Research Efforts for the Energy System

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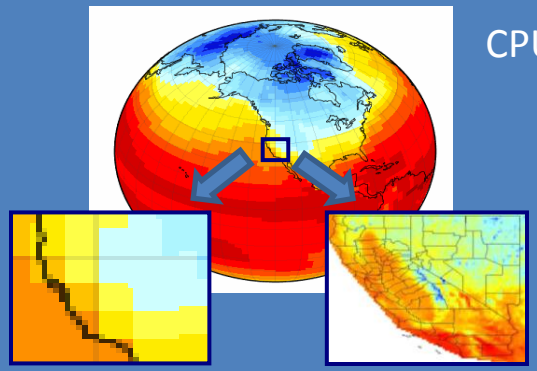


CPUC/CEC Workshop on Climate Adaptation Opportunities for the Energy Sector
San Francisco
July 27, 2015

Outline

- Background Information
- Examples of potential impacts
- Potential adaptation options
- Planned studies
- Conclusions

Background Information

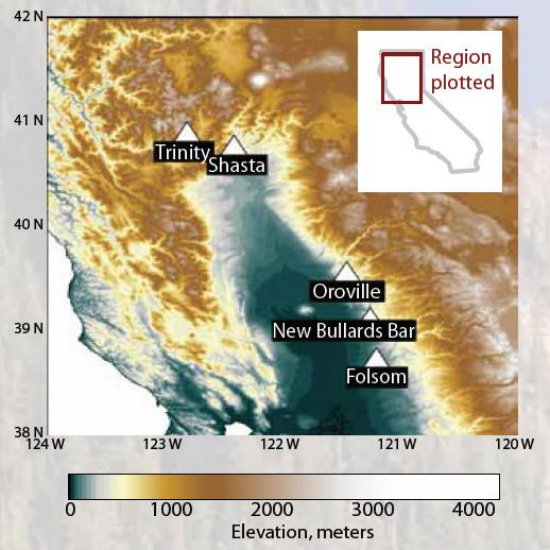
Supporting Energy-Related Climate Change Research

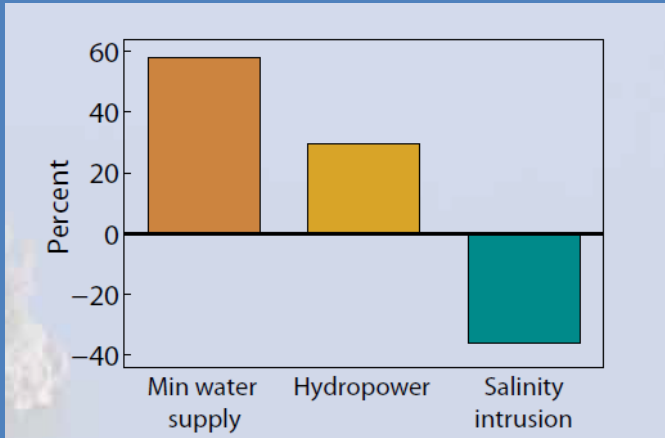
- The Energy Commission started supporting climate change research in earnest in the early 2000s with the creation of the Public Interest Research Program (PIER).
- Energy-related work continues with the creation of the Electric Program Investment Charge (EPIC).
- PIER Natural Gas funds also contributes to natural gas related research.
- The vast majority of past energy studies have been supported by the State of California via PIER.
- CPUC has been a key player in climate change research in California supporting the Energy Commission. Thank you!

Examples of Potential Impacts

Low Elevation Hydropower Units

- Associated with large reservoirs (e.g., Folsom Dam)
- Provide about 25% of hydro generation
- Main functions are flood protection, water supply, and recreation.
- Multiple studies since 2001
- Using probabilistic forecasts and a modern decision support system (e.g., INFORM) is a win-win strategy; but regulatory, institutional, and legal requirements may impede the implementation of this adaptation option.



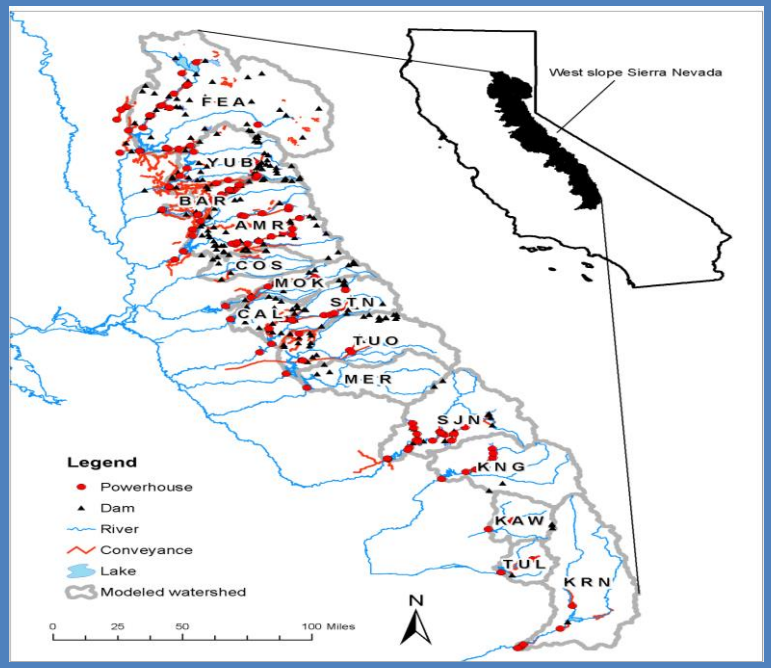


Compared to current practice, under future simulated climates INFORM gives a larger minimum water supply, more hydropower, and less salinity intrusion from the SF Bay.

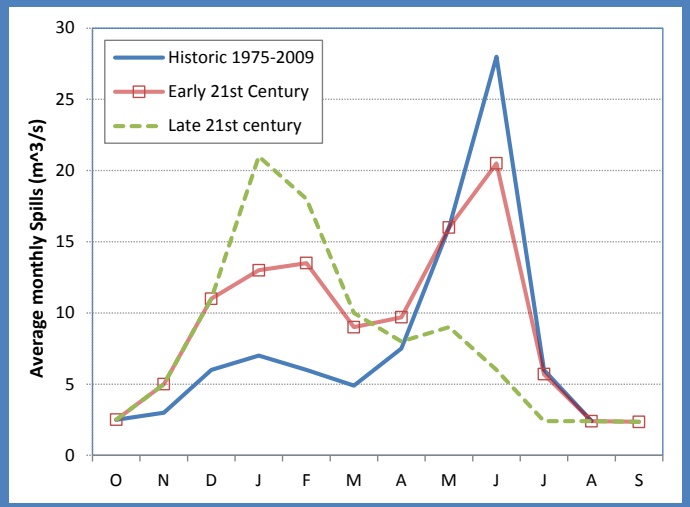
High Elevation Hydropower Units

- Provide about 75% of hydro generation. Snowpack is the main "reservoir."
- Four studies by UC Davis and UC Berkeley since 2006.
- Even without changes in precipitation, generation goes down due to loss of water due to evapotranspiration.
- Less generation in the hot months of the year.
- Increased flows in the winter time discharged to low elevation hydro units (risk of flooding?).
- Lack of detailed data has hampered more realistic simulations.

Source: Joshua Viers (UC Davis)



Simulated Operations for Upper American River Project



Source: Vicuña et al., 2011

Electricity and High Temperatures

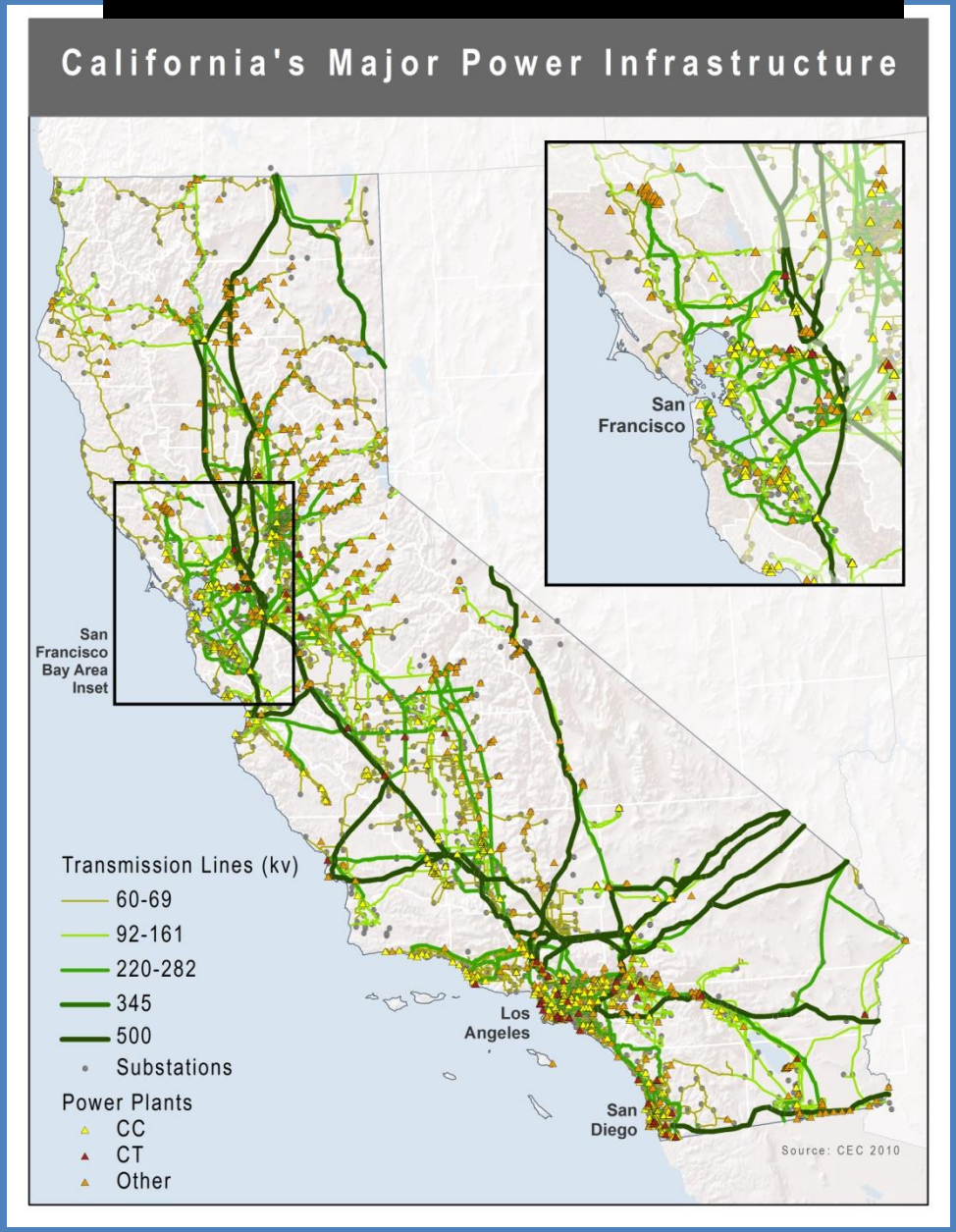
LONG-TERM IMPACTS

- **Need for More Generation on Hottest Days**
  - Decreased Thermal Power Plants Generation Efficiency
    - Need additional GW (8%)
  - Peak Period Demand (90%tile)
    - 21% higher cooling demand
    - Need additional GW (27%)
  - Substation Loss
    - 2.7% higher losses
    - Need more GW (3.6%)
- **Total Required Generation Capacity**:
    - Need 39% more capacity GW
- **Need for More Transmission Capacity**
  - Transmission lines
    - 7% - 8% loss of peak period capacity (static rating)

NEAR-TERM IMPACTS

- **Same as long-term but at a lesser degree. For example:**
  - Need additional capacity of 1.6 GW in the next 10 years (2013 IEPR)

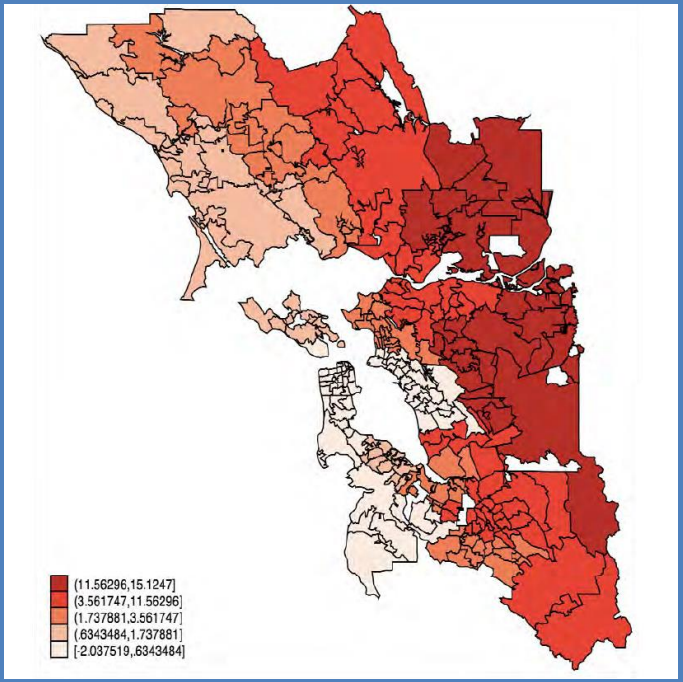
Current Infrastructure & Future Climate

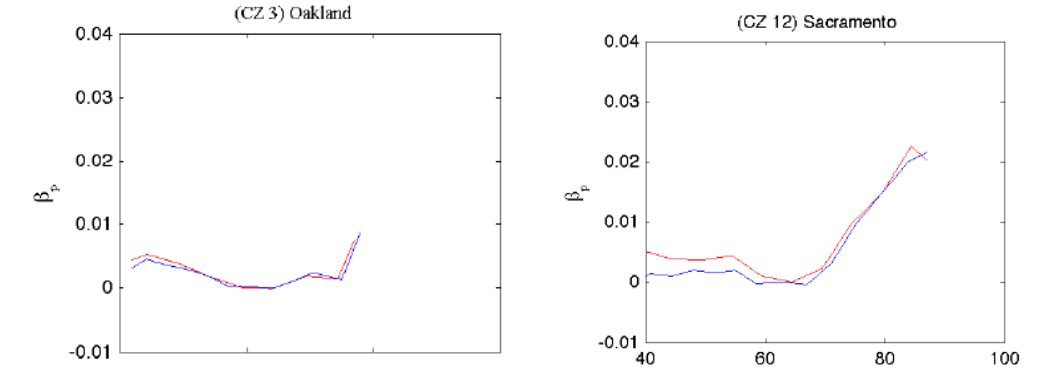


Source: Sathaye et al., 2013

Electricity Demand in the Residential Sector

- Utilities have shared confidential electricity consumption data with UC Berkeley.
- Prof. Auffhammer estimated aggregated demand as a function of temperature by zip code regions. Results were used to identify local groups with disproportional impacts and long-term potential climate impacts.
- The Energy Commission only received aggregated results.
- This is an example of excellent cooperation between utilities, the research community, and a public agency.



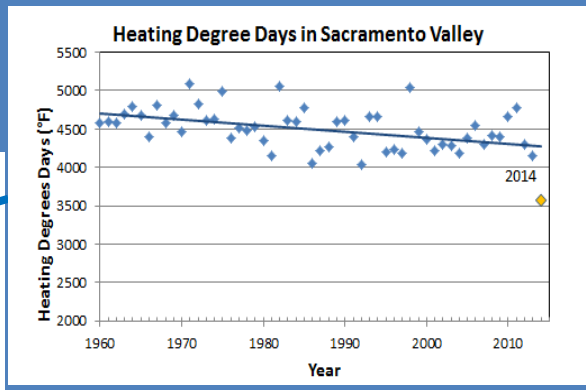


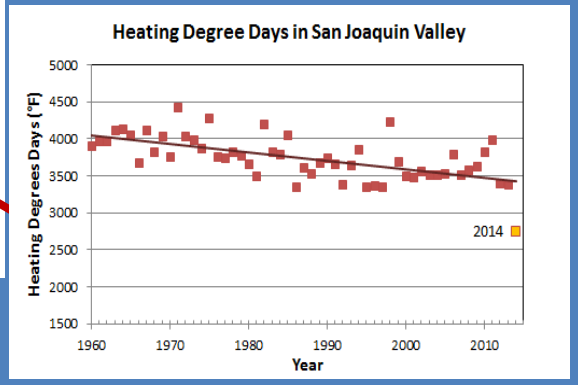
Source: Auffhammer and Aroonruengsawat, 2012

Demand for Space Heating

- Heating Degree Days (HDD) are going down (about 15% from the 1960s in the San Joaquin Valley). Note 2014.
- HDD will continue its downward trend reducing energy demand for space heating.
- However, as shown by Scripps Institution of Oceanography, extreme cold nights will not disappear but they will be less frequent.

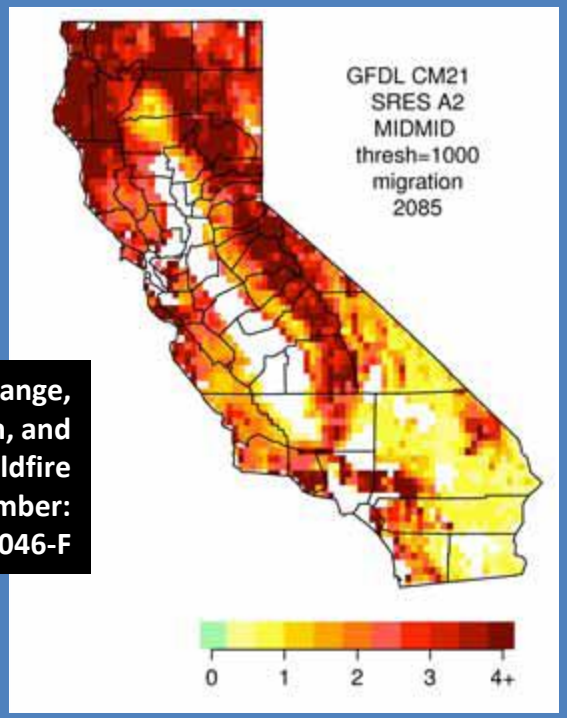
NOAA Climate Divisions: California





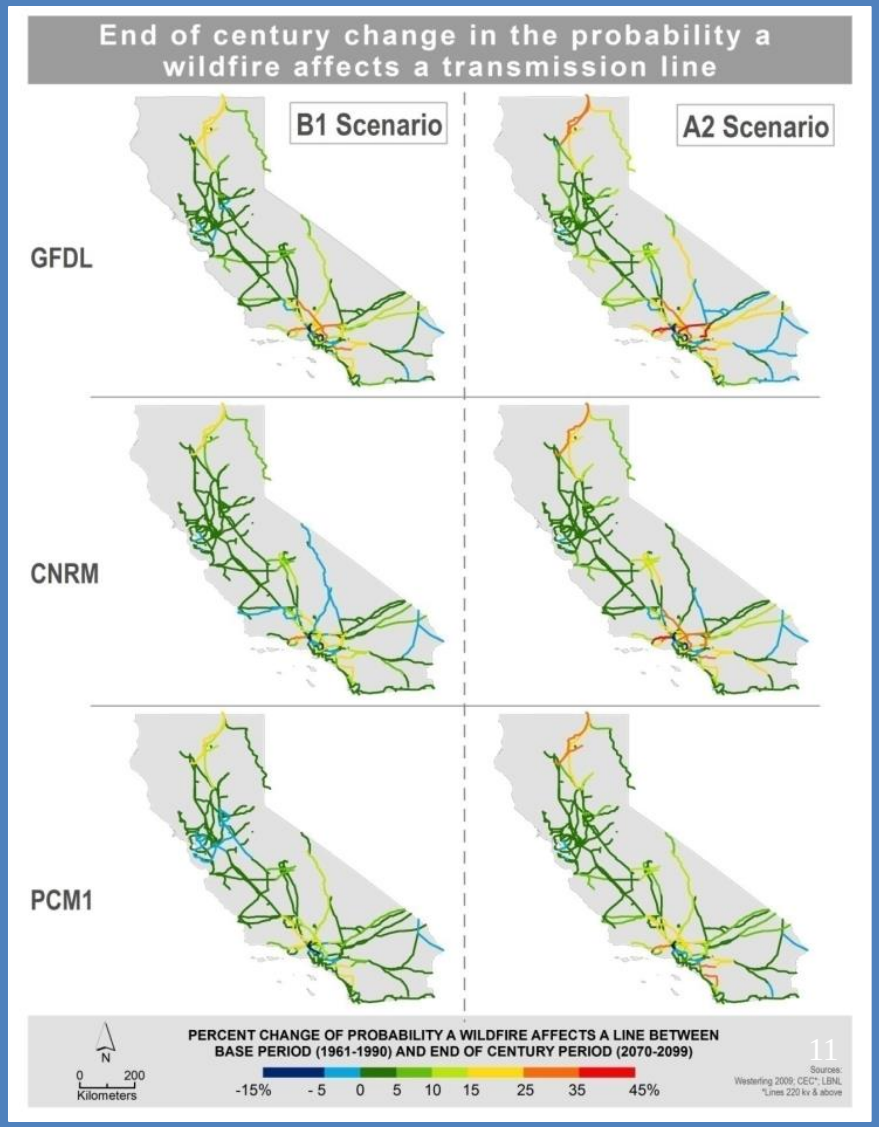
Data source: NOAA

Wildfires and Transmission Lines



Climate Change, Growth, and California Wildfire
Publication Number: CEC-500-2009-046-F

Study was hampered by the lack of access to historical data.

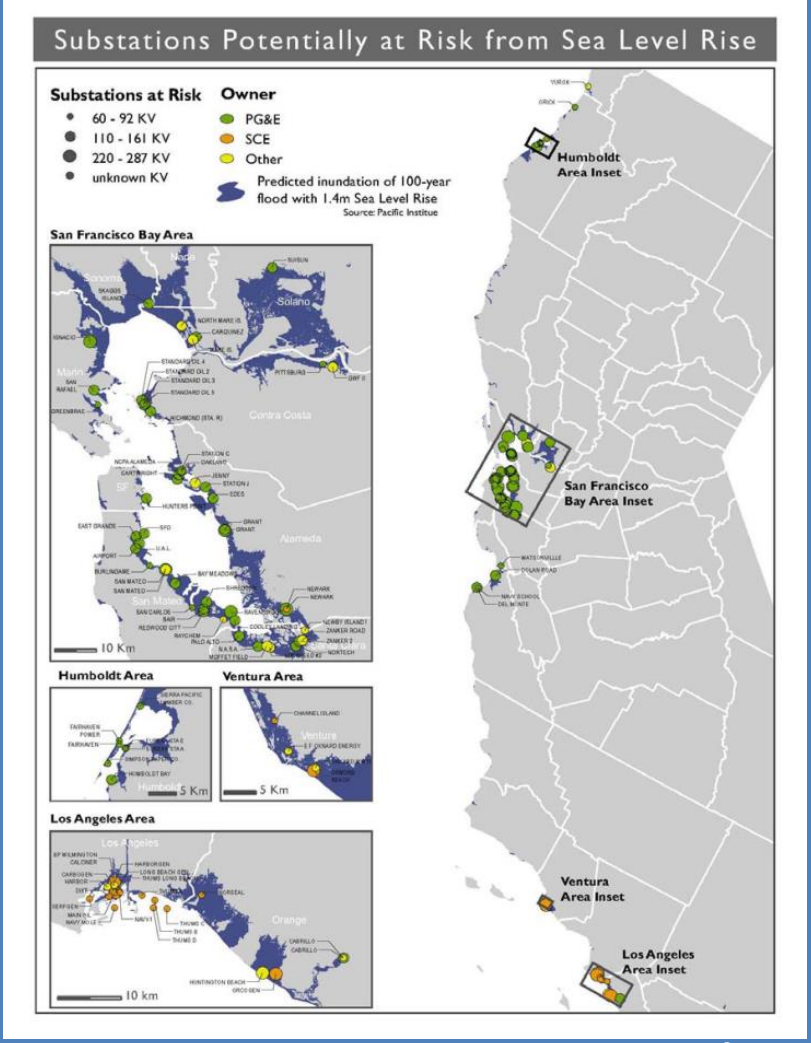


Estimating Risk to California Energy Infrastructure from Projected Climate Change
Publication Number: CEC-500-2012-057

Coastal Impacts

- Potential exposure of coastal power plants and substations to sea level rise.
- The study did not consider existing protection measures such as levees and coastal armoring.
- Available GIS data may have been distorted for security reasons.

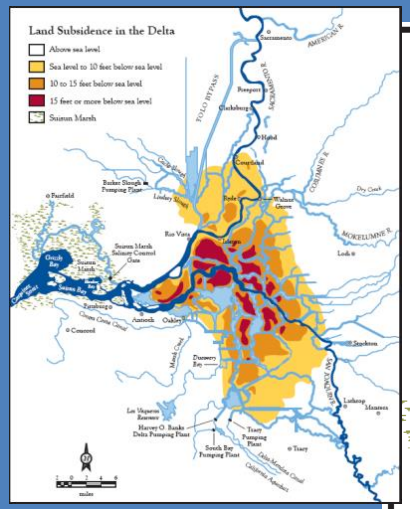
Source: Heberger et al., 2012

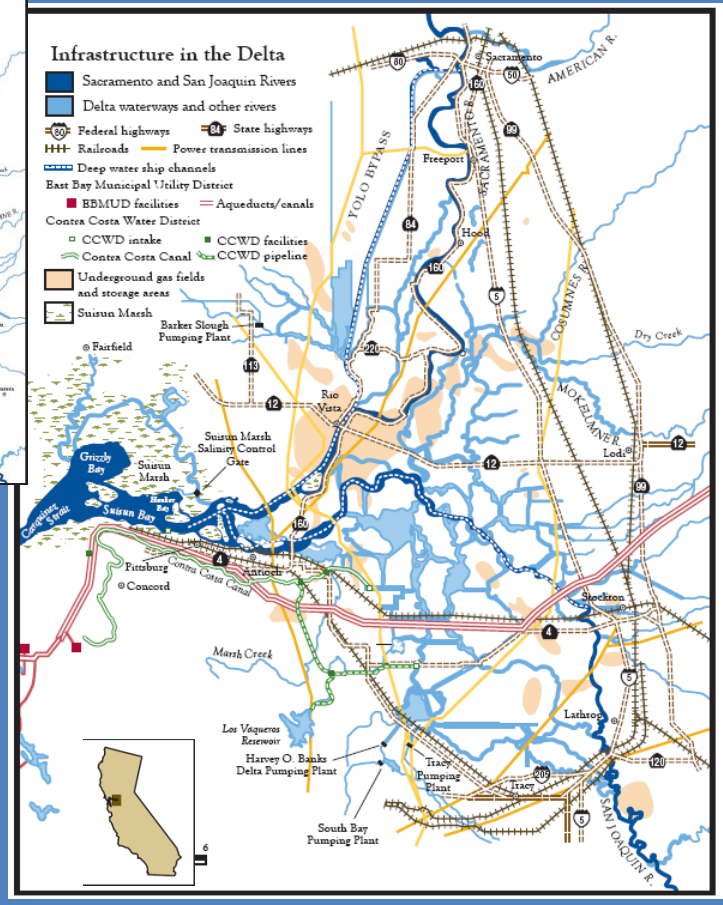


100-year coastal flood with 1.4 m sea-level rise

Energy Facilities in the Delta

- The Sacramento-San Joaquin Delta is protected by levees. Delta islands are below sea level
- Energy Facilities:
  - Underground natural gas reservoirs
  - Transmission lines
  - Natural gas pipelines
  - Power plants on the west side of the Delta
- Report from UC Berkeley will be available in the next few months (natural gas infrastructure).



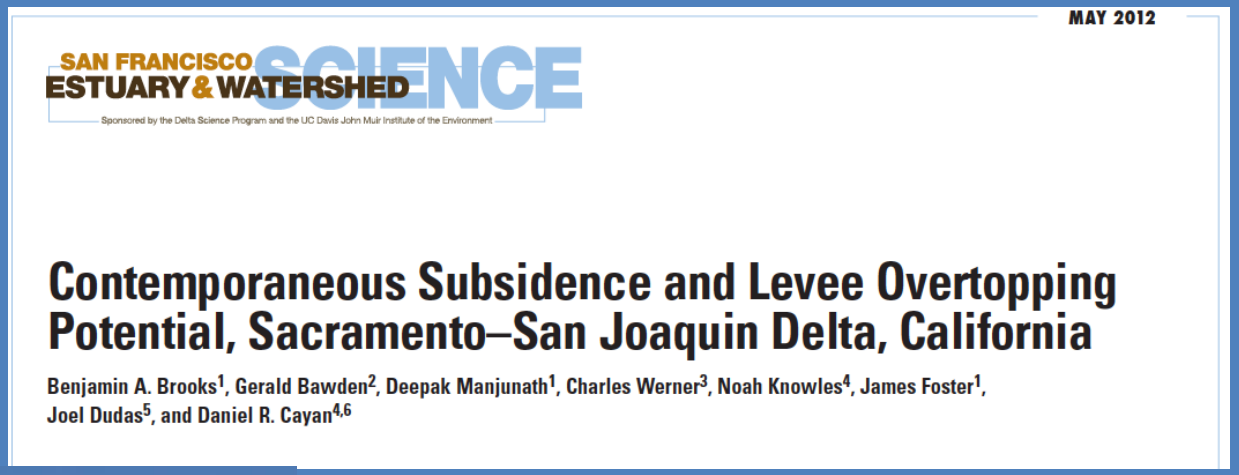


Source: PPIC 2007

Delta Levees Seem to be Subsiding, Increasing Relative Sea Level Rise

InSAR measurements may underestimate subsidence

New on-going follow up study


MAY 2012

SAN FRANCISCO ESTUARY & WATERSHED SCIENCE

Sponsored by the Delta Science Program and the UC Davis John Muir Institute of the Environment

Contemporaneous Subsidence and Levee Overtopping Potential, Sacramento–San Joaquin Delta, California

Benjamin A. Brooks[1], Gerald Bawden[2], Deepak Manjunath[1], Charles Werner[3], Noah Knowles[4], James Foster[1], Joel Dudas[5], and Daniel R. Cayan[4,6]

Sherman Island

Source: Ben Brooks, 2013

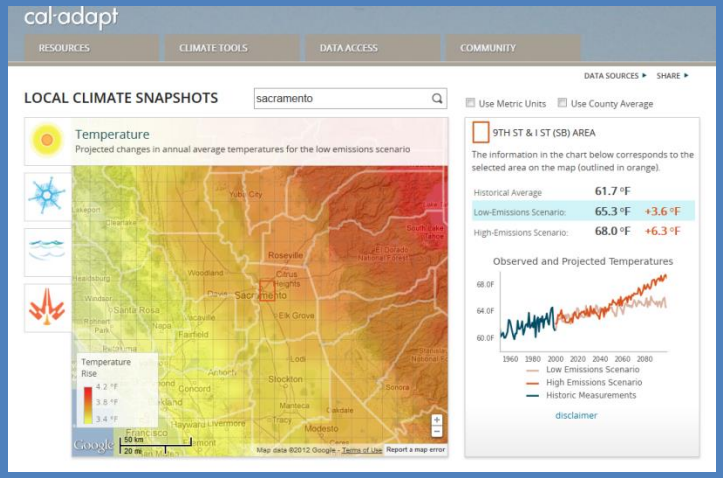
Adaptation Opportunities: some examples

“Win-Win” Opportunities must be Identified

- Improved operation of hydro units using probabilistic hydrologic forecasts and modern decision support systems.
- Microgrids to reduce vulnerability of critical assets.
- Seasonal and decadal forecasts for the electricity and natural gas systems.
- Making information available to decision makers, research managers, and the public in general (e.g., Cal-Adapt) in a usable form.

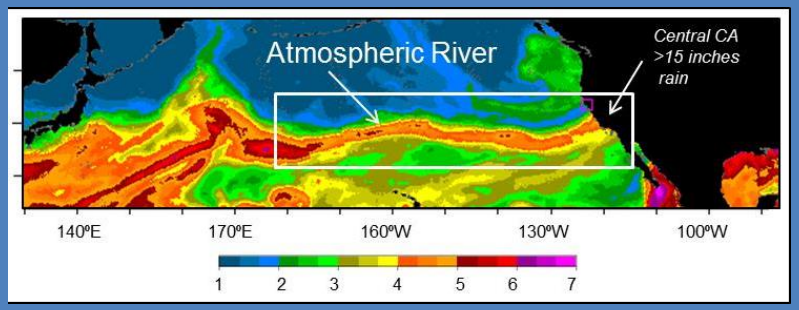
Power Outage
September 2011

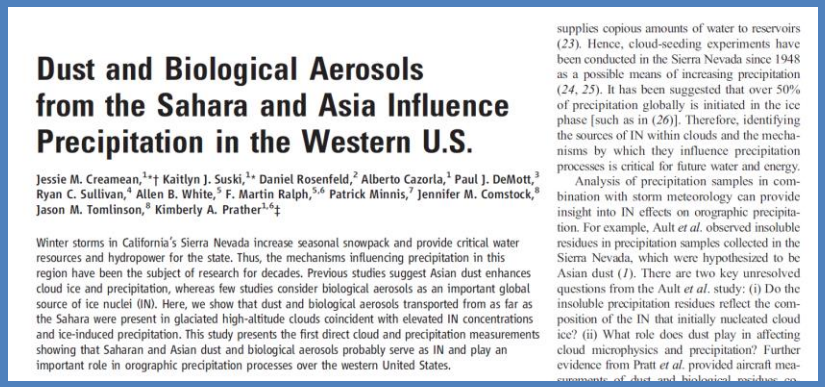
The Geisel Library at night, lit by locally-sourced microgrid energy | Photo: Nathan Rupert/Flickr/Creative Commons License



Extreme Precipitation in California

- DWR and NOA have deployed a network that tracks atmospheric rivers (ARs) when they reach California where satellites are not able to follow them due to interference with land.
- Since ARs are one of the main sources of heavy precipitation that can replenish snow in the Sierra or cause severe floods and since climate change is expected to impact ARs, this effort will be useful in the foreseeable future as an early flood warning tool.
- The Energy Commission supported work has shown that considering the role of small particles in the air should substantially improve hydro-meteorological forecasting and, therefore, the management of hydro units.
- Initial investment by the Energy Commission (CalWater I) resulted in a multi million dollar study by NOAA, DOE, NASA, and other federal agencies (CalWater II).





Dust and Biological Aerosols from the Sahara and Asia Influence Precipitation in the Western U.S.

Jessie M. Creamean,[1*†] Kaitlyn J. Suski,[1*] Daniel Rosenfeld,[2] Alberto Cazorla,[1] Paul J. DeMott,[3] Ryan C. Sullivan,[4] Allen B. White,[5] F. Martin Ralph,[5,6] Patrick Minnis,[7] Jennifer M. Comstock,[8] Jason M. Tomlinson,[8] Kimberly A. Prather[1,6‡]

Winter storms in California's Sierra Nevada increase seasonal snowpack and provide critical water resources and hydropower for the state. Thus, the mechanisms influencing precipitation in this region have been the subject of research for decades. Previous studies suggest Asian dust enhances cloud ice and precipitation, whereas few studies consider biological aerosols as an important global source of ice nuclei (IN). Here, we show that dust and biological aerosols transported from as far as the Sahara were present in glaciated high-altitude clouds coincident with elevated IN concentrations and ice-induced precipitation. This study presents the first direct cloud and precipitation measurements showing that Saharan and Asian dust and biological aerosols probably serve as IN and play an important role in orographic precipitation processes over the western United States.

supplies copious amounts of water to reservoirs (*23*). Hence, cloud-seeding experiments have been conducted in the Sierra Nevada since 1948 as a possible means of increasing precipitation (*24*, *25*). It has been suggested that over 50% of precipitation globally is initiated in the ice phase [such as in (*26*)]. Therefore, identifying the sources of IN within clouds and the mechanisms by which they influence precipitation processes is critical for future water and energy.

Analysis of precipitation samples in combination with storm meteorology can provide insight into IN effects on orographic precipitation. For example, Ault *et al.* observed insoluble residues in precipitation samples collected in the Sierra Nevada, which were hypothesized to be Asian dust (*1*). There are two key unresolved questions from the Ault *et al.* study: (i) Do the insoluble precipitation residues reflect the composition of the IN that initially nucleated cloud ice? (ii) What role does dust play in affecting cloud microphysics and precipitation? Further evidence from Pratt *et al.* provided aircraft mea-

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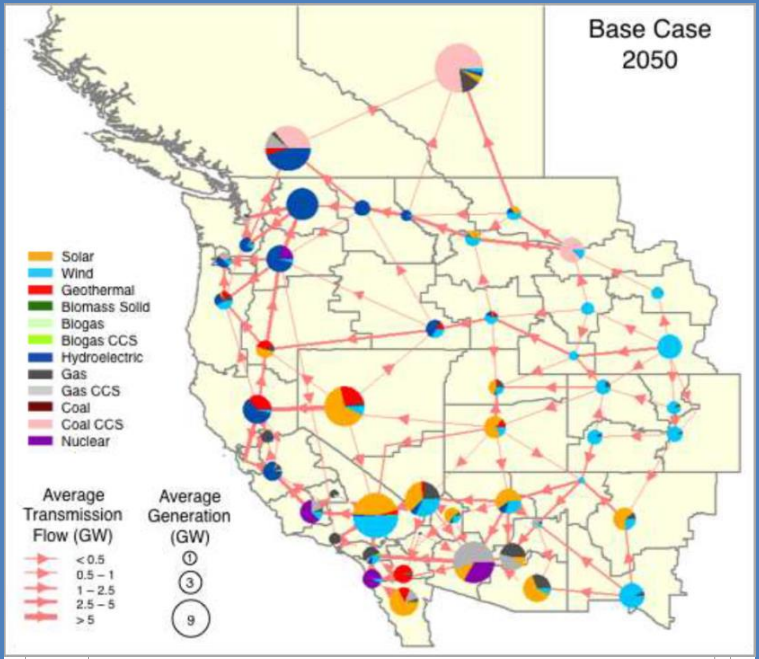
Transformation of the Energy System

- The electricity system is changing very rapidly
- This represents an opportunity to develop a more climate resilient system (2013 IEPR).
- A research project on this topic is starting with E3, LBNL/Berkeley, UC Irvine.



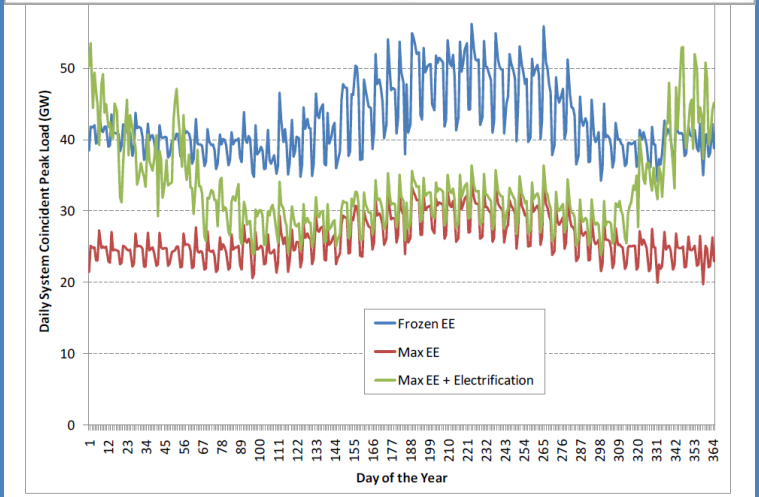


Figure 4-13. *Daily system coincident peak load from buildings in 2050 in California.*

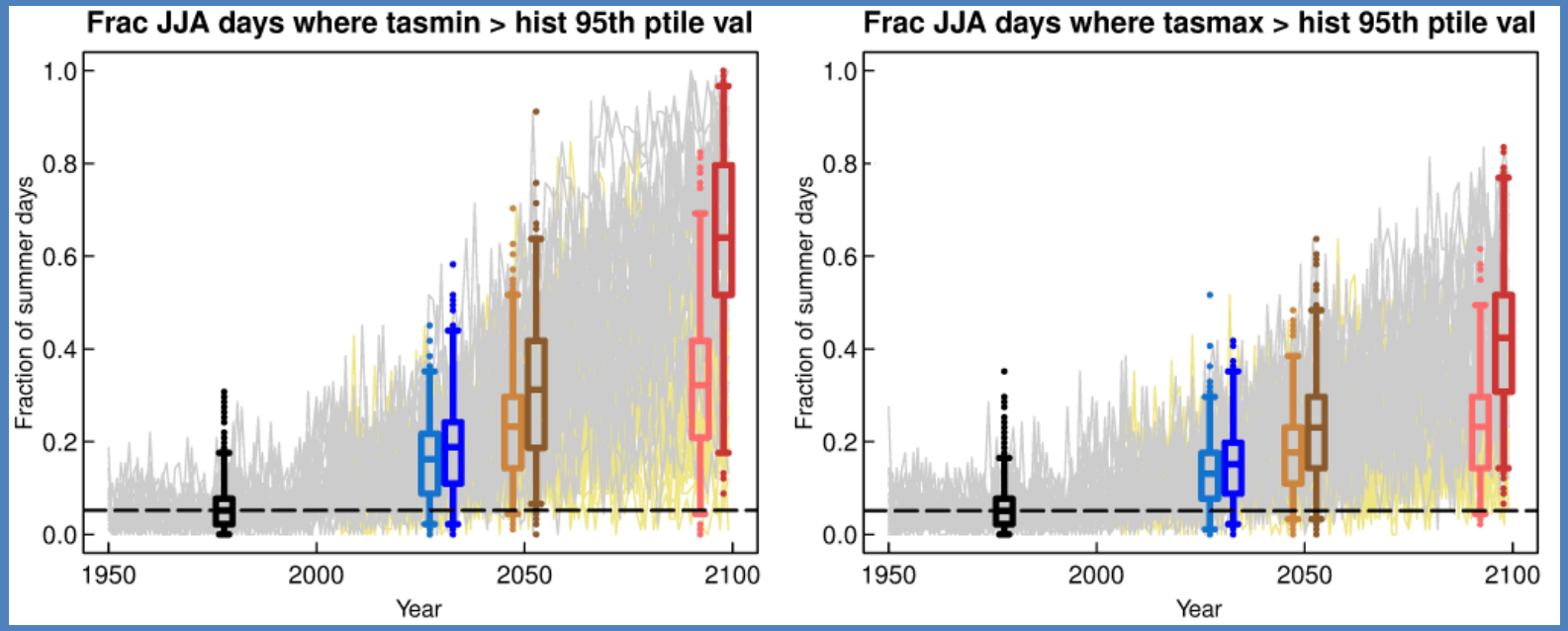
Source: Wei et al., 2012

Planned Studies

California's Fourth Climate Change Assessment

CA's Fourth Climate Change Assessment

- The California Natural Resources Agency (CNRA) is leading the preparation of California's Fourth Climate Change Assessment: about 20 state agencies are involved.
- Report to the Governor in 2018.
- The Energy Commission is supporting energy-related research including studies of adaptation options for the energy sectors
- The energy (CEC) and non-energy studies (CNRA) will use a common set of climate, sea level rise, and socio-economic scenarios.



Pierce et al., 2015. Scripps Institution of Oceanography

Partial List of Studies

- For the California Assessment (reviewing research proposals)
  - Probabilistic climate and sea level rise projections for the energy system.
  - Potential impacts of wildfires to the electricity distribution system and exploration of adaptation options.
  - Regional adaptation options for the electricity and natural gas system.
  - Long-term energy scenarios for California taking climate change into account (phase III).
  - Investigation of win-win strategies.
  - Investigation of climate vulnerabilities to the petroleum system such as refineries and oil pipelines (one time allocation of funds).
- Future projects
  - Simultaneous simulation of low and high elevation hydro units.
  - Barriers to adaptation and options to overcome them.
  - Impacts of climate change on resource availability of solar, wind, and biomass.
  - Long-term energy scenarios for California taking climate change into account (phase IV).
  - Demonstration phase of near-term, seasonal, and decadal forecast for the energy system.

Conclusions

- There is an urgent need to work more closely with the energy utilities to make sure we provide actionable science. A workable framework must be established.
- A mechanism should be established to allow researchers to receive confidential information from energy utilities to perform scientific studies. Energy utilities must be fully assured about the protection of confidential information.
- A steady stream of funds for climate studies for the petroleum sector may be needed. EPIC and PIER Natural Gas can not fund these studies.

Thank you!

Panchito Franco

Disclaimer: The views and opinions in this presentation do not necessarily represent the views and opinions of the Energy Commission or the State of California.