Renewable & Appropriate Energy Laboratory
RAEL

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http://rael.berkeley.edu

Joint Hearing of the Senate Environmental Quality Committee and the Select Committee on Climate Change and AB32 Implementation

Daniel Kammen

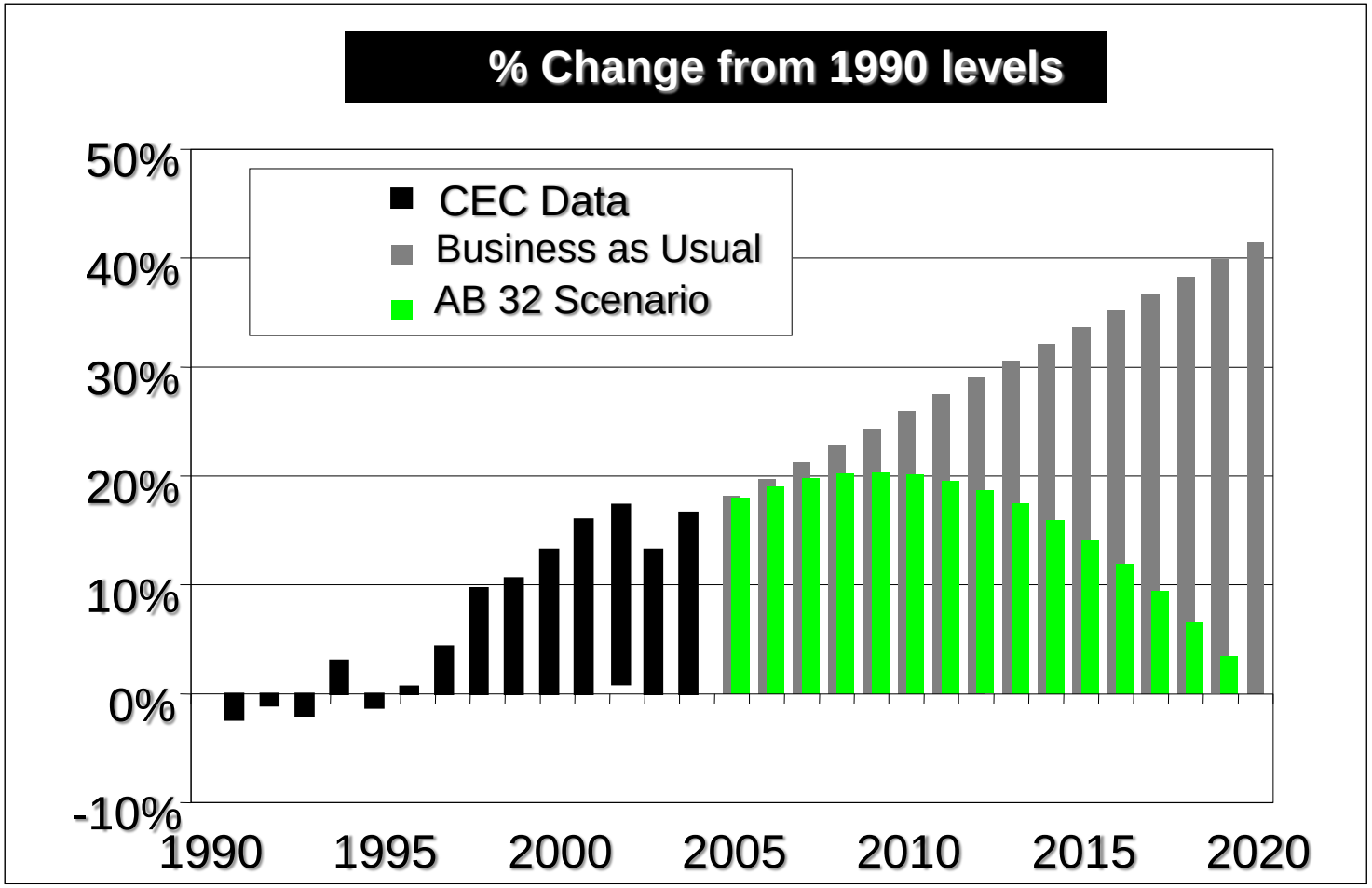
Class of 1935 Distinguished Professor of Energy
Energy and Resources Group | Goldman School of Public Policy
Director, Renewable and Appropriate Energy Laboratory
University of California, Berkeley

State Capitol, Room 4203**,** Sacramento, CA, March 12, 2014

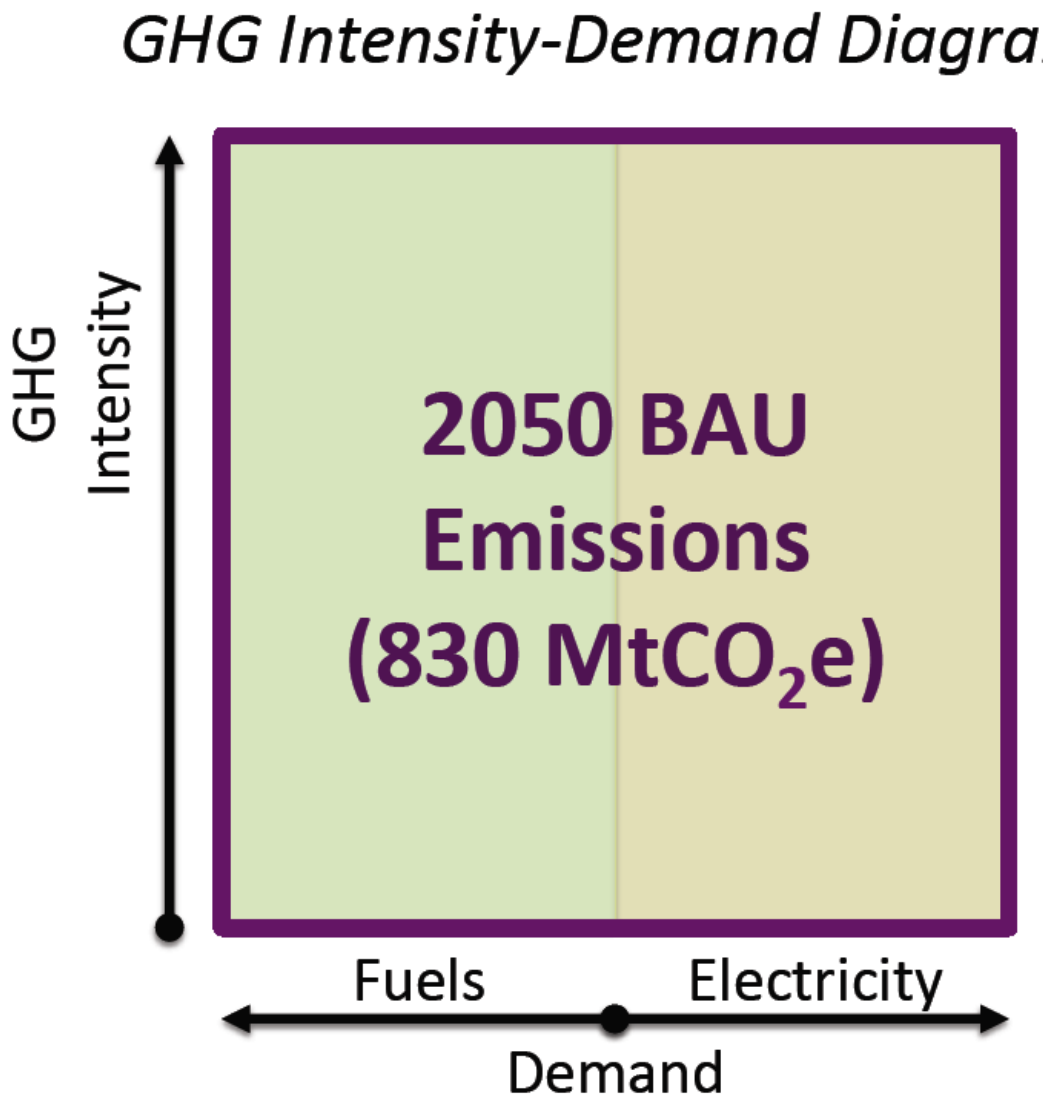
California Global Warming Solutions Act:

~25% cut in emissions by 2020 to 1990 baseline,

and then reduce by 80%

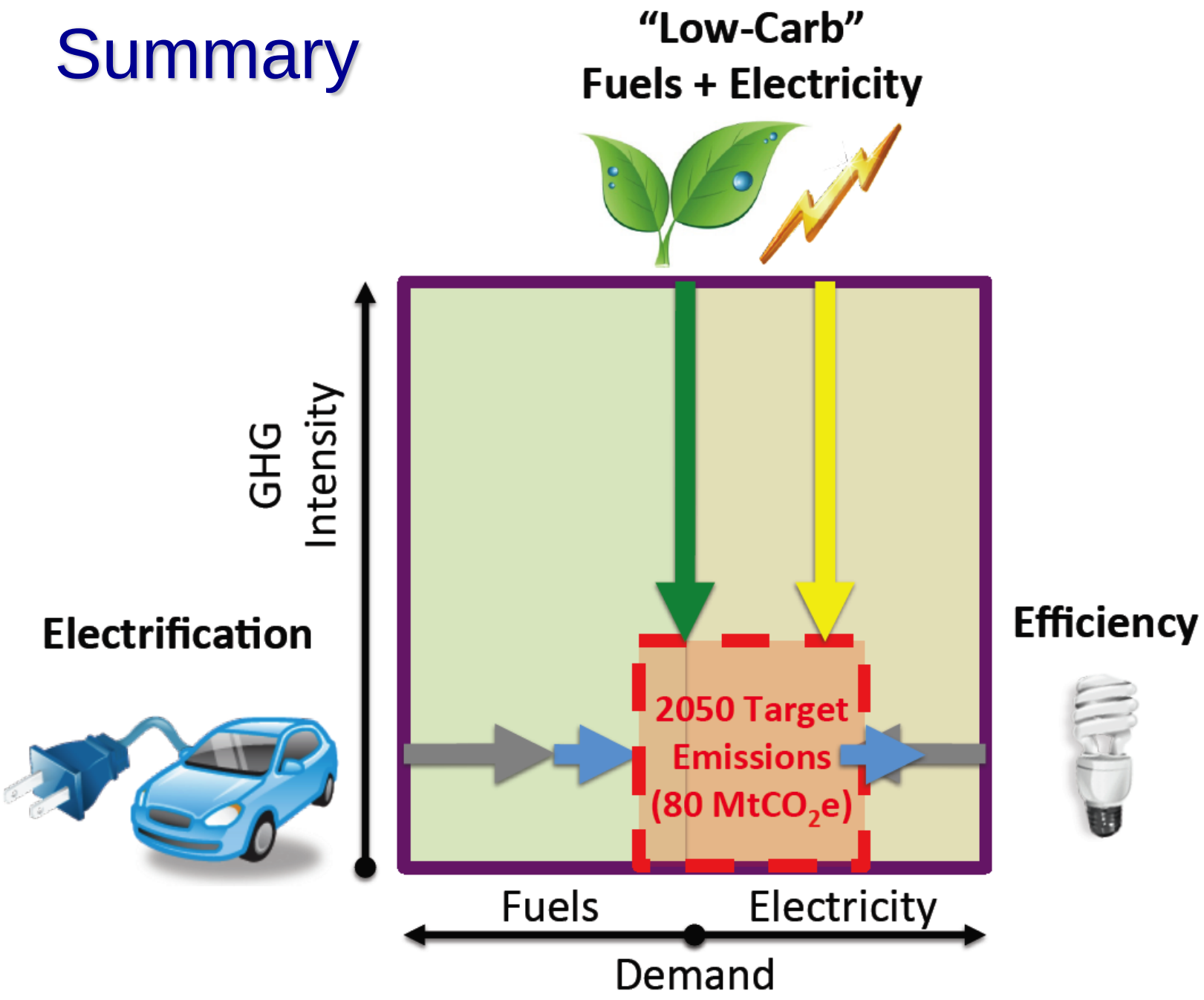


Actions to reduce emissions



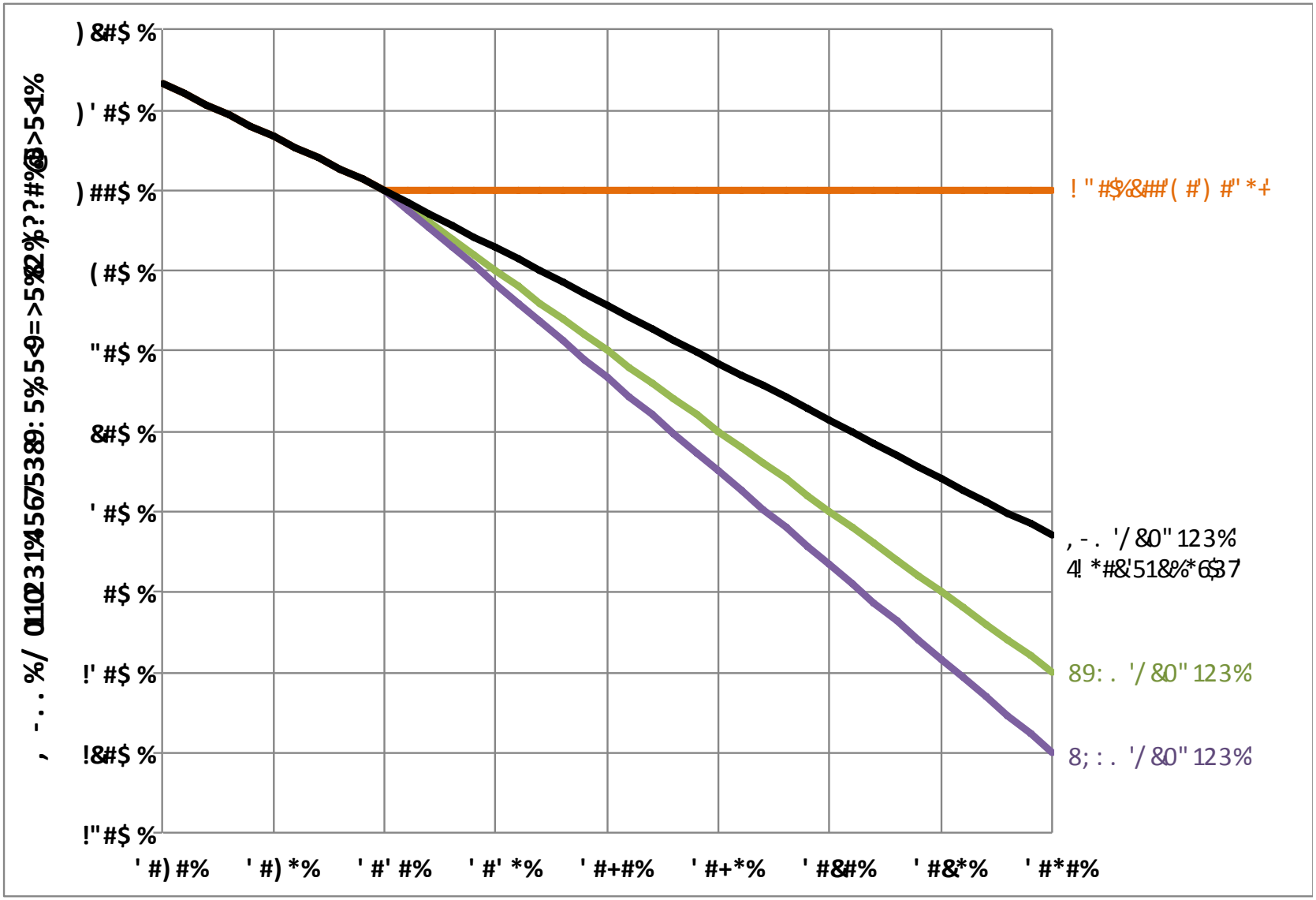
From: California's Energy Future – The View to 2050, California Council on Science and Technology, 2011

Summary



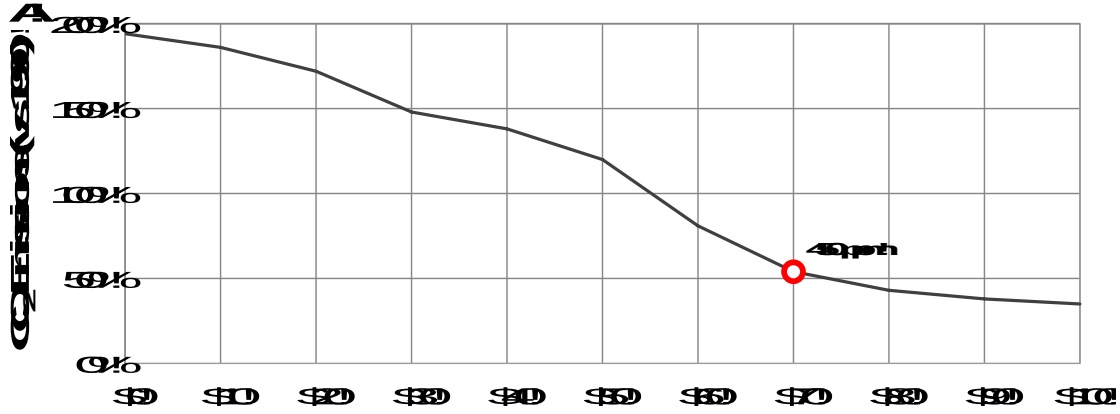
From: California's Energy Future – The View to 2050, California Council on Science and Technology, 2011

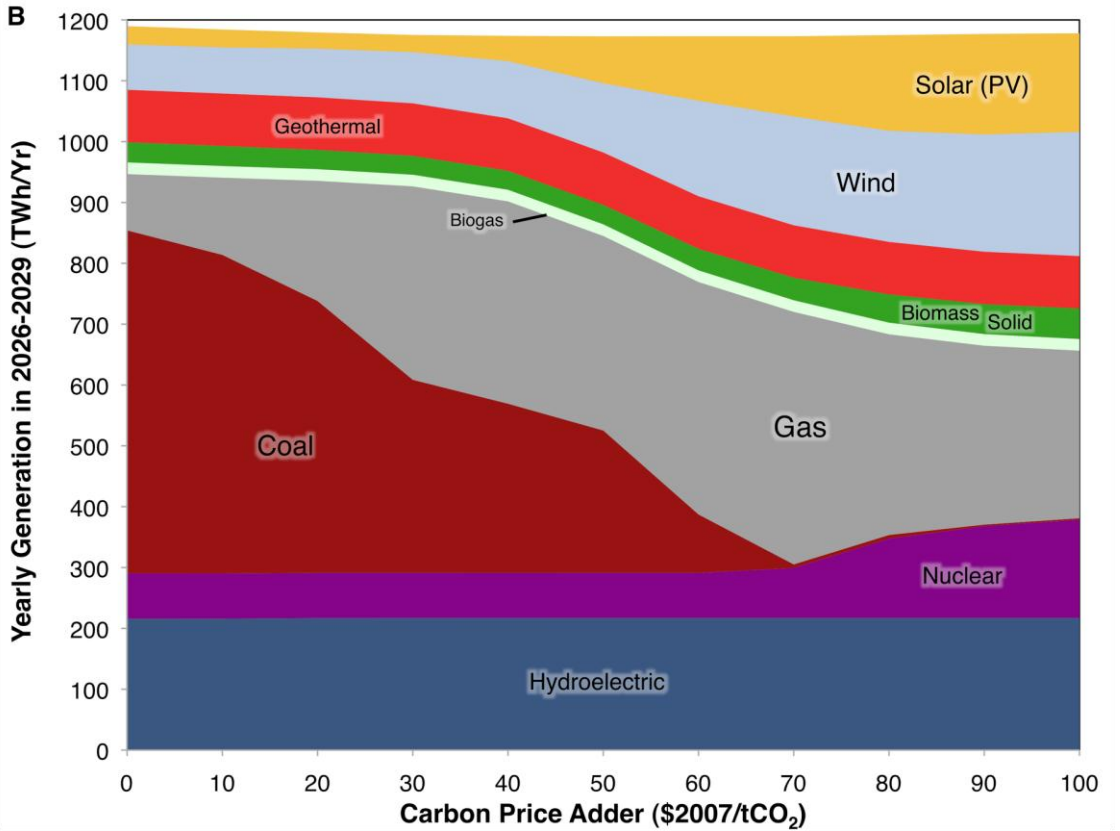
Carbon Caps: California Pathways



High-Resolution Modeling of Clean Energy Futures

Professor Daniel Kammen, UC Berkeley





HIGH SPATIAL AND TEMPORATL RESOLUTION MODEL OF THE REGIONAL POWER GRID (WESTERN NORTH AMERICA)

LEAST-COST LINEAR PROGRAM MODEL FOR WESTERN NORTH AMERICA:

- **TOP: CO_2 emissions relative to 1990**
- **BOTTOM: power generation by fuel in 2022029 as a function of carbon price adder**
- **Climate stabilization target of 450 ppm is reached at a carbon price adder of ~$70/t$CO_2$.**

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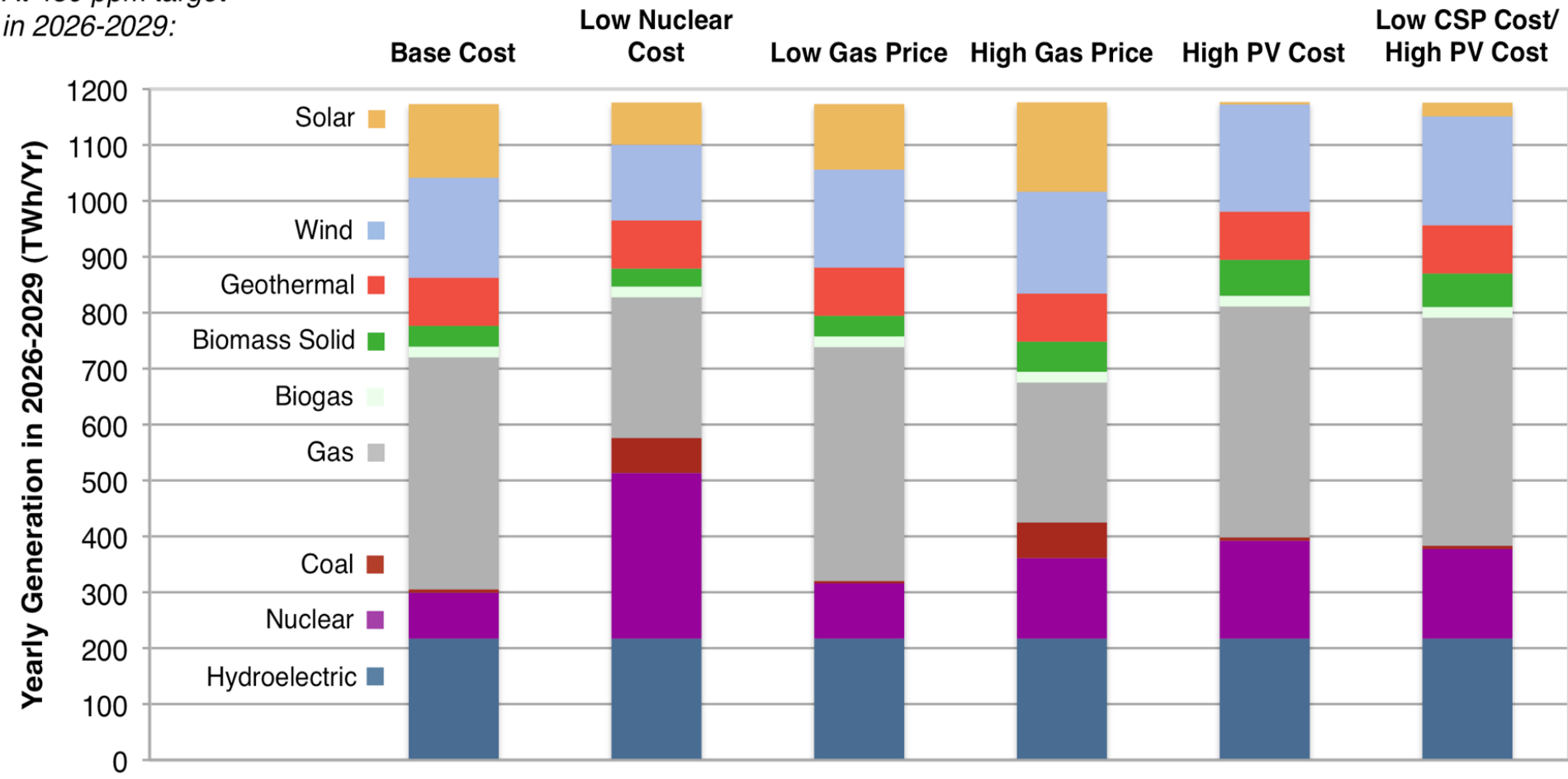
At 450 ppm target in 2026-2029:

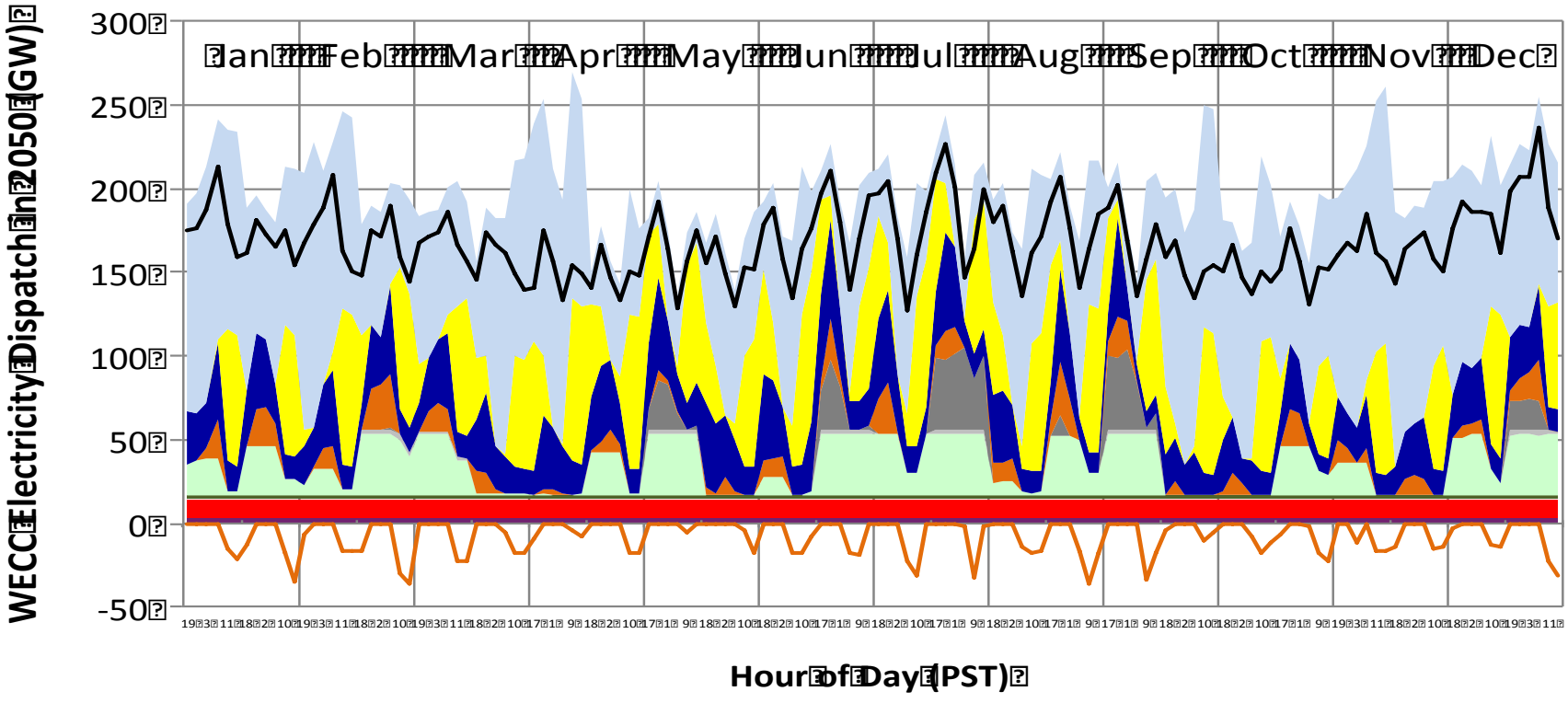


Carbon price adder ($2007/tCO$_2$)	70	59	87	66	84	86
Power cost ($2007/MWh)	113	110	110	114	114	114
Cumulative new transmission built by 2030 (10^3 GW-km)	9.8	6.0	9.0	11.7	12.0	12.3

Nelson, J. et al., *Energy Policy*, 43 (**2012**) 436–447 | http://rael.berkeley.edu/switch

Dispatch in 2050: Flexibility and variable renewables dominate

- Storage almost exclusively moves solar to the night
- Geothermal only remaining substantial baseload



COOLCALIFORNIA
CITY CHALLENGE
Sponsored by: energy upgrade CALIFORNIA

Summary | My Community | Requests | Directory | Settings | Challenge | Donate

Betsy

LEVELS

- GURU 10,000 PTS
- CHAMPION 5,000 PTS
- MAGICIAN 2,000 PTS
- WARRIOR 500 PTS
- MINION 100 PTS

EARN KUDOS

ADD PHOTO (50 PTS)

TAKE SURVEY (500 PTS)

CALCULATOR (coming soon!)

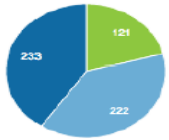
INVITE FRIEND (20 PTS EACH)

Type e-mail address

Submit

SHARE YOUR STORY

MY HOUSEHOLD



7397 total points

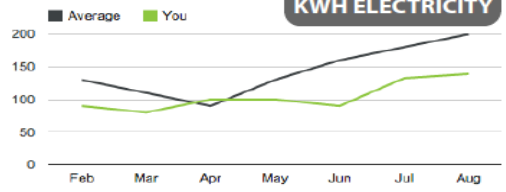
#2 of 12 households in Gonzales

207 pounds of CO_2 saved

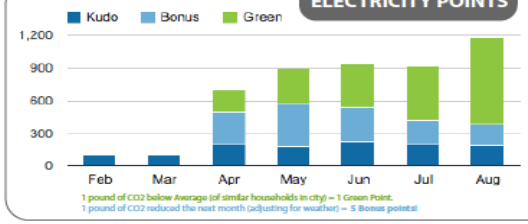
My Household | My Team | My City | California

Electricity | Natural Gas | Transportation | CO_2

KWH ELECTRICITY



ELECTRICITY POINTS



1 pound of CO2 below Average (of similar households in city) = 1 Green Point.
1 pound of CO2 reduced the next month (adjusting for weather) = 5 Bonus points!

ADD KWH DATA

My household used 14 kwh of electricity from

mm/dd/yyyy Start Date mm/dd/yyyy End Date Submit

2014 LEADERBOARD

	CITY	POINTS	PARTICIPANTS
#1	Davis	100,000	20,000
#2	Tracy	75,000	15,000
#3	El Monte	50,000	7,000
#4	Sacramento	25,000	5,000
#5	Chula Vista	20,000	2,000
#6	Davis	15,000	20,000
#7	Tracy	10,000	15,000
#8	El Monte	5,000	7,000
#9	Sacramento	4,000	5,000
#10	Chula Vista	2,000	2,000

Participants | Teams | Cities

RECENT ACTIVITY

BETSY - DAVIS, CA
Earned 500 points by ....

GEORGE - SACRAMENTO, CA
Earned 250 points by ....

BOB - CHULA VISTA CA
Earned 1,000 points by ....

BETSY - DAVIS, CA
Earned 500 points by ....

GEORGE - SACRAMENTO, CA
Submitted at sustainability story

BOB - CHULA VISTA CA
Earned 1,000 points by ....

BETSY - DAVIS, CA
Earned 500 points by ....

DAVE- DAVIS, CA
Earned 500 points by ....

PROJECT PARTNERS

California Environmental Protection Agency Air Resources Board

University of California RAEL Renewable & Appropriate Energy Laboratory

CoolClimate Network

MAJOR SPONSOR

energy upgrade CALIFORNIA

Environmental Science & Technology

Policy Analysis

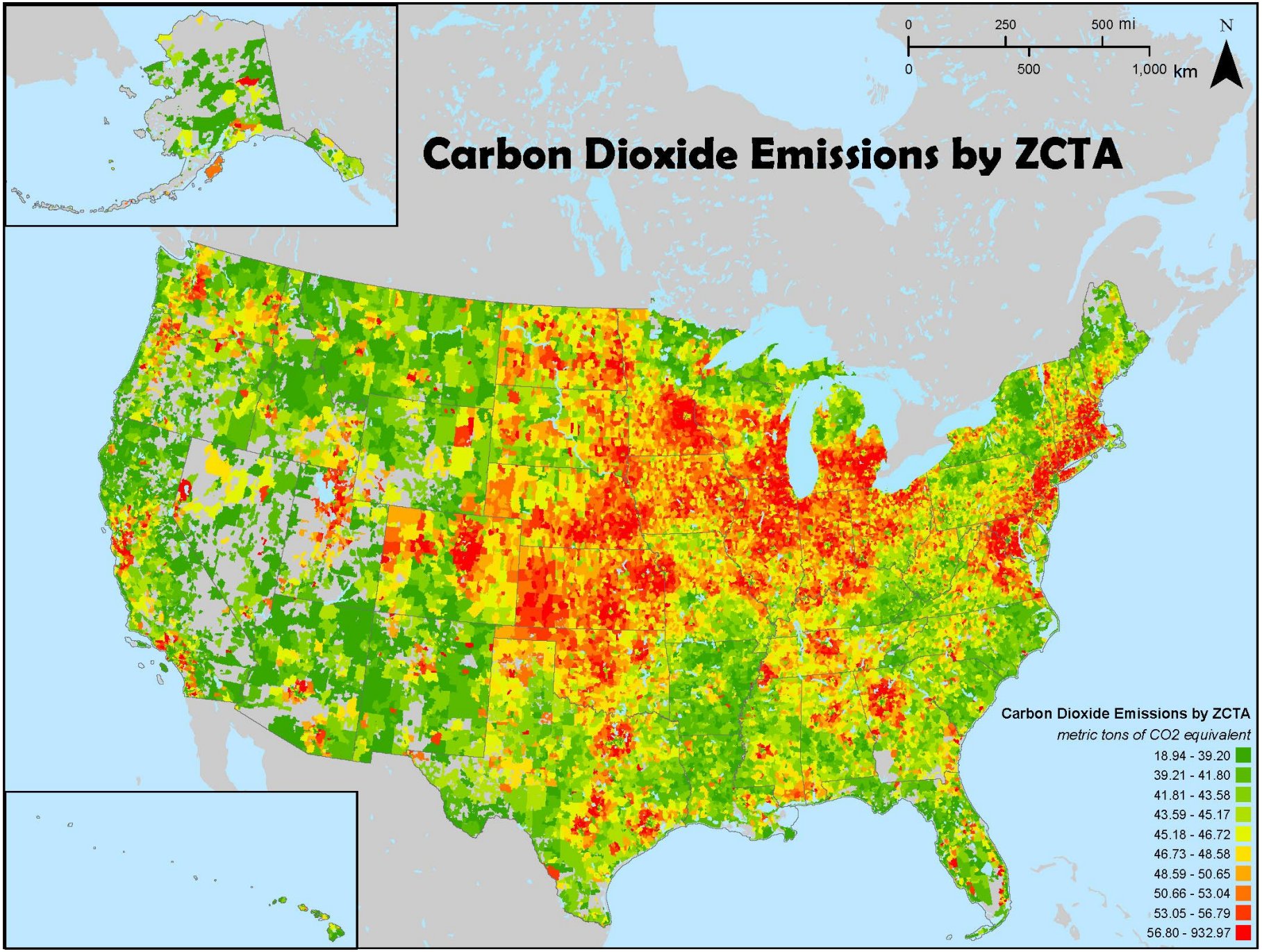
pubs.acs.org/est

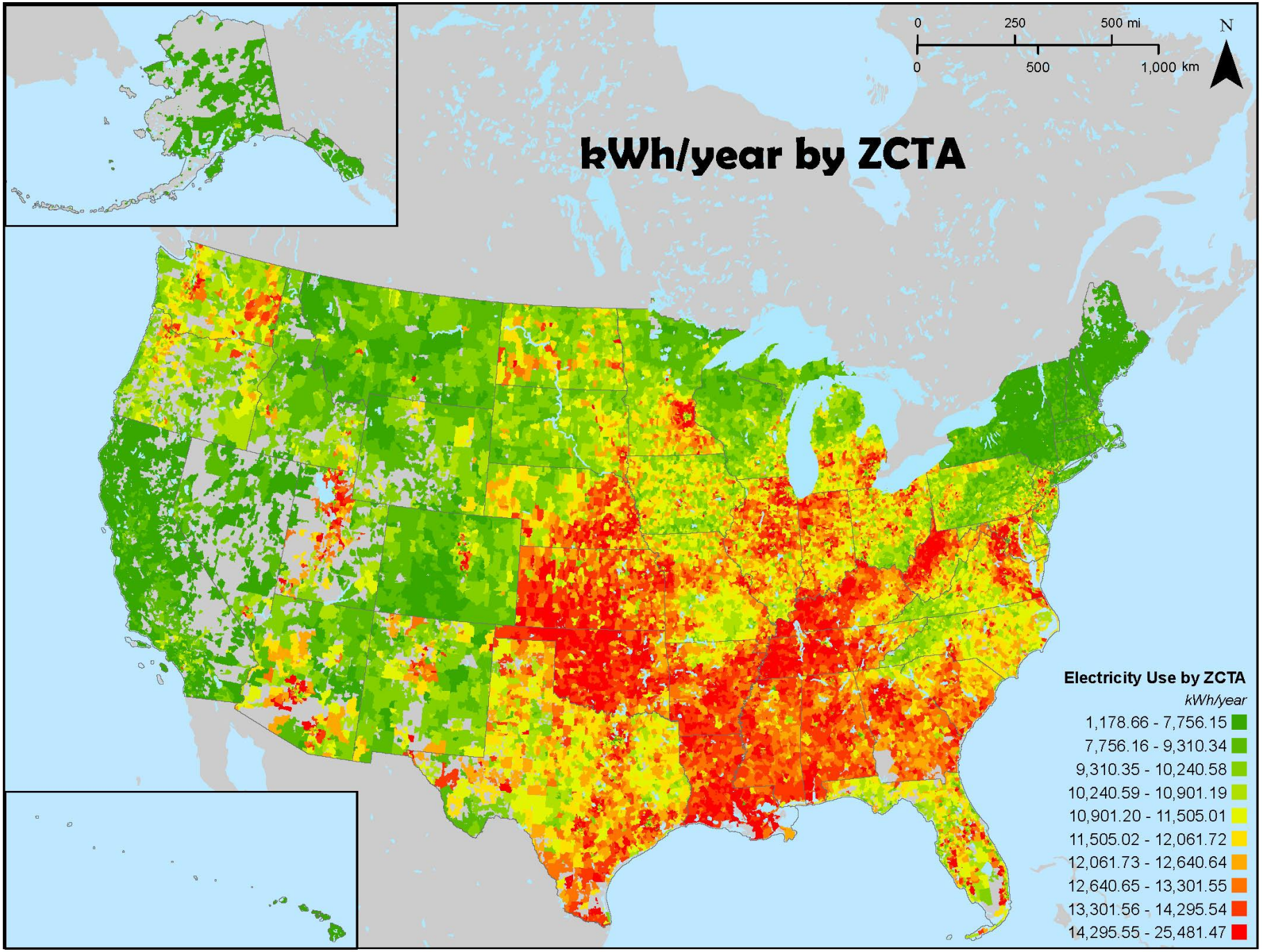
Spatial Distribution of U.S. Household Carbon Footprints Reveals Suburbanization Undermines Greenhouse Gas Benefits of Urban Population Density

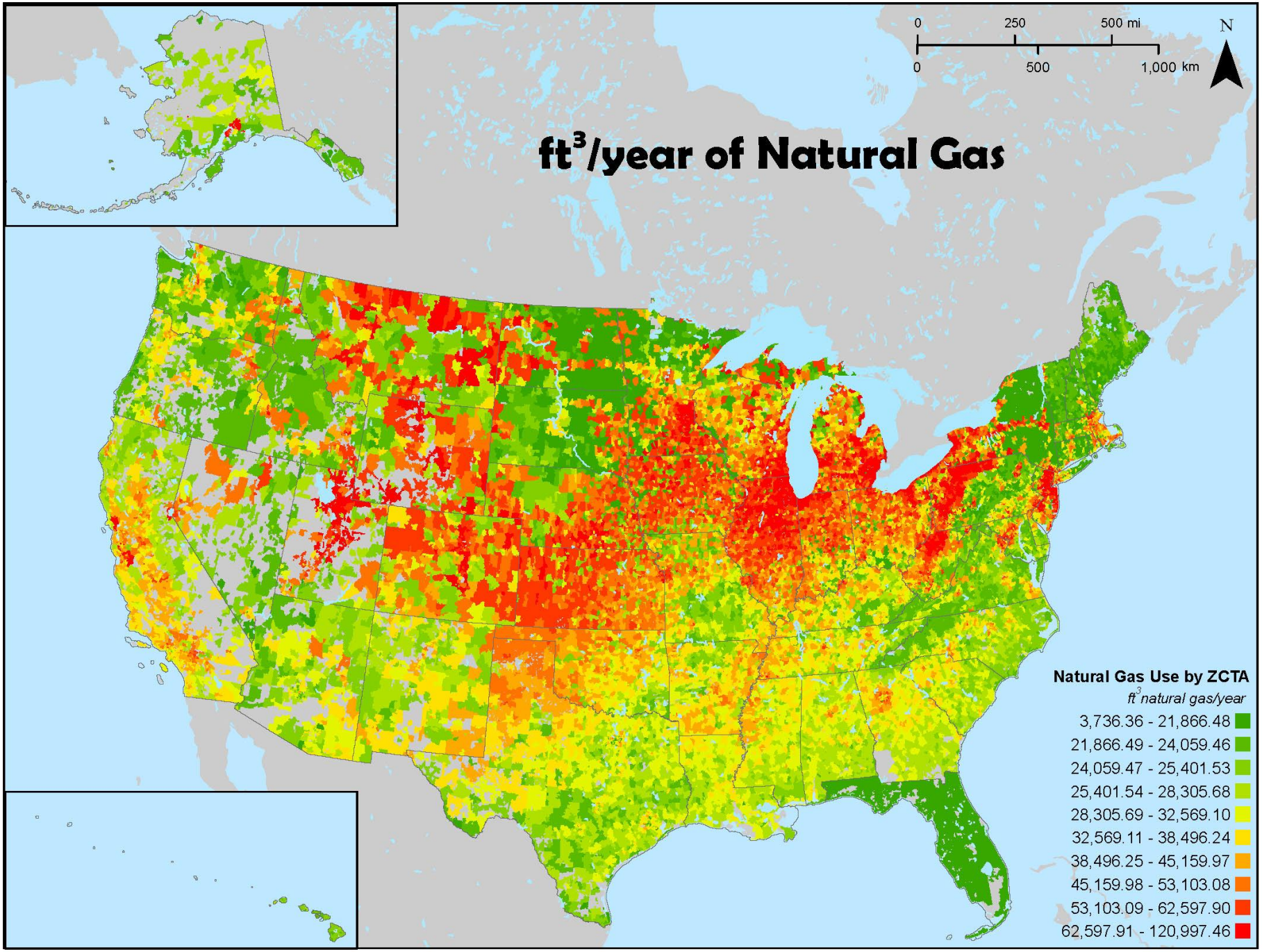
Christopher Jones*,† and Daniel M. Kammen*,†,‡,§

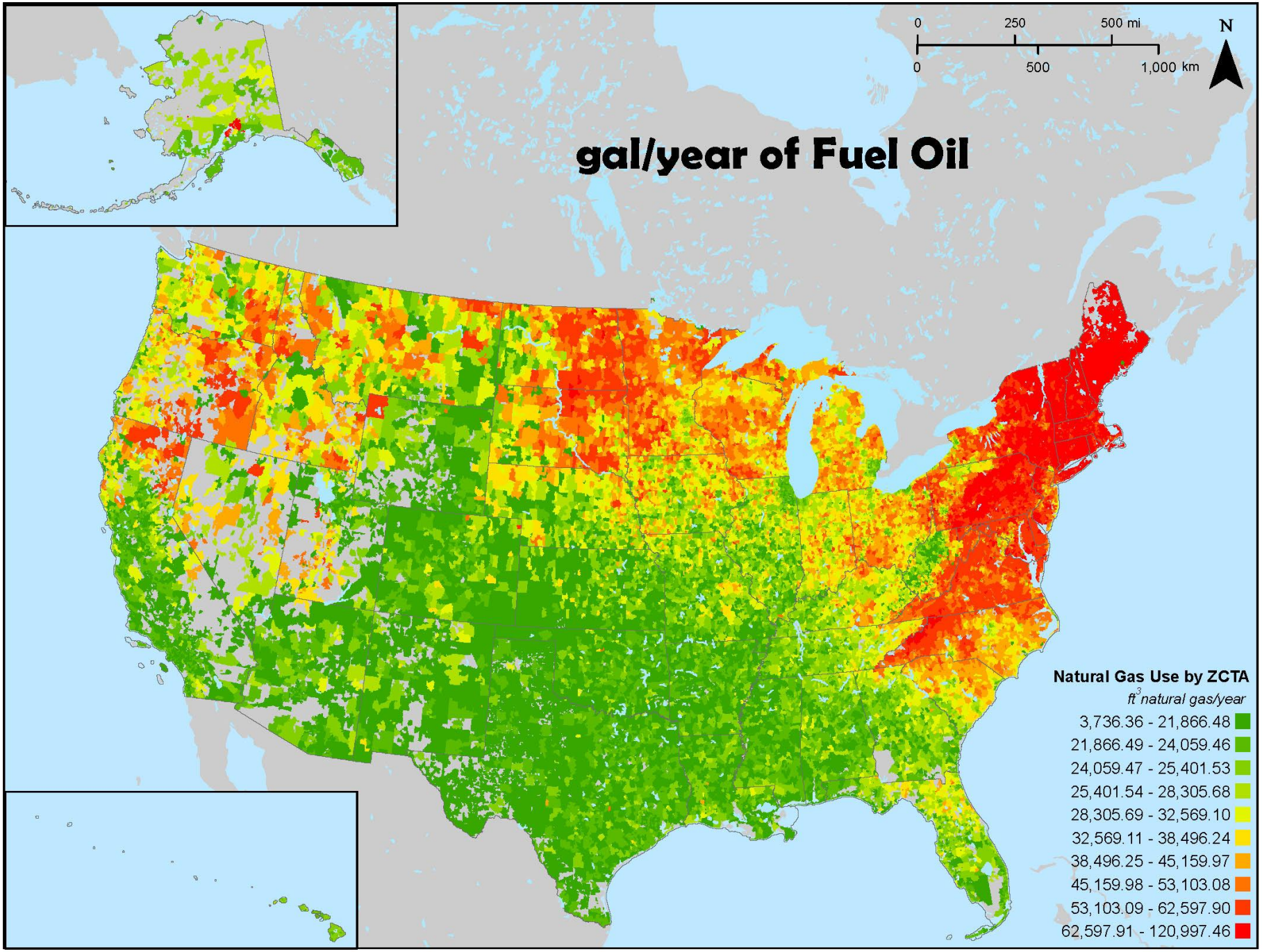
†Energy and Resources Group, ‡Goldman School of Public Policy, and §Department of Nuclear Engineering, University of California, Berkeley, California 94720, United States

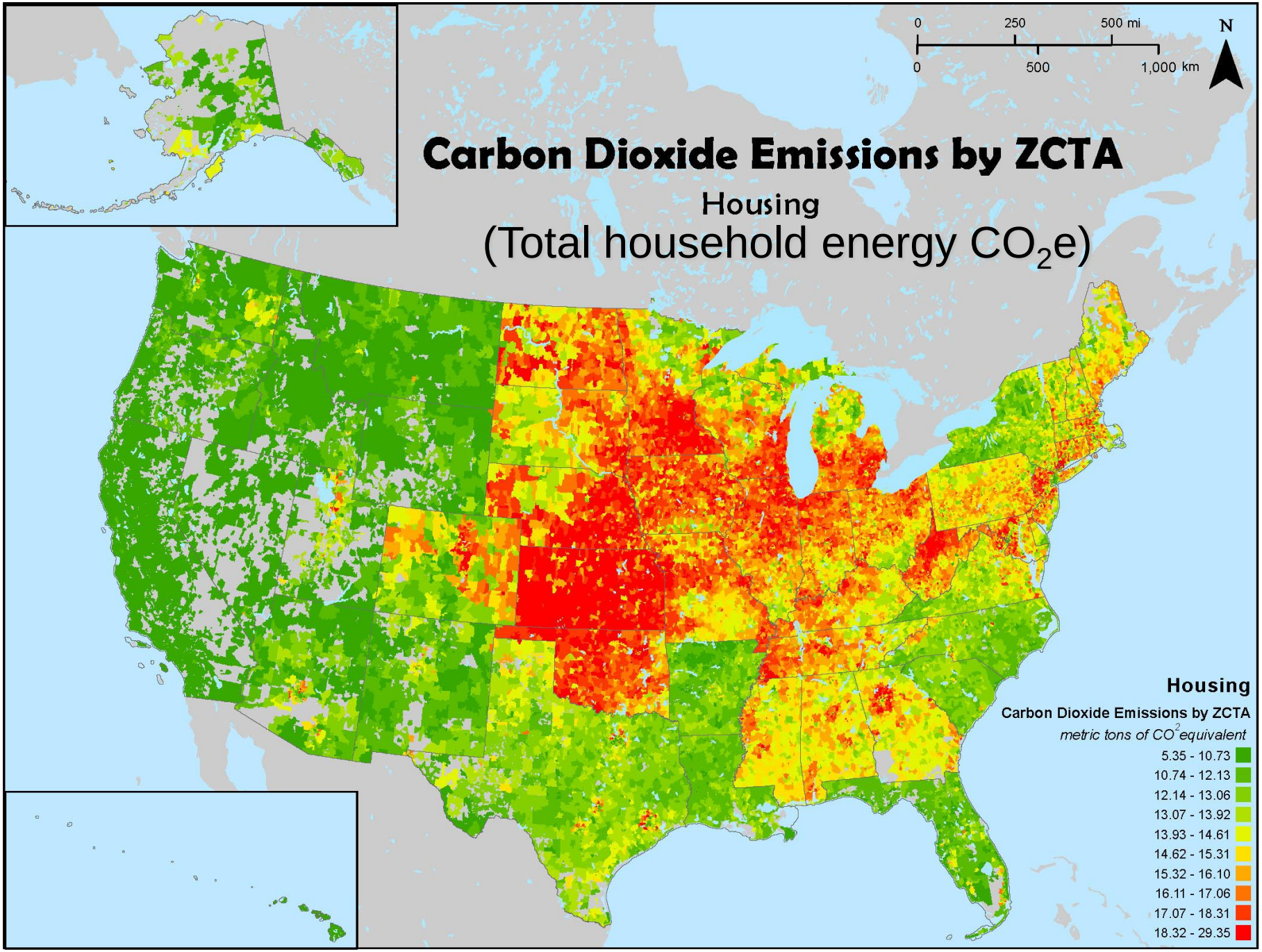
http://coolclimate.berkeley.edu/maps

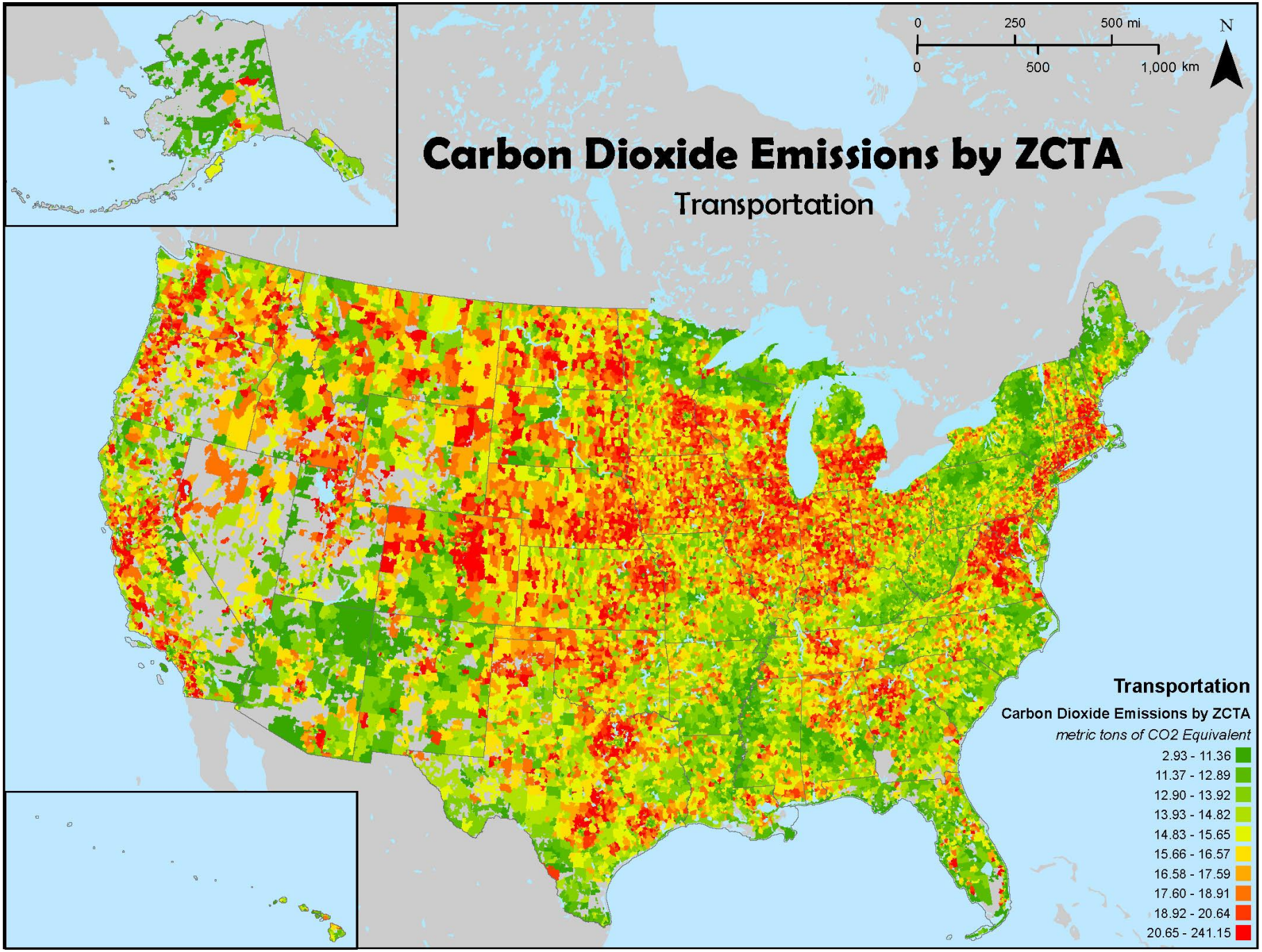

0
250
500 mi
0
500
1,000 km
N
Carbon Dioxide Emissions by ZCTA
Carbon Dioxide Emissions by ZCTA
metric tons of CO2 equivalent
18.94 - 39.20
39.21 - 41.80
41.81 - 43.58
43.59 - 45.17
45.18 - 46.72
46.73 - 48.58
48.59 - 50.65
50.66 - 53.04
53.05 - 56.79
56.80 - 932.97

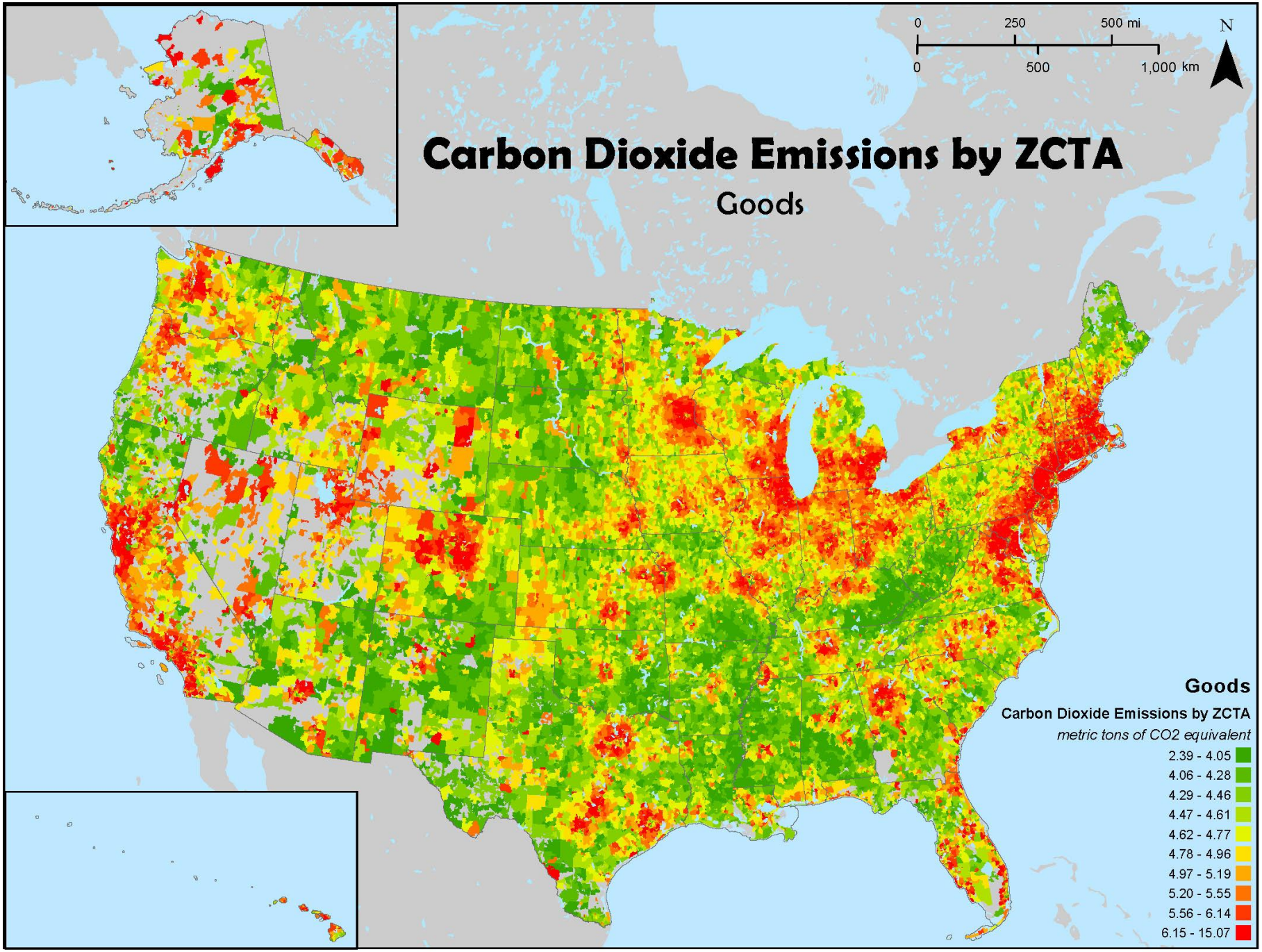

0
250
500 mi
0
500
1,000 km
N
kWh/year by ZCTA
Electricity Use by ZCTA
kWh/year
1,178.66 - 7,756.15
7,756.16 - 9,310.34
9,310.35 - 10,240.58
10,240.59 - 10,901.19
10,901.20 - 11,505.01
11,505.02 - 12,061.72
12,061.73 - 12,640.64
12,640.65 - 13,301.55
13,301.56 - 14,295.54
14,295.55 - 25,481.47

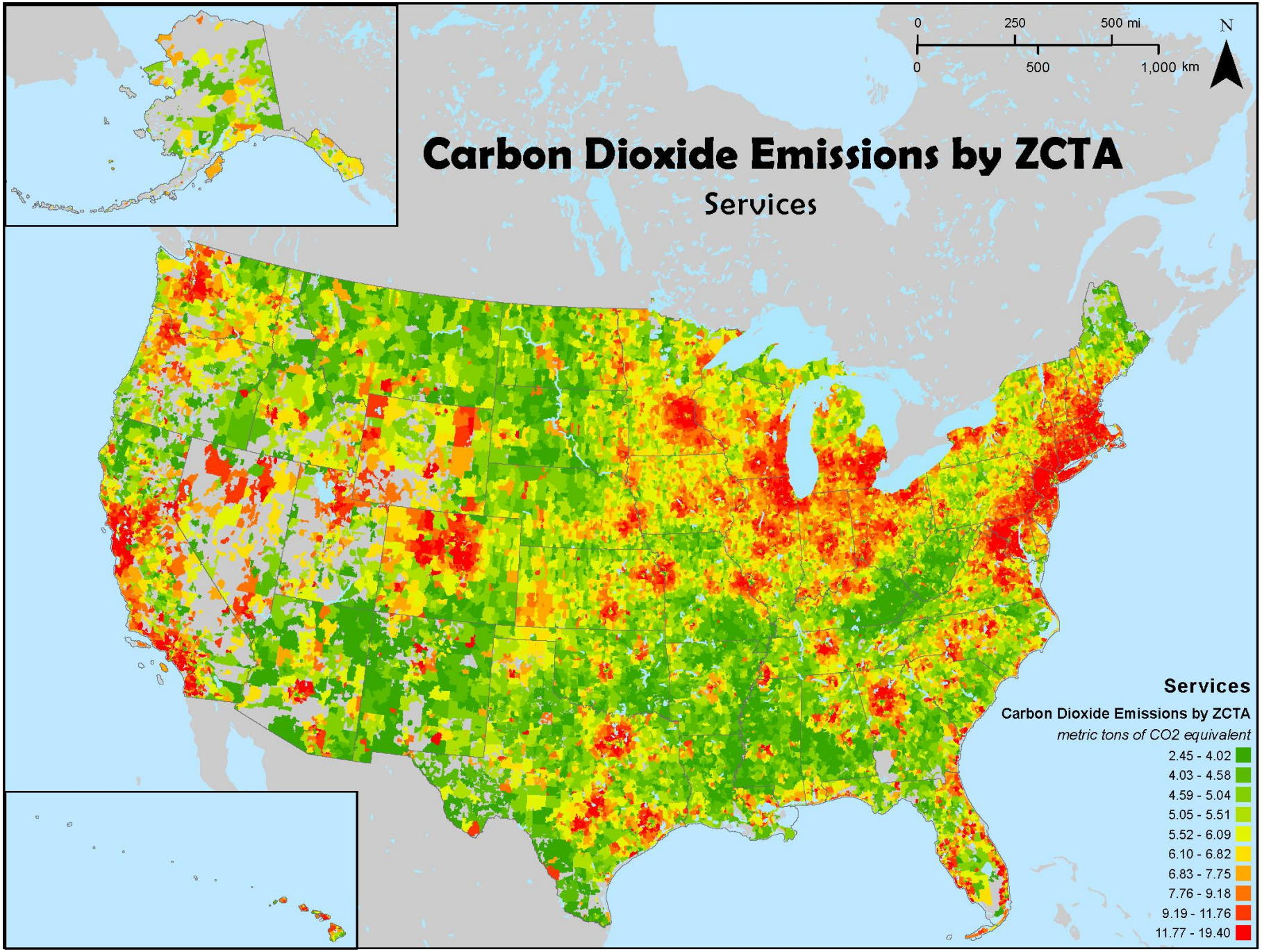

0
250
500 mi
0
500
1,000 km
N
ft3/year of Natural Gas
Natural Gas Use by ZCTA
ft3 natural gas/year
3,736.36 - 21,866.48
21,866.49 - 24,059.46
24,059.47 - 25,401.53
25,401.54 - 28,305.68
28,305.69 - 32,569.10
32,569.11 - 38,496.24
38,496.25 - 45,159.97
45,159.98 - 53,103.08
53,103.09 - 62,597.90
62,597.91 - 120,997.46

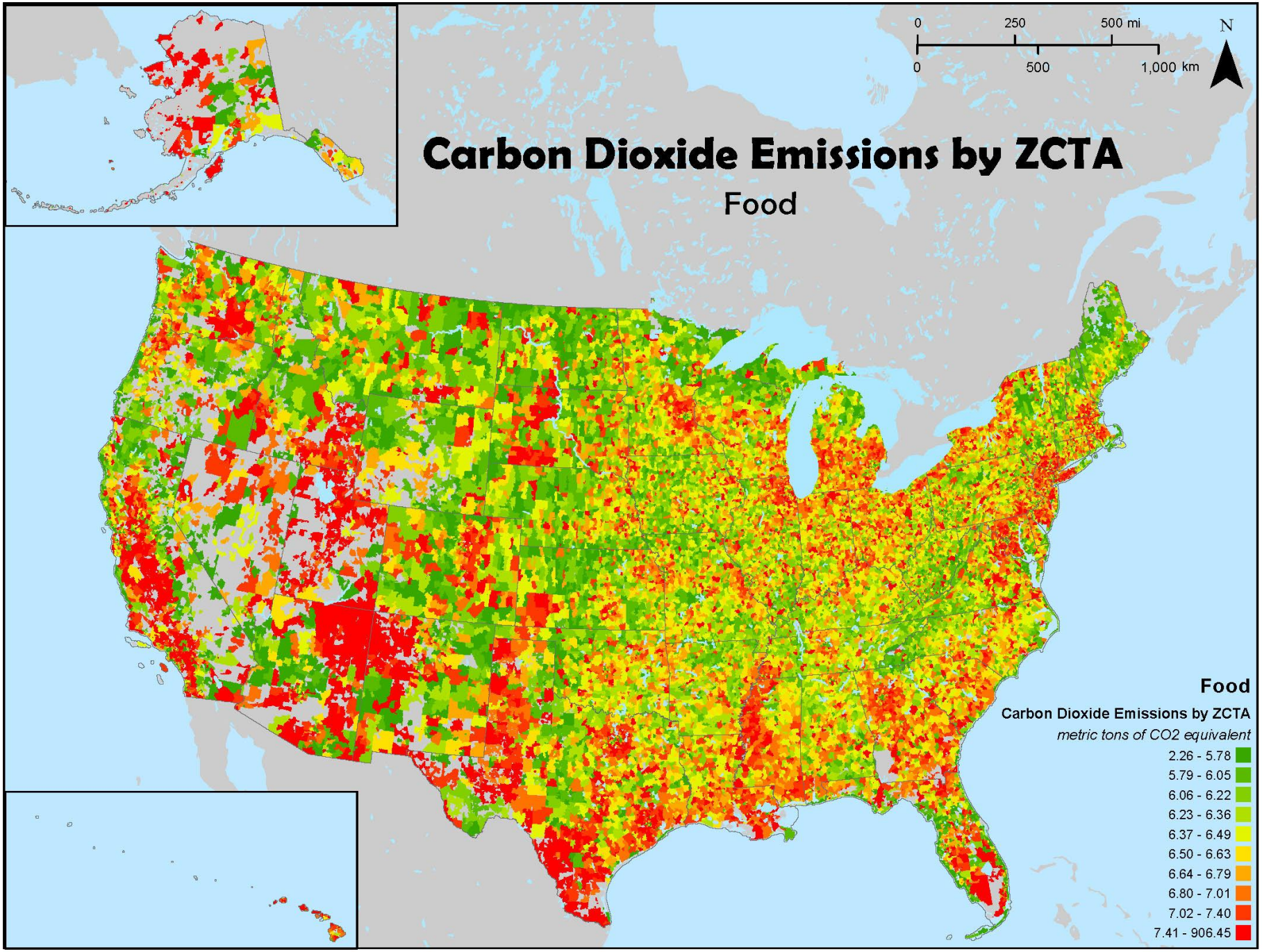

0
250
500 mi
0
500
1,000 km
N
gal/year of Fuel Oil
Natural Gas Use by ZCTA
ft3 natural gas/year
3,736.36 - 21,866.48
21,866.49 - 24,059.46
24,059.47 - 25,401.53
25,401.54 - 28,305.68
28,305.69 - 32,569.10
32,569.11 - 38,496.24
38,496.25 - 45,159.97
45,159.98 - 53,103.08
53,103.09 - 62,597.90
62,597.91 - 120,997.46


0 250 500 mi
0 500 1,000 km
N
Carbon Dioxide Emissions by ZCTA
Housing
(Total household energy CO_2e)
Housing
Carbon Dioxide Emissions by ZCTA
metric tons of CO^2 equivalent
5.35 - 10.73
10.74 - 12.13
12.14 - 13.06
13.07 - 13.92
13.93 - 14.61
14.62 - 15.31
15.32 - 16.10
16.11 - 17.06
17.07 - 18.31
18.32 - 29.35

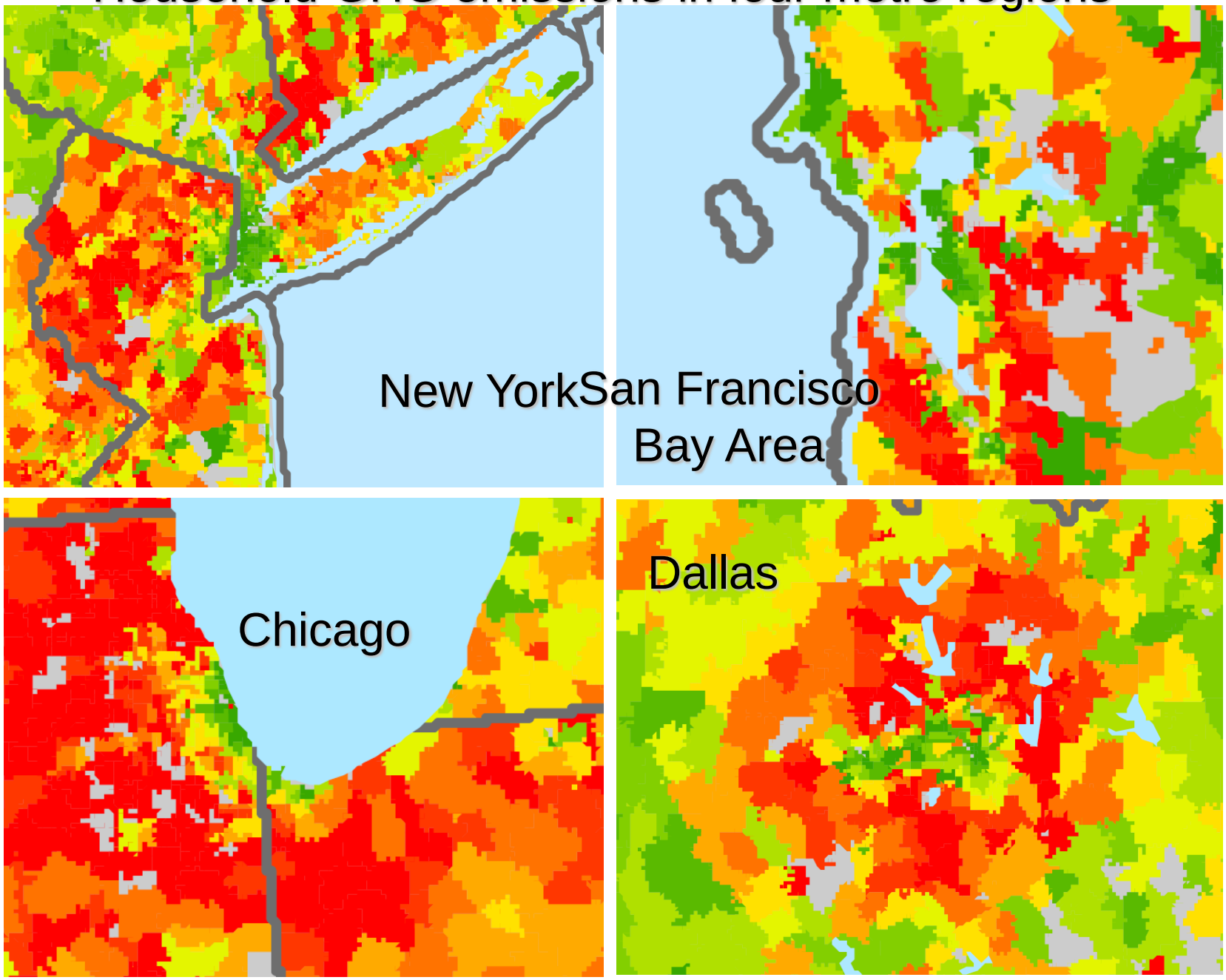

0
250
500 mi
0
500
1,000 km
N
Carbon Dioxide Emissions by ZCTA
Transportation
Transportation
Carbon Dioxide Emissions by ZCTA
metric tons of CO2 Equivalent
2.93 - 11.36
11.37 - 12.89
12.90 - 13.92
13.93 - 14.82
14.83 - 15.65
15.66 - 16.57
16.58 - 17.59
17.60 - 18.91
18.92 - 20.64
20.65 - 241.15


0
250
500 mi
0
500
1,000 km
N
Carbon Dioxide Emissions by ZCTA
Goods
Goods
Carbon Dioxide Emissions by ZCTA
metric tons of CO2 equivalent
2.39 - 4.05
4.06 - 4.28
4.29 - 4.46
4.47 - 4.61
4.62 - 4.77
4.78 - 4.96
4.97 - 5.19
5.20 - 5.55
5.56 - 6.14
6.15 - 15.07


0
250
500 mi
0
500
1,000 km
N
Carbon Dioxide Emissions by ZCTA
Services
Services
Carbon Dioxide Emissions by ZCTA
metric tons of CO2 equivalent
2.45 - 4.02
4.03 - 4.58
4.59 - 5.04
5.05 - 5.51
5.52 - 6.09
6.10 - 6.82
6.83 - 7.75
7.76 - 9.18
9.19 - 11.76
11.77 - 19.40


0
250
500 mi
0
500
1,000 km
N
Carbon Dioxide Emissions by ZCTA
Food
Food
Carbon Dioxide Emissions by ZCTA
metric tons of CO2 equivalent
2.26 - 5.78
5.79 - 6.05
6.06 - 6.22
6.23 - 6.36
6.37 - 6.49
6.50 - 6.63
6.64 - 6.79
6.80 - 7.01
7.02 - 7.40
7.41 - 906.45

Household GHG emissions in four metro regions



Recommendation 1: This focus on climate leadership is not just a high-concept platitude. This is a critical observation. In my role as the Energy and Climate Fellow working for the U.S. Secretary of State, I can document that the California Global Warming Solutions Act is demonstrably inspiring communities, states and nations worldwide to innovate and act. This focus on an evolving AB32 process **has brought investment in, and business opportunities to, California-based companies**. **California should expand the number and scope of state-to-state and international partnerships around climate solutions.**

Recommendation 2: To continue and expand our ability to build a climate-friendly, job-creating, economy, **interim targets in 2030 and 2040 are vital** to streamline and focus the research and development efforts to feed the research, development, and deployment (RD&D) pipeline.

Recommendation 3: Citizen, community, and business engagement – indeed *excitement* over the steps and objectives -- is vital to the sustainable energy and sustainable society process. We must focus on the means to make behavior change profitable and easy, and to build new partnerships that clarify and expand the benefits of a low-carbon economy to socioeconomically, ethnically, and other disadvantaged communities and individuals, and that make the business case for a sustainable economy clear to the private sector both in and out of California.