The Potential Impact of Climate Change to Energy Infrastructure in California: Study Design

Workshop on Climate Change Impacts and Integration Assessment

ENERY MODELING FORUM

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Snowmass, CO

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Public Interest Energy Research (PIER) Program

California Energy Commission

Outline

- Background Information
- Energy Demand and Generation
- Vulnerability Assessment
- Conclusions

Background Information

- The PIER Program has been supporting regional climate change science since 2001
- 2003 PIER climate change plan (5-yr) implemented via the CA Climate Change Center (~ 6 million/yr)
- June 1, 2005 Executive Order (EO) mandates the preparation of biennial science reports to the Governor and the Legislature. PIER leads the preparation of these reports (2006, 2009)
- Late in 2008 the Governor signed another EO mandating the preparation of adaptation plans. PIER to provide the scientific foundation
- PIER core research develops the tools and information needed for both reports (e.g. climate scenarios)

Energy Demand and Generation

Energy Demand

- Mendelsohn, 2003. The Potential Impact of Climate Change on Energy Expenditures in CA.
- Franco and Sanstad, 2006.
- Miller et al. 2006

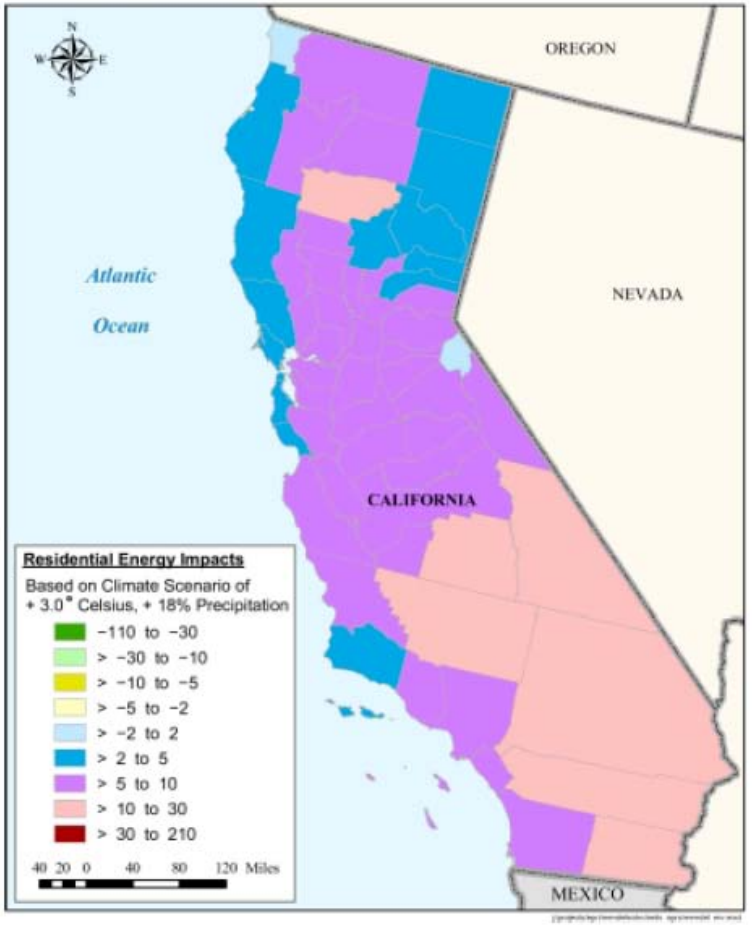

Figure 2. Percentage change in residential energy for a 3.0°C warming with 18% increase in precipitation

Source: Mendelsohn, 2003

Climate Scenarios for California

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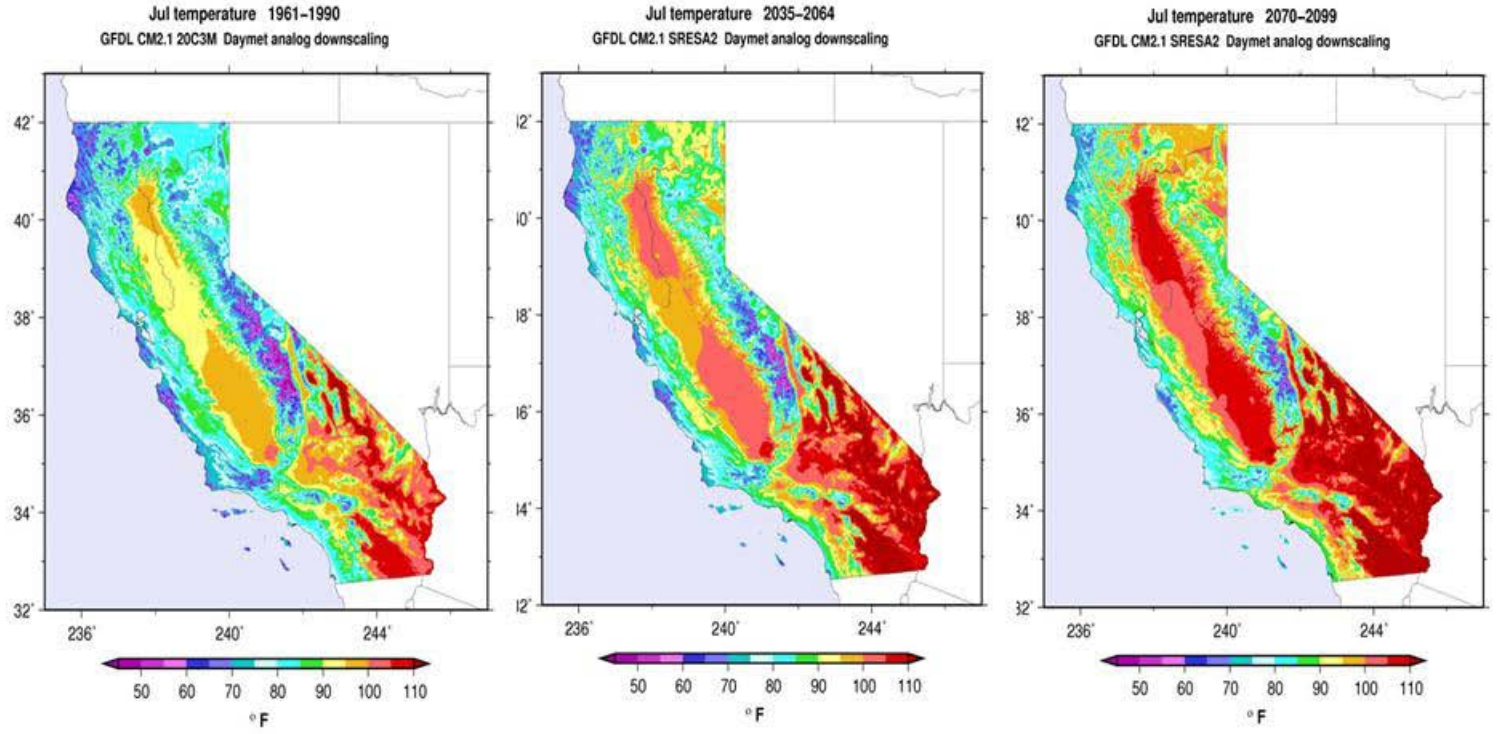
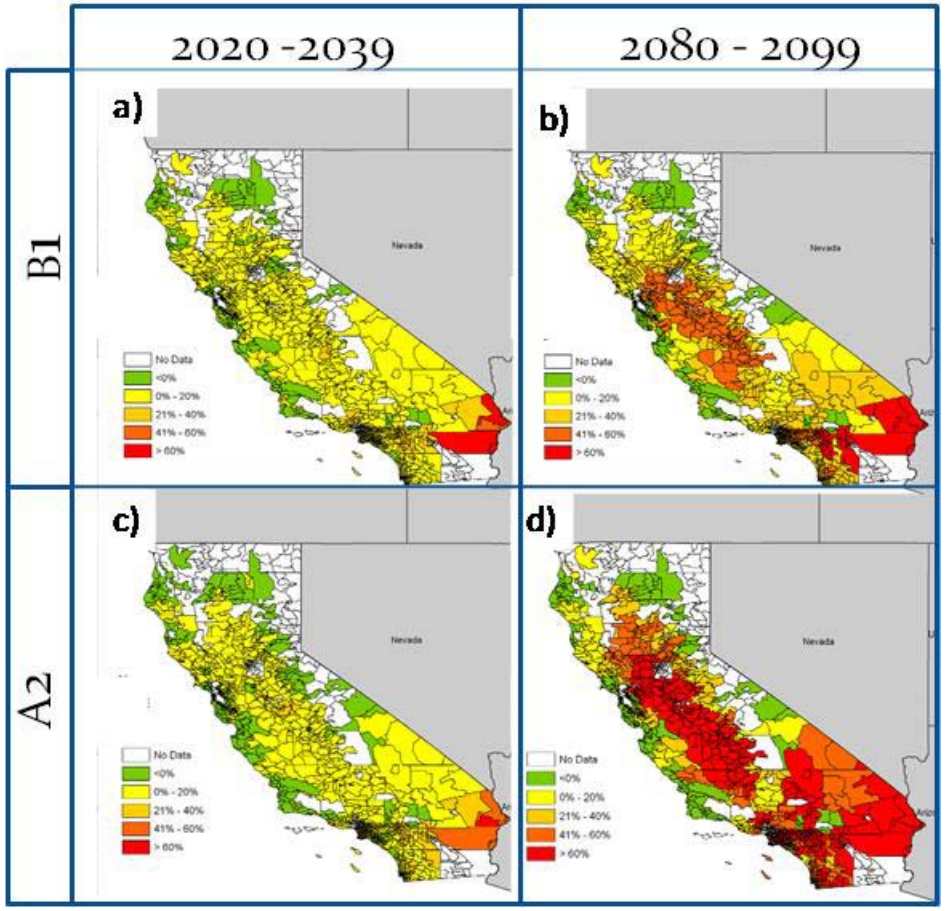


Source: Cayan et al. 2009

Energy Demand (cont.)

- Auffhammer, 2009. Impact of Climate Change on Residential Electricity Consumption: Evidence From Billing Data
  - Regional climate projections (12 Km x 12 Km)
  - Use of detailed household level consumption data; Analysis and results at ZIP code level
  - Significantly higher estimated impacts--Statewide electricity demand would go up by about 7% in the next few decades due to climate change. By end of this century demand would increase by 20 % in the B1 scenario and by 50 percent in the A2 scenario. Results for the PCM model (low warming)

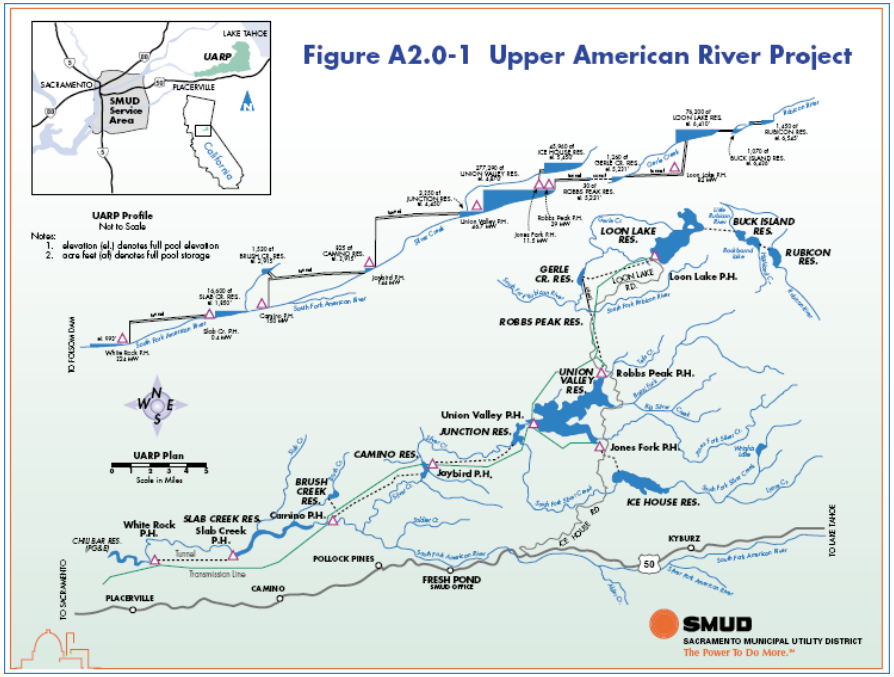


Simulated increase in per-household electricity consumption by zip code for the periods 2020–2039 (a)(c) and 2080–2099 (b)(d) in percent over simulations using climate data for the 1980–1999 period. Model

NCAR PCM forced by IPCC SRES B1 (a)(b) and A2 (c)(d).

Energy Generation

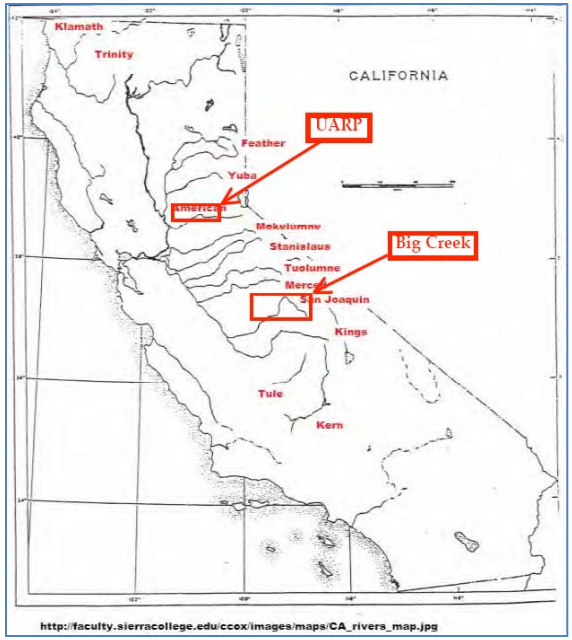
- Hydropower generation contributes about 15% of in-state generation
- Lund et al., 2006. Use of the CALVIN to simulate low-elevations units
- Vicuna et al. 2006. A new engineering-economic model for a particular high-elevation system (SMUD)
- The majority of the generation comes from high-elevation units that have relatively low storage capacity

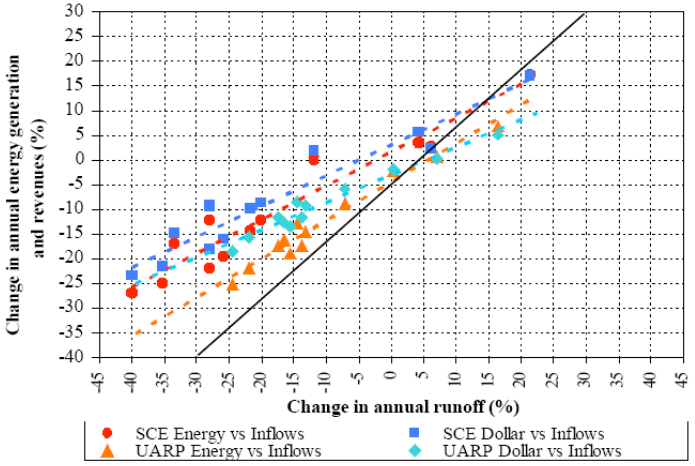


Source: SMUD 2001

Energy Generation (cont.)

- Two methods to estimate the potential impacts of climate change on high-elevation units
- Lund et al, 2009 used statistical relationship between streamflows and generation to estimate impacts (monthly data)
- Vicuna et al. 2009 improved his model (e.g., limited foresight) and simulated a second system in the southern part of the Sierra owned by Sothern California Edison.
- Capacity (MW) is available in the summer months but at the end of the new "summer season" capacity is curtailed
- Increased spills in the winter months. Risk of flooding should be analyzed with models that simulate both high- and low-elevation units

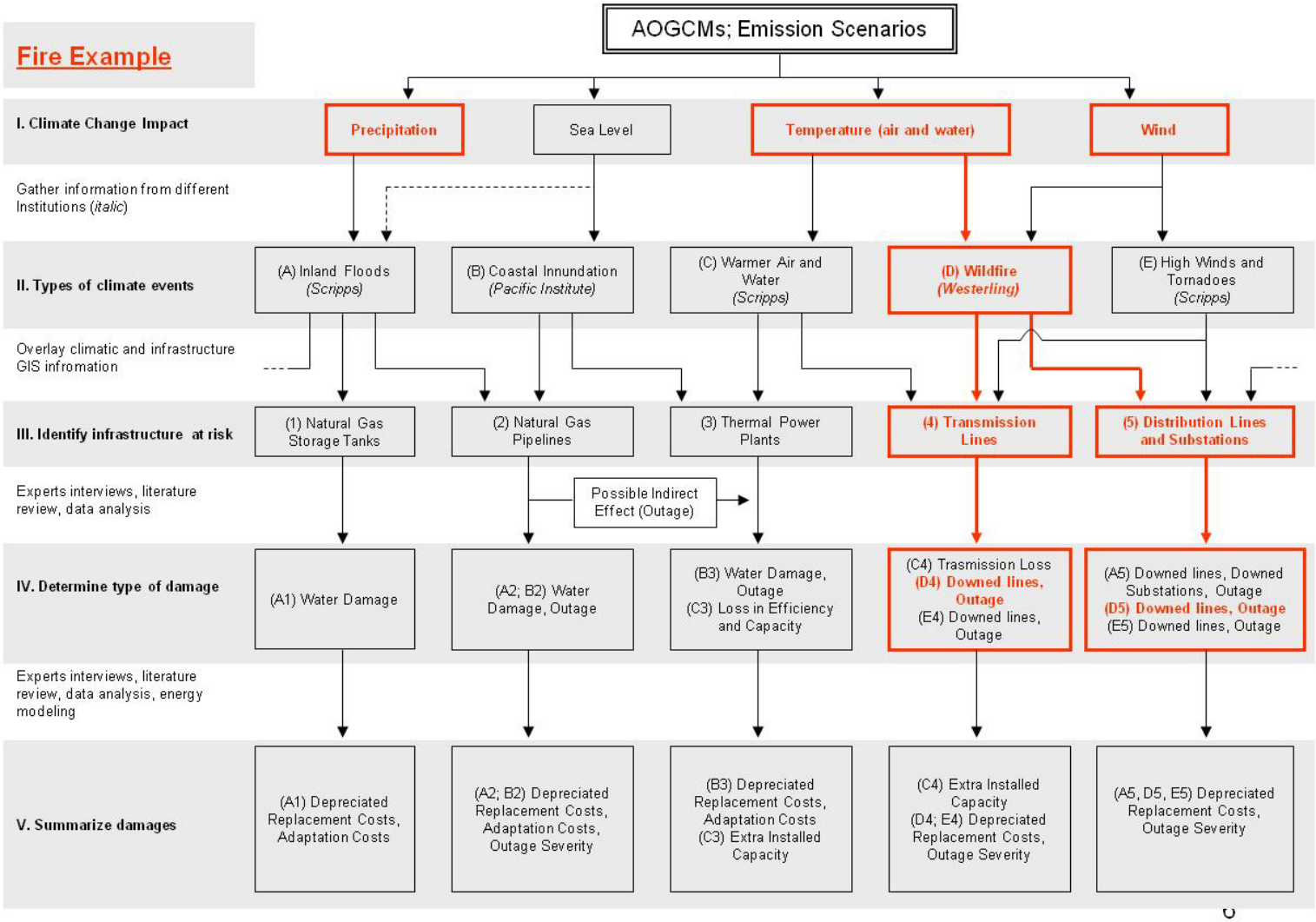




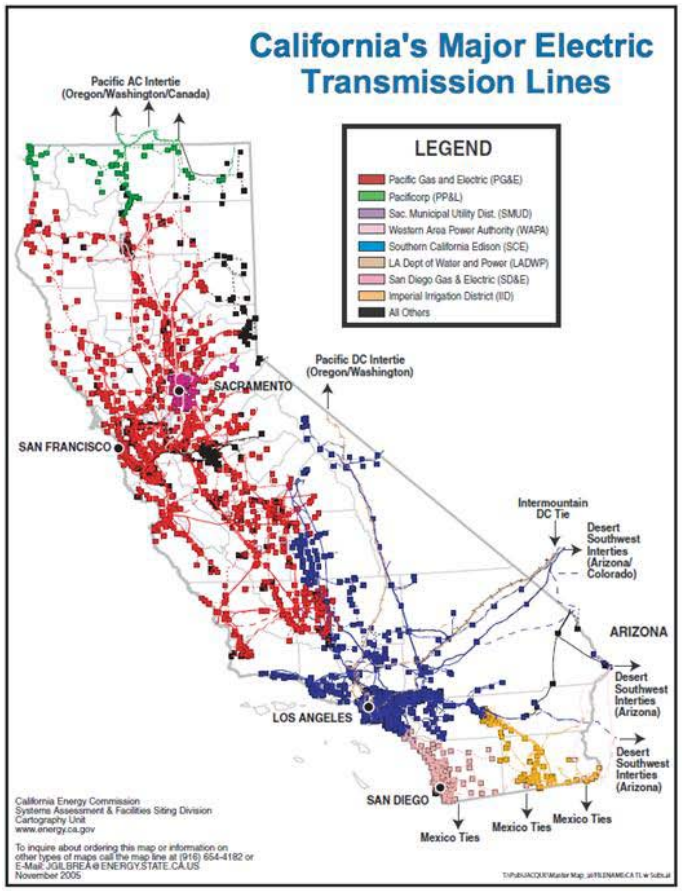
Vulnerability Assessment

Strategy

- The Synthesis and Assessment Product 4.5 (Effects of Climate Change on Energy Production and Use in the United States) informed the design of our strategy
- Determine under what weather conditions the energy system is vulnerable (e.g., forest fires in Northern CA).
- Use the results from the different studies prepared for the 2009 biennial report to estimate the increase/decrease probability of such events
- Assume current energy infrastructure+
- Work started a month ago (LBNL)

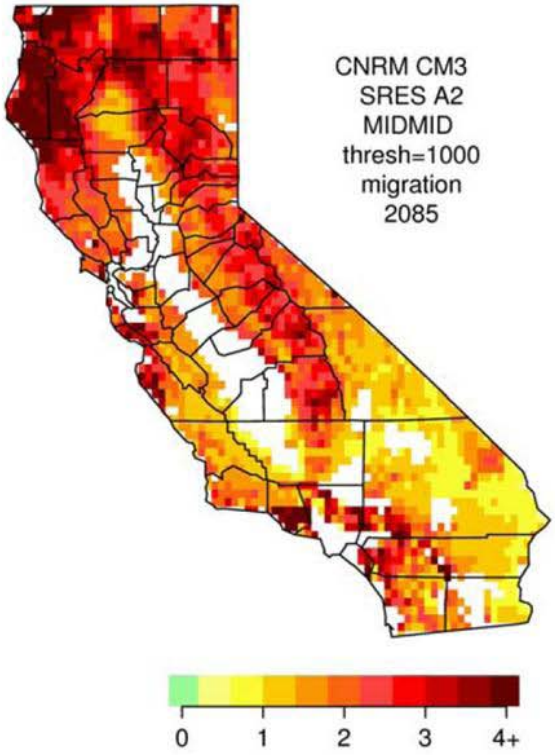

Fire Example
AOGCMs; Emission Scenarios
I. Climate Change Impact
Precipitation
Sea Level
Temperature (air and water)
Wind
Gather information from different Institutions (italic)
II. Types of climate events
(A) Inland Floods (Scripps)
(B) Coastal Innundation (Pacific Institute)
(C) Warmer Air and Water (Scripps)
(D) Wildfire (Westerling)
(E) High Winds and Tornadoes (Scripps)
Overlay climatic and infrastructure GIS infromation
III. Identify infrastructure at risk
(1) Natural Gas Storage Tanks
(2) Natural Gas Pipelines
(3) Thermal Power Plants
(4) Transmission Lines
(5) Distribution Lines and Substations
Experts interviews, literature review, data analysis
Possible Indirect Effect (Outage)
IV. Determine type of damage
(A1) Water Damage
(A2; B2) Water Damage, Outage
(B3) Water Damage, Outage
(C3) Loss in Efficiency and Capacity
(C4) Trasmission Loss
(D4) Downed lines, Outage
(E4) Downed lines, Outage
(A5) Downed lines, Downed Substations, Outage
(D5) Downed lines, Outage
(E5) Downed lines, Outage
Experts interviews, literature review, data analysis, energy modeling
V. Summarize damages
(A1) Depreciated Replacement Costs, Adaptation Costs
(A2; B2) Depreciated Replacement Costs, Adaptation Costs, Outage Severity
(B3) Depreciated Replacement Costs, Adaptation Costs
(C3) Extra Installed Capacity
(C4) Extra Installed Capacity
(D4; E4) Depreciated Replacement Costs, Outage Severity
(A5, D5, E5) Depreciated Replacement Costs, Outage Severity

Wildfires and T. Lines



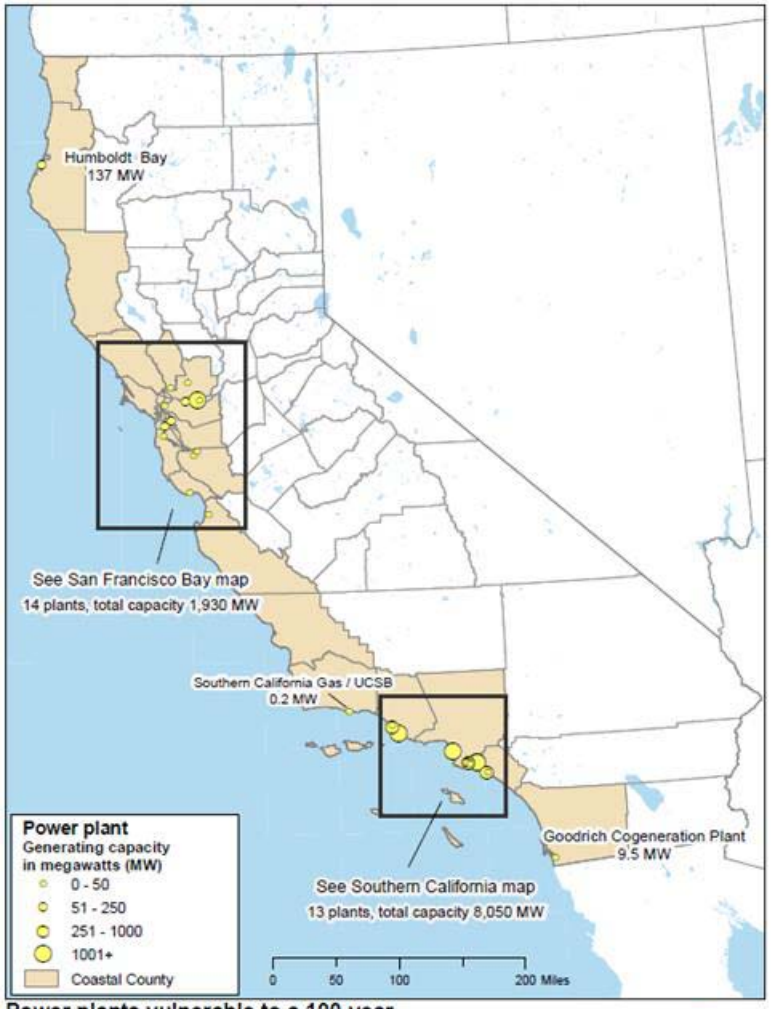
2085 Predicted Burned Areas (multiple of reference period)

Source: Westerling et al. (2009)



Costal Power Plants

- 30 Power Plants totaling over 10,000 MW vulnerable to a 100-year coastal flood with a 1.4 meter sea level rise.
- In some cases whole piece of infrastructure is at risk, whereas in other cases, only portions of structure are at risk (e.g., intake or other peripheral structures are exposed to flood risk).
- Information gathering:
  - What are the consequences (and costs) to each specific power plant that might be impacted?
  - What is the expected useful life span of each specific power plant?
  - Are there adaptation measures being taken (or proposed) to prevent (or reduce) damages from projected flooding? At what costs?



Power plants vulnerable to a 100-year coastal flood with a 1.4 meter sea-level rise

Data sources: USGS/Scripps Institution of Oceanography,California Energy Commission, CaSIL, ESRI.
http://www.pacinst.org/reports/sea_level_rise

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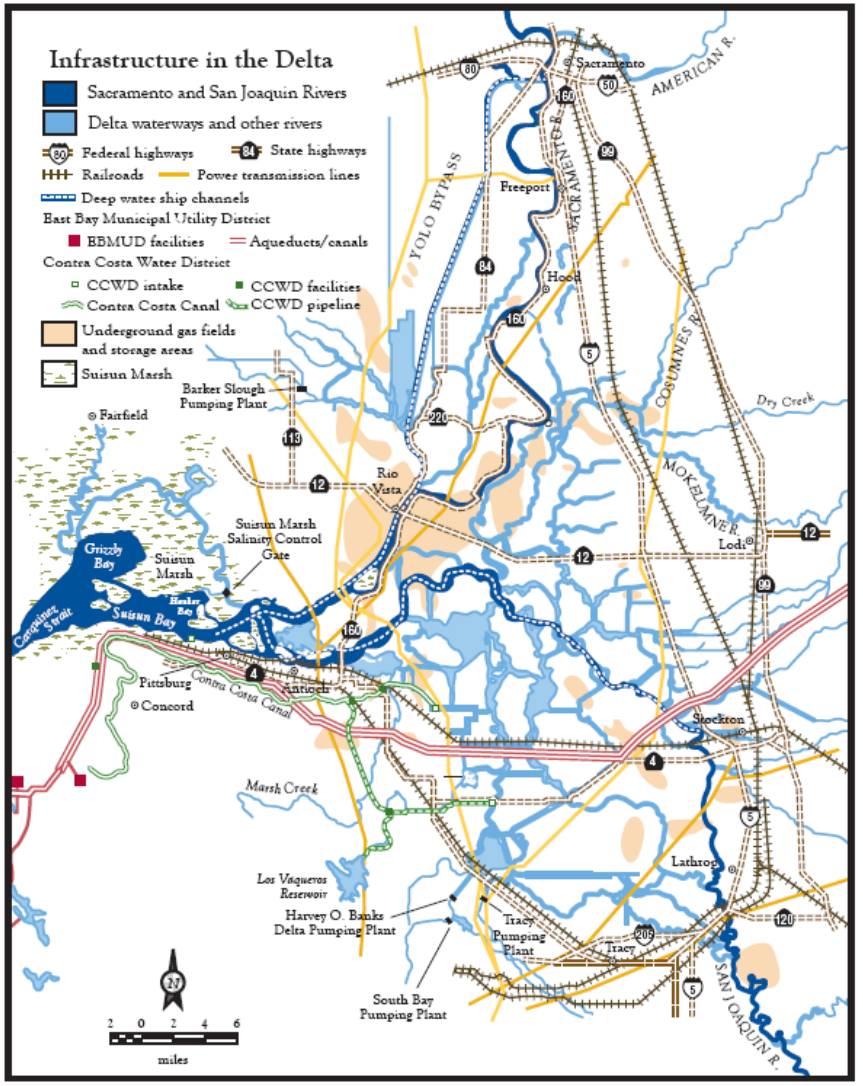
Other Areas

- Effect of temperature on generation from conventional power plants
- Flooding in the Sacramento-San Joaquin Delta region and its effect on underground natural gas storage tanks and pipelines and electric transmission lines
- Simultaneous high electricity demand in multiple regions in California



Source: IPCC 2007

Final Remarks

- Policy makers are more interested in what may happen in the next 20 to 30 years
- Development of tools and methods to adapt to climate variability now can be a powerful tool to adapt to future increase in climate variability (INFORM project)
- The identification of barriers to adaptation (regulatory, legal, socio-economic, etc.) and ways to overcome these barriers is now a high priority item for PIER

Final Remarks (cont.)

- Treatment of extreme events: daily meteorological and hydrologic data – paper by Mastrandrea, Tebaldi, et al., 2009
- Approach to Integration: soft integration via an overall vulnerability assessment that would start late this year
- Finance? NO
- Preparedness Plans: In theory yes via IEPR and adaptation plan for California
- Treatment of vulnerable populations: limited but some GIS analyses possible – Public health and EJ groups
- Governance issues: start with study on barriers to adaptation