



Renewable & Appropriate Energy Laboratory

RAEL

Clean Energy in the Age of COVID-19

Daniel Kammen

Energy and Resources Group (Chair)
Goldman School of Public Policy
Department of Nuclear Engineering
Director, Renewable and Appropriate Energy Laboratory
University of California, Berkeley

Former Science Envoy, United States Department of State

OurEnergyPolicy, April 8, 2020

1

Resources:

<http://rael.berkeley.edu>



@dan_kammen



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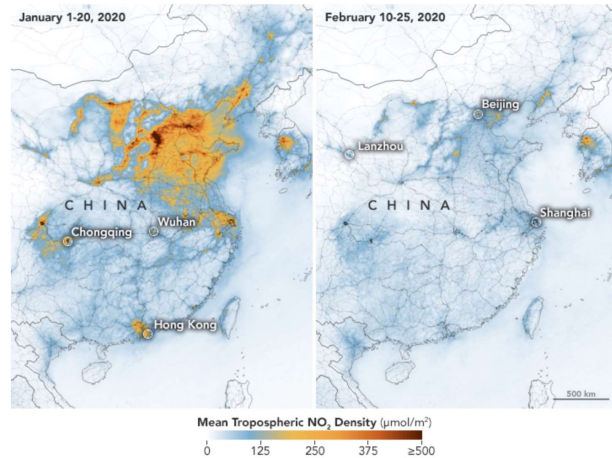
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2

Carbon Emissions, Air Quality, & the Coronavirus Pandemic: Airborne Nitrogen Dioxide Plummeted over China

- Decreases in industrial production + transportation have decreased carbon emissions and air pollution
- Air quality improvements in China may have saved more lives than were lost to the pandemic (Stanford U study, 3/20)

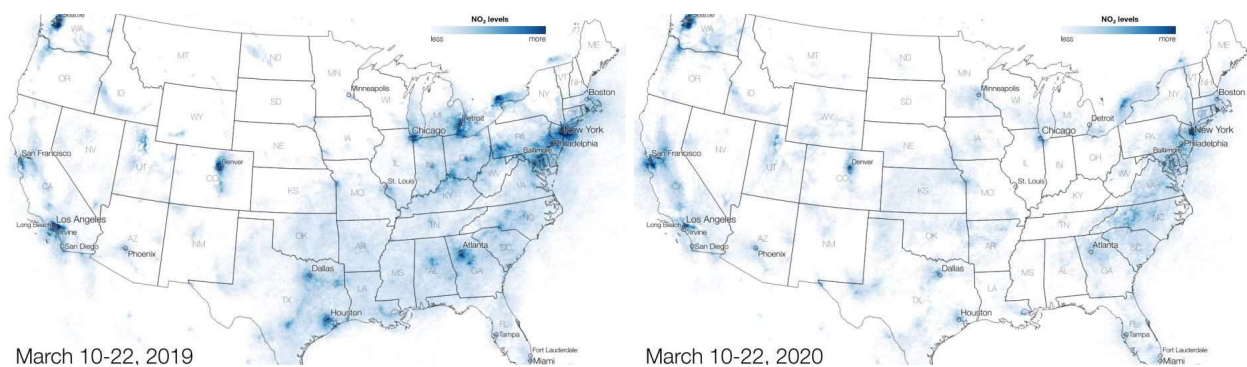


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3

Carbon Emissions, Air Quality, & the Coronavirus Pandemic: N₂O levels down 50%+, CO₂ down 20%+



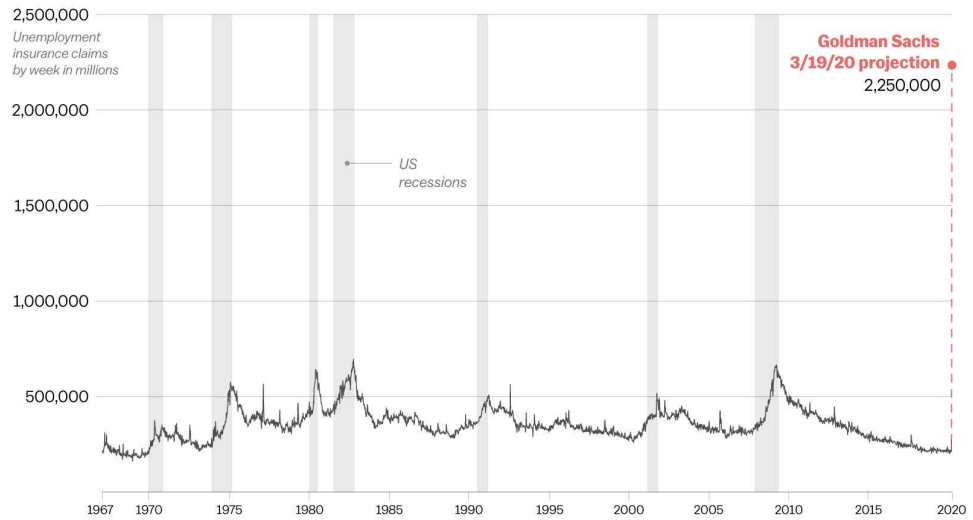
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4

Unemployment to hit 20%?

An unprecedented rise in unemployment

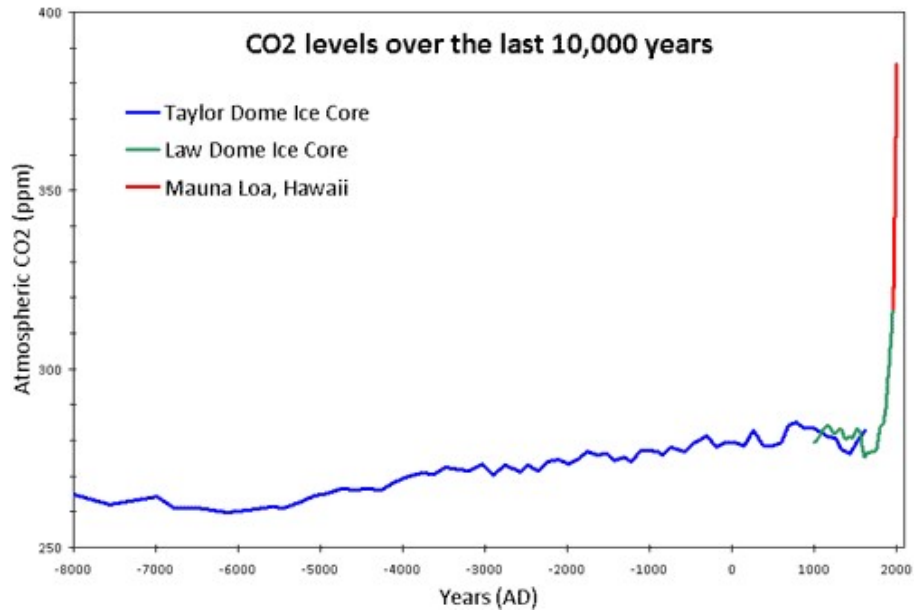


Sources: US Employment and Training Administration; David Choi, Goldman Sachs

Vox



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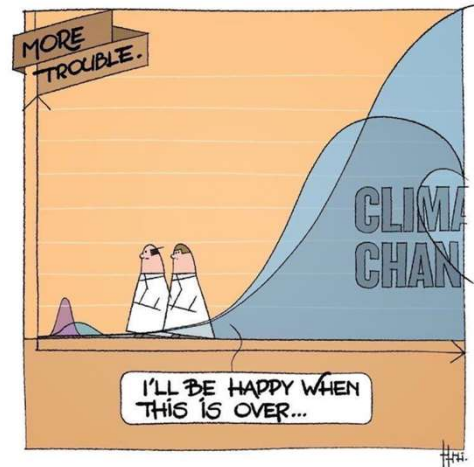
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The COVID-19 Crisis Rightly has our Attention Today

But we also know that ...

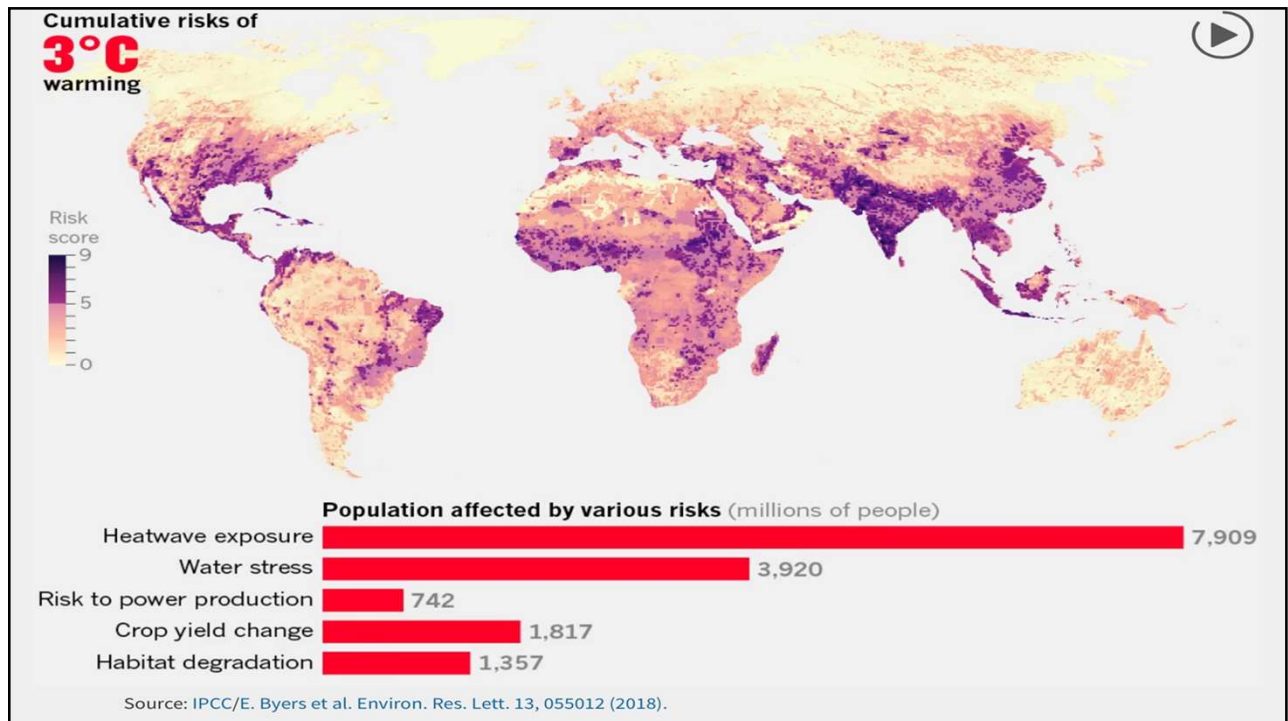


Climate is COVID-19 on steroids ...

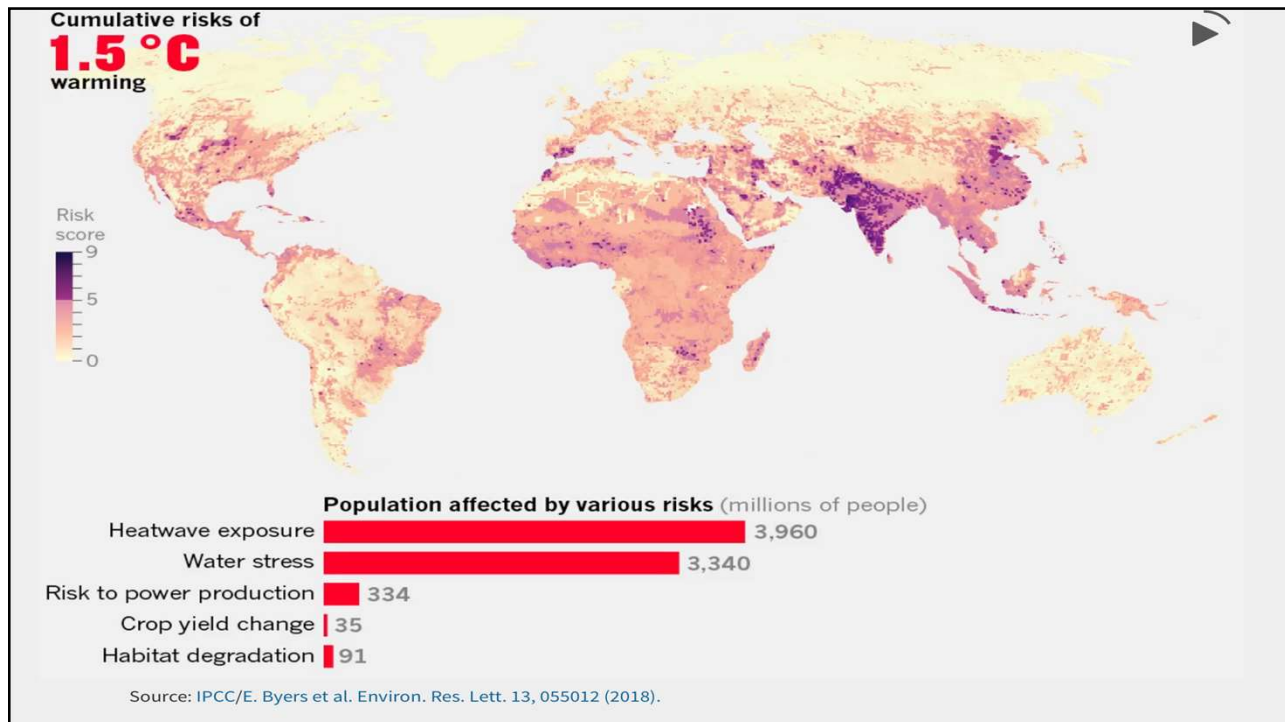


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7



8



9

Critical COVID-19 Lessons for the Climate Emergency

- There is no substitute for research & development, and education
- Supply chains are vulnerable on a crowded, denuded, planet
- Tipping points can happen fast
- We are all in this together
- Individual actions matter (infection & education)
- We only as resilient as the most vulnerable (Environmental Justice)



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10

Carbon Emissions, Air Quality, & the Coronavirus Pandemic

What if reductions *were* achieved sustainably, through increasing efficiency, replacing fossil fuels with clean energy, and drawing down carbon from the atmosphere?

- Pandemic estimated to lead to short-term worldwide reductions in carbon emissions of 10-15%
- Emission pathways to a 1.5°C future require ~40% reductions in carbon emissions by 2030

- If the changes we're seeing today were achieved through energy source switching, we'd already be 25-38% of the way to our Paris target in *just a few months*.

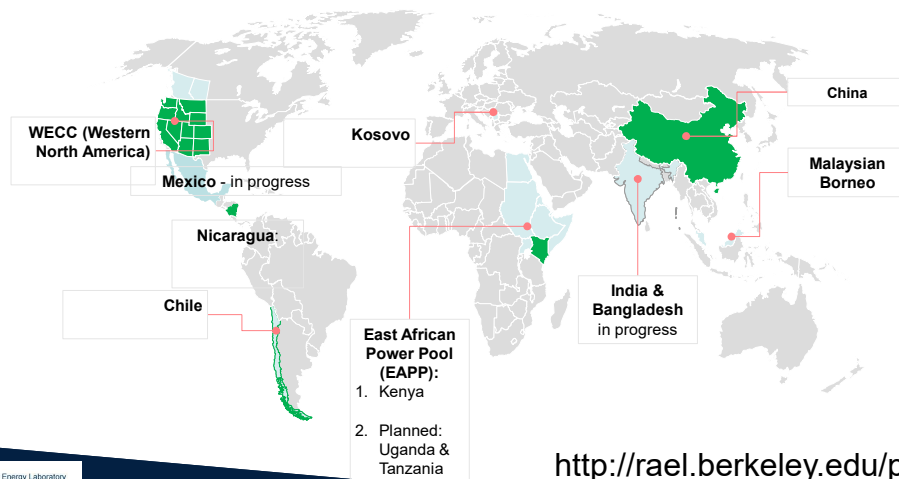


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11

Energy and Transportation System Transition

Energy system models say we can
The "SWITCH" model, at UC Berkeley finds clean energy solutions in each region studied



<http://rael.berkeley.edu/projet/SWITCH>

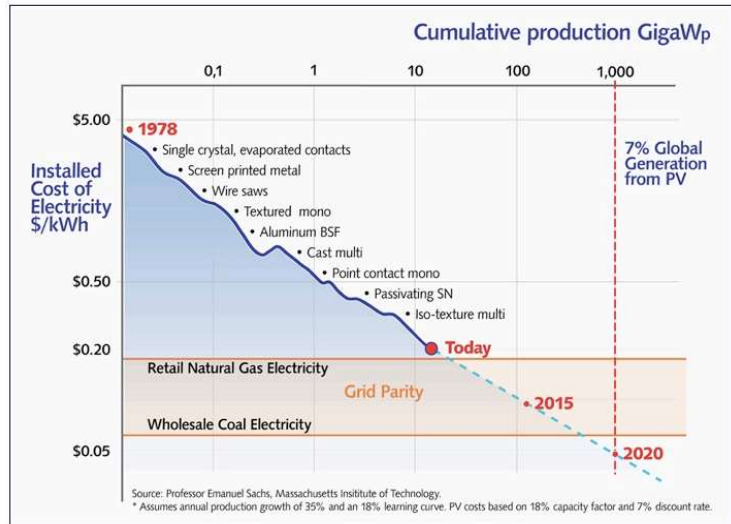


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12

$$\frac{C_2}{C_1} = \left(\frac{V_2}{V_1}\right)^{-b}$$

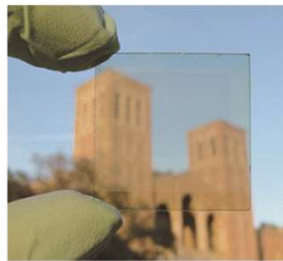
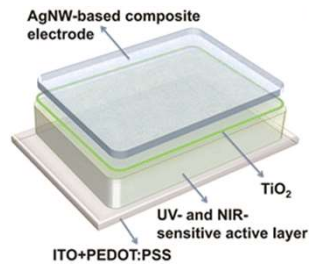
Solar cost decreases 10% per year



Source: Professor Emanuel Sachs, Massachusetts Institute of Technology. *Assumes annual production growth of 35% and an 18% learning curve. PV costs based on 18% capacity factor and 7% discount rate.



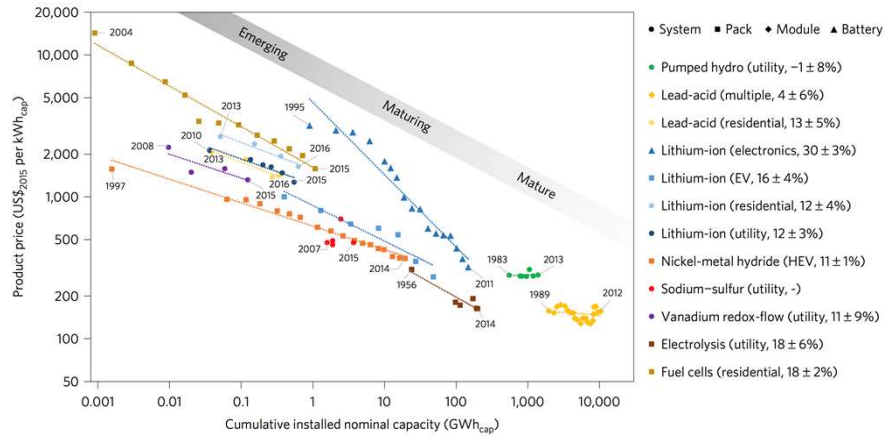
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14

Materials Science for Storage Innovation



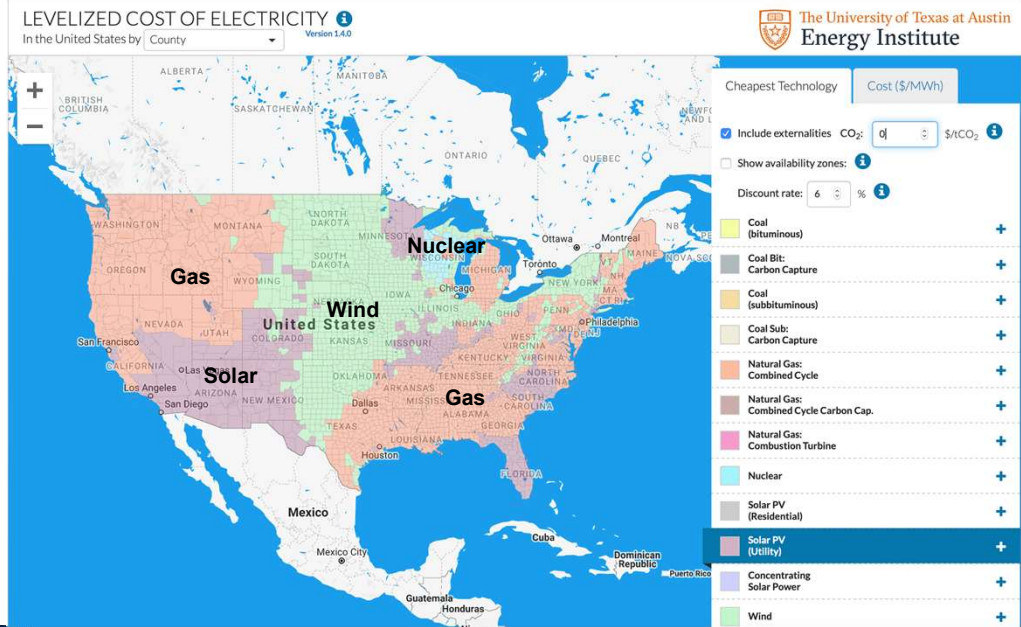
Data from: Schmidt, O., Hawkes, A., Gambhir, A., & Staffell, I. (2017). The future cost of electrical energy storage based on experience rates. *Nature Energy*, 2, 20171110. Qiu, Y., & Anadon, L. D. (2012). The price of wind power in China during its expansion: Technology adoption, learning-by-doing, economies of scale, and manufacturing localization. *Energy Economics*, 34(3), 772-785. ;



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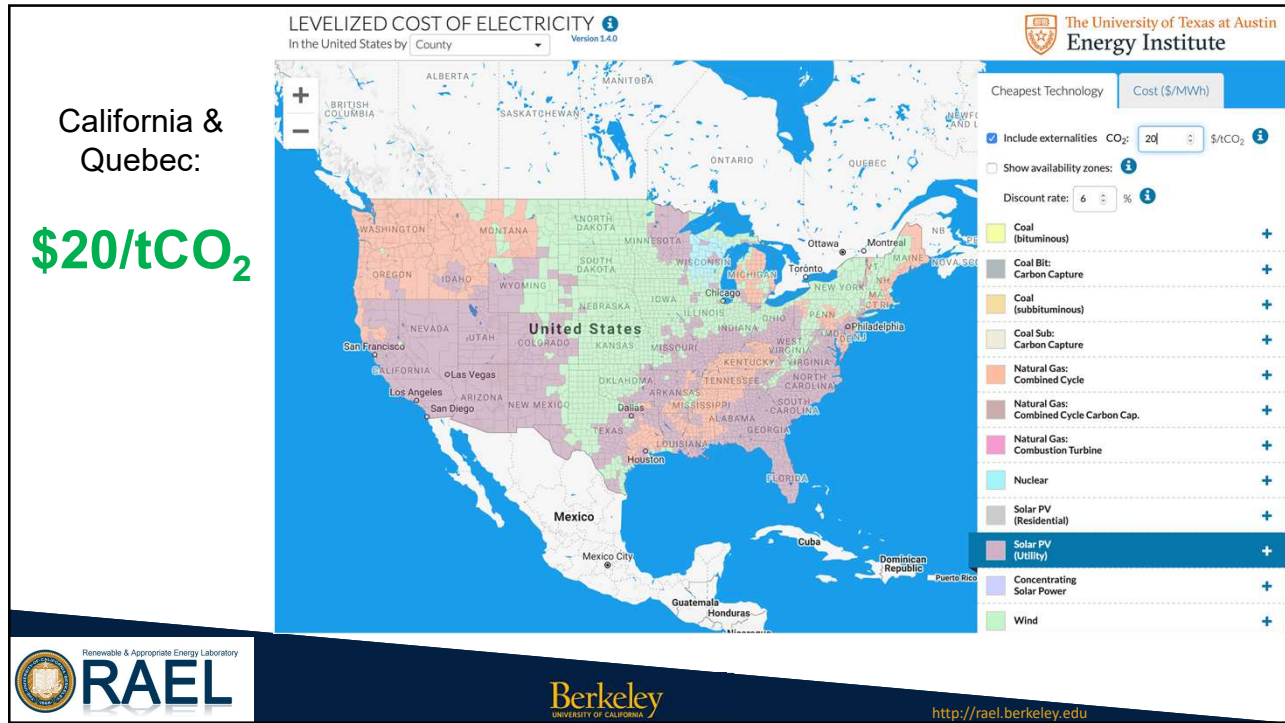
Overnight
Energy costs:

\$0/tCO₂

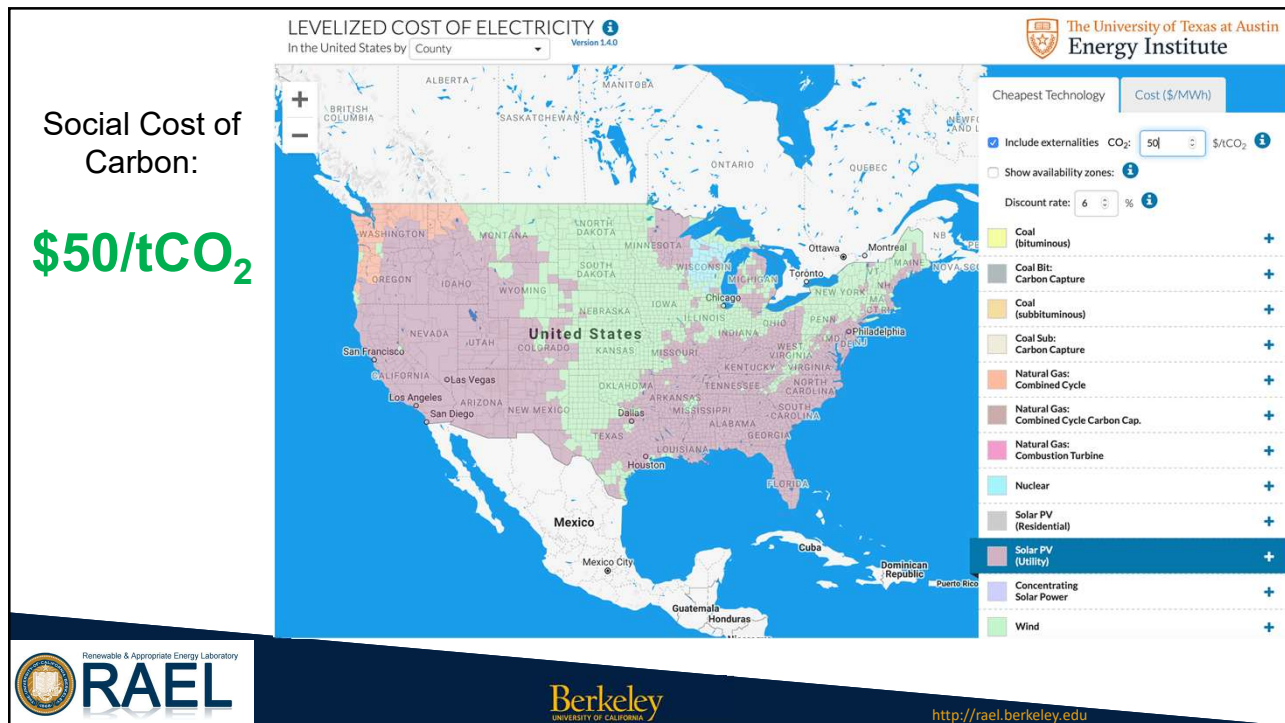


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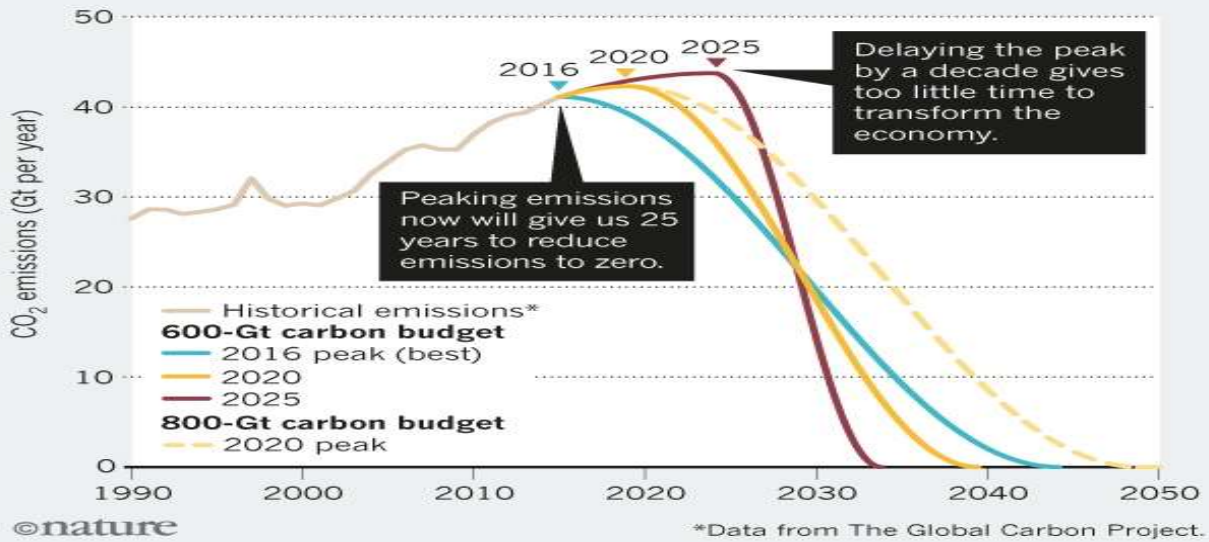


18

CARBON CRUNCH

C. Figueres, et al, 2017, *Nature*

There is a mean budget of around 600 gigatonnes (Gt) of carbon dioxide left to emit before the planet warms dangerously, by more than 1.5–2°C. Stretching the budget to 800 Gt buys another 10 years, but at a greater risk of exceeding the temperature limit.



19

The Green Energy Economy

Global energy savings accelerated (haltingly) after 2010

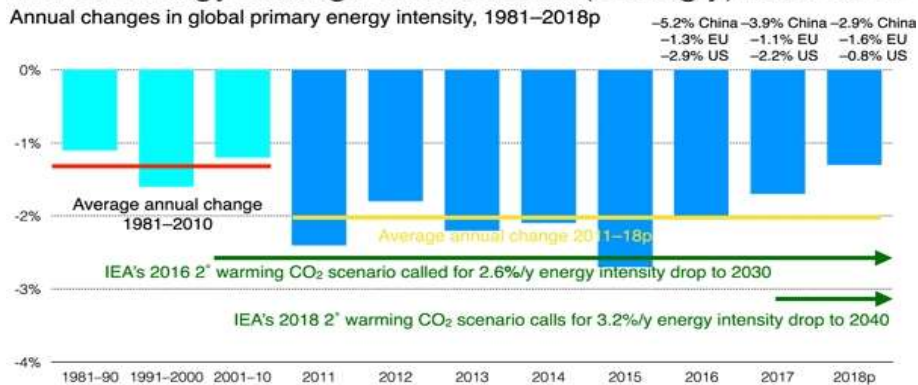


Figure 2 from "Recalibrating climate prospects"

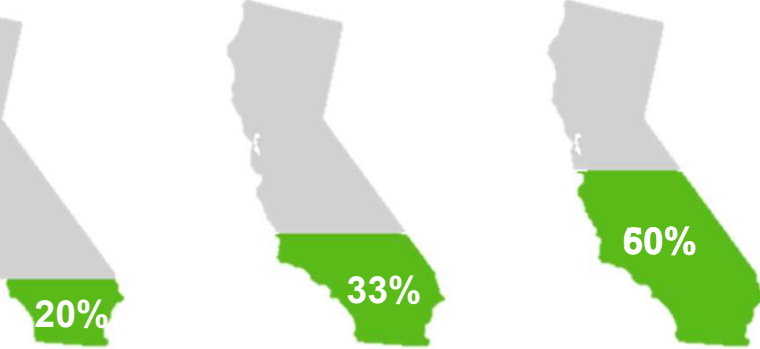
Lovins, Ürge-Vorsatz, Mundaca, Kammen & Glassman

Environ. Res. Lett. 14, 120201 (2019)
 doi:10.1088/1748-9326/ab55ab



20

California Energy Goals: Aggressive & Evolving



2013

2020

2030

California Senate Bill 100: 100% clean energy by 2045 and 2030 standard now 60% (without nuclear or large hydro)

21

21

E6 insight | SAN FRANCISCO CHRONICLE AND SFCHRONICLE.COM | Sunday, August 19, 2013

NATION

CLIMATE ACTION

Growth in green energy is gold for California, U.S.

By Daniel M. Kammen

I am a physicist, and an energy and sustainability science researcher, and I live in California because of its penchant for not just setting but actually achieving big goals and adopting bold visions where many consider too ambitious. What California proposes, we research, debate and then accomplish. In fact, we often exceed the goals despite having deemed unmettable. This is why I believe that California should — and ultimately will — pass into law the “100 Percent Clean Energy Act” (Senate Bill 100), which would establish a bold goal of 100 percent clean, zero-carbon electricity by 2045.

To fully appreciate the manufactured benefits of SB100 for California and the country, a bit of history is needed.

Thanks to a law California passed in 2002 (the Renewables Portfolio Standard), the state has nearly tripled its use of electricity produced from renewable resources. Today, solar, wind, biomass and geothermal power (the “renewables”) meet more than a third of the state’s electricity demand — up from a percent in only a decade.

Just last month, the California Air Resources Board announced that the state has met its goal of reducing greenhouse gas emissions below 1990 levels in 2006 — a full four years ahead of its state deadline. Our citizens’ renewable electricity generation is a key driver of that success.

In fact, the state Public Utilities Commission has estimated that California will probably meet its goal of producing 50 percent of electricity from renewable resources well ahead of the 2010 deadline. California and New York state have emerged as national leaders in energy efficiency and in setting and meeting clean energy targets that together have kept utility rates low. Financial benefits follow directly. The majority of all U.S. “clean tech” investment has come through these two states.

This transition has been a net job



The state Legislature’s goal of having 1 million solar rooftops in the state was once seen as too ambitious, but now there are close to 200,000 installed.

generator. California now has more people employed in the solar energy industry than in traditional utilities. For 15 years, I have been tracking job creation in the clean energy sector, where today we find two to four times more jobs in solar, wind, sustainable biomass, efficiency, and energy storage than in any fossil-fuel sector. The price of wind and solar-generated energy has dropped faster than expected and is cost-competitive or cheaper than the cost of building new fossil-fuel power-plant plants. The fact that the best solar and wind energy projects are actually cheaper than natural gas has been an enormous surprise to many not following the sector closely.

Next up is for California to establish the bold new goal to power our state with 100 percent zero-carbon energy by 2045. SB100 would mandate that 60

percent of our electricity demand be met with renewable sources, and allow flexibility for how the other 40 percent might be met via additional renewables, existing large hydropower, or other clean energy sources — including new technologies. Some critics note that SB100 does not explicitly prohibit carbon emissions if we also capture the carbon. This is less useful — and more expensive — in my analysis than a mixture of zero-carbon sources and energy storage, but permitting the flexibility is a broader, more inclusive mandate that does not try to pick specific winners and losers.

More synergies between clean energy and jobs for Californians exist here, too. The same wave of innovation we saw in solar energy — where California played key research and deployment roles — is now seen in the energy storage industry. California is leading this charge, too, and stands to profit in revenue and more jobs.

Big transformational goals are precursors of innovation. In 2002, the Legislature passed legislation that set a target of 1 million solar rooftops by 2020. At the time, the typical response was that it was too ambitious, and more details were needed. Today, California has done to 700,000 solar rooftops, well on the way to the goal. Each rooftop saves the homeowner money, too, as solar power costs panel out at under 5 cents per kilowatt-hour, while utility-generated power retails at more than four times that cost. Despite some legal and regulatory bottlenecks, residential rooftop solar saves utilities money, too, as rooftops are generating power during the day — i.e. during the time of the peak of power demand. Any extra generation can be put into storage.

Since 1999, I have served as a coordinating lead author for the Intergovernmental Panel on Climate Change, where scientists have recognized that clean and renewable energy sources must become the dominant source of electricity powering buildings, industry and transportation if we are to avoid the worst climate change effects that threaten California. As the world’s fifth-largest economy, California will gain economically as we develop new technologies and sectors that others will need as they work toward global climate goals. Current political troubles aside, this is where the United States must go.

As the world will see at the Global Climate Action Summit that California will host Sept. 22 in San Francisco, we have demonstrated the capacity and leadership needed to achieve big goals. SB100 sets a new goal for a clean, healthy and profitable energy system. With the global clean energy market growing far faster than the fossil-fuel sector, what California is doing is a good business decision for the state and the nation.

David M. Kammen is the founding director of the Renewable and Appropriate Energy Laboratory and director of the Center for Environmental Public Policy at UC Berkeley. Kammen has served as the chief technical specialist for renewable energy at the World Bank, and senior energy for the U.S. State Department. Twitter: @dankammen. To comment, submit your letter to the editor at SFChronicle.com/letters.

Evolving California Climate Laws

Assembly Bill 32

Return to 1990 emission levels by 2020

Senate Bill 100:

100% green energy in 2045

Senate Bill 32:

Cap & Trade carbon market
And 35% or more of revenues for marginalized communities

Solar Mandate & EV Mandate:

1 million solar roofs & EVs by 2020

Many other bills pending.

22

California Energy Efficiency & Solar Policy Drives Innovation



Residential Construction

Zero net energy after January 1, 2020



23

Big Bold EE Strategies



Commercial New Construction

- All new commercial construction in California will be zero net energy by 2030.
- Leverage opportunities from emerging technologies initiatives, incentive programs, and local initiatives targeting commercial building/ property developers.

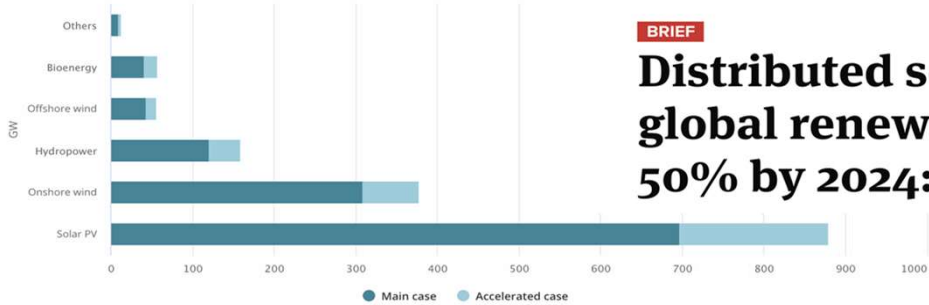


24

Communities are changing the way energy is produced and consumed.



Renewable capacity growth between 2019 and 2024 by technology



BRIEF

Distributed solar to drive global renewable growth 50% by 2024: IEA

IEA. All rights reserved.



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25

Sunrun Lands Another Big Virtual Power Plant Deal, This Time in Hawaii

SUNRUN | 26

Aggregated residential solar-storage systems will be used to help meet Hawaii's unique grid challenges.

Big Win for Local Energy: First Virtual Power Plant Snags Contract in US Wholesale Capacity Auction

07.20.19 | WORLD CHANGING IDEAS

This "virtual power plant" made of solar and batteries means Oakland can stop burning jet fuel

The solar panels will power low-income housing—and then fill up batteries to use when demand peaks.

DEEP DIVE

Hollywood's next star could be virtual power plants as LADWP closes out natural gas

Sunrun's 295 MW residential solar-storage VPP proposal for Los Angeles could be proof-of-concept

26

Many Opportunities: Speed and scale green

<https://theclimatecenter.org/our-work/community-choice/>

<https://cal-cca.org/cca-impact/>



Key role in growing Community Choice Energy: 20 CCAs serving 11 million Californians- 1/4 of state- with 88% clean energy today!



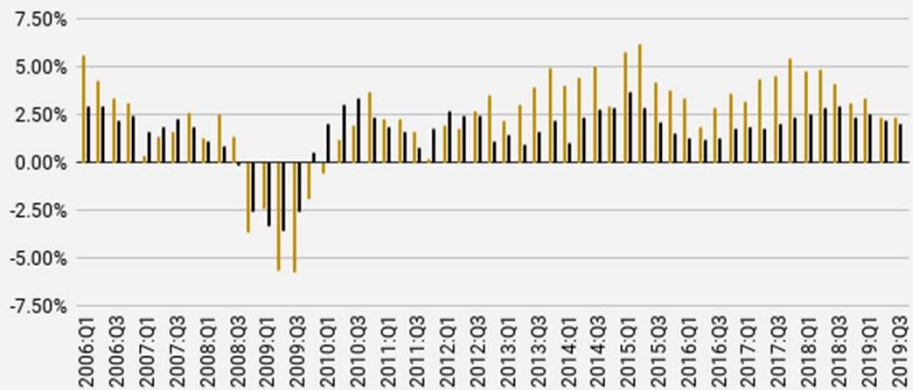
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27

California business growth vs. rest of US

Yearly rate of change in gross domestic product

■ California ■ Rest of US



2006: CA AB32

2009: Federal Stimulus



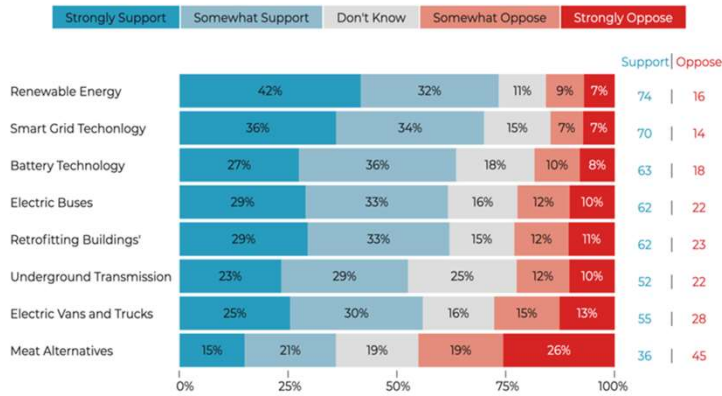
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28

Clean Energy Polls Well

March 20 – 25, 2020, n = 4500

Support for Major Public Investments in Green Solutions



DATA FOR PROGRESS



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29

Many Opportunities: The Green Stimulus

https://medium.com/@green_stimulus_now/a-green-stimulus-to-rebuild-our-economy-1e7030a1d9ee

A Green Stimulus to Rebuild Our Economy

An Open Letter and Call to Action to Members of Congress
Green Stimulus Proposal

A GREEN STIMULUS TO REBUILD OUR ECONOMY

An Open Letter and Call to Action for Members of Congress

Author team:

Johanna Bozuwa, J. Mijin Cha, Daniel Aldana Cohen, Billy Fleming, Jim Goodman, Ayana Elizabeth Johnson, Daniel M Kammen, Julian Brave NoiseCat, Mark Paul, Raj Patel, Thea Riofrancos (2020) “A Green Stimulus”,

https://medium.com/@green_stimulus_now/a-green-stimulus-to-rebuild-our-economy-1e7030a1d9ee



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30

The Green Stimulus

https://medium.com/@green_stimulus_now/a-green-stimulus-to-rebuild-our-economy-1e7030a1d9ee

A Green Stimulus package of at least \$2 trillion

This is meant to be money for the recovery. The first rounds of stimulus were aimed at addressing the public health crisis and stabilizing the economy - that's economic relief.

But we will need more stimulus to get the economy moving again and get the millions of workers who have been sidelined by this crisis back to work
Stimulus should focus on our most pressing social need: the climate crisis.

This stimulus should be automatically renewed annually at 4% of GDP per year (roughly \$850 billion) until the economy is fully decarbonized and the unemployment rate stays below 3.5% for at least three consecutive months.



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31

A green stimulus of shovel-ready projects

https://medium.com/@green_stimulus_now/a-green-stimulus-to-rebuild-our-economy-1e7030a1d9ee

Labor & Housing



- Low-income home retrofits
 - DOE weatherization
 - Native American
 - Public housing
- School Retrofits
 - Preference for Title 1
 - Solar schools

Transportation



- Public Transit Rescue Packages
- No-interest, no-match loans for local govt. & transit authorities to clear backlogs
- "Fix it First" for infrastructure
- EV investment funds

Energy



- Expand & restore the clean energy tax credits
- Open to nonprofits and low-income communities
- Loan guarantee program for clean energy manufacturing
- Expand ARPA-E 10x, extend to DoA, DoT, HUD

Land Use



- Expand food quality programs (TANF, SNAP, WIC)
- Classify Farmers Markets as 'essential services'
- Target new and socially disadvantaged farmers, including women and minorities
- Carbon farming

Financing Innovation



- National green bank (e.g. NY, CT)
- Pass a Federal Reserve Bank Act to make green bonds as secure as treasury bills & drive down cost
- Assistance for community & tribal colleges for green jobs training

Foreign Policy



- Fair trade agreements based on worker and environmental protections
- Expedite aid including technology transfer for lowest income nations that adopt 1.5 deg C targets
- Restart Science Envoy program



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32

Learn from our Mistakes: The need for Environmental Justice

- Lack of solar power and electric vehicle access where the health benefits are highest
- California Green New Deal: Dedicated seed fund of \$3.5 billion/yr for disadvantaged areas
- One California proposal (not yet passed): affordable housing at transit hubs.



The New York Times

Opinion

Why Housing Policy Is Climate Policy

In California, where home prices are pushing people farther from their jobs, rising traffic is creating more pollution.

By Scott Wiener and Daniel Kammen

Senator Wiener is the chairman of the California Senate's Housing Committee. Dr. Kammen is a professor of energy at the University of California, Berkeley.

March 25, 2019

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33

nature sustainability ANALYSIS
<https://doi.org/10.1038/s41893-018-0204-z>

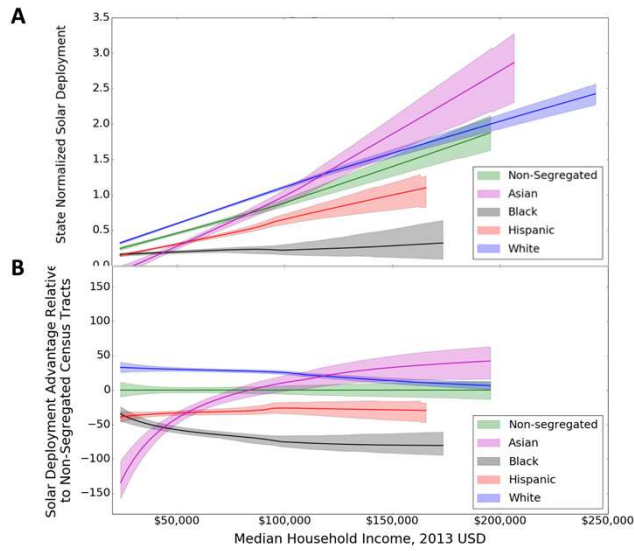
Disparities in rooftop photovoltaics deployment in the United States by race and ethnicity

Deborah A. Sunter^{1,2,3,4*}, Sergio Castellanos^{3,4,5,6*} and Daniel M. Kammen^{3,4,7}

The rooftop solar industry in the United States has experienced dramatic growth—roughly 50% per year since 2012, along with steadily falling prices. Although the opportunities this affords for clean, reliable power are transformative, the benefits might not accrue to all individuals and communities. Combining the location of existing and potential sites for rooftop photovoltaics (PV) from Google's Project Sunroof and demographic information from the American Community Survey, the relative adoption of rooftop PV is compared across census tracts grouped by racial and ethnic majority. Black- and Hispanic-majority census tracts show on average significantly less rooftop PV installed. This disparity is often attributed to racial and ethnic differences in household income and home ownership. In this study, significant racial disparity remains even after we account for these differences. For the same median household income, black- and Hispanic-majority census tracts have installed less rooftop PV compared with no majority tracts by 69 and 30%, respectively, while white-majority census tracts have installed 21% more. When correcting for home ownership, black- and Hispanic-majority census tracts have installed less rooftop PV compared with no majority tracts by 61 and 45%, respectively, while white-majority census tracts have installed 37% more. The social dispersion effect is also considered. This Analysis reveals the racial and ethnic injustice in rooftop solar participation.

34

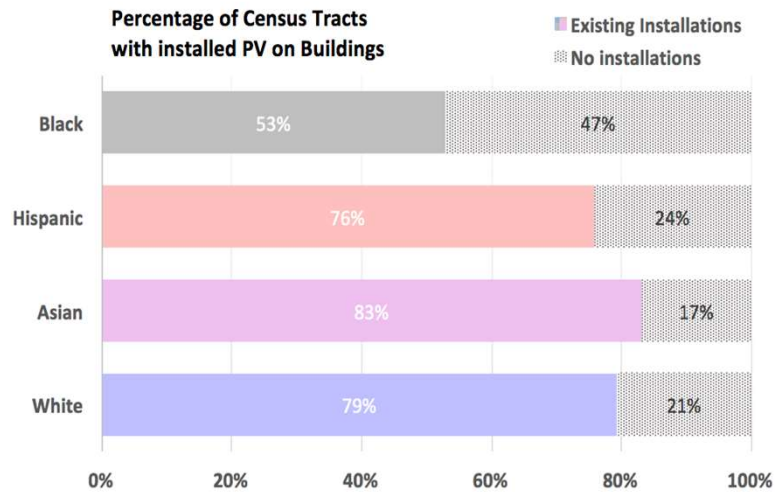
Large Racial disparity in solar – even at same income



Deborah Sultzer, Sergio Castellanos & Daniel M Kammen (2019) "Disparities in rooftop photovoltaics deployment in the United States by race and ethnicity." *Nature Sustainability* 2, 71–76

35

Solar Installations by Racial Composition in Identified Tracts



Deborah Sultzer, Sergio Castellanos & Daniel M Kammen (2019) "Disparities in rooftop photovoltaics deployment in the United States by race and ethnicity." *Nature Sustainability* 2, 71–76

36

Thank you & Extra Slides:

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@dan_kammen



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37

Appendix 2: Green Stimulus Contact Information

https://medium.com/@green_stimulus_now/a-green-stimulus-to-rebuild-our-economy-1e7030a1d9ee

- ❑ **Johanna Bozuwa**, Co-Manager, Climate & Energy Program, The Democracy Collaborative (@johannabozuwa), jbozuwa@democracycollaborative.org
- ❑ **J. Mijin Cha**, Assistant Professor of Urban and Environmental Policy, Occidental College; Fellow at Cornell University Worker Institute; Senior Fellow at Data for Progress, (@jmijincha), jmijin@gmail.com
- ❑ **Daniel Aldana Cohen**, Assistant Professor of Sociology and Director of the Socio-Spatial Climate Collaborative, or (SC)2, University of Pennsylvania; Senior Fellow at Data for Progress, (@aldatweets), aldanacohen@gmail.com
- ❑ **Billy Fleming**, Wilks Family Director of the Ian L. McHarg Center (@mchargcenter), University of Pennsylvania; Senior Fellow at Data for Progress, (@joobilly), billy.fleming3@gmail.com
- ❑ **Jim Goodman**, Food Sovereignty Advocate, r.j.goodman@mwt.net
- ❑ **Ayana Elizabeth Johnson, Ph.D.**, Marine biologist, founder of Ocean Collectiv and Urban Ocean Lab, and advisor to the Blue New Deal plan, (@ayanaeliza), ayanaelizabeth@gmail.com
- ❑ **Daniel M Kammen**, Professor in the Energy and Resources Group, the Goldman School of Public Policy, and in the Department of Nuclear Engineering, University of California, Berkeley. Former Science Envoy, United States State Department, (@dan_kammen), kammen@berkeley.edu
- ❑ **Julian Brave NoiseCat**, Vice President of Policy & Strategy, Data for Progress, (@jnoisecat), jnoisecat@gmail.com
- ❑ **Raj Patel**, Research Professor, Lyndon B Johnson School of Public Affairs, University of Texas at Austin; Research Associate, Unit for Humanities at Rhodes University (UHURU), South Africa. (@_RajPatel), rajpatel@utexas.edu
- ❑ **Mark Paul**, Assistant Professor of Economics and Environmental Studies, New College of Florida; Fellow, Roosevelt Institute; Senior Fellow, Data for Progress, (@MarkVinPaul), markvpaul62@gmail.com
- ❑ **Thea Riofrancos**, Assistant Professor of Political Science, Providence College; Senior Fellow at Data for Progress; Faculty Collaborator at Socio-Spatial Climate Collaborative, or (SC)2, (@triofrancos), thea.riofrancos@gmail.com

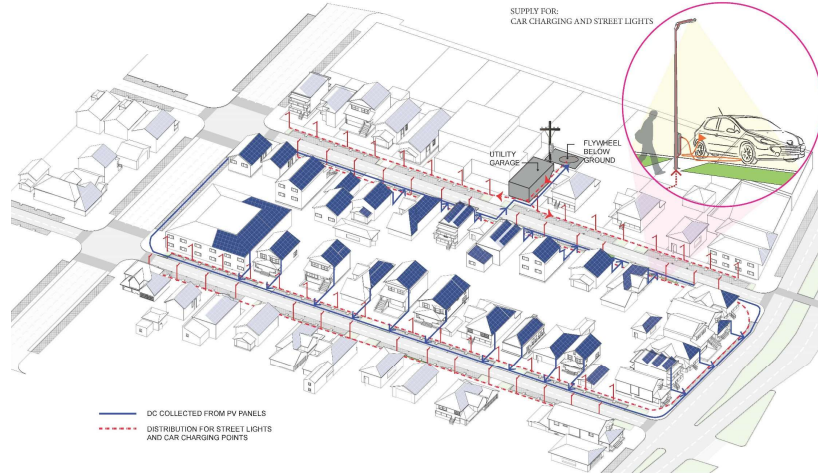
38

EcoBlock Vision: A Multi-Customer Microgrid Solution

Electrical system combines DER

- Communal rooftop solar PV
- Communal energy storage system (flywheel and/or battery)
- Intelligent loads and electric demand response
- Shared Electric vehicle (EV) charging
- Smart controls in a direct-current (DC) microgrid infrastructure

behind a single interconnection with PG&E



39



CEC Phase II Partners



40

Electricity



- System Architecture
 - ~200 kW PV DC microgrid based on utility backbone with single inverter connection to the grid
 - Charging stations for shared EVs – or Individual charging stations
 - 10 x 25 kWh/10 kW flywheel storage
- Estimated ~250 to 300 MWh/year PV production.



41

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EDITORIALS | OP-EDS | LETTERS TO THE EDITOR | COLUMNS | THE SOAPBOX | EDITORIAL CARTOONS | SUBMIT A LETTER TO THE EDITOR | SUBMIT

UC's investments in fossil fuels are hurting the planet

BY DANIEL KAMMEN | SPECIAL TO THE DAILY CAL LAST UPDATED DECEMBER 3, 2013

330 STEPHENS HALL
UNIVERSITY OF CALIFORNIA
July 2, 2019

ANDREW DICKSON
Secretary of the Assembly

Re: Berkeley Division Memorial Resolution on Fossil Fuel Divestment Ballot Results

Dear Secretary Dickson,

The Berkeley Division held an electronic vote in accordance with Senate Bylaws 90 and 95 on the proposed Memorial to the Regents on fossil fuel divestment. The ballot was open from June 6-27, 2019. The certified results of the ballot are as follows:

Total ballots cast:	423
"Yes" votes:	339
"No" votes:	84
Invalid ballots:	0

Please contact me or Berkeley Division Associate Director Sumei Quiggle if there are any questions concerning this ballot.

Sincerely,

 David Milnes
 Chair, Committee on Rules and Elections and Secretary, Berkeley Division of the Academic Senate

Cc: Barbara Spackman, Chair, Berkeley Division of the Academic Senate
 Jocelyn Surla Banaria, Executive Director, Berkeley Division of the Academic Senate
 Hilary Baxter, Executive Director, UC Academic Senate

DM/scq

42

Led by
 Dr Cheng Zheng, CEO, Aspiring Citizens Cleantech (ACC), Chengdu, China
 & Gordon Bauer & Daniel Kammen (ERG, UC Berkeley)



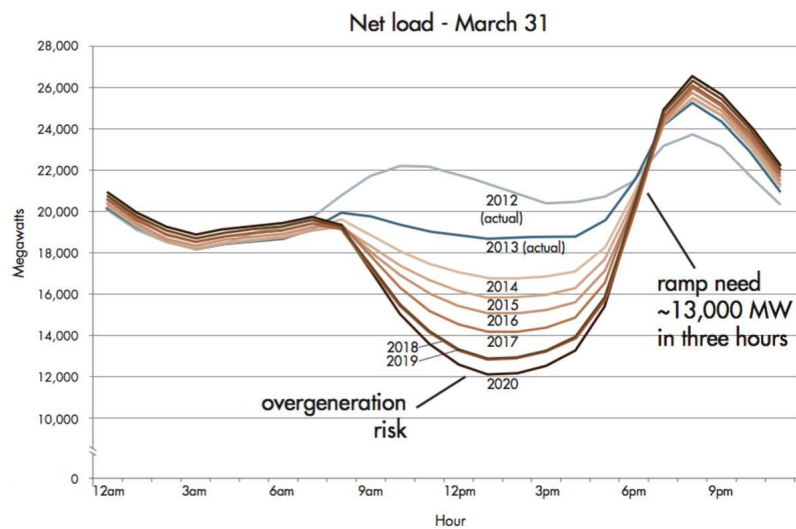
100% EV taxi fleet in Shenzhen, China (25,000+ vehicles)
 24 month fleet conversion



43

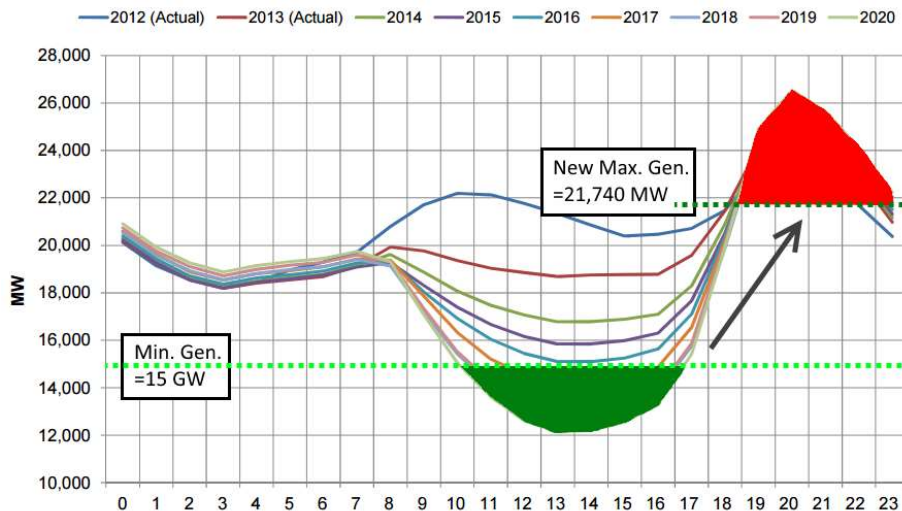
California Advancing Energy Efficiency

Figure 2: The duck curve shows steep ramping needs and overgeneration risk



44

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45

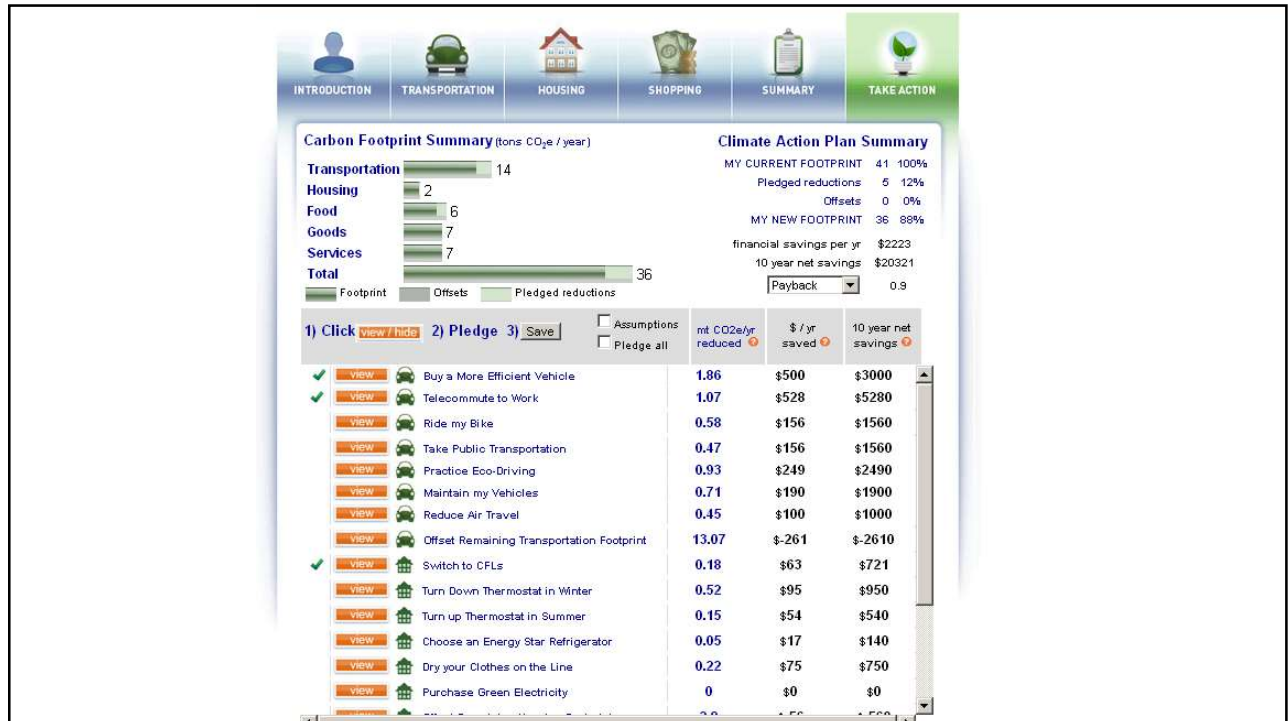
Spatial Distribution of U.S. Household Carbon Footprints Reveals Suburbanization Undermines Greenhouse Gas Benefits of Urban Population Density

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

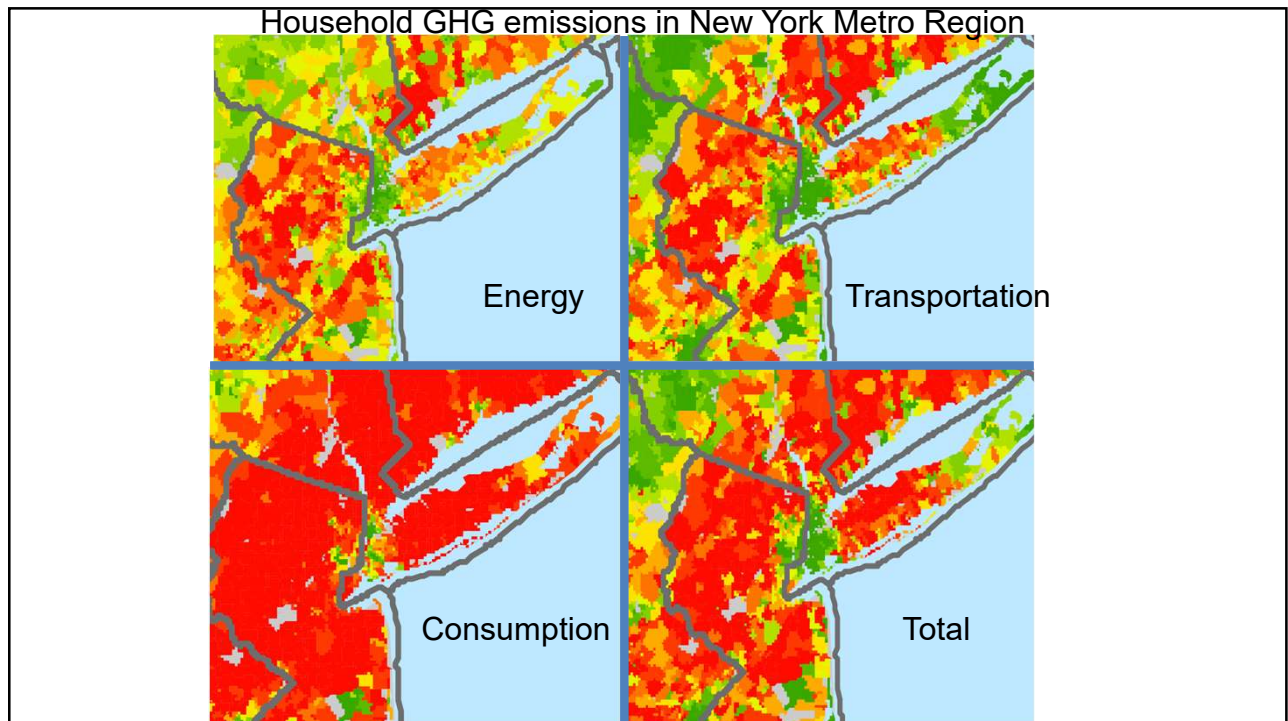
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<http://coolclimate.berkeley.edu/maps>

46



47



48

