DOCKETED	
Docket Number:	18-IEPR-05
Project Title:	Climate Adaptation and Resiliency
TN #:	224632
Document Title:	Climate change and residential electricity and natural demand - Implications for California's GHG emissions reduction goals
Description:	Presentation by Maximilian Auffhammer, University of California, Berkeley
Filer:	Raquel Kravitz
Organization:	Berkeley University of California
Submitter Role:	Public Agency
Submission Date:	8/29/2018 1:30:56 PM
Docketed Date:	8/29/2018

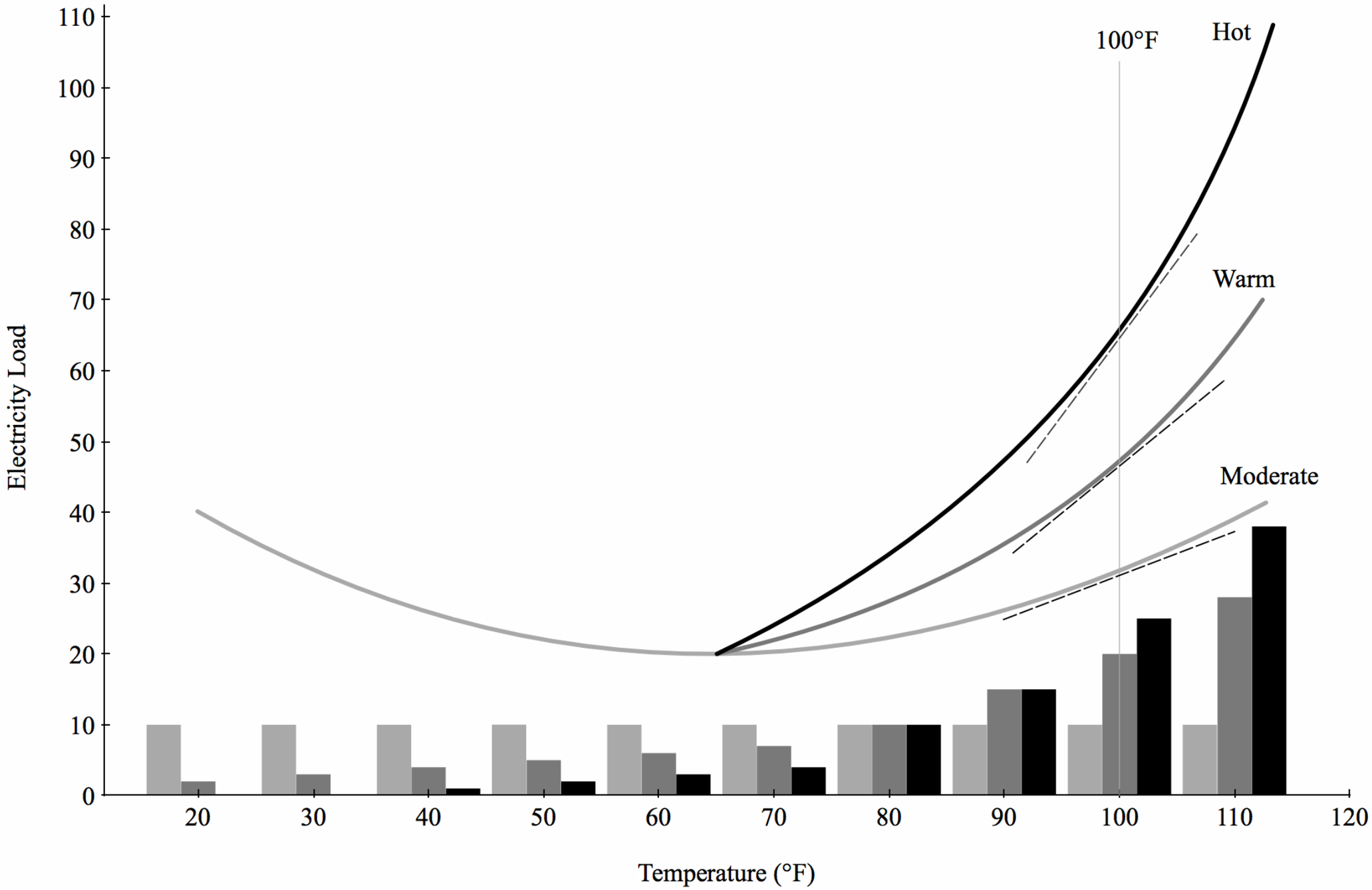
Climate change and residential electricity and natural demand: Implications for California's GHG emissions reduction goals

Maximilian Auffhammer
George Pardee Jr. Professor of Sustainable Development
Associate Dean of Interdisciplinary Studies
University of California at Berkeley
National Bureau of Economic Research

California Energy Commission Workshop
Sacramento, August 30, 2018

Berkeley
UNIVERSITY OF CALIFORNIA

Hotter Climate - Steeper Temperature Response



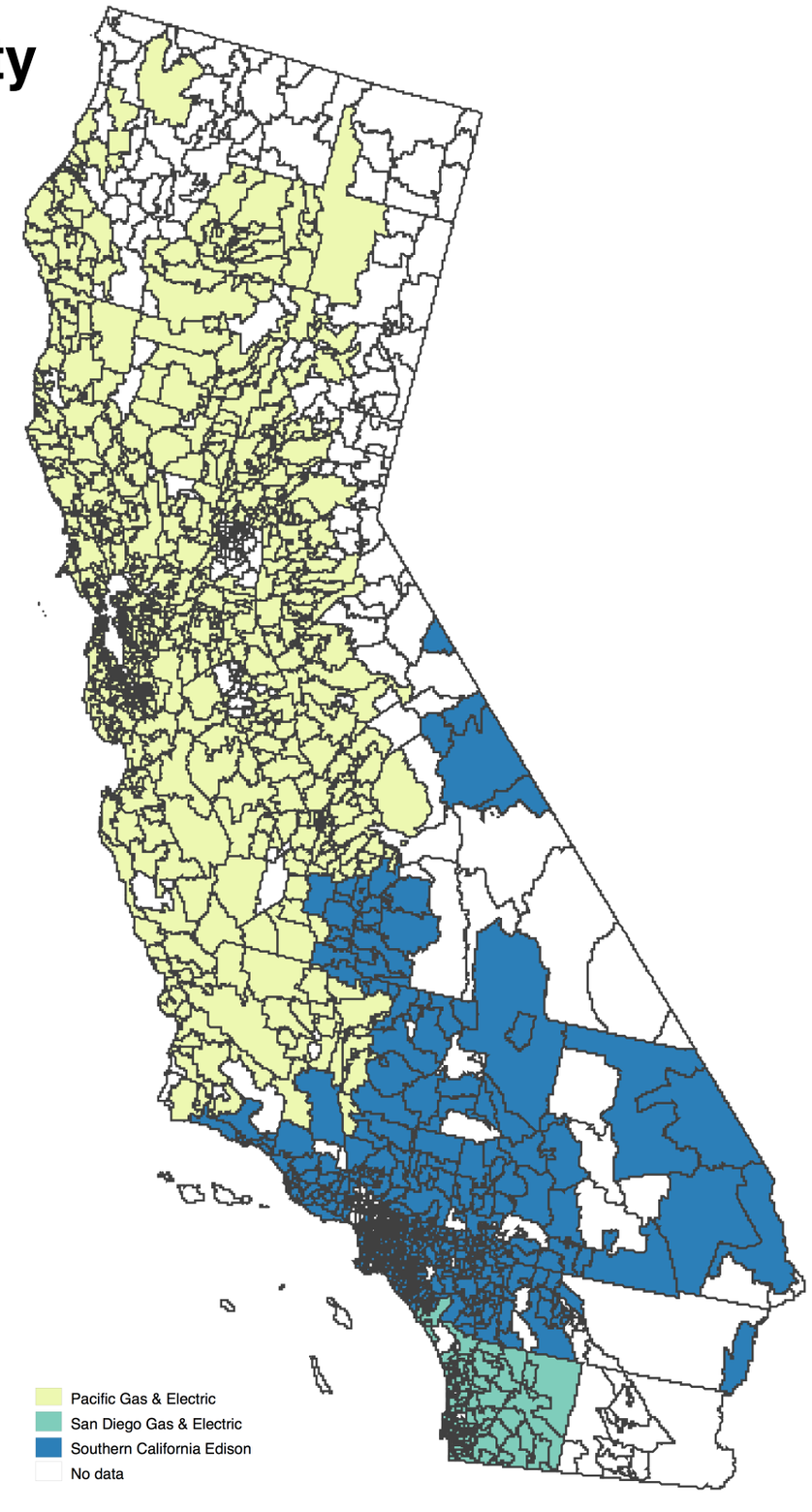
Research Question

1. How much would **residential electricity consumption change** if we imposed projected end of century climate on today's economy
    - holding **air conditioner penetration constant** (intensive margin)
    - letting **air conditioner penetration change** (extensive margin)

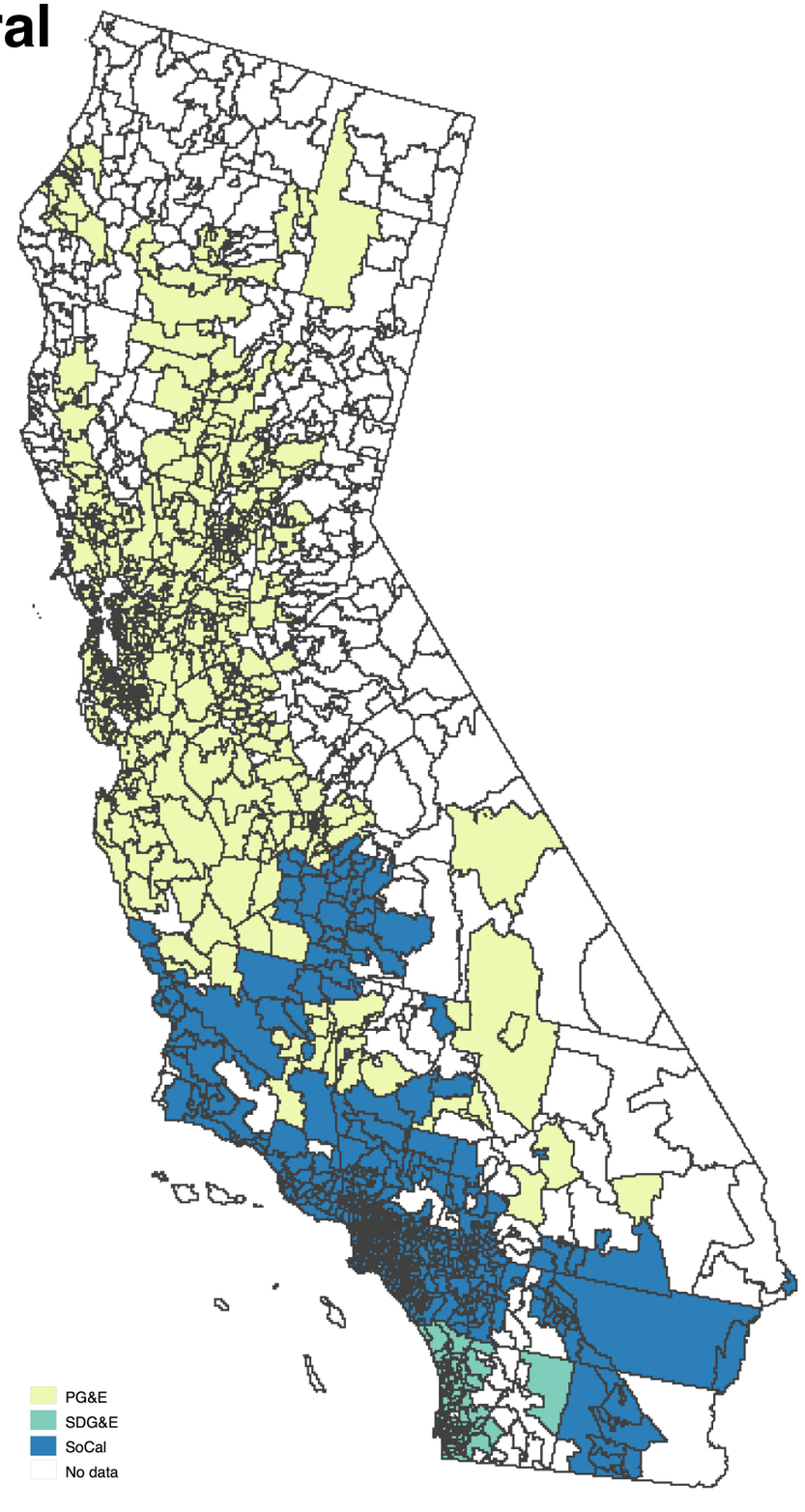
2. How much will residential **natural gas consumption change** if we imposed projected end of century climate on today's economy **holding technology constant.**

IOUs provided 2 billion electricity and gas bills

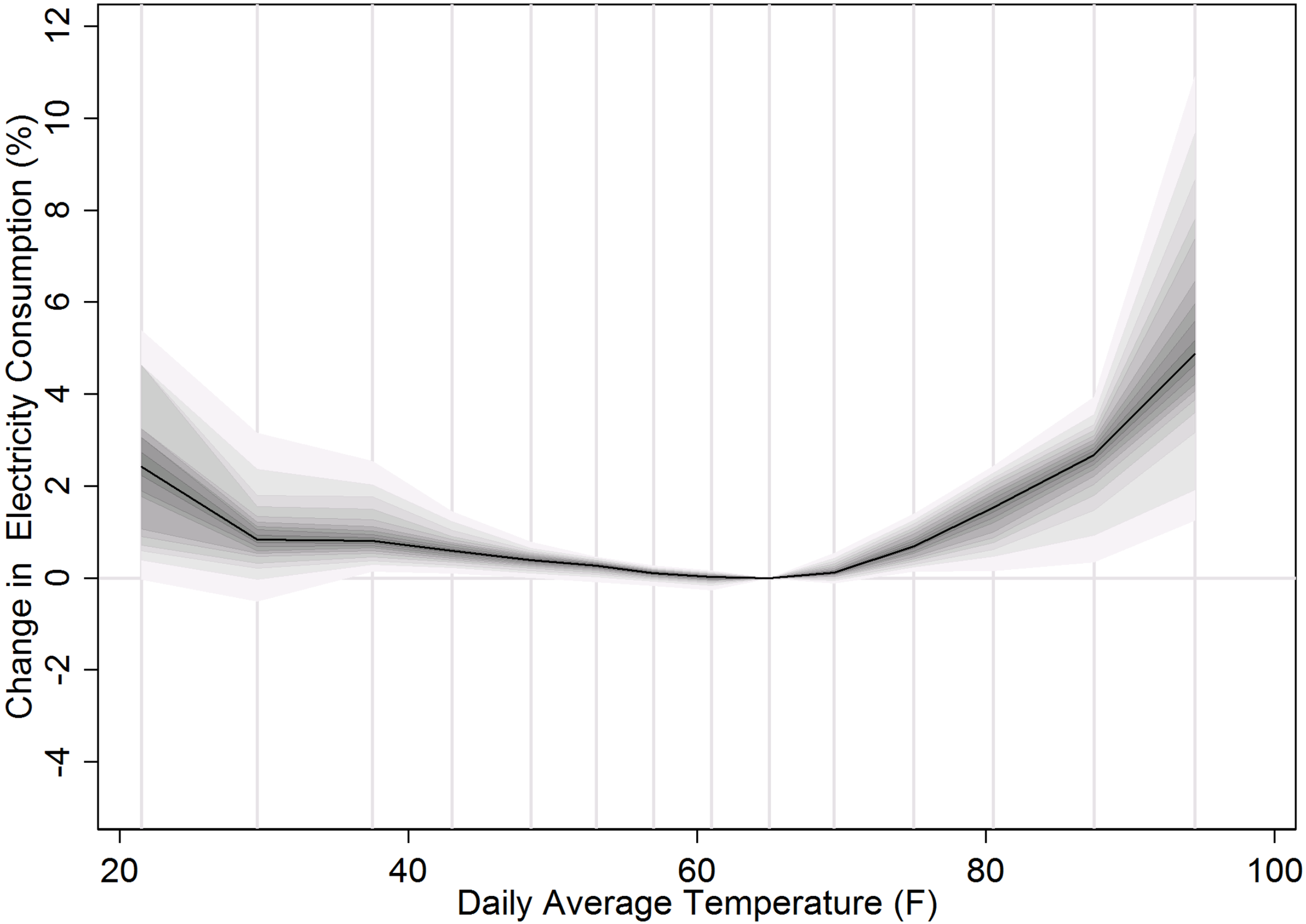
Electricity



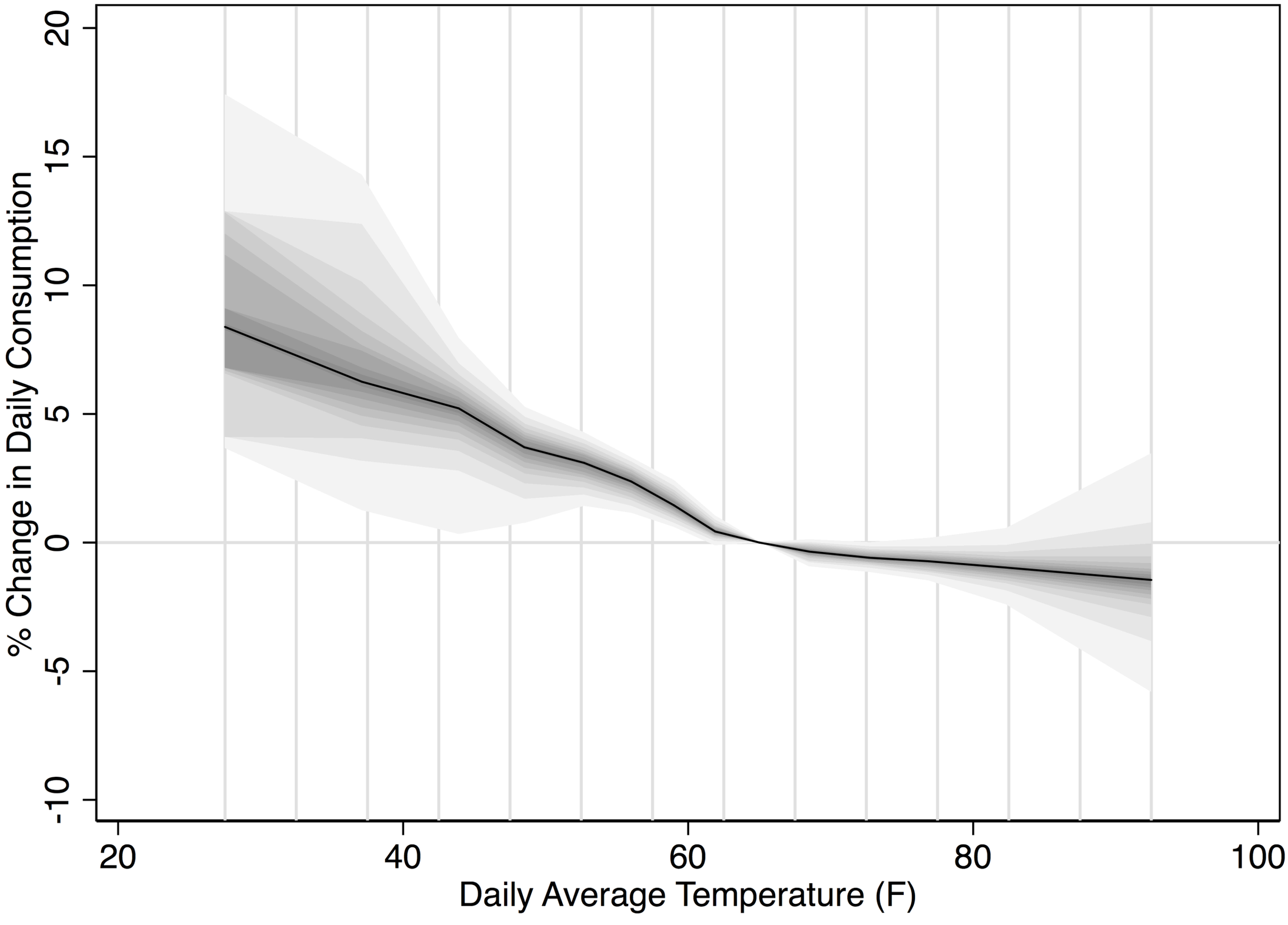
Natural Gas



Temperature Response: Normal households

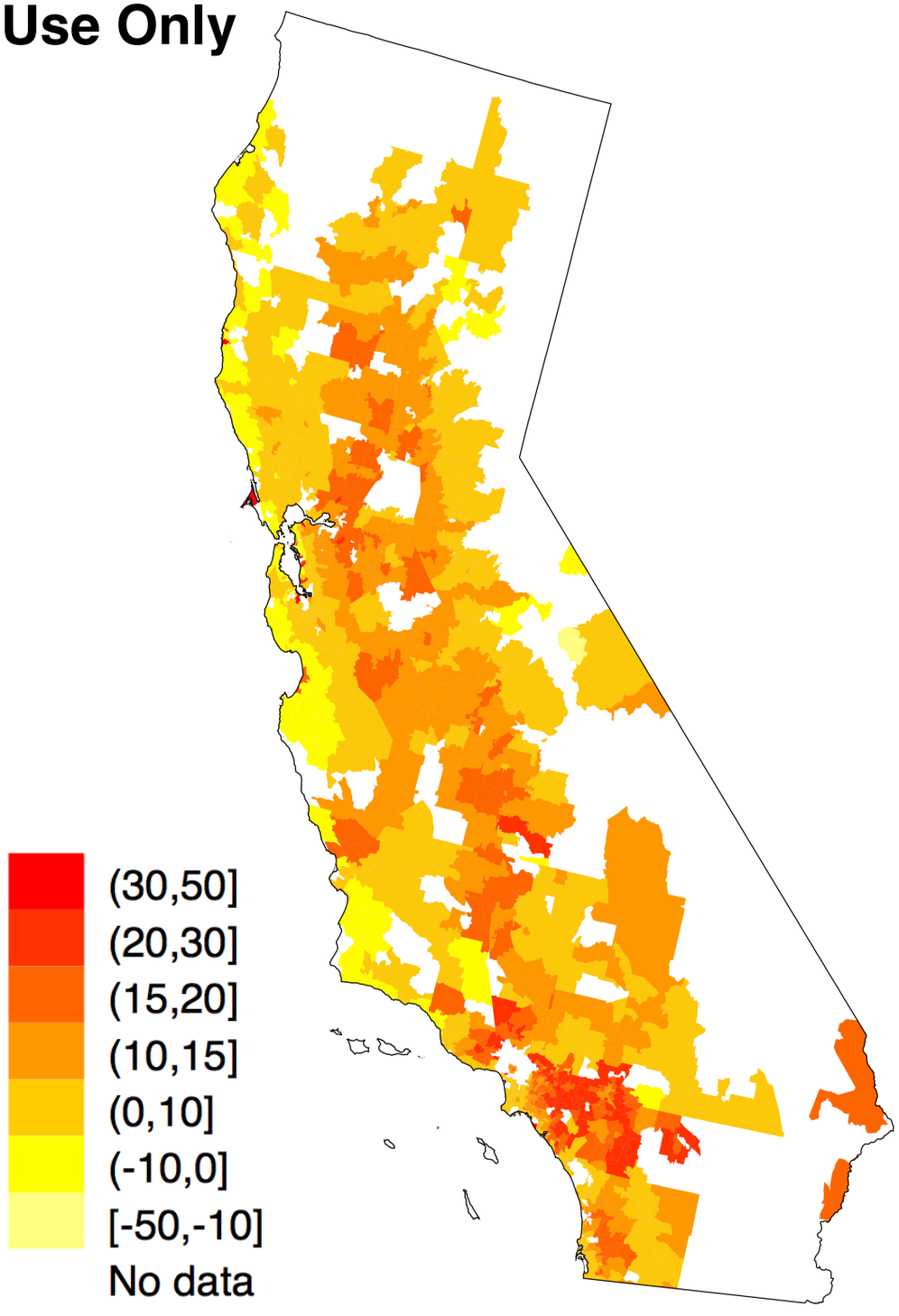


Natural Gas Response

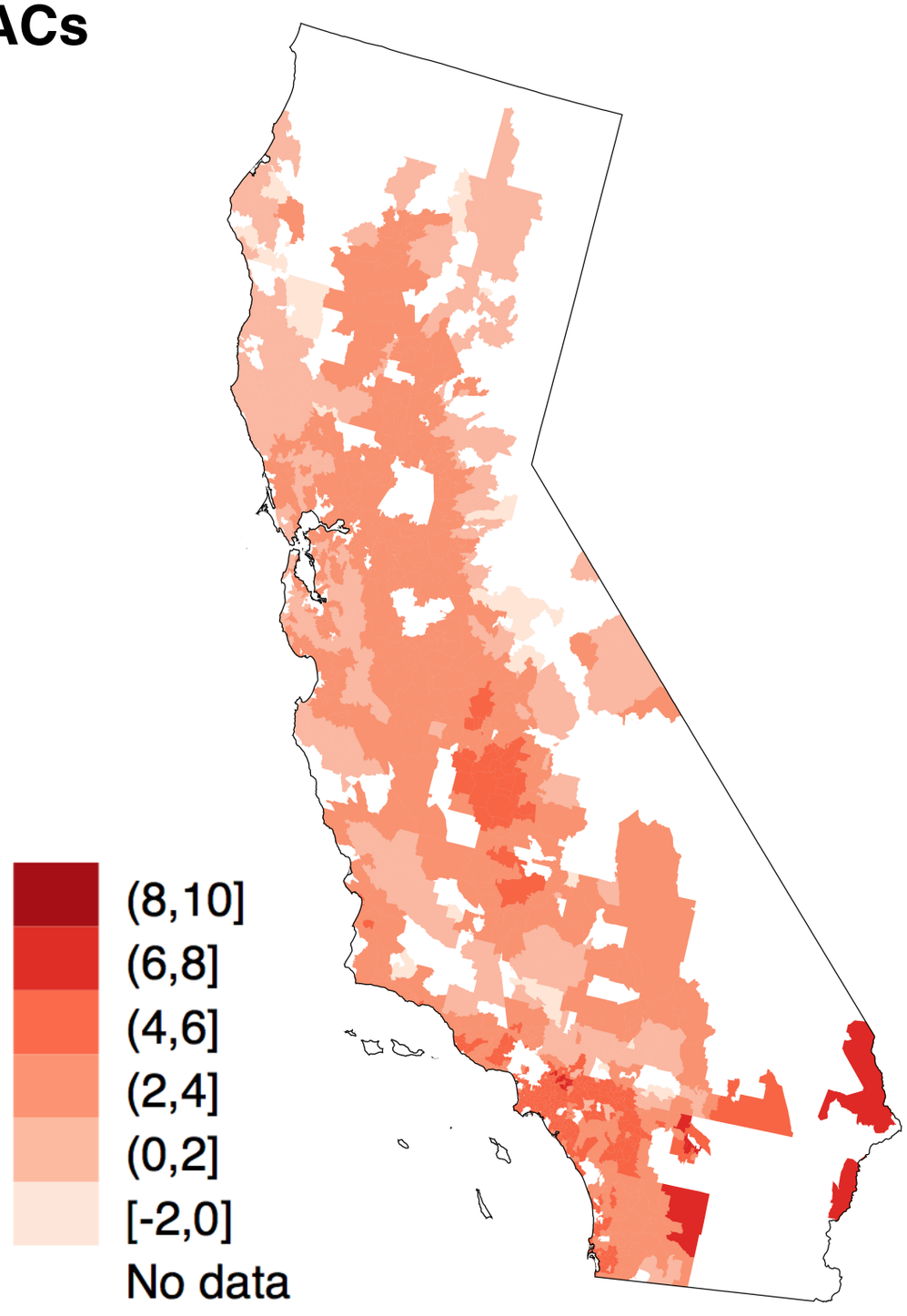


% Changes in Consumption

Use Only



+ New ACs



Projected aggregate temperature impacts in %

Simulation	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
RCP	4.5	8.5	4.5	8.5	4.5	8.5	4.5	8.5
Special Customer	No	No	CARE	CARE	All-E	All-E	No	No
Fuel	Elec.	Elec.	Elec.	Elec.	Elec.	Elec.	Gas	Gas
Price Controls	No	No	No	No	No	No	No	No
Intensive Margin								
2020-39	1.3	1.6	1.4	1.6	0.3	0.3	-4.0	-4.9
2040-59	2.7	3.7	2.6	3.5	0.6	0.9	-7.9	-10.4
2060-79	3.7	7.2	3.5	6.7	0.8	2.5	-10.3	-16.1
2080-99	4.2	11.4	3.9	10.5	1.0	5.0	-11.3	-20.5
Extensive Margin								
2020-39	1.0	1.4	1.0	1.3	0.3	0.4	NA	NA
2040-59	2.8	4.2	2.7	4.0	0.9	1.6	NA	NA
2060-79	4.2	8.6	3.9	8.6	1.5	4.3	NA	NA
2080-99	4.9	14.7	4.6	14.1	1.9	8.0	NA	NA

Conclusions from my study

- California Homes used 0.287 quadrillion BTU of electricity and 0.439 quadrillion BTU of natural gas in 2009 (EIA, RECS).
- Climate Change is simulated to lead to a **0.039 quad BTU net decrease** in energy consumption for the residential sector in California (~total non transportation energy consumption of 650,000 households)
- But we are ignoring the **impacts on peak load** in this study!
- Climate Change may require **additional investments** in **peak generating capacity**.

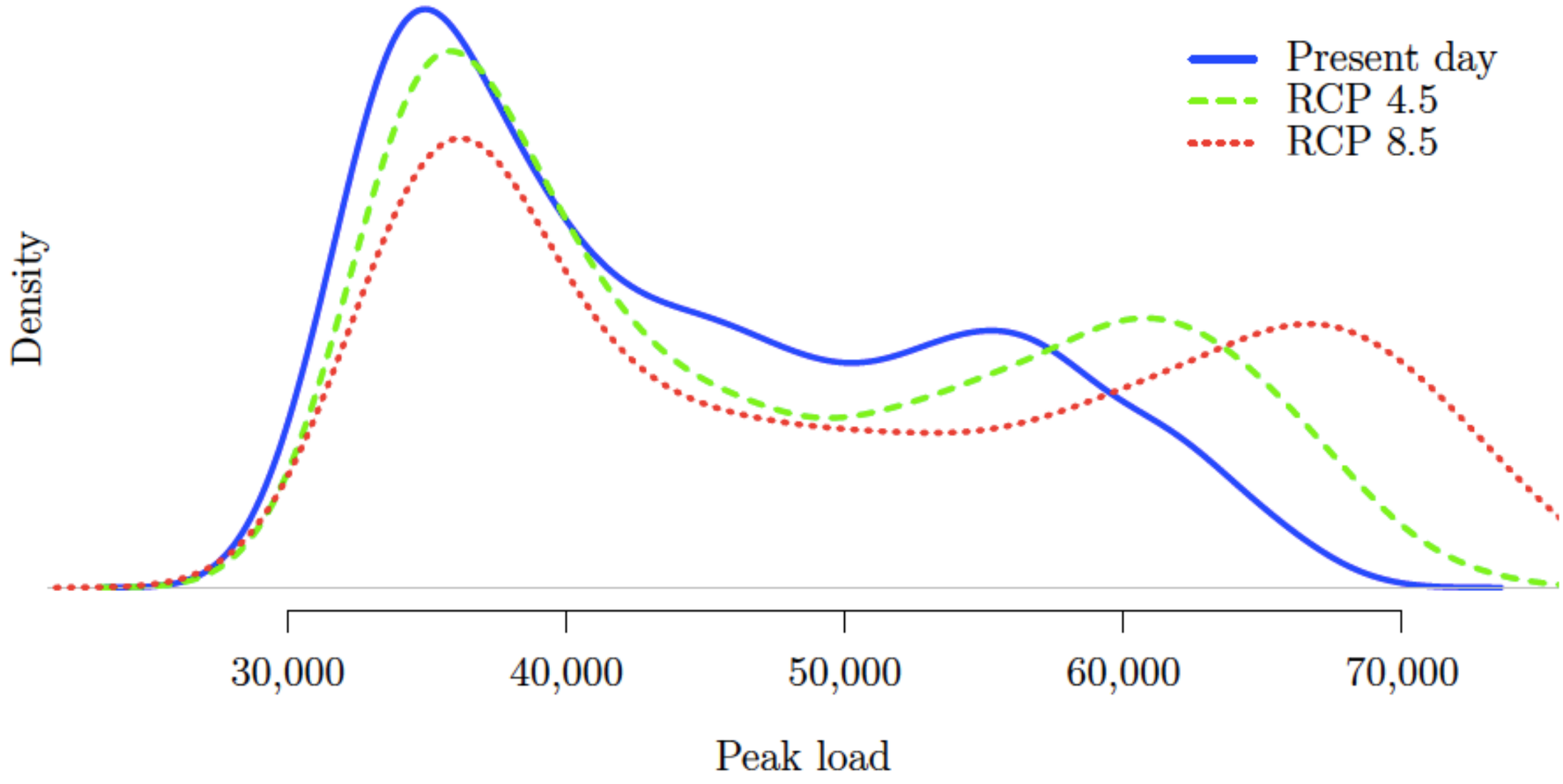
Climate change is projected to have severe impacts on the frequency and intensity of peak electricity demand across the United States

Maximilian Auffhammer[a,b,1,2], Patrick Baylis[c,d,1], and Catherine H. Hausman[b,e,1]

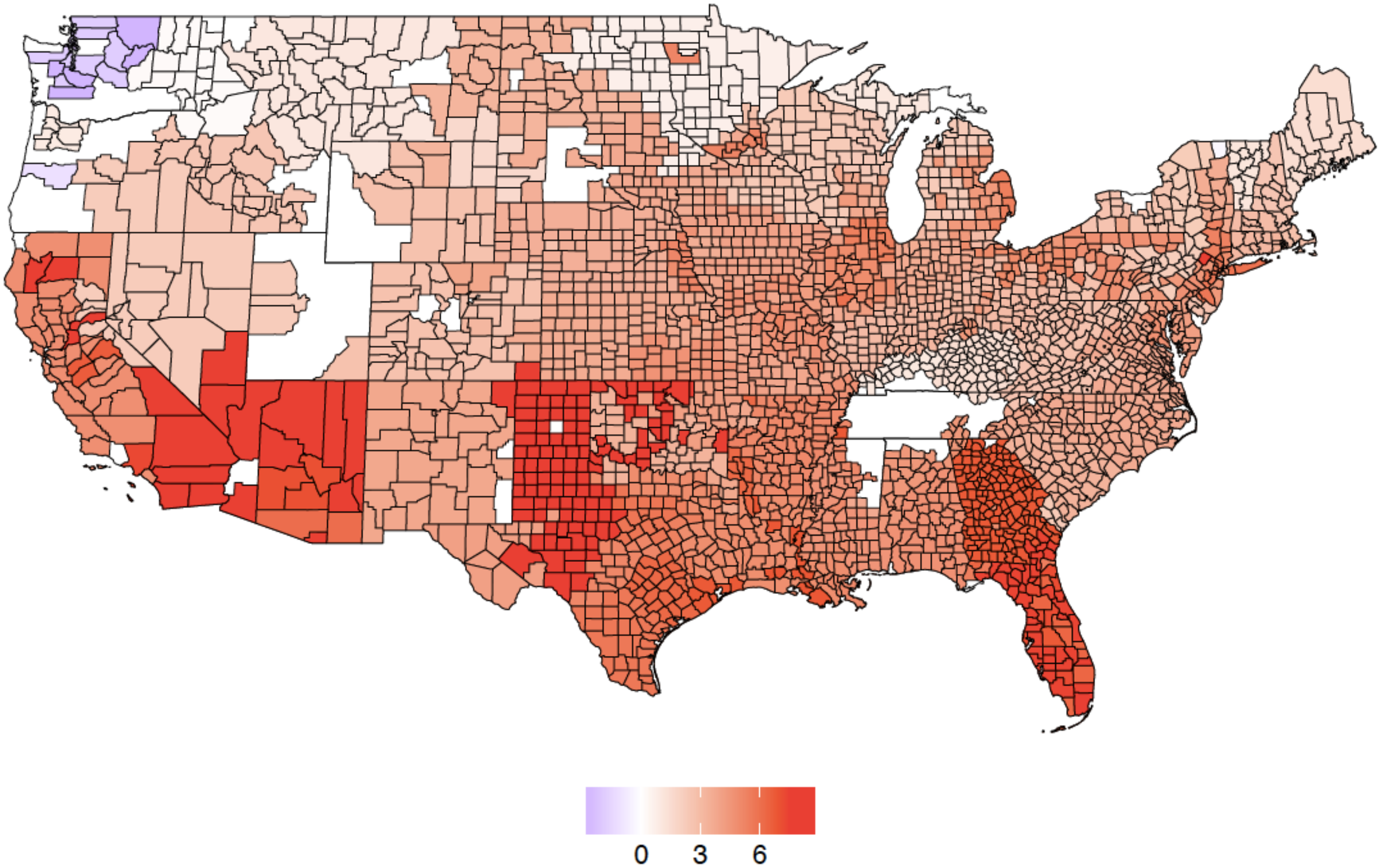
[a]Department of Agricultural and Resource Economics, University of California, Berkeley, CA 94720; [b]National Bureau of Economic Research, Cambridge, MA 02138; [c]Center on Food Security and the Environment, Stanford University, Palo Alto, CA 94305; [d]Vancouver School of Economics, University of British Columbia, Vancouver, BC V6T 1L4, Canada; and [e]Ford School of Public Policy, University of Michigan, Ann Arbor, MI 48109

Edited by V. Kerry Smith, Arizona State University, Tempe, AZ, and approved December 23, 2016 (received for review August 8, 2016)

ERCOT: Distribution of peak load by end of century



Projected intensity of peak load end of century (RCP4.5)



Changes in intensity and frequency of peak load

	%Δ average hourly load	%Δ peak daily load	%Δ 95th percentile daily peak load	%Δ frequency days w. peak load > current 95th percentile	%Δ frequency days w. peak load > current 99th percentile
Simulation type	Intensity	Intensity	Intensity	Frequency	Frequency
			RCP 4.5		
FERC	2.8	3.5	6.8	158	382
ERCOT	3.7	4.3	6.2	150	460
ISONE	1.6	2	7.1	103	260
NYISO	2.7	3.3	8.5	128	312
PJM	2.3	3.1	8	133	329
Total	2.8	3.5	7	152	374
			RCP 8.5		
FERC	8	9.7	17.2	407	1, 532
ERCOT	10.1	11.5	15.2	406	1, 634
ISONE	5	6	17.7	281	1, 024
NYISO	8	9.2	21.2	334	1, 230
PJM	7	8.9	20.5	354	1, 347
Total	7.9	9.6	17.6	395	1, 492

Column 1 is the projected percent change in hourly generation, column 2 is the projected percent change in daily peak load, column 3 is the projected percent change in the 95th percentile of daily peak load, and columns 4 and 5 are the projected percent change in the number of days with peak load greater than the present-day 95th and 99th percentiles, respectively. Each projection is based on the average projected change in temperature for 19 independent climate models. The five rows display results across five geographic regions of the United States.

Policy Implications

- Electricity **consumption will rise** because of rising **temperatures**, **incomes** and **population**.
- Energy efficiency programs, DRM, and **smart pricing policies** will help **offset this increase in demand**.
- **Electrification** might **shift peak**, yet will certainly **increase demand** further.
- **Electrification** and the **decarbonization** of the sector results in **dramatic reductions of conventional air pollutants**
- System must be **sized to meet peak demand**!