California's Electricity Consumption under Climate Change

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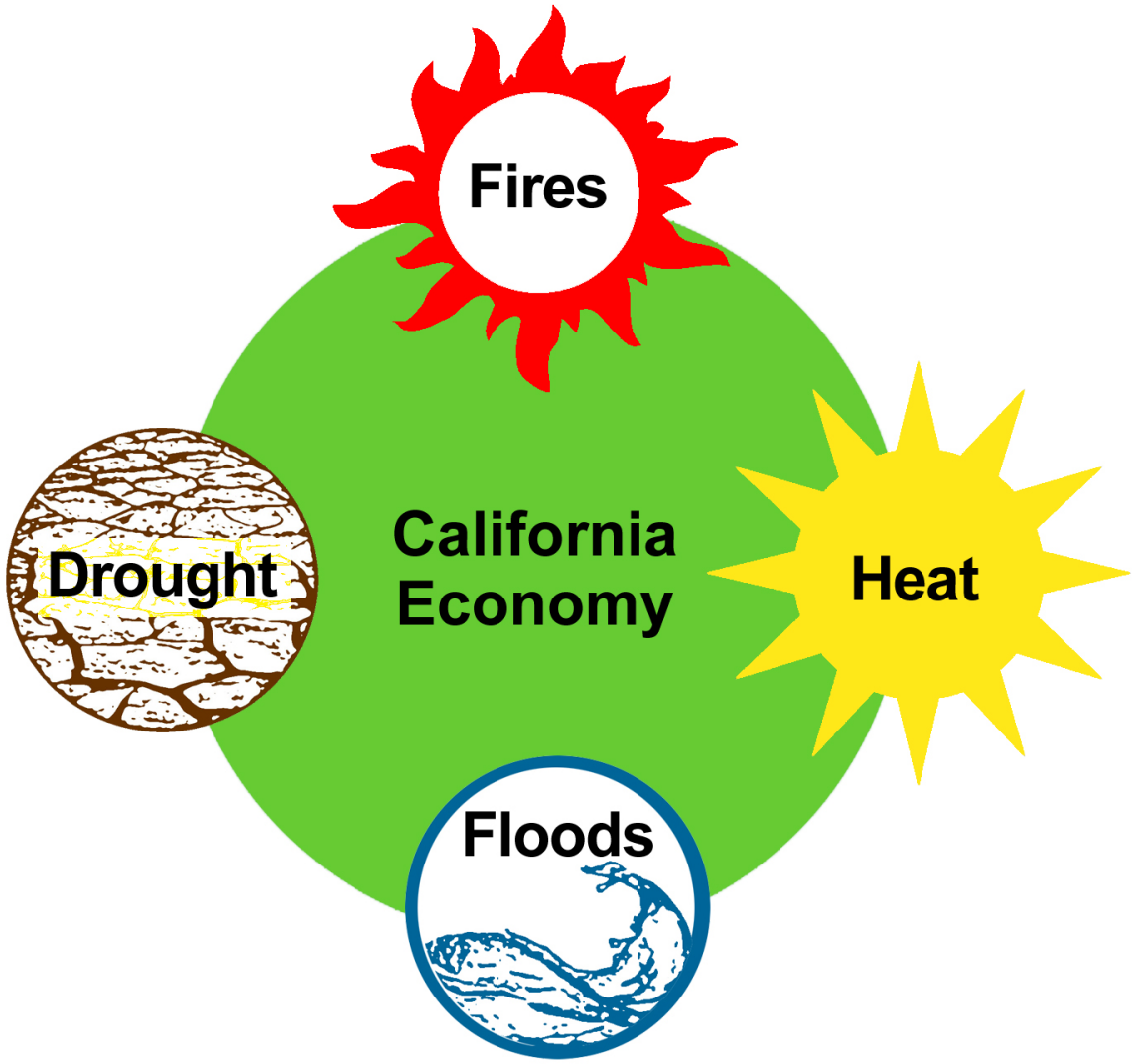
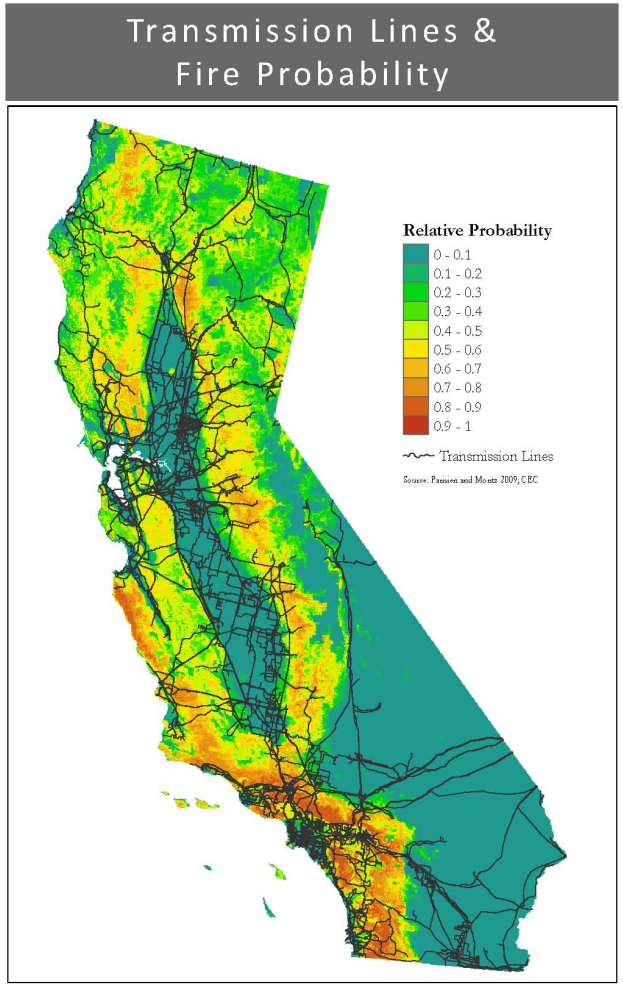
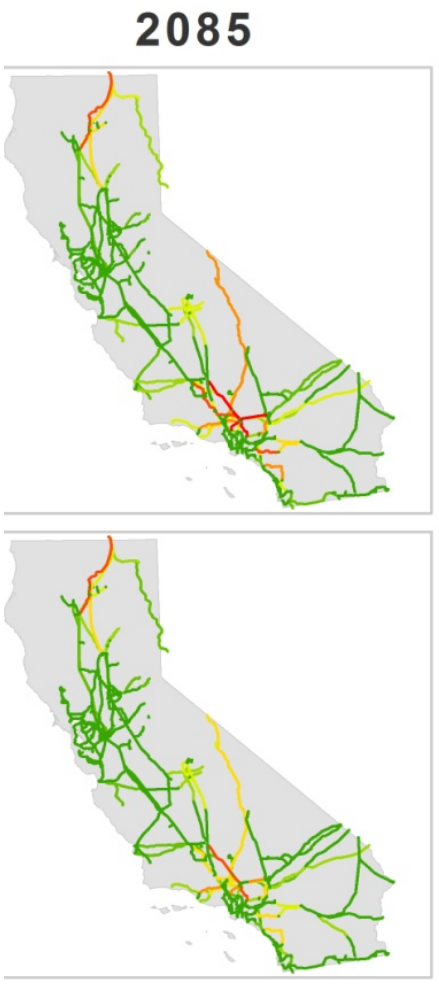
CESifo

Climate Change will negatively affect California's Economy



Existing Transmission Lines Under Increased Fire Risk





Probability Line Affected by Fire
w/in 30-yr Period

* Lines 220kv & above

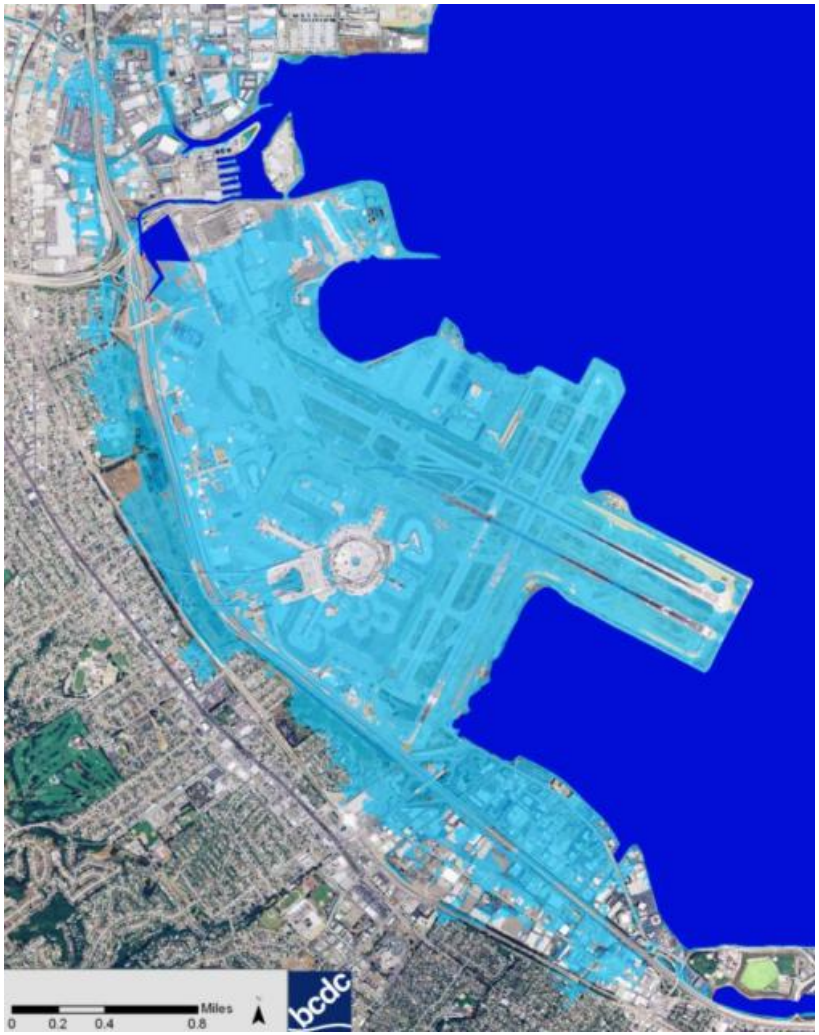
- 0% - 10%
- 10.1% - 20%
- 20.1% - 30%
- 30.1% - 40%
- 40.1% - 50%
- 50.1% - 60%
- 60.1% - 70%
- 70.1% - 80%

Source: LBNL, 2011

Sea Level Rise Leads to large Scale Inundation

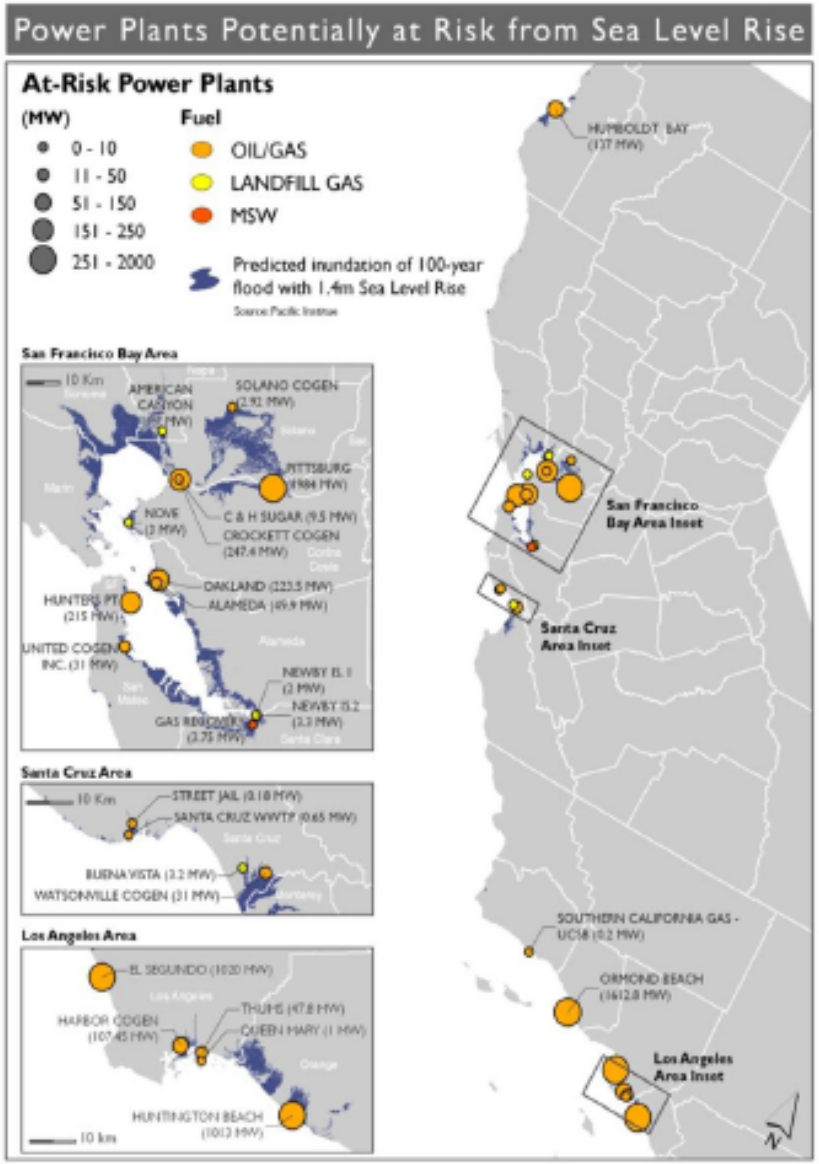
Source: BCDC, 2011

San Francisco International Airport & Oakland International Airport

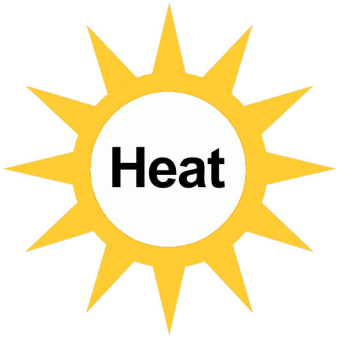


Source: BCDC, 2011

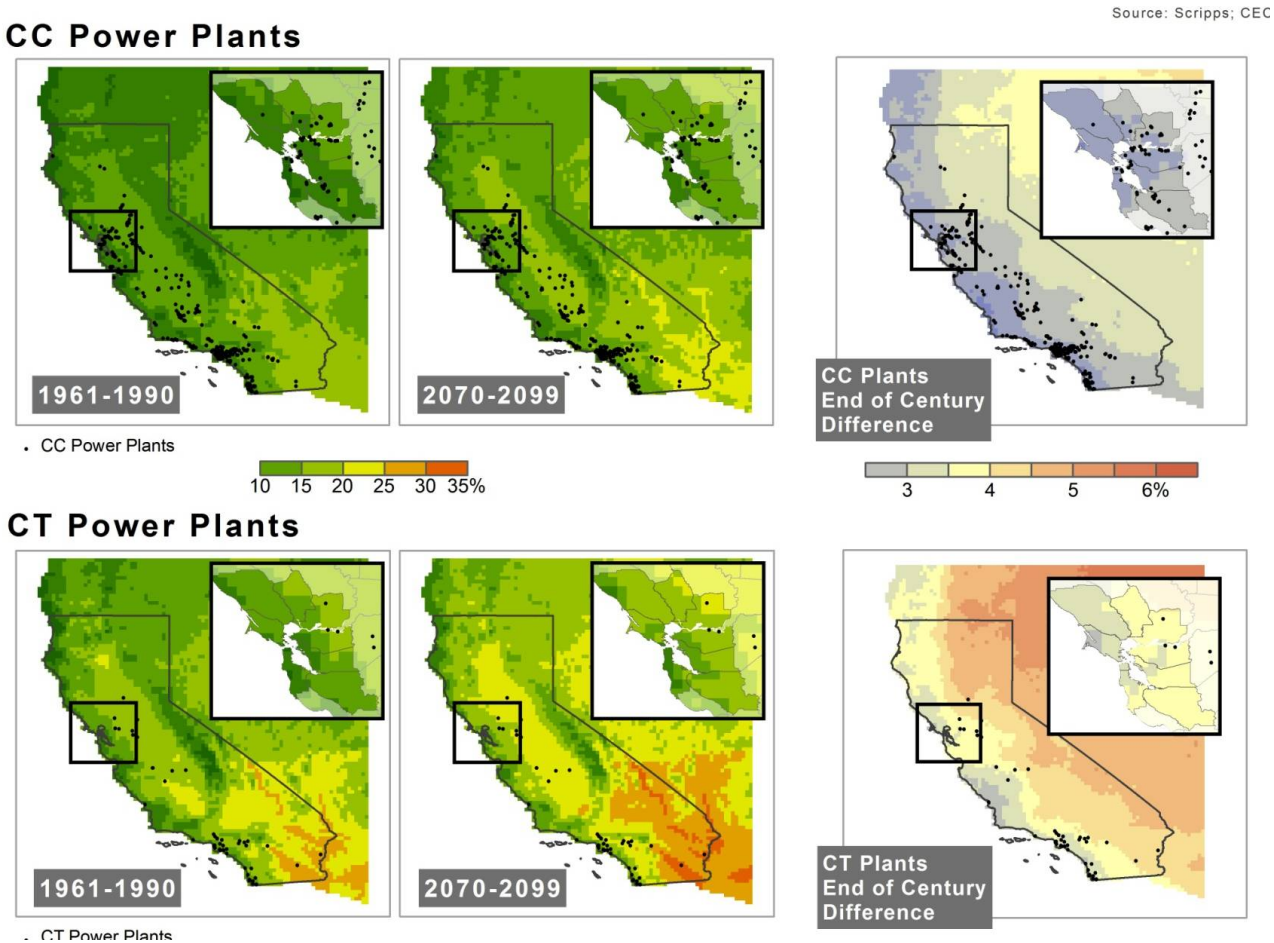
Power Plants Potentially at Risk



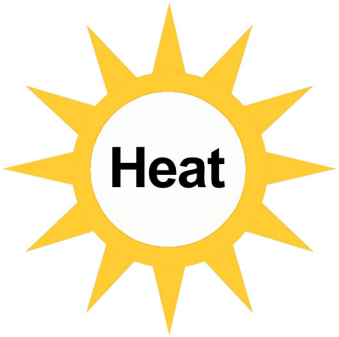
Source: BCDC, 2011



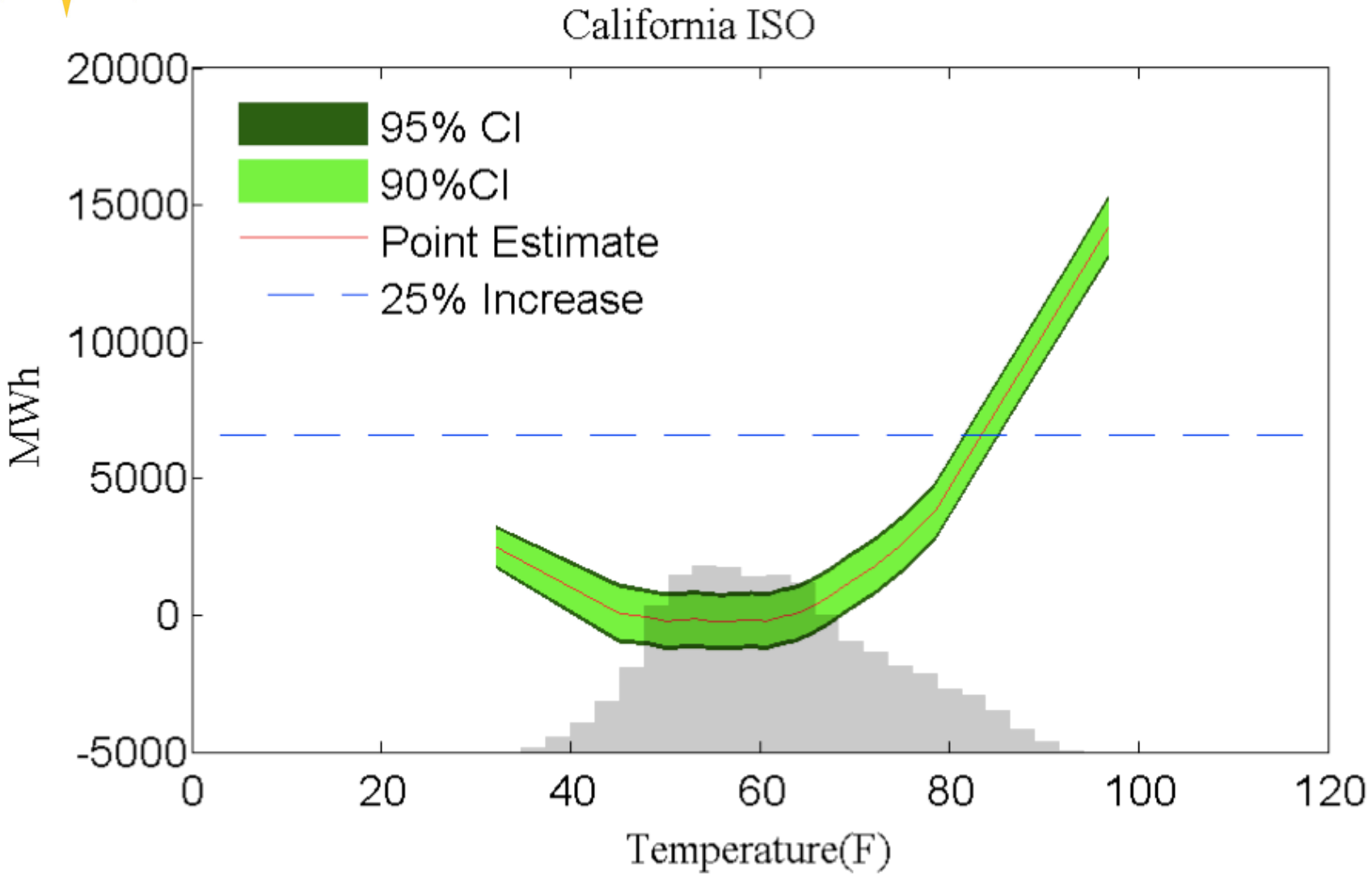
Power Generation and Transmission Losses

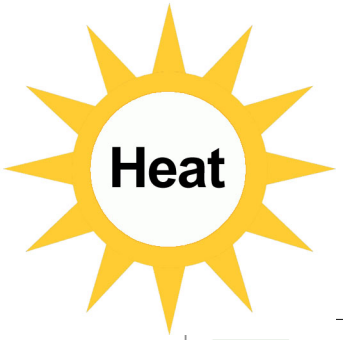


Source: LBNL, 2011

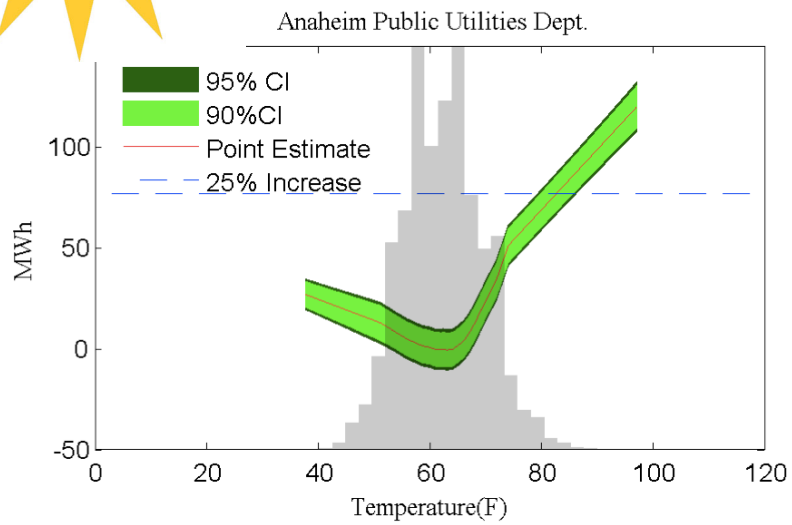


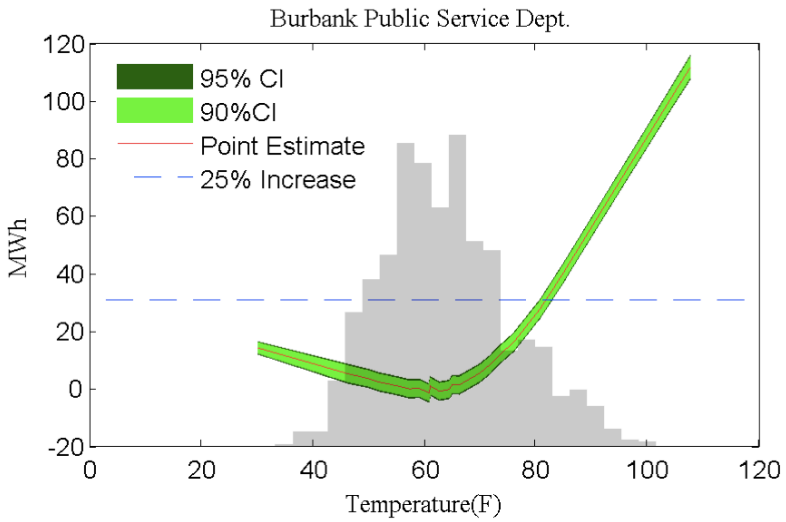
Electricity Load Increases on Hot Days

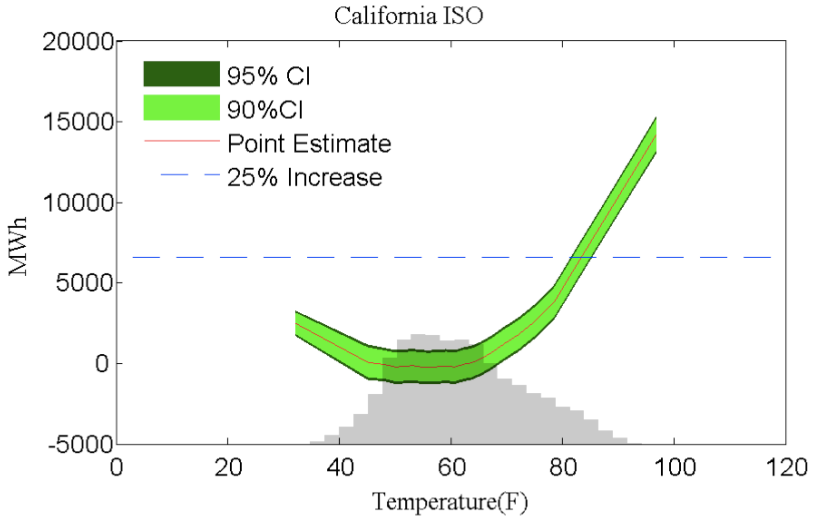


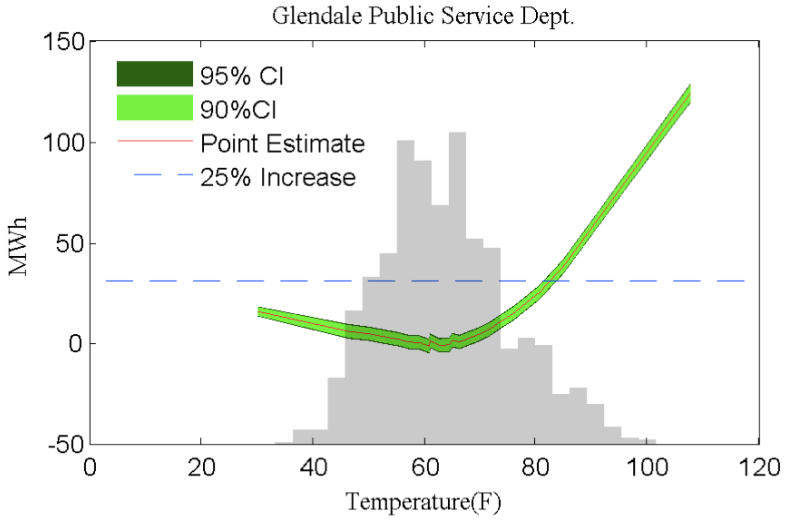


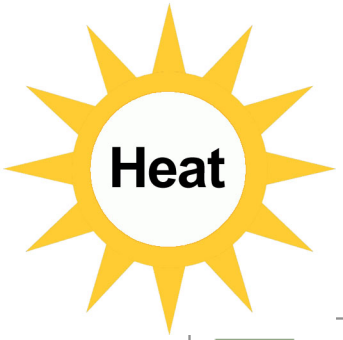
Electricity Load and Weather



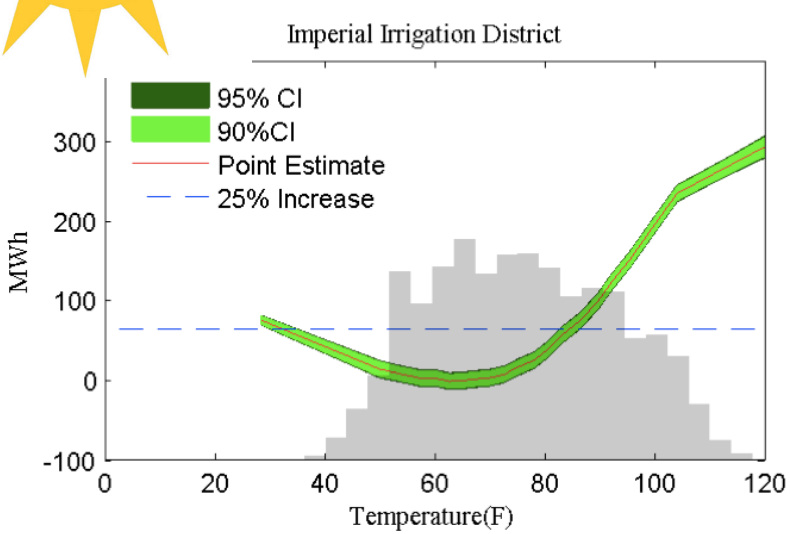


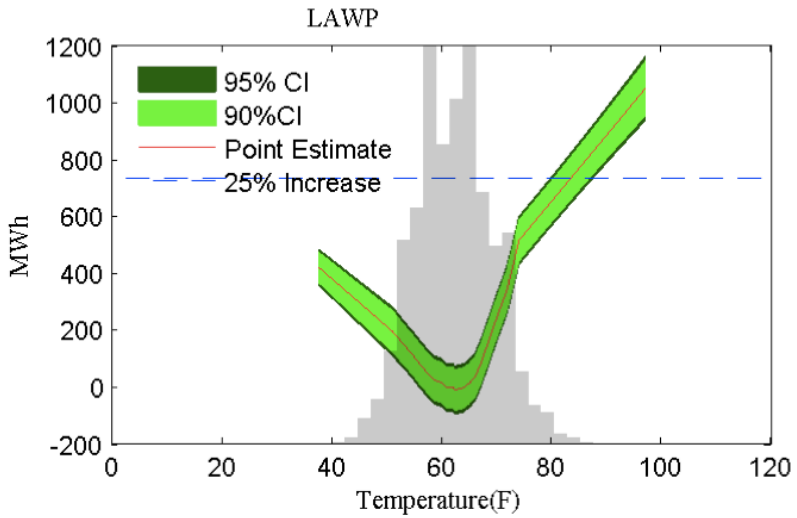


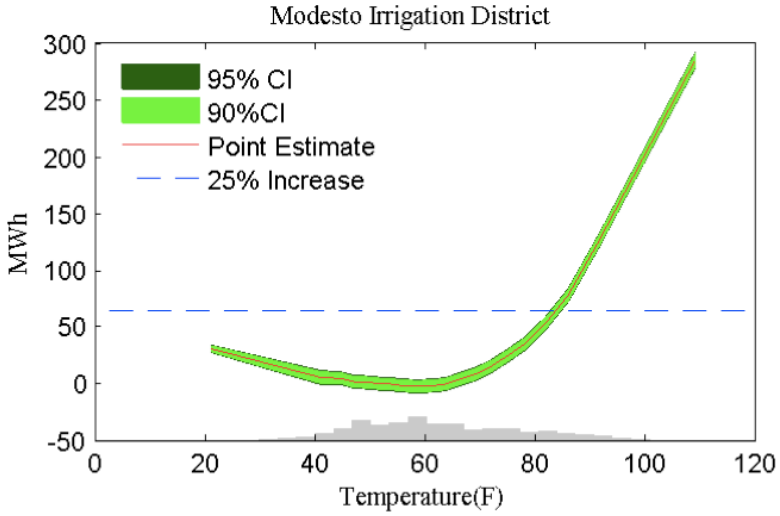


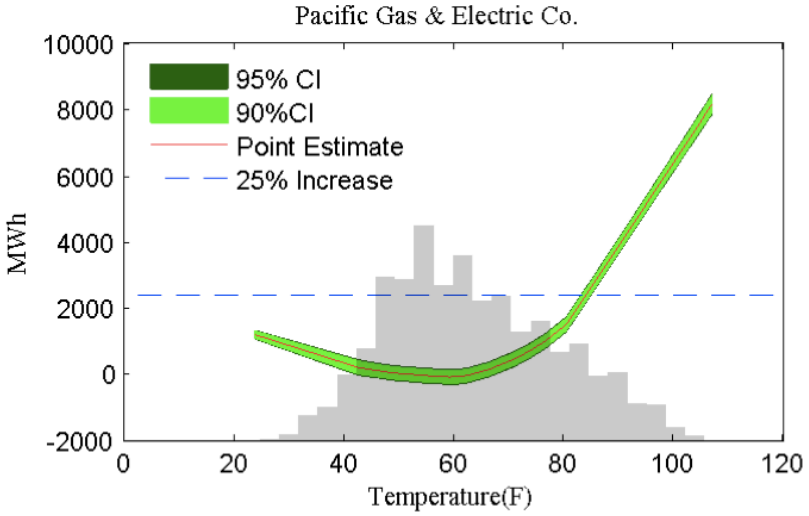


Electricity Load and Weather









California's Residential Sector Electricity Consumption

- More than quadrupled since 1960
- Share in total consumption increased from 26% to 34%.
- Consumption equivalent to total consumption of Finland, Argentina or half of Mexico
- Provided by three major investor owned utilities (SCE, SDG&E, PG&E) and over 100 municipal utilities.

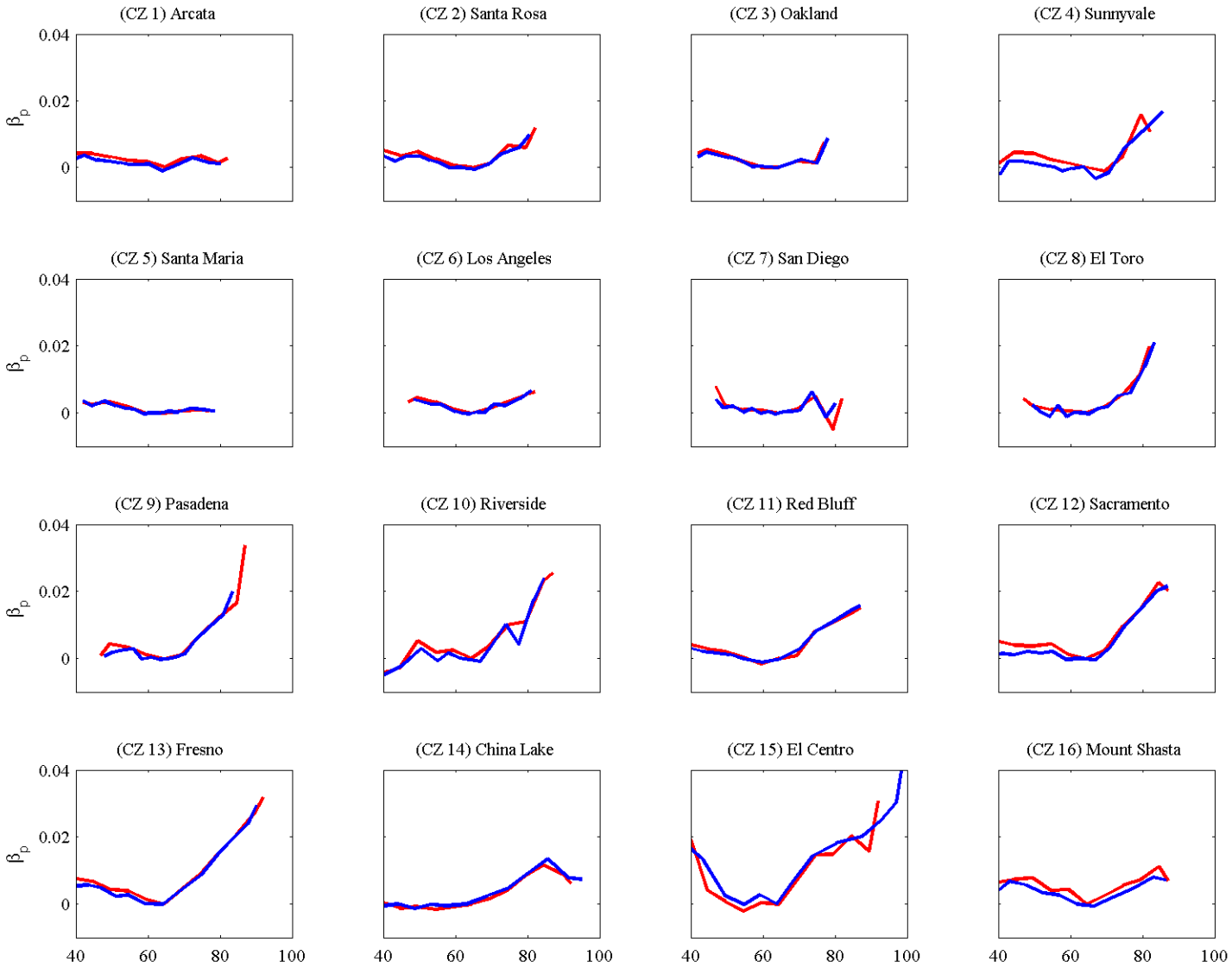
Our Approach

- Use random fluctuations in weather to estimate temperature response of residential electricity consumption.
- Use flexible functional form of temperature response.
- Allow for geographically differentiated temperature response
- Simulate future household and aggregate demand under different climate, price and population scenarios

Billing Data

- Complete residential billing data for California's investor owned utilities (thanks to UCEI/CSEM).
- ~80% of all California households from 2003-2006
- Separate out CARE households
- Limit to households with 25-35 day billing cycle
- Drop bills with daily consumption less than 2 Kwh and more than 80 Kwh
- Randomly sample data by zip code

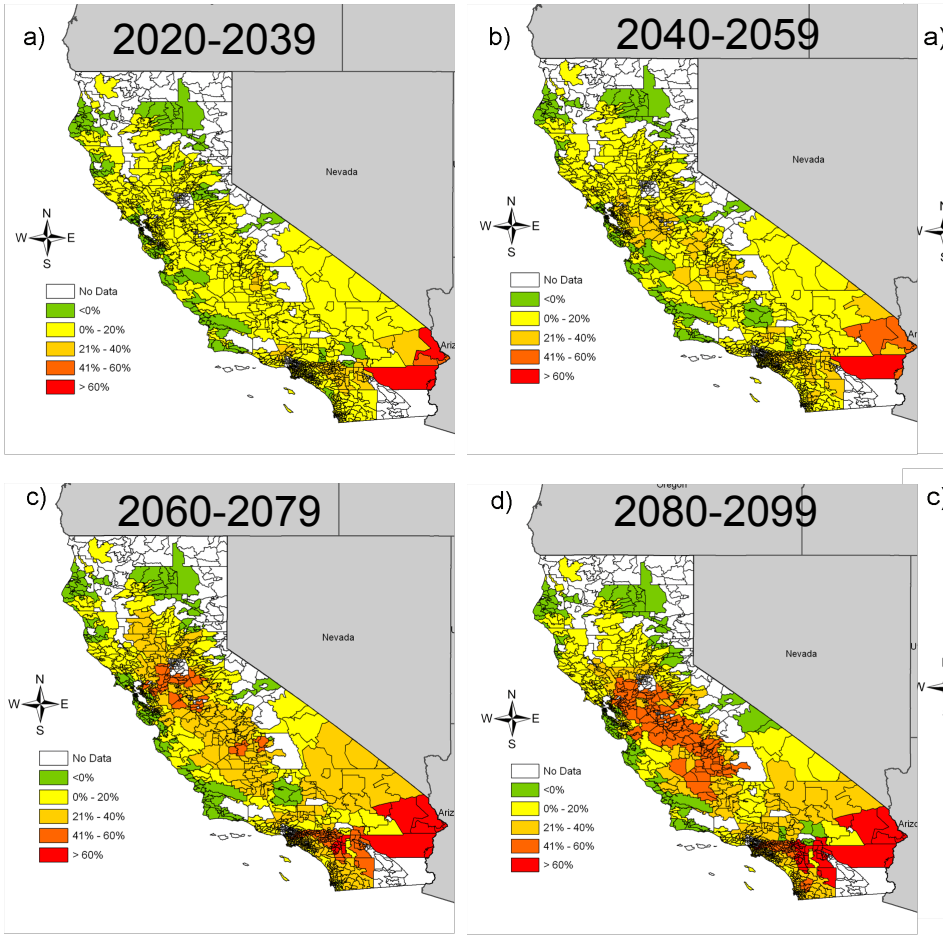
Temperature Response of residential electricity consumption is spatially heterogeneous



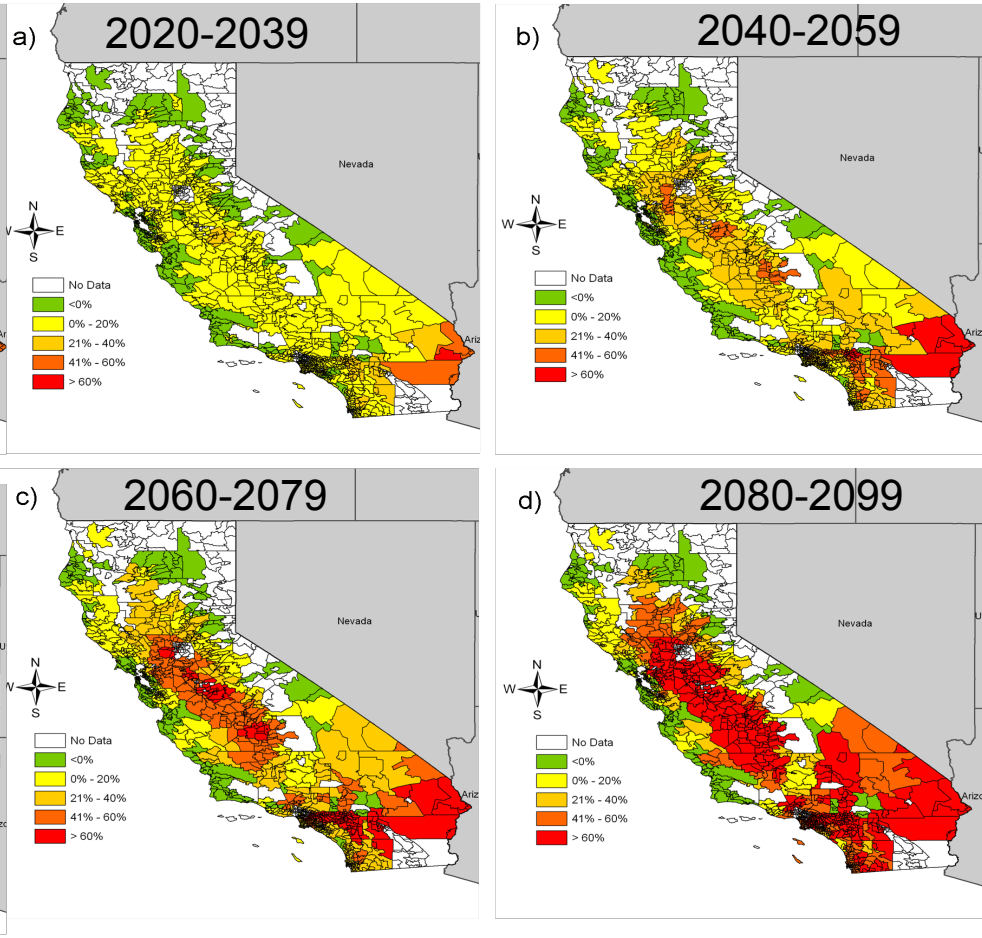
Source: Auffhammer and Aroonuegsawat (2011)

So are impacts on household consumption.

Household Impacts (NCAR PCM, B1)



Household Impacts (NCAR PCM, A2)



Source: Auffhammer and Aroonuegsawat (2011)

Simulation: Climate Only

weighted average increase in household electricity consumption using the number of households by zip code as weights.

Bin Type		Equidistant				Percentile			
Downscaling		BCSD		CA		BCSD		CA	
IPCC Scenario		A2	B1	A2	B1	A2	B1	A2	B1
	Price Increase								
2000-19	±0%	5%	2%	5%	3%	6%	3%	5%	3%
2020-39	±0%	5%	8%	7%	8%	6%	9%	7%	8%
2040-59	±0%	15%	9%	17%	10%	17%	11%	17%	10%
2060-79	±0%	24%	15%	28%	16%	28%	17%	28%	16%
2080-99	±0%	48%	18%	50%	20%	55%	21%	50%	20%

Constant Price/Population Scenario

Downscaling		BCSD	
IPCC Scenario		A2	B1
	Price Increase		
2000-19	±0%	5%	2%
2020-39	±0%	5%	8%
2040-59	±0%	15%	9%
2060-79	±0%	24%	15%
2080-99	±0%	48%	18%

30% Higher Price Scenario

Downscaling		BCSD	
IPCC Scenario		A2	B1
	Price Increase		
2000-19	±0%	5%	2%
2020-39	+30%	-6%	-3%
2040-59	+30%	3%	-2%
2060-79	+30%	11%	3%
2080-99	+30%	33%	6%

30%/30% Higher Price Scenario

Downscaling		BCSD	
IPCC Scenario		A2	B1
	Price Increase		
2000-19	±0%	5%	2%
2020-39	+30%	-6%	-3%
2040-59	+60%	-9%	-13%
2060-79	+60%	-1%	-9%
2080-99	+60%	18%	-6%

Constant Price/Population Scenario

Downscaling		BCSD	
IPCC Scenario		A2	B1
	Price Increase		
2000-19	±0%	5%	2%
2020-39	±0%	5%	8%
2040-59	±0%	15%	9%
2060-79	±0%	24%	15%
2080-99	±0%	48%	18%

Low Population Growth Scenario

Downscaling		BCSD	
IPCC Scenario		A2	B1
	Price Increase		
2000-19	±0%	17%	13%
2020-39	±0%	31%	34%
2040-59	±0%	48%	41%
2060-79	±0%	66%	52%
2080-99	±0%	113%	65%

Medium Population Growth Scenario

Downscaling		BCSD	
IPCC Scenario		A2	B1
	Price Increase		
2000-19	±0%	19%	15%
2020-39	±0%	48%	52%
2040-59	±0%	99%	88%
2060-79	±0%	154%	133%
2080-99	±0%	258%	179%

High Population Growth Scenario

Downscaling		BCSD	
IPCC Scenario		A2	B1
	Price Increase		
2000-19	±0%	23%	19%
2020-39	±0%	64%	68%
2040-59	±0%	135%	123%
2060-79	±0%	240%	212%
2080-99	±0%	464%	342%

Maximum Temperature Response at ZIP Code Level

$\beta^{MTR} \le 0$

$0 < \beta^{MTR} \le 0.02$

$0.02 < \beta^{MTR} \le 0.04$

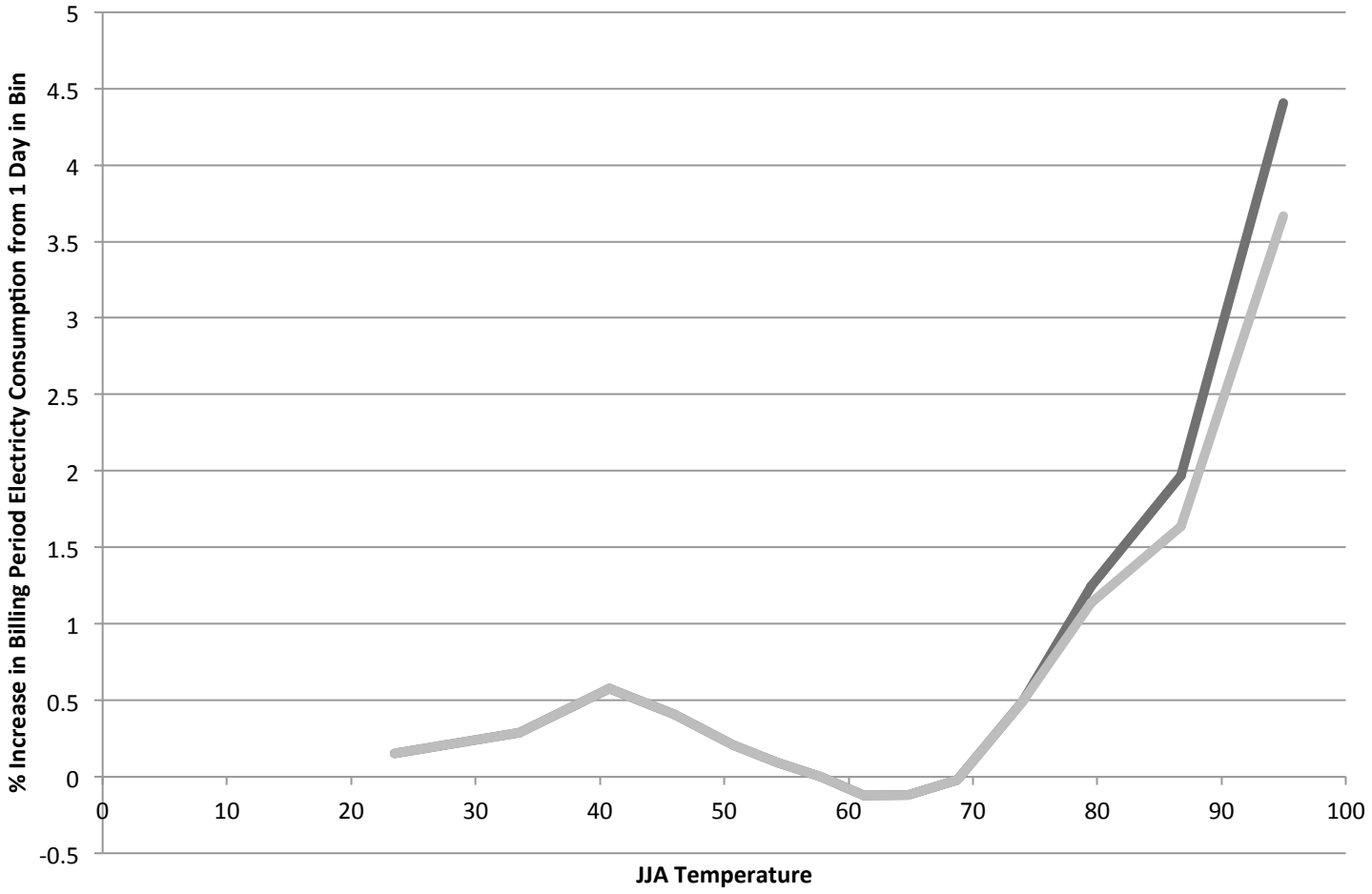
$\beta^{MTR} > 0$

Decomposing Maximum Temperature response

	(1)	(2)	(3)	(4)	(5)	(6)
JJA Temp	0.357***	0.361***	0.386***	0.385***	0.380***	0.321***
	(0.039)	(0.039)	(0.042)	(0.041)	(0.041)	(0.036)
Elevation		-0.000	-0.000	-0.000	-0.000	-0.000**
		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Household Income			0.239***	0.235***	0.245***	0.279***
			(0.066)	(0.066)	(0.070)	(0.087)
Population				0.000	0.000	0.000
				(0.000)	(0.000)	(0.000)
Share White					0.686	1.394
					(1.152)	(0.856)
Share Latino					0.658	1.902**
					(0.899)	(0.772)
Share Afr. Am.					0.474	2.287
					(1.567)	(1.574)
Constant	-5.800***	-5.758***	-7.514***	-7.554***	-8.154***	-7.704***
	(0.856)	(0.859)	(1.111)	(1.124)	(1.533)	(1.373)
Observations	1,337	1,337	1,337	1,337	1,337	661
R-squared	0.075	0.076	0.087	0.088	0.088	0.138

Notes: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

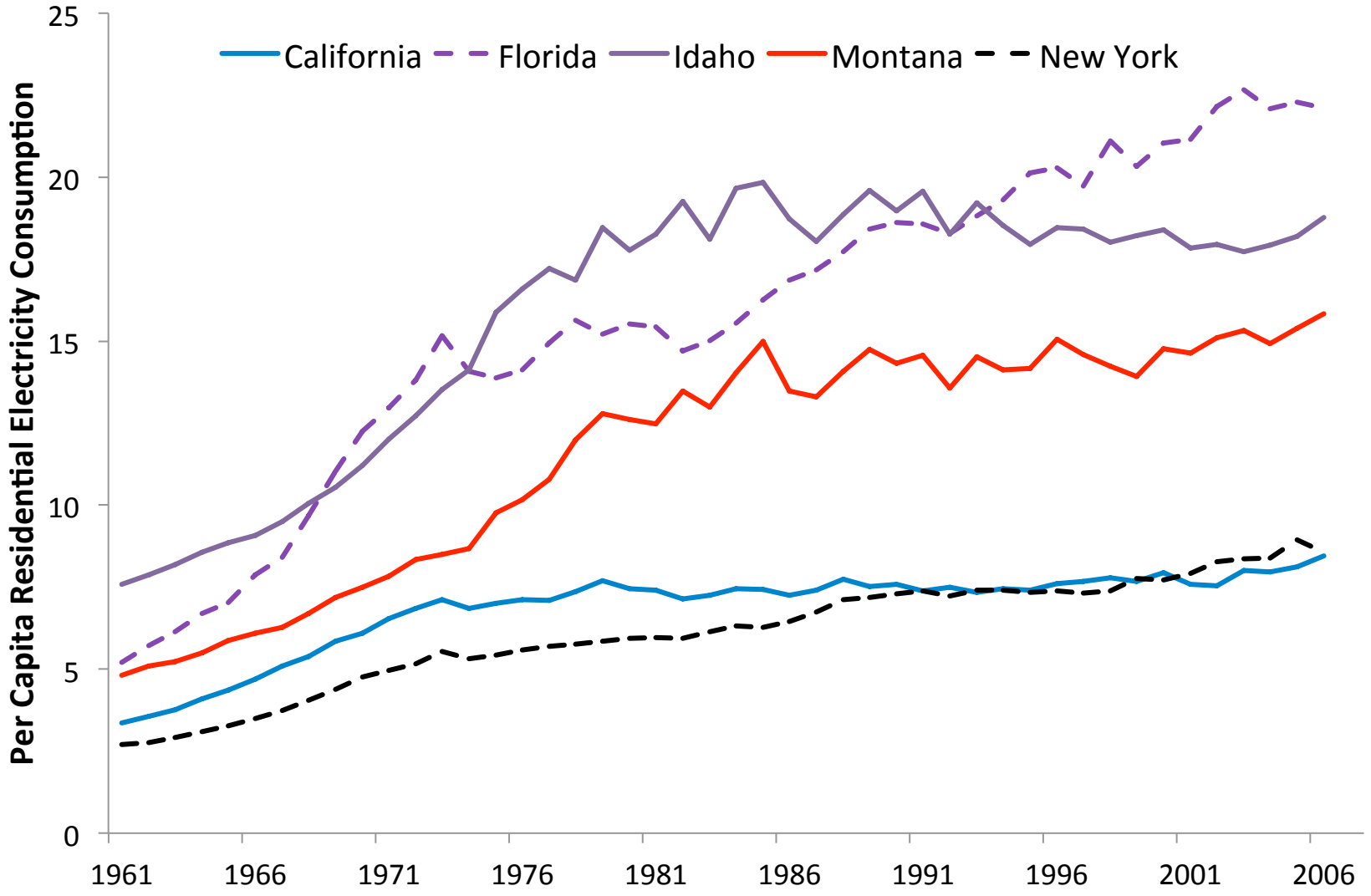
Temperature Response with Climate Change



The crucial importance of energy efficiency.

- California's goal: By 2050 reduce GHG emissions by 80%
- People live in bigger and more temperature responsive homes
- Fight this trend by:
  - Requiring more efficient buildings
  - Mandating more efficient appliances
  - Smarter Urban Planning
  - Increase share of Carbon neutral renewables.

The Rosenfeld Curve



The road ahead

- Policy makers need to design policies now that provide incentives to commit to the right emissions path.
- Researchers need to better understand what makes people “make the right choice”
- Where should public dollars go? R&D? Into Solar PV on roofs?
- Better understand adaptation.

Thank you.

Questions?

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