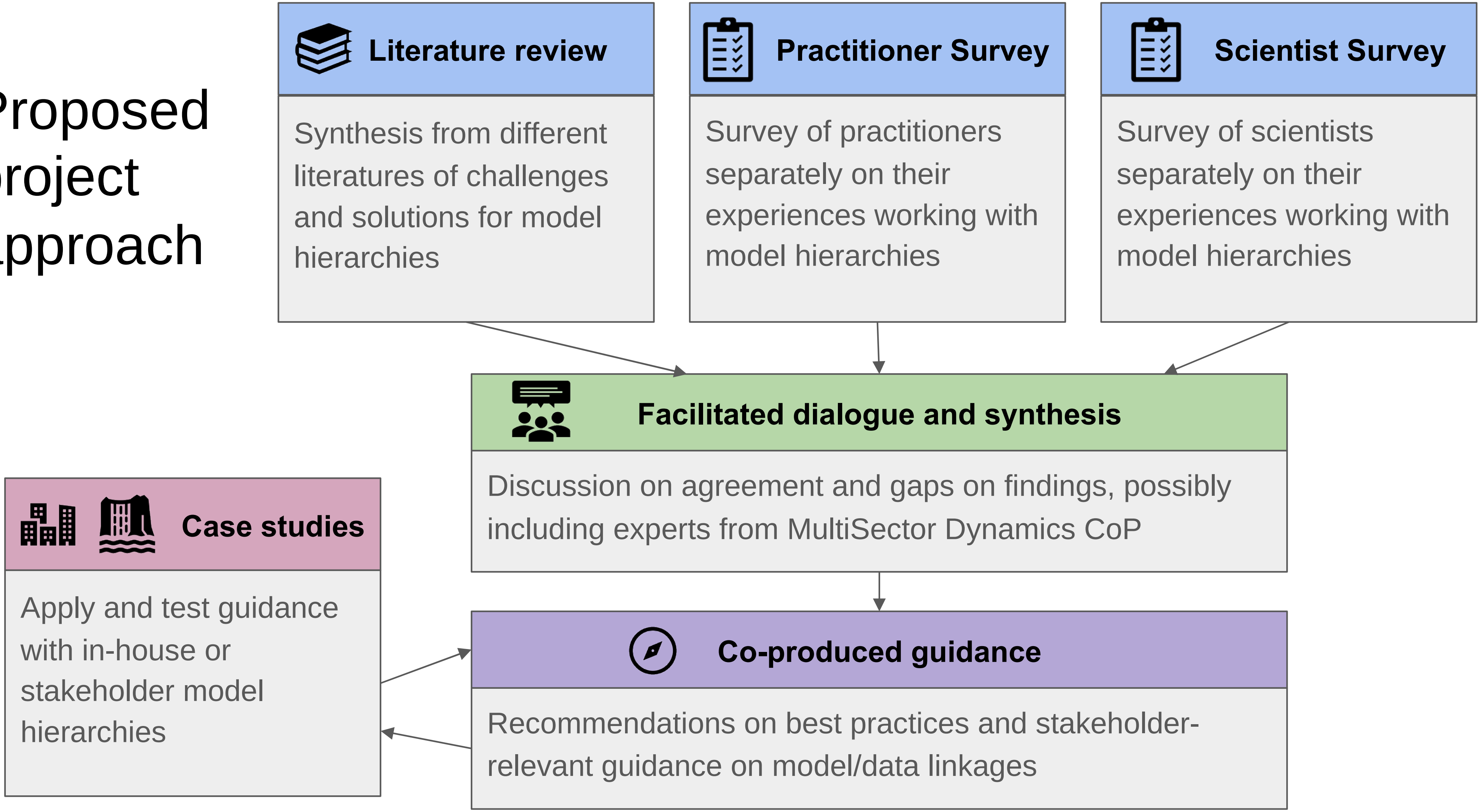
- Different flavors of models and data:
  - Climate model hierarchy: global models, regional models, regional refined global models, ML models driven by global/regional models
  - Process-based ML models vs. statistical models
  - Climate models connected with impact models



- Different ways to evaluate credibility of different models:
  - “Better” skill differs based on type of model, intended use or question to be answered, variable (extremes vs. average, application, location)
  - One type of model (e.g. ML) can diagnose the behaviors of another type

- Challenges:
  - Temporal and spatial mismatch among models in hierarchy
  - Error propagation and uncertainties across model hierarchies
  - Communication of model outcomes and uncertainties

Proposed project approach



Survey question themes

1. Details of climate models and observation data use

- For what applications/research questions are you using climate model data?
- What data do you use, how is it used, how do you access it, how do you choose it, downscale it?
- Observational vs. climate model data and formats?

2. Challenges of integrating climate data into impact models

- Overall challenges in integration?
- How do extreme events affect modeling choices?
- Do you have any spatial and temporal mismatch challenges
- Computational challenges?

3. Tools or techniques used to overcome integration challenges

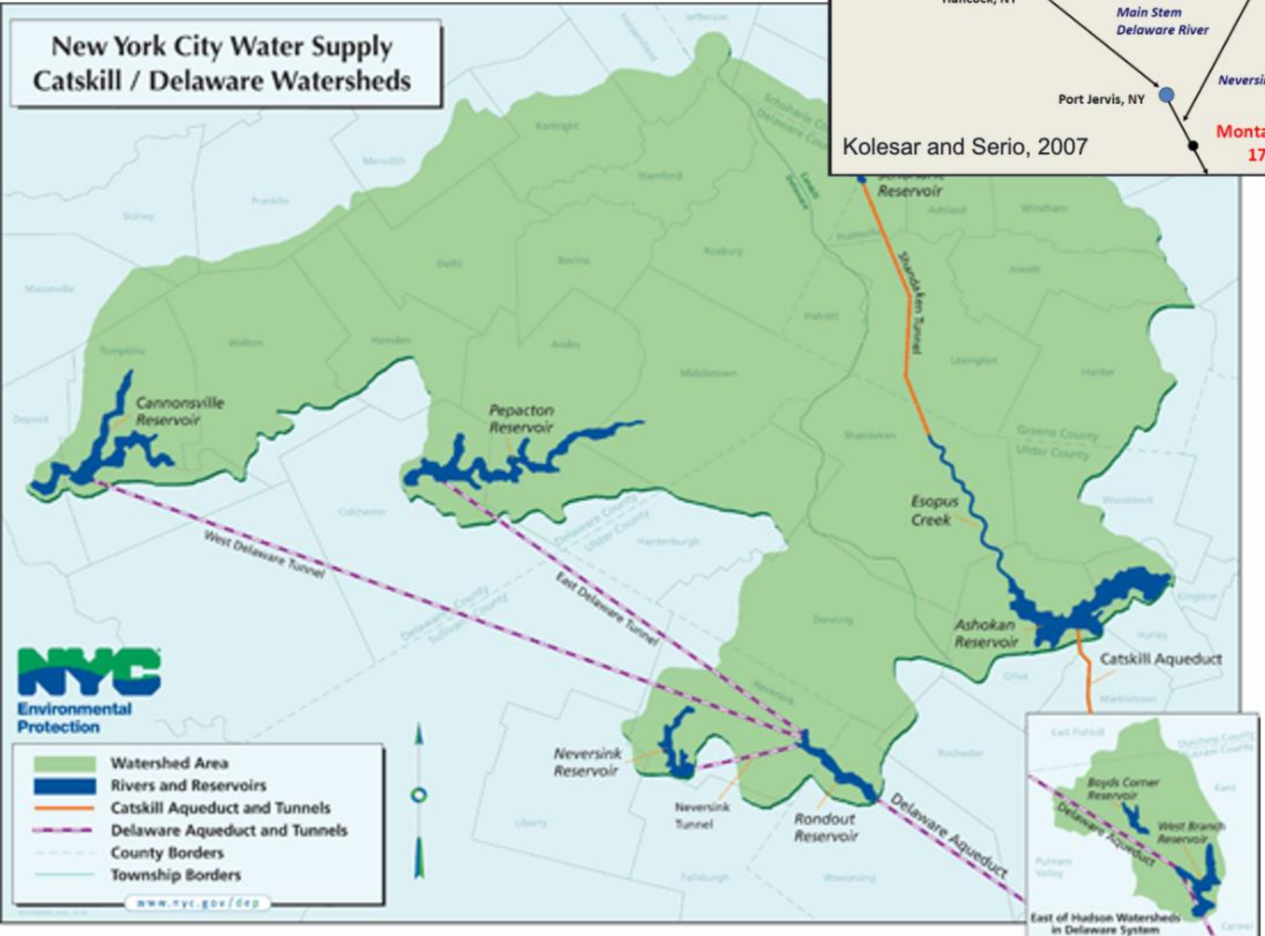
- What solutions do you use to address integration challenges?
- Do you adjust for extreme events?
- How do you resolve spatial/temporal mismatches?
- How do you overcome computational challenges?

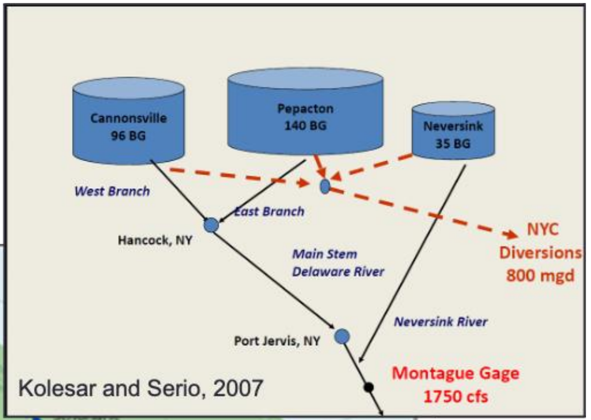
4. Uncertainty & Error Propagation

- How do you assess and communicate error propagation and uncertainty given challenges?
- Do you separate how you consider and communicate uncertainty from climate model data versus impact model data?

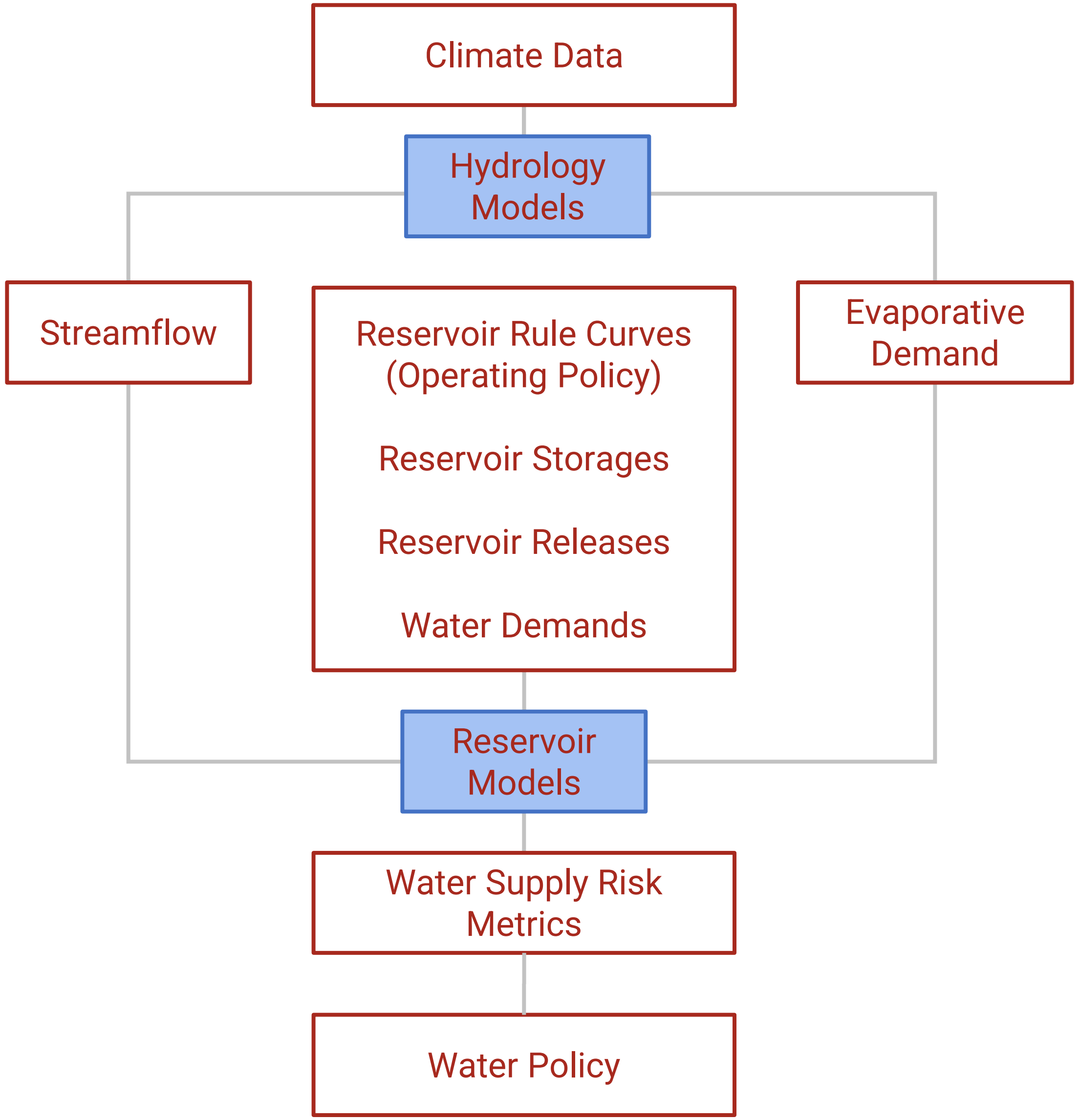
Case Studies

Drought-induced Water Stress





Kolesar and Serio, 2007



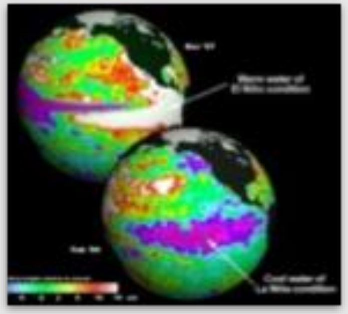
The Cannonsville, Pepacton and Neversink reservoirs provide up to 50% of the water to NYC and serve downstream ecosystem

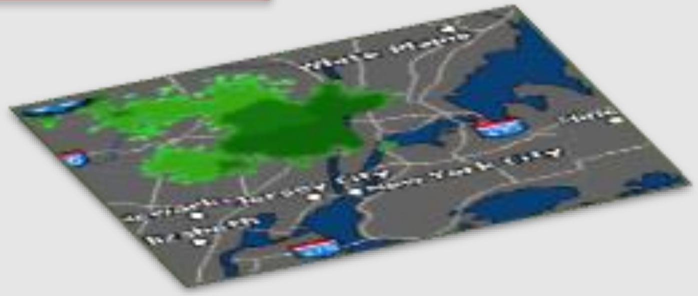
Case Studies

Urban Flood Scenarios

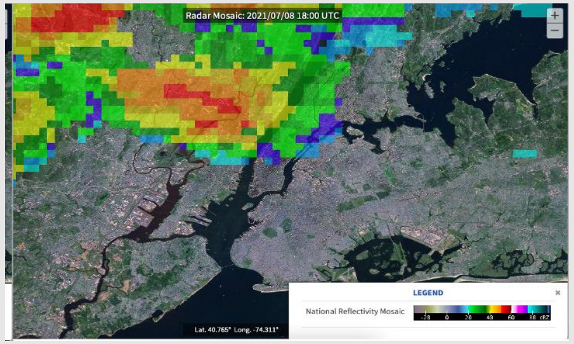
Outcomes will be useful in planning for storm emergencies and improving the design/analysis of infrastructure

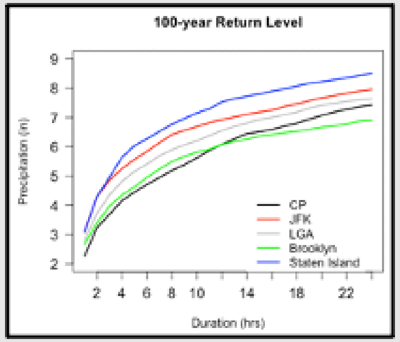
Climate Data





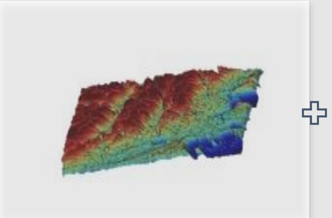
Extreme Rainfall Simulations
IDF Creation

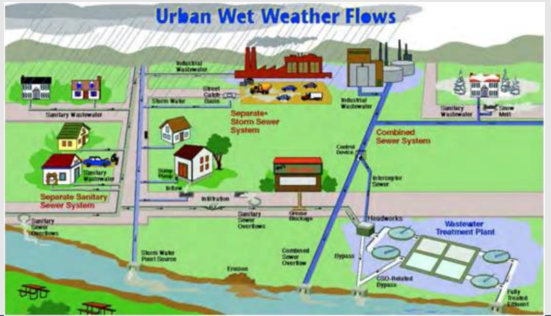




SWMM

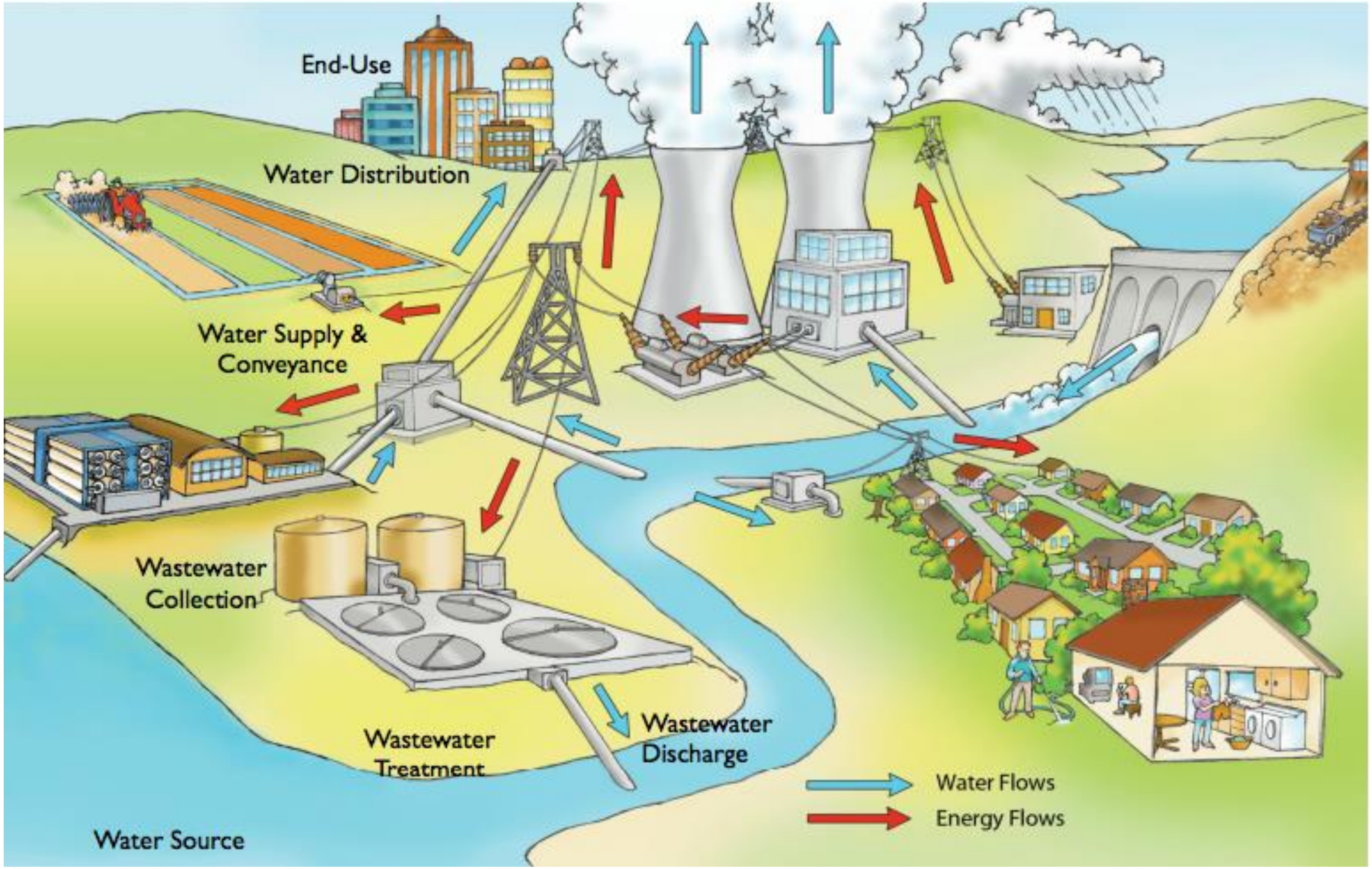
HEC-RAS





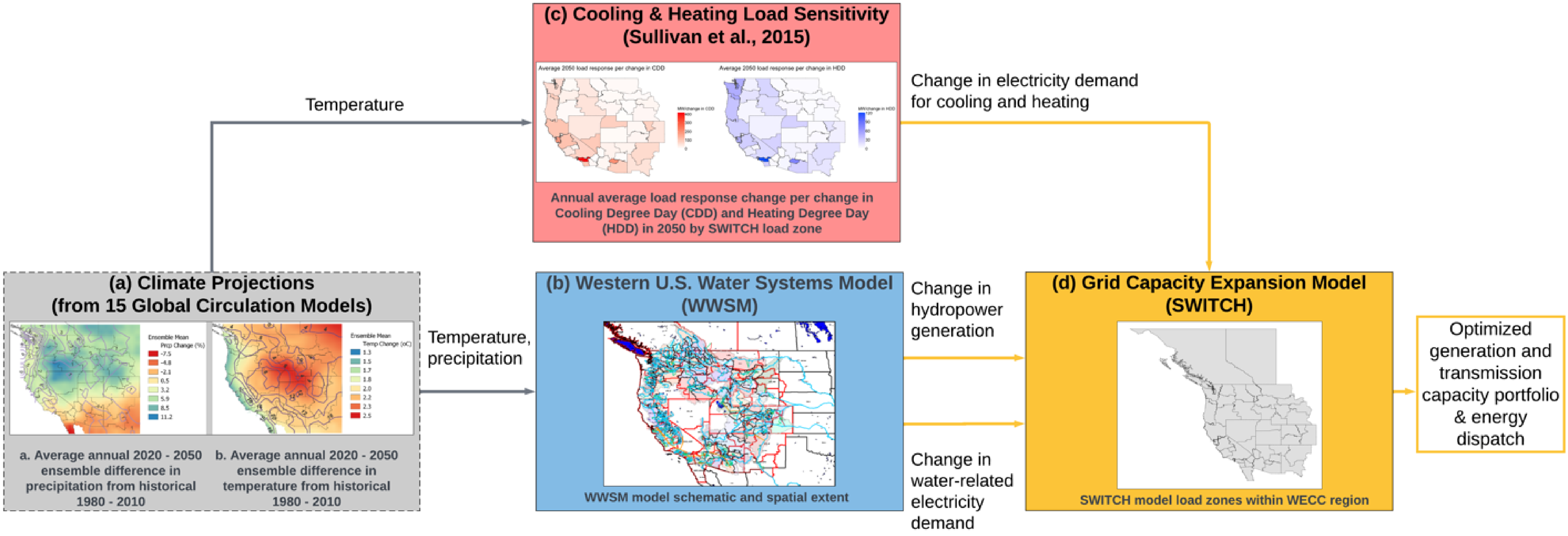
Case Studies

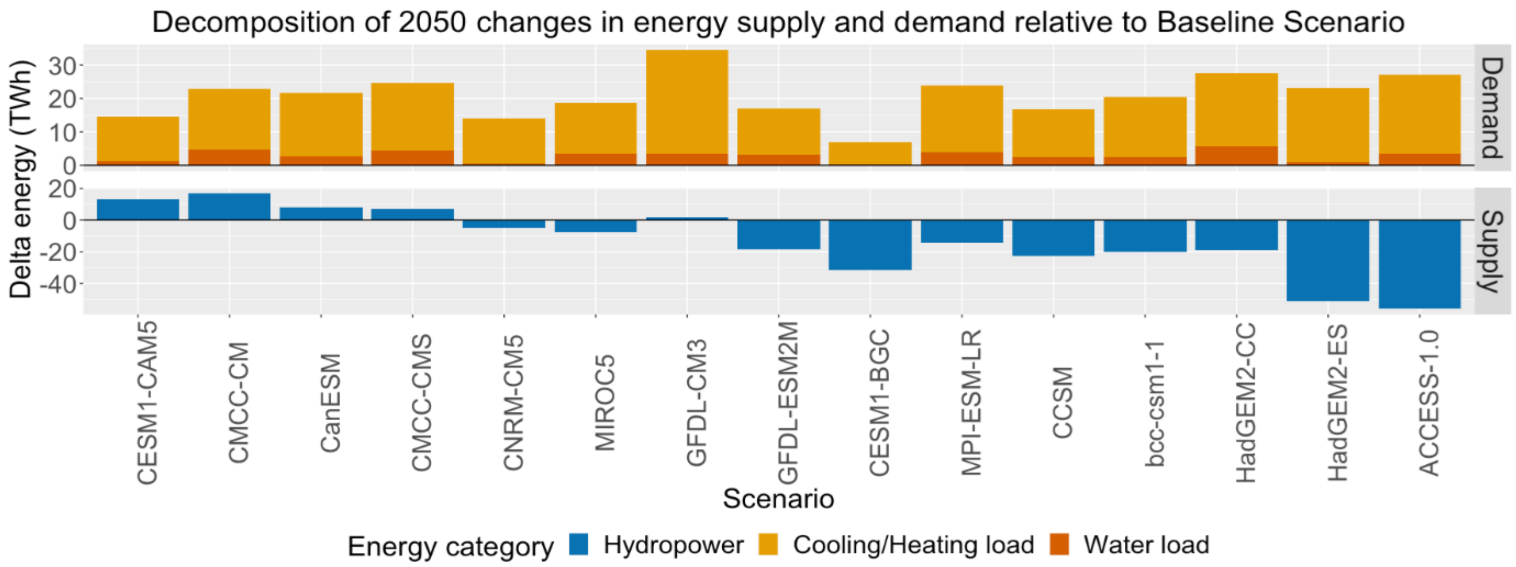
Water and energy system transformation to achieve decarbonization and resilience



Source: U.S. Dept. of Energy, Energy Demands on Water Resources, Report to Congress on the Interdependency of Energy and Water, 2006.

Climate-Water-Energy System Linkages

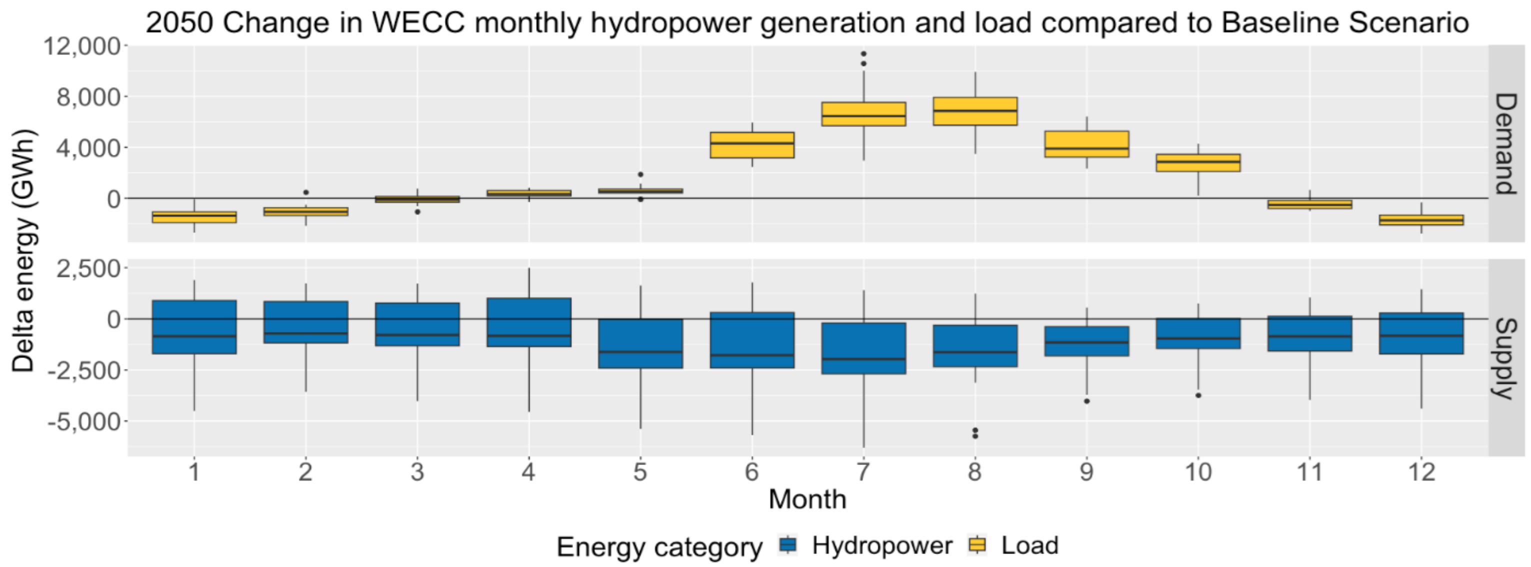


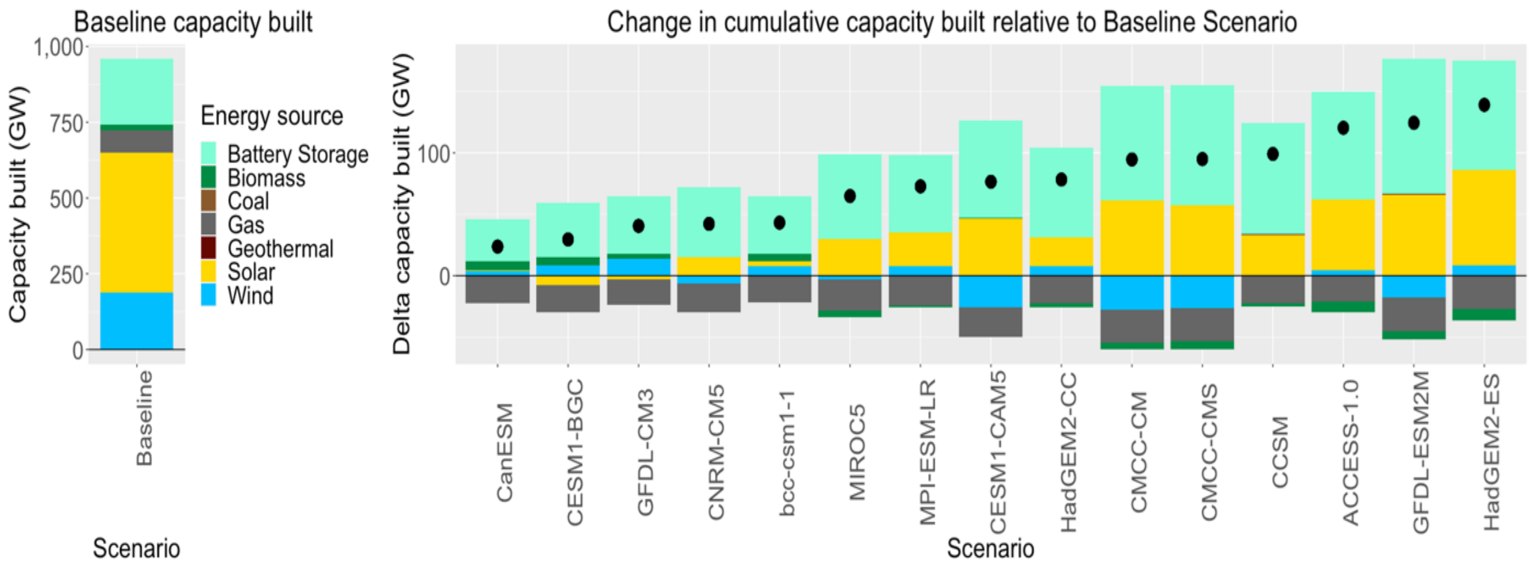


Electricity demand increases to varying degrees across all climate scenarios

Hydropower supply is more variable

Supply and demand imbalances tend to concentrate in summer months, compounding one another.

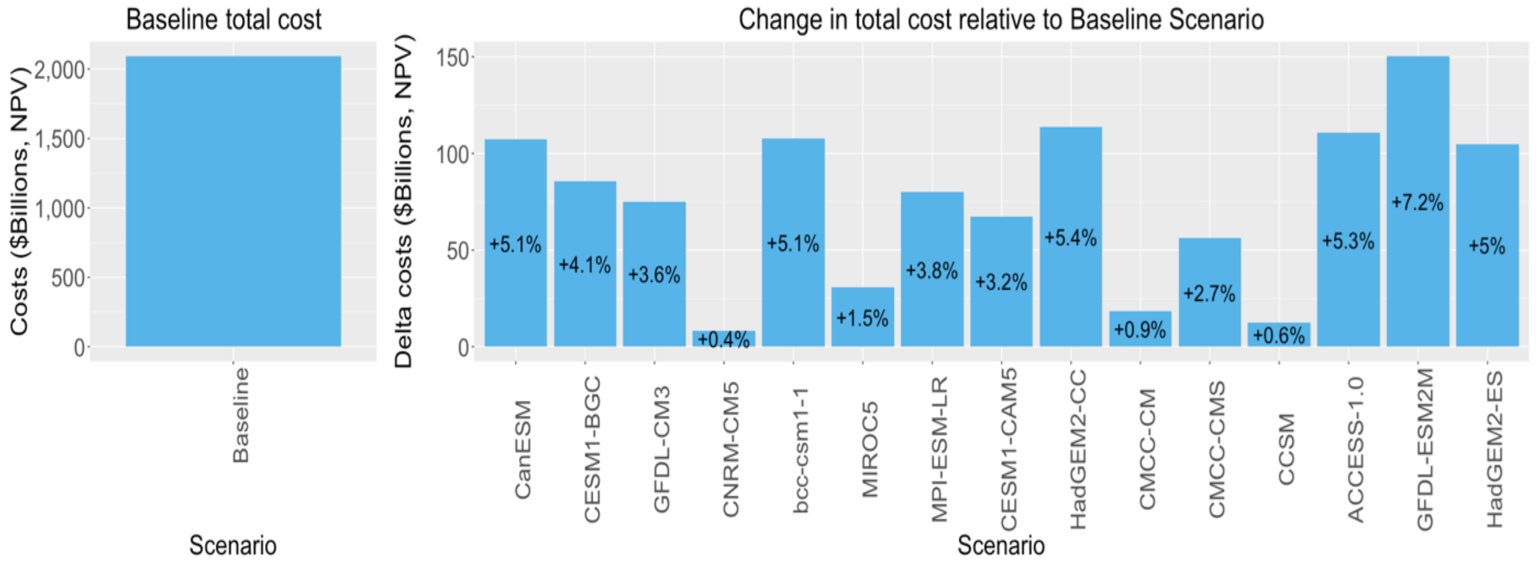




Additional capacity for adaptation can be substantial

Up to 139GW, which is 3X current peak demand in CA

Costs of adaptation vary significantly across climate scenarios



Learn more:

Szinai J.K., D. Yates, P. A. Sánchez-Pérez, M. Staadecker, D. M. Kammen, A. D. Jones, P. Hidalgo-Gonzalez (in review). Climate change and its influence on water systems increases the cost of electricity system decarbonization. *Nature Communications*

Yates, D., J. Szinai, A.D. Jones (2024). Modeling the Water Systems of the Western US to Support Climate-Resilient Electricity System Planning. Earth’s Future. https://doi.org/10.1029/2022EF003220

Buddhavarapu, S., K. Jagannathan, A.D. Jones (2023). HyperFACETS 2023 Workshop: Summary Report.