Environmental Research Area

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Goals

Develop cost-effective approaches to evaluating and resolving environmental effects of energy production, delivery and use in California; and explore how new energy applications and products can solve/mitigate environmental problems.

Complement national and international research efforts by producing California specific products that also inform policy formulation, in four areas of research:

- **Climate Change for the energy sector -** 1) climate monitoring, analysis, and modeling at scales specific for CA; 2) investigating cost-effective options to reduce GHG emissions; and 3) impact and adaptation studies for the energy sector
- **Air Quality and energy –** 1) building efficiency and indoor environmental quality; and 2) outdoor air quality implications of new technologies, controls and fuels
- **Aquatic Resources and energy–** 1) energy generation effects on aquatic species, water quality and water supply; and 2) energy and water management
- **Terrestrial Resources and energy–** 1) environmental barriers to renewable energy development; and 2) tools and best management practices to facilitate siting energy facilities

General Approach

- **Research Gap –** Identified in Roadmaps, subject workshops, advisory board meetings, steering committees, technical advisory committees, contacts with experts and literature review.
- **Climate Action Team -** Climate change energy-related research coordinated via the CAT Research Working Group headed by Commissioner James Boyd.
- **Increasing partnerships** with other PIER areas (Efficiency, Transportation, Renewable), Divisions (Siting, Efficiency, Transportation, Renewable, Forecasting), agency, industry.
- **Integrated our projects into the** three enabling areas of Efficiency, Renewables and Smart Infrastructure.

Refocusing our Climate Change Sub-program

OLD

- Climate monitoring, analyses, and modeling for CA
- GHG Inventory Methods
- Options to reduce GHG emissions: all sectors
- Impacts and adaptation studies: all sectors

New

- No change
- No new projects
- Identification of offsets/allowances for utilities
- Direct link to the energy sector

Proposed Overall Portfolio FY 2011-12

- **Smart Infrastructure**
  - Evaluate in-basin air quality impacts of electrification
  - Identify potential sources of Greenhouse gas (GHG) offsets/allowances for utilities
  - Investigate beneficial uses of carbon dioxide for the production of chemicals, chemical feed stocks, working fluids, and building materials
  - Estimate potential climate changes impacts and adaptation options for the energy sector
  - Improve regional climate models
- **Energy Efficiency**
  - Healthy indoor air quality for net zero energy buildings
  - Validation of the air quality and energy benefits of cool communities
- **Renewable Energy**
  - Removing environmental barriers to the deployment of renewable energy facilities

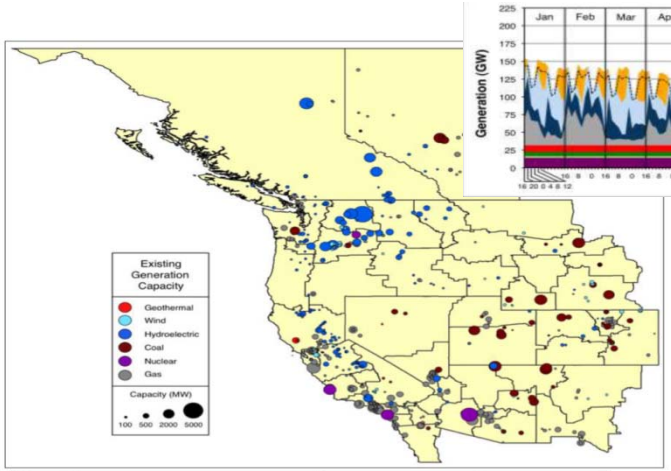
Energy Infrastructure

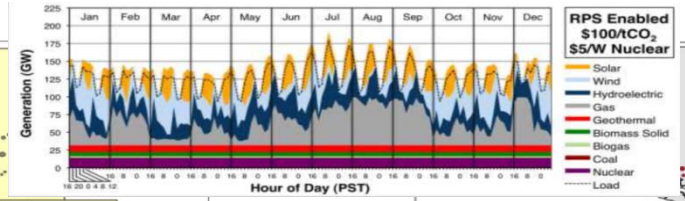
Current Portfolio

- Assessing water demand and potential impacts from future on-road transportation systems
- Investigating ways to enhance the performance of dry cooling systems for power plants
- Assessing near source air quality impacts from distributed generation
- Improving methods to estimate air pollutant emissions from power plants
- Investigating the benefits of interbasin and interpollutant offsets
- Investigating the impacts of climate change on energy infrastructure: scoping study
- Studying options to reduce GHG emissions
- Using regional climate models for seasonal and multi-year probabilistic electricity demand forecasts
- Developing long-term energy scenarios for California and investigation of their potential environmental implications: scoping study

Energy Scenarios for California

SWITCH Model





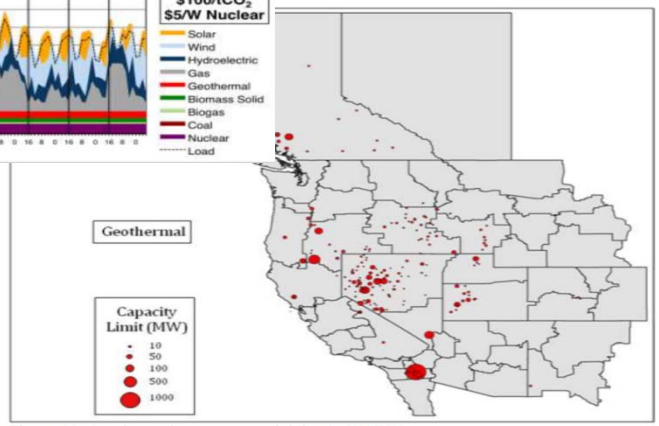


Figure S8: *Geothermal resource availability in SWITCH.*

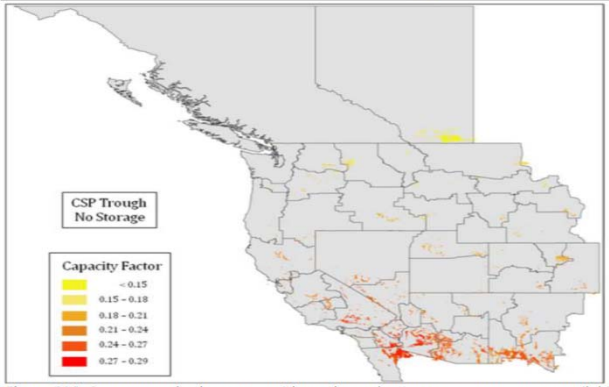


Figure S14: *Concentrated solar power without thermal energy storage resource availability and quality in SWITCH.*

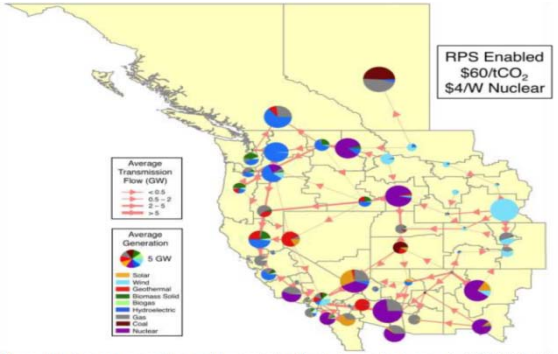
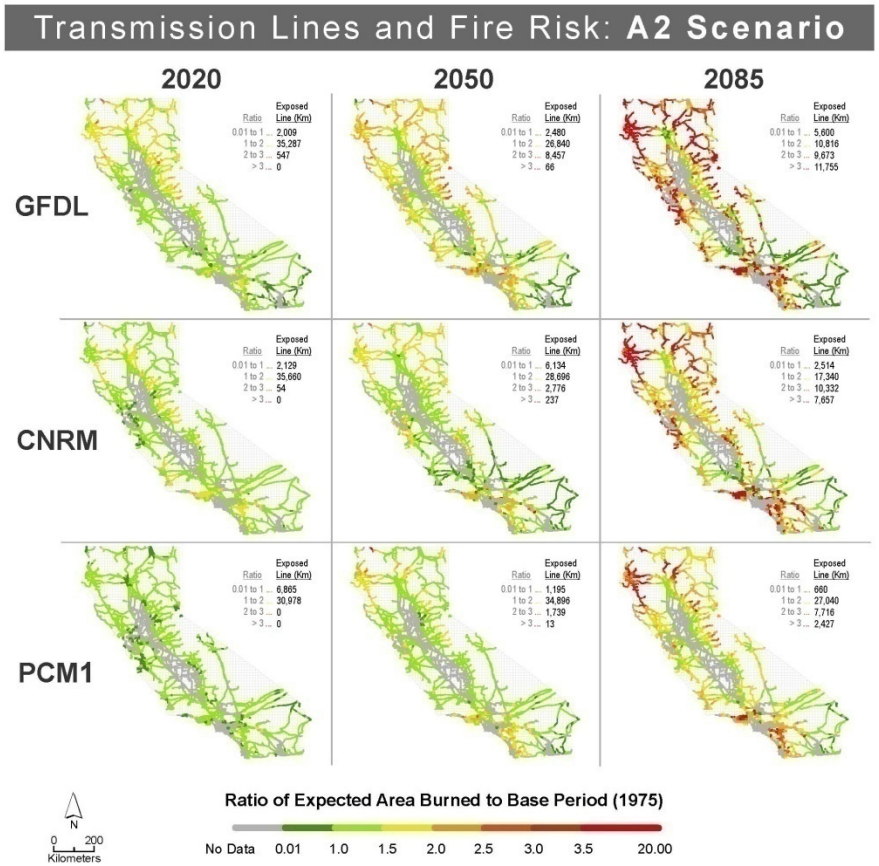


Figure S17: *Average generation and transmission flow between load areas in 2026-2029 with RPS enabled at a carbon cost of $60/tCO$_2$ and a new nuclear plant cost of $4/W.*

Source: Dan Kamenn et al. 2011

Source: LBNL and Dan Kammen. Work in progress. PIER

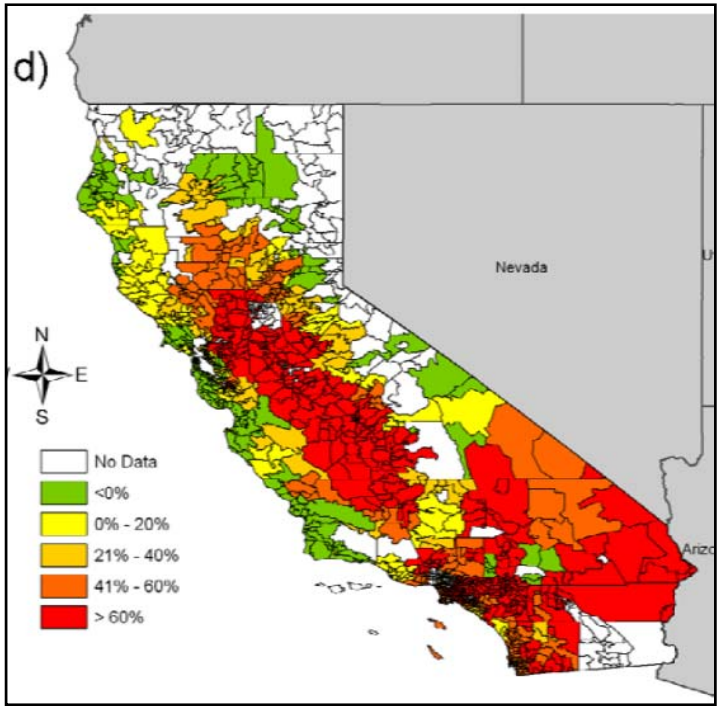
Wildfires and Transmission Lines



Source: LBNL 2011. Draft PIER Report

Potentially Substantial Increases in Electricity Demand

- Higher ambient temperatures will increase the demand for electricity, negating somewhat the expected gains from our aggressive energy efficiency programs
- The problem of increased demand will be exacerbated by a reduced generating efficiency in our thermal power plants and less hydropower generation in the summer

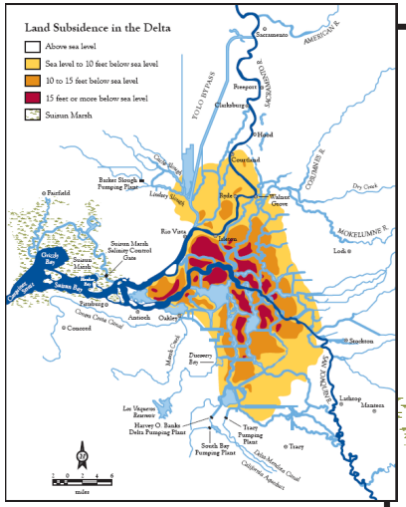


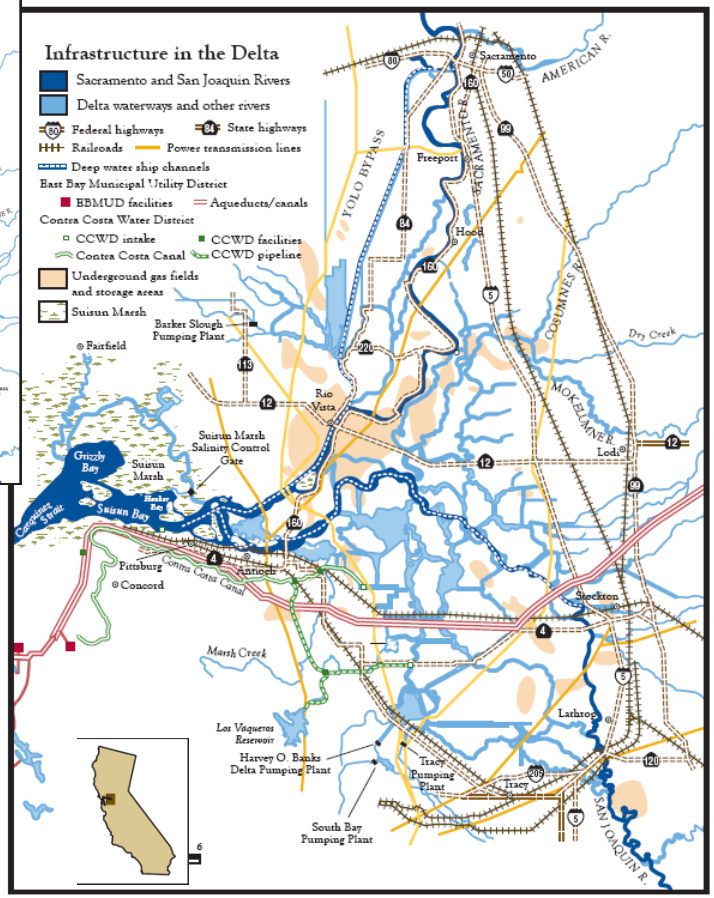
Simulated increase in household electricity consumption by zip code for the period 2080–2099 in percent over 1980–1999 simulated consumption.
Model NCAR PCM forced by IPCC SRES A2.

Source: Prof. Max Auffhammer (UC Berkeley).
PIER Report 2009

The Delta is home of important energy facilities

- 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

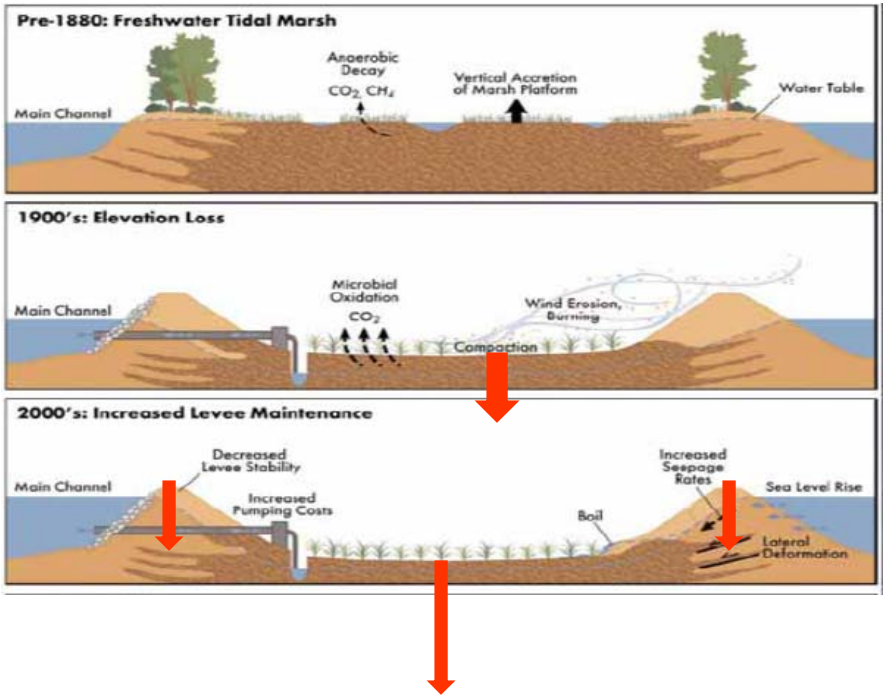




Source: PPIC 2007

Preliminary research suggests overall subsidence

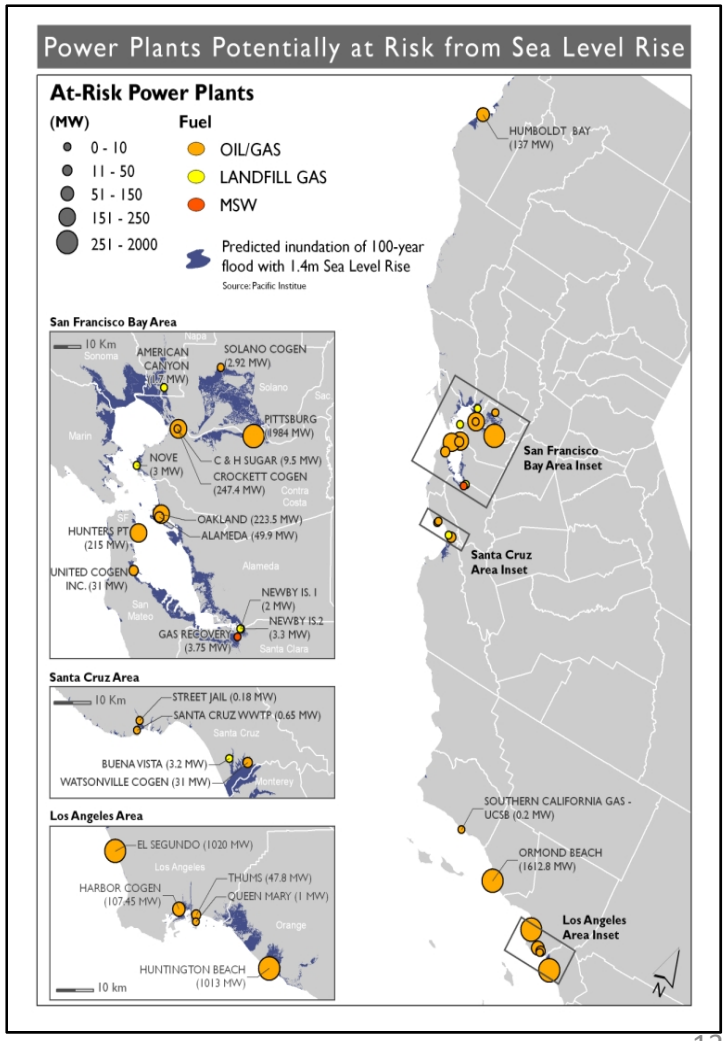
- GPS and InSAR (Synthetic Aperture Radar Interferometry) suggest a synoptic subsidence throughout the Delta at rates of 5-20 mm/yr
- Projections including sea-level rise indicate large-scale overtopping threat in the 21st century



Source: B. Brooks et al., Draft PIER report 2011.

Coastal Power Plants

- About 25 power plants in areas that would experience increase risk of coastal flooding due to sea level rise



Proposed Portfolio
Fiscal Year 2011-12

Evaluate in-basin air quality impacts of electrification

- Issue: Electrification should improve air quality conditions but the net effect of multiple factors including the placement and type of power units to meet power need will impact basin air quality in a differentiated way
- Approach: 1) Work with local air district, utilities, and other stakeholders to develop the scenarios; 2) Develop air basin scale energy scenarios compatible with statewide energy scenarios; 3) perform AQ evaluations of these scenarios; and 4) Investigate solutions to the lack of low-cost offset situation

Identify potential sources of GHG offsets/allowances for utilities

- Issue: Load serving entities will receive allowances equal to the emissions that ARB has estimated would be needed in the future. Electricity generators will have to purchase allowances/offsets in auctions. Shortfall of allowances/offsets would occur under the following circumstances:
  - If energy efficiency programs are not as effective as expected
  - Serious reductions in hydropower generation due to prolonged droughts
  - If ARB underestimated economic growth
- Approach: Fund research designed to uncover potential source categories of low-cost allowances/offsets. The selected studies will be for options with reasonable chances of being adopted by ARB:
  - Complies with the surplus requirement
  - No increase in criteria or air pollutants
  - Verifiable and enforceable GHG reductions
  - Clear project boundaries
  - Emissions reductions must take place in a sector not subject to the cap (offsets)

Beneficial Uses of Carbon Dioxide

- **Issue:** Carbon dioxide from energy generation could have beneficial uses reducing net atmospheric emissions while at the same time delivering a useful product (e.g., construction materials, natural gas from enhanced NG recovery, CO_2 as a working fluid for geothermal energy)
- **Approach:** Release a request for proposals to find out if some practical and relatively near-term applications would be feasible in California

CATEGORIES	TECHNOLOGY DESCRIPTION
CO_2 as a working fluid	• Enhanced oil recovery (EOR) • Enhanced gas recovery (EGR) • Enhanced coal bed methane recovery (ECBM) • Enhanced geothermal systems (EGS)
CO_2 for Building Materials Manufacture	• Carbonates and other construction materials
Biochar	• Pyrolysis of biomass
Fuel and Chemical Production	• Chemical Conversion • Biological Conversion
Power Generation Applications	• Super critical CO_2 for Brayton Cycle Turbines • Working fluid / cushion gas for energy storage
CO_2 as a Solvent	• Supercritical fluid extraction and other food processing applications • Dry cleaning
CO_2 in Agriculture and Biomedical Applications	• Greenhouse atmosphere additive • Grain silo fumigant • Sterilization for biomedical applications
Miscellaneous Industrial Applications	• Fire extinguishers • Shielding gas for welding • Refrigeration and heat pump working fluid • Propellant • Rubber and plastics processing - blowing agent • Cleaning during semiconductor fabrication
Water from displaced aquifer fluids	• Water purification • Extraction of Value Added Solids from Water

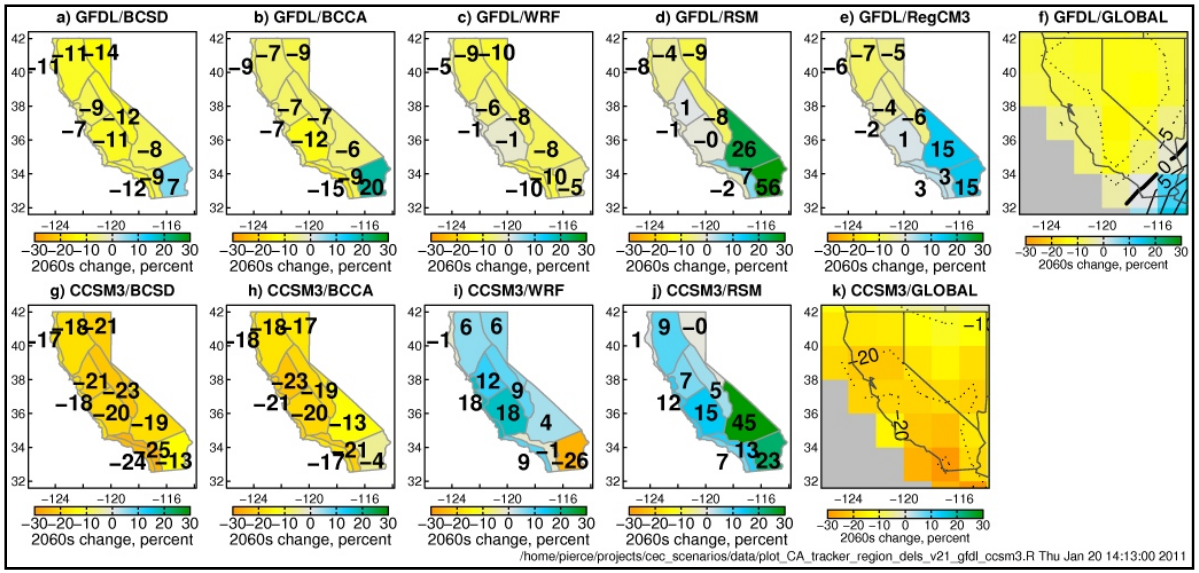
Source: Draft roadmap of research. LLNL/CIEE 2011

Impacts and Adaptation Options for the Energy Sector

- Issues: Climate change will affect energy generation (e.g., hydropower, the efficiency of thermal power plants), energy demand (e.g., increased cooling load in the hot summer season), and the reliability of energy services (e.g., wildfires and transmission lines). There is not enough scientific information showing how to use climate change science in the environmental evaluation of energy facilities.

- Approach: Work with electric utilities, regulators, Cal-ISO, CPUC, NGOs, and stakeholders to identify specific research projects

Improve Regional Climate Models



The electricity sector needs improved models to better estimate impacts and develop adaptation options but some results, warming, are robust

Source: Pierce et al. Draft PIER Report undergoing external peer-eiview

Questions

- Should PIER be involved in the identification of potential sources of criteria pollutant and greenhouse gas offsets/allowances?

- Should PIER address the issue of habitat and species range shifts resulting from climate change to better evaluate energy development impacts, mitigation and habitat compensation required under CEQA assessments? Currently permitting is subject to challenge because CEQA evaluations of large energy facilities do not take climate change into account due to lack of readily available information.

- How much should PIER focus on addressing environmental barriers to deploying existing or near renewable energy technologies compared to the environmental effects of emerging technologies, potentially ten years or more away from commercial deployment?

- Are there synergies or collaborative opportunities with other programs?

- How can we better communicate the benefits to California ratepayers?