U.S. House of Representatives
Committee on Science, Space, and Technology
Subcommittee on Energy,
10 AM, July 16, 2021, Hearing on:

Fostering Equity in Energy Innovation

Daniel M Kammen

Representative Eddie Bernice Johnson, Chairwoman, Representative Frank Lucas, Ranking Member, and other members of the Subcommittee on Energy, my thanks for holding this hearing and for inviting me to testify on the critical and timely topic of fostering diversity and equity in energy innovation.

My resume is attached. I am the James and Katherine Lau Distinguished Professor of Sustainability at the University of California, Berkeley. At Berkeley am the Chair of the Energy and Resources Group, Professor in the Goldman School of Public Policy, and Professor of Nuclear Engineering. Since 1999, I have served as a Coordinating Lead Author for a number of reports of the Intergovernmental Panel on Climate Change (IPCC), which shared the 2007 Nobel Peace Prize. I served as the Chief Technical Specialist for Renewable Energy and Energy Efficiency at the World Bank (2010 – 2011). In 2011, I was appointed by Secretary of State Hilary Clinton as the first Energy Fellow of the Energy and Climate Partnership of the Americas (ECPA), and then served as Lead Scholar for the Fulbright NEXUS program on partnership and innovation in energy and climate across the Americas. In 2016, I was appointed Science Envoy for the U. S. Department of State working for Secretary John Kerry. My research is focused on innovation in energy systems, directed at decarbonizing energy systems at the utility/grid level, at the city community level, as well as working on energy access and social justice in the US, Africa and in southeast Asia. My research team, the Renewable and Appropriate Energy Laboratory (RAEL[1]), in active in both basic and applied research in partnership with university, government, and civil society colleagues in a number of US states, as well as in sub-Saharan Africa, the Mekong region of southeast Asia, and in China.

The Opportunity for Energy Innovation and Social Justice
Today's topic, fostering equity in energy innovation, is critical for a number of interlinked reasons. First, as part of President Biden's commitment to decarbonize the electricity sector by 2035, a huge amount of work is needed not just on developing and deploying technology, but also in making the energy transition socially and racially just. The benefits of this *joint* technological and social transformation are vast, and increasingly studied. In my own laboratory, RAEL, we have examined the jobs benefits of clean energy for over a decade[2]. The results, since confirmed by a wide range of independent studies, find that per dollar invested, energy efficiency and renewable energy produce significantly more jobs than does an equal investment in fossil fuel energy systems (in some cases 2 – 3 *times* more jobs). In 2017 the U. S. Department of Energy reported that at that time, nearly 1 million Americans were working near- or full-time in the energy efficiency, solar, wind, and alternative vehicles sectors. That total is almost five times the 2017 employment in the fossil fuel electric industry, which includes coal, gas, and oil workers[3]. Table 1 summarizes the differences in job creation across technologies.

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[1] http://rael.berkeley.edu
[2] Daniel Kammen (2001) Testimony for the 'Hearing on the Role of Tax Incentives in Energy Policy' for the U. S. Senate Committee on Finance, July 11 (United States Senate: Committee on Finance); Max Wei, Shania Patadia, and Daniel Kammen (2010) "Putting renewables and energy efficiency to work: How many jobs can the clean energy industry generate in the U. S.?" *Energy Policy*, **38**, 919 - 931.
[3] U. S. Department of Energy (2017) *Energy and Employment Report* https://www.energy.gov/downloads/2017-us-energy-and-employment-report

Energy Source	Direct Jobs	Indirect Jobs	Induced Jobs	Total Jobs
Oil & natural gas	0.8	2.9	2.3	**5.2**
Coal	1.9	3.0	3.9	**6.9**
Building retrofits	7.0	4.9	11.8	**16.7**
Mass transit/ rail	11.0	4.9	17.4	**22.3**
Smart grid	4.3	4.6	7.9	**12.5**
Biomass	7.4	5.0	12.4	**17.4**
Solar	5.4	4.9	8.4	**13.3**
Wind	4.6	4.4	9.3	**13.7**

Table 1: Job creation per million $ spending across fossil fuel (grey), infrastructure (blue) and renewable energy (green). Data is compiled from a range of sources including annual updates of the Wei, Patadia and Kammen (2010) paper, and the U. S. Department of Energy (2017) *Energy and Employment Report.*

With the dramatic declines in the cost of solar, wind, electric vehicles, and energy storage (Kittner, Lill & Kammen, 2017), more than 90% of new energy generation installed in 2020 was from renewable energy sources. The International Energy Agency's 2021 *Renewable Energy Market Update*[4], documented 280 GW of new renewable energy generation capacity was installed globally during the 2020 – a 45% increase on the amount installed during 2019. According to the Update, 45% is the steepest year-on-year increase in capacity in three decades. When the increase is broken down by generation method, wind capacity additions fared best, with a 90% increase. Polar PV, meanwhile, saw a 50% increase. In a truly remarkable shift, today, it is less expensive to *install new* renewable energy technologies than to *operate* many fossil fuel energy systems[5].

That is the good news on innovation in the technology and market aspects of the energy transition.

It is now abundantly clear, however, that the massive decarbonization we need in the next two decades will require a huge influx of talent into the clean energy space, with job training, job creation, and greater coordination across sectors. Essentially, for the United States and the world, we will need to exceed and sustain a 3% or greater pace of decarbonization *for the coming decades*, compared to the recent rates that were often as slow a 1 – 2%/year (Lovins, et al, 2019).[6] These data are shown in Figure 1. Only an inclusive approach to energy, climate, justice and employment will be able to sustain these needed levels of innovation.

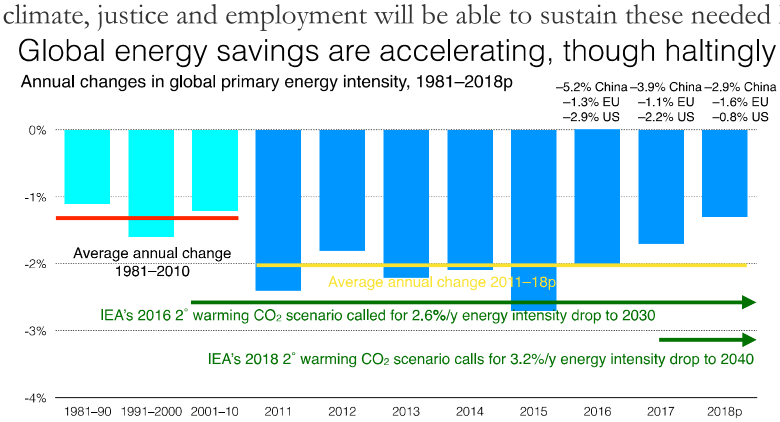

Figure 1: The International Energy Agency (IEA 2017, 2018, 2018b, 2019, all averaging annual rates of change without compounding) reports that global energy intensity (primary energy consumption per dollar of real GDP_{PPP}) fell nearly a percentage point per year faster during 2011–18 than in the previous three decades. The text inserts above the three bars on the right show high sensitivity to Chinese and US fluctuations (Lovins, *et al.*, 2019).

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[4] International Energy Agency (2021) https://www.iea.org/reports/renewable-energy-market-update-2021

[5] https://www.bloomberg.com/news/articles/2021-06-23/building-new-renewables-cheaper-than-running-fossil-fuel-plants

[6] Amory B Lovins, Diana Ürge-Vorsatz, Luis Mundaca, Daniel M Kammen, and Joacob W Glassman (2019) "Recalibrating climate prospects", *Environmental Research Letters,* **14 (12)**. https://iopscience.iop.org/article/10.1088/1748-9326/ab55ab

In summary, to achieve and sustain these rates of decarbonization, we must *bake in, not sprinkle on*, racial and socioeconomic justice[7].

The critical nexus of innovation and social justice is, literally, the *special sauce* needed to meet climate and social goals of job creation, community empowerment, and racial equality. To illustrate, I will present in this testimony both a disturbing case of new technology deployment without sufficient attention to social justice, and a positive case of the integration of energy and systems innovation with early, attention to the benefits of equity and social justice in driving energy innovation and deployment.

Race and the deployment of solar photovoltaics (PV)

In a recent paper, "Disparities in rooftop photovoltaics deployment in the United States by race and ethnicity"[8], my colleagues Profess Deborah Sunter (Tufts University), Professor Sergio Castellanos (University of Texas, Austin), and I combined data on existing rooftop solar installations across the United States from the Google LLC's Project Sunroof, and demographic data, including household income, home ownership, and ethnicity and race from the American Community Survey. The Project Sunroof Data[9] includes information on over 60 million rooftops. Across a full order of magnitude of household income levels (below the family poverty line, $25,000/year to $250,000/year in household income) *significant differences in the relative adoption of rooftop PV when compared across census tracts grouped by racial and ethnic majority. Black- and Hispanic-majority census tracts show on average significantly less rooftop PV installed*. There was insufficient data for comparable statistical treatment of AAPI households.

The results are striking: at the *same* median household income, black- and Hispanic-majority census tracts have installed less rooftop PV compared with those areas with no majority ethnic group, 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 (black and red, respectively) have installed less rooftop PV compared with no-majority tracts by 61 and 45%, respectively, while white-majority census tracts (blue) have installed 37% more than those neighborhoods without a dominant (> 50%) racial group (green).

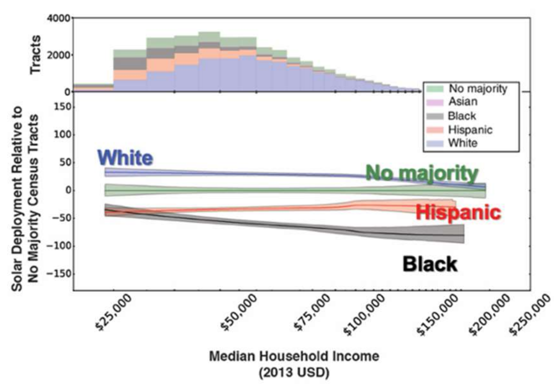

Figure 2: The relationship between household income and rooftop photovoltaic (PV) installation. Top: Histogram of the distribution of census tracts, color-coded by racial majority (> 50%). Bottom: Rooftop PV installations relative to the available rooftop PV potential and normalized by state as a function of the median household income for majority census tracts with existing rooftop PV in absolute values (b); and normalized relative to the rooftop adoption of no-m Majority census tracts (c). *Methods:* Lines represent the results of the LOWESS method applied to all data in each racial and ethnic majority group. Lighter shading represents the 90% Confidence Intervals. Source: Sunter, Castellanos and Kammen, 2019.

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[7] Comments by Professor Manuel Pastor at the NSF Workshop on Climate and Environmental Justice, University of Massachusetts, Amherst (April, 2021).

[8] Deborah Sunter, Sergio Castellanos & Daniel M Kammen (2019) "Disparities in rooftop photovoltaics deployment in the United States by race and ethnicity", *Nature Sustainability* **2**, 71 – 76. DOI 10.1038/s41893-018-0204-z.

[9] https://sunroof.withgoogle.com

There is a great deal more one could say about this data and analysis, but the message is clear. Without efforts to recognize past biases (such as in FICA scores that have in some cases been used in discriminatory and predatory ways – redlining -- to deprive individuals and communities of color of the capital to invest in homes and upgrades such as photovoltaics)[10].

The Oakland, CA EcoBlock: Building energy and social justice into the innovation and planning process

An ongoing project in Oakland, California illustrates one approach to implementing clean energy where innovations on the hardware side (novel solar and energy storage technologies and smart-grid interlinking technologies) are partnered *from the outset* with efforts to build inclusive input from diverse, low-income and racially diverse participants. The Eco-Block (Figure 3) is a project built around *shared* solar PV, energy storage, communal access to on-street electric-vehicle (EV) charging, and block-scale water reclamation efforts. The block, in effect, becomes a modular *mini-grid*, providing low-cost clean energy services to residents. The block provides smart-card access to shared EV charging so that renters and not just home-owners and those with their own garages and driveways can benefit from the low-cost per mile of EV driving.

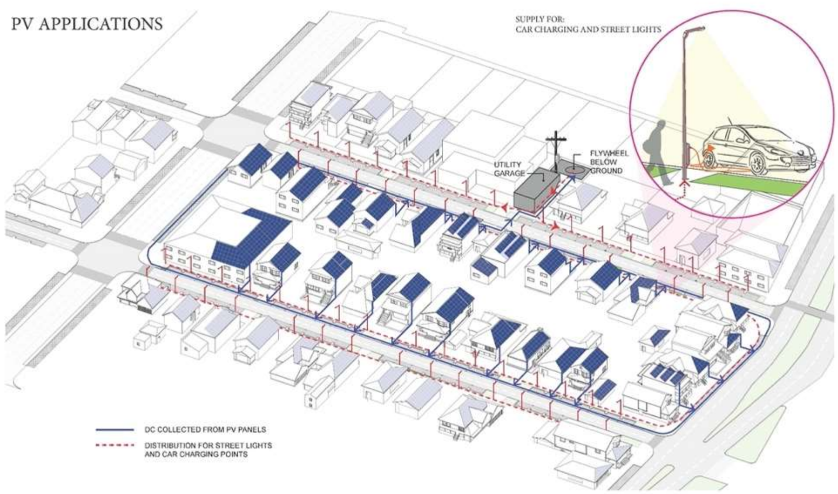

Figure 3: The EcoBlock (~40 residences, some homes, and some apartment buildings) with pooled rooftop solar, stored in a collective and centralized energy storage facility, which then feeds-back power to each energy efficient home, EV charging bays along the street, and which also powers water reclamation systems. Excess power is sold to the utility, although this is contested at present. The project is funded as a pilot by the California Energy Commission and donations from some of the many participating organizations (see Appendix A for a community flyer and list of participants).

The EcoBlock concept includes (at no additional cost to the homeowner):

- **Energy efficiency retrofits:** floor and attic insulation, weather sealing (doors/windows), efficient exhaust fans replacement, replace gas-fueled space and water heating and clothes drying appliances with efficient electrical equipment/appliances, smart thermostat, LED upgrades, ceiling fans.
- **Water efficiency retrofits**: laundry-to-landscape greywater system, drought tolerant planting, water-efficient dishwasher and clothes washer replacement, water-efficient fixture replacement (toilets, lavatories, faucets)

[10] Michelle Singletary (2020) "Credit scores are supposed to be race-neutral. That's impossible," *The Washington Post*, https://www.washingtonpost.com/business/2020/10/16/how-race-affects-your-credit-score/

- Solar electric (electricity-generating) **Photovoltaic (PV)** panels for the roof, sized to meet 100% of electrical demand.
- Neighborhood-shared **energy storage** using "flywheel" or battery storage. (A flywheel is a large spinning weight, located in the ground, that can absorb and produce energy, and is safer than conventional chemical battery storage.)
- Shared **Electric Vehicle (EV) charging stations** (up to six, based on the PV system size)
- DC (direct current) "**microgrid**" across multiple residential buildings; each house has its own solar electric generation, and a shared DC infrastructure connects to the flywheel or battery energy storage and the Electric Vehicle charging stations.
- Legal, regulatory, and financial innovation to facilitate these and future projects.

These two examples – that of solar deployment without significantly engaging minority businesses, stake-holders and public officials widely enough to promote equity (Sunter, Castellanos and Kammen, 2019), and the EcoBlock pilot – provide two examples and lenses on both the warning signs, and opportunities to make the process of the fundamental innovation, design and implementation of decarbonization efforts ones that build job creation, social acceptance, and economic empowerment. These cases only begin to scratch the surface of opportunities to *co-create* clean energy and social equity, but they do illustrate many of the opportunities where pro-justice, *mission-driven* basic and applied research can accelerate the clean energy transition.

Lessons learned and examples of pro-justice & pro-climate actions for the federal government

Among the clear lessons from this work are:

- *Data analytics* are a key tool in identifying aspects of all socio-technical systems –including energy systems – where racial and socioeconomic injustice hold us back from achieving social progress, energy access or equity, and from meeting our clean energy and climate goals. The *CalEnviroScreen* program, website, and data system[11] is an example of an integrated effort across all aspects of California state government to make available transparent data on the pollution impacts, the levels of energy access (including power outages which disproportionately impact communities of color across the United States), levels of air, water and noise pollution. Since the founding of the California Cap & Trade carbon system, 35% or more of the total funds are directed to meeting the needs of under-served, under-resourced and fence-line communities. In that context, a strong and transparent data collection, analysis, and feedback system is vital. At the federal level, EIA-DoE programmatic-DoT and EPA coordination is even more complex and warrants an even more integrated approach to achieving both climate and social justice goals.

- *The social cost of carbon* (SCC, examined in Appendix B for energy planning projects) is a critical data-intensive analytic tool to empower federal, state, and local agencies to quantify the costs of pollution across communities, ecosystems, and the global biosphere in ways that can drive new technology development, new market and social policies, and to uplift disadvantaged communities. The Presidential Executive Order of 20 January, 2021 establishing a SCC working group (with a hugely

[11] https://oehha.ca.gov/calenviroscreen. *CalEnviroScreen* is used to dentify California communities that are most affected by many sources of pollution, and where people are often especially vulnerable to pollution's effects. *CalEnviroScreen* uses environmental, health, and socioeconomic information to produce scores for every census tract in the state. The scores are mapped so that different communities can be compared. An area with a high score is one that experiences a much higher pollution burden than areas with low scores. *CalEnviroScreen* ranks communities based on data that are available from state and federal government sources.

important report scheduled for January 2022 release) is a vital step in the science and data-based approach to quantifying human and environmental impacts of energy and infrastructure choices. No single metric is a panacea, but if utilized through the federal system, and then propagated through state interactions (e.g. via Public Utility Commissions and in federal and regional cost/benefit assessments) the power of this tool can be considerable. The data can be used to build inclusive approaches to innovation, deployment, and validation of the social, economic, and environmental benefits of clean energy, water, air and via biodiversity and cultural diversity conservation.

This holds true both for domestic projects, but also in terms of efforts at the State Department, USAID, and via PowerAfrica and other regional efforts, quantifying the impacts of clean energy choices in US foreign policy will open doors for US companies (and thus job creation) in a global economy where clean energy was more than 90% of new deployed energy projects (IEA, 2021; Puig, *et al.,* 2021). US overseas policy and partnerships to meet and exceed the Paris Climate Accords – a topic I worked on extensively while Science Envoy in the US State Department – could be accelerated by the use of similar international data systems. Critically, building the *global* clean energy economy will then become a huge market and source of jobs for US companies, contractors, and increasingly skilled US labor in a world.

As just one example, my laboratory builds power sector models (see Appendix B). Kenya was considering a joint Chinese-US (General Electric) funded coal plant for deployment in an ecologically and culturally critical coastal location near Lamu. Kenyan civil society backed by technical analytic power sector work and solar, wind and geothermal pilot project work where I was engaged as Science Envoy for the US State Department resulted in the cancellation of the coal project (Carvallo *et al*, 2017). The *opportunity* today is for US and other companies to partner with Kenyan government, civil society, and the private sector to instead build renewable energy and energy storage in the region to meet the growing power needs with technologies that meet climate goals, produce more local (and US) jobs, and preserve the unique culture of the region.

- *A pipeline of minority <u>businesses</u> as well as <u>educational opportunities</u> are both critical elements of a diverse, green, and vibrant energy economy.* It is critical to expand STEM and other energy, water, and other resource-focused training programs to make training available to all Americans. Recent efforts to build new undergraduate majors in Energy Engineering, with specific outreach to Native American, LatinX, African-American, AAPI, and other under-served communities, are key steps. So, too, however, are efforts to launch, support, and expand markets for minority-owned businesses. Is is the lack of these businesses, that likely resulted in the unequal access to solar that we see today across the US (Sunter, Castellanos and Kammen, 2019). Further, investing in minority-owned businesses builds in-community capacity and also opens educational channels to individuals and families who have in the past been bypassed by new, cleaner, often less-expensive technologies. Nation decarbonization requires buy-in and full participation. This effort is central to job creation and sustained decarbonization.

- *Tracking programs*, such as can be established by the Energy Information Agency, the US Environmental Protection Agency, the Department of Transportation, and other federal, state and local offices, are critical to both identify problems and to track progress in addressing these areas of environmental and social injustice. Many of the more pressing impacts on disadvantaged communities (power outages, utility disconnections, unhealthy air and water episodes, huge over-payments for energy services via inefficient and older technologies) *can* and *need to* be tracked by the Energy Information Agency and utilized in integrated resource planning.

- *Justice 40:* Many key opportunities require working across technology, society, and agency boundaries. Efforts like the *Justice40* initiative (Executive Order 14008 Tackling the Climate Crisis at Home and

Abroad; Section 223 which directs 40% of federal energy infrastructure spending to under-served, frontline, and otherwise disadvantaged communities), are tremendous steps forward that need to be both applauded, and tracked to clarify how significant are the ability of federal programs to spur innovation – often in areas not previously seen as priorities. Examples include significant benefits in climate-smart heating and cooling through education and pilot programs to bring heat-pumps to neglected communities (low-income and those who rent), and the massive potential for ride-sharing and fleet purchases of electric-vehicles to be deployed to reduce pollution (see below). Examples of places to *bake-in* diversity include making community participation and feedback (as in the Oakland, CA EcoBlock) core elements of ARPA-E, ARPA-Agriculture, and the Department of Energy Science for the Future Act (H.R. 3593)

- *Recognize that housing policy is both key to social justice and to climate policy*[12]. Across the United States, low-income citizens often commute the longest distances to find the housing they can afford, and often in the oldest, and most expensive cars to operate. Efforts such as the announcement by *Lyft* that their fleet (globally 2 million vehicles) will be all-electric by 2030 *and* they will make EVs available via lease and rental for their drivers *at or below cost*[13]. This program, if accelerated and spread to other fleet and community applications (in conjunction with public transportation) can build the market for EVs and promote mobility that is crucial for economic opportunity. In India, a fraction of the ride-sharing fleet is nationally mandated to be electric. This mandate is then set to ramp up to an ultimately all-electric light-duty fleet. This is a key point of integration where in the US, the DoE, DoT, and EPA programs can be coordinated through data collection and sharing to assess the cost (e.g. using the social cost of carbon) and benefit and level of inclusiveness and justice in federal investments. Work on deploying EV charging infrastructure so that it is readily accessible to all citizens, making energy reliable to even low-income Americans (and tracking utility shut-offs) are some of the examples of opportunities to build justice into the design of the clean energy economy (Committee on Energy and Commerce, Hearing on "Building a 100% clean energy economy, 2019).

The over-arching message in the cases and programs examined here is that far greater job creation, economic potential and public acceptance of the energy transition come from making social justice a core component of programs often seen in the past as technology-based. Indeed, today we are equipped with the technological and policy tools to meet and sustain that needed 3% (or greater) level of annual decarbonization. Equity and justice will make that progression a reality.

I thank you for the opportunity to present and to engage with the Committee.

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[12] Scott Wiener and Daniel M Kammen (2019) "For U. S. cities, housing policy is climate policy", *The New York Times,* March 25. https://www.nytimes.com/2019/03/25/opinion/california-home-prices-climate.html

[13] Daniel Kammen (2020) "How electric vehicles can help advance social justice," *The San Francisco Chronicle, June 21*, https://www.sfchronicle.com/opinion/article/How-electric-vehicles-can-help-advance-social-15351293.php

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Appendix A: The Oakland EcoBlock: Community Informational Flyer

Want to reduce carbon emissions, save money on your energy bill, & survive the next power outage?

The **Oakland Ecoblock** is an effort to develop a path towards rapidly reducing greenhouse gas emissions through residential retrofits, develop a resilient electric "microgrid" that can provide power during outages, and demonstrate efficient block-scale energy and water systems. The project is funded primarily by the California Energy Commission through their Advanced Energy Communities program and led by UC Berkeley with the City of Oakland. The project is expected to run 10/1/2019 - 5/31/2023.

The project aims to find 10-20 neighboring houses on an existing block in Oakland. Participation is voluntary.

The EcoBlock design includes (at no cost to the homeowner):

- **Energy efficiency retrofits:** floor and attic insulation, weather sealing (doors/windows), efficient exhaust fans replacement, replace gas-fueled space and water heating and clothes drying appliances with efficient electrical equipment/appliances, smart thermostat, LED upgrades, ceiling fans.
- **Water efficiency retrofits**: laundry-to-landscape greywater system, drought tolerant planting, water-efficient dishwasher and clothes washer replacement, water-efficient fixture replacement (toilets, lavatories, faucets)
- Solar electric (electricity-generating) **Photovoltaic (PV)** panels for the roof, sized to meet 100% of electrical demand.
- Neighborhood-shared **energy storage** using "flywheel" or battery storage. (A flywheel is a large spinning weight, located in the ground, that can absorb and produce energy, and is safer than conventional chemical battery storage.)
- Shared **Electric Vehicle (EV) charging stations** (up to six)
- DC (direct current) "**microgrid**" across multiple residential buildings; each house has its own solar electric generation, and a shared DC infrastructure connects to the flywheel or battery energy storage and the Electric Vehicle charging stations.
- Legal, regulatory, and financial innovation to facilitate these and future projects.

The **benefits** enjoyed by the participants include reduced utility bills and reduced carbon footprint (the goal is to eliminate the gas bill, reduce the water bill, and substantially reduce the electricity bill), improved comfort in one's home by improving insulation and reducing leaks, updated appliances and fixtures, and lack of electrical interruption through the next power outage.

Energy storage such as batteries is expensive, and often not utilized well by an individual house due to variability in energy consumption. Sharing energy storage allows the cost and energy loads to be dispersed across many homes.

The shared systems, such as storage, connections and EV charging, will likely be collectively owned by all participants. The research team will help the participants select and develop an appropriate governance vehicle, such as a **Trust**, Co-op, or HOA-lite organization like a Green Retrofit Organization, to deal with ongoing maintenance and insurance.

The shared infrastructure (energy storage, connections and control, EV charging, and possibly the PVs) will require funds for maintenance and insurance after the system is installed, tested and commissioned, and the project is over in 2023. The research team has identified a **Communities Facilities District** (CFD) as a trusted secure means of assessing all the participating neighbors an annual fee, based on the ability to pay and amount of shared resources at each property, over the lifetime of the microgrid (e.g., 30 years). As a property tax line item or lien, residents pay through their taxes, similar to assessment district financing. The homeowner would need to disclose this **tax lien** at time of resale. The participants will maintain their connection to PG&E, thus if the participants decide to abandon the microgrid for any reason in the future, they can simply continue to use the PG&E. The project expects to eliminate the gas bill and reduce the electricity and water bills of each participating household—estimated $1000+/year; this is expected to outweigh the annual fee.

The impact of the energy and water improvements to each home's **tax assessment** is expected to be minimal. Remodeling and repair that are part of normal maintenance or cosmetic are not considered assessable, neither is replacing fixtures and appliances; solar panel installations are excluded from reassessment (https://www.hjta.org/news-events/taxing-times-online-winter-2018-2019/your-questions-answered-if-i-remodel-my-home-will-my-property-taxes-go-up/).

Data from each participant (e.g., energy and water consumption) will be collected during the project for analysis only by the project team; CIEE and the project team will not publish or release your name, address or any other identifying information.

The construction phase of the project is expected to last 4-6 months in late 2021, which may increase **traffic** during some hours to this block and neighboring blocks.

Depending on the needs of the neighborhood, the project expects to add up to six curb-side Electric Vehicle charging stations, which will replace existing **parking** spaces.

Because this project is a research project and goods and services will be provided at no cost to the owner, the contracted goods and services will not always be selected based on competitive bid based on quality, price, and servicing. The research team will be transparent about the selection process and the reasons for the selection. The participant is under no obligation to receive all goods and services.

The extensive team of academic, public sector, and private sector partners in this project is reflected in the visual graphic below of the full EcoBlock team:

http://ecoblock.berkeley.edu

dta

Coblentz Patch Duffy & Bass LLP

BerkeleyLaw
UNIVERSITY OF CALIFORNIA
Center for Law, Energy & the Environment

Morgan Lewis

PERKINS COIE

tsrc
UNIVERSITY OF CALIFORNIA Berkeley
Transportation Sustainability
RESEARCH CENTER

SHERWOOD
DESIGN ENGINEERS

Stanford
University

City of
Oakland

Page/

Cathy Leonard

Appendix B*: Power sector modeling and the social cost of carbon to address fossil fuel subsidies that stand in the way of clean energy and social justice*

In the U. S., while solar and wind are already the least-cost forms of energy for much of the country, this calculation does not take into account a price on carbon (Figure 4a [top]). If we include those costs at the California level of $20/ton of CO_2 emissions, the map changes significantly, with solar gaining at the expense of natural gas (Figure 4b [bottom left]). And if we move further, to including a Social Cost of Carbon, currently estimated at roughly $50/t$CO_2$, the map transforms further (Figure 4c [bottom right]). Of course, a range of perspectives exist on how best to implement, and of course to allocate or rebate a price on carbon, and the while the radical restructuring of energy costs we have seen already barely require this component, it is most assuredly coming in some form, and likely to everyone, everywhere.

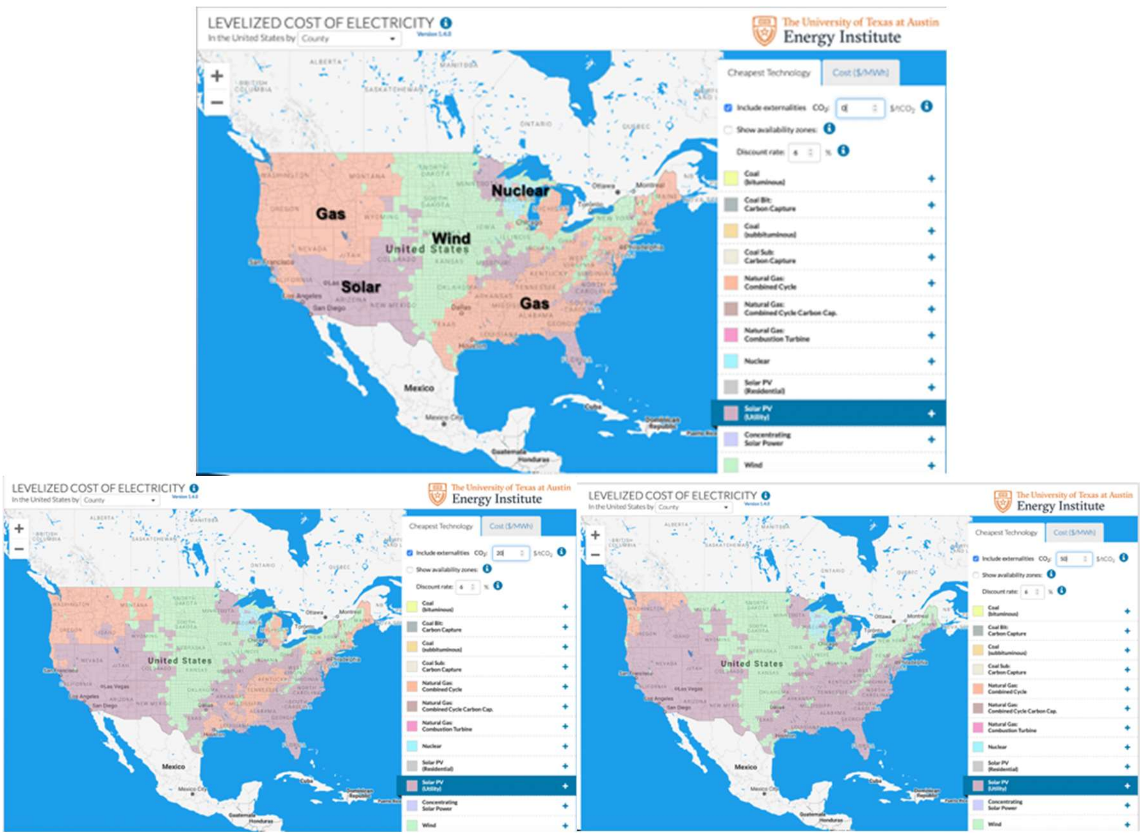

Figure 4: Top panel (a); least overnight cost energy by type with no carbon price ($0/tCO2); Left lower panel (b) at the current California cost of $20/tCO2; Right lower panel (c) energy costs at the Social Cost of Carbon of ~ $50/tCO2. The most dramatic change as the carbon price is increased is the replacement of natural gas (rust color) with solar (mauve). Source: University of Texas at Austin LCOE calculator: https://energy.utexas.edu/calculators

These assessments – done by many different research groups using diverse methodologies – are consistent across the US and for essentially every nation. My own research group has developed an expanded greatly the use of a model – SWITCH[14] -- pioneered by one of my doctoral students, Matthias Fripp to examine optimal expansions of the energy infrastructure in a wide range of nations – Bangladesh, Chile, the US, China, Kenya, Mexico, Nicaragua (Carvallo, *et al*., 2017*;* Mileva *et al.,* 2013 & 2016; He *et al.,* 2016; Nelson, *et al*., 2012; Ponce de Leon, *et al.,* 2015) to study the interacting forces of technology price changes, and the costs of

[14] SWITCH: Solar and Wind Integrated with Transmission and Conventional Generation.

both energy efficiency programs and grid expansions to bring these new energy technologies to market (http://rael.berkeley.edu/project/SWITCH).

Consistently across all of these cases a decade or so is needed for the transition *if technology choices were* coordinated and optimized. In simulation a decade to transform energy systems sounds astounding to many, but with clean energy and storage costs where they are, the real need is to maximize energy efficiency investments and to build transmission to take advantage of large-scale renewables and to incentivize 2-way sales between residential and commercial customers.

Further, these lost costs and high flexibility for renewable energy and energy storage are not only largely without the benefits of carbon pricing, but are prevailing even with the massive levels of fossil-fuel subsidies that exist worldwide, which total anywhere from $0.5 trillion to 5 trillion annually (IEA, 2020). There are few ways to put that level of subsidy for pollution in context, but one measure may be to note that renewable energy investment worldwide for the past *decade* is about 2.5 trillion, or the mid-level estimate of fossil fuel subsidies worldwide *for one year* (IISD, 2019). Quite simply that level of subsidy is hold the U. S. back economically and in terms of job creation and social justice given the current costs and the cost trends of clean energy.

Dr. Daniel M. Kammen holds the James and Katherine Lau Distinguished Chair in Sustainability at the University of California, Berkeley, with parallel appointments in the Energy and Resources Group where he serves as Chair, the Goldman School of Public Policy where he directs the Center for Environmental Policy, and the department of Nuclear Engineering. Kammen is the founding director of the Renewable and Appropriate Energy Laboratory (RAEL; **http://rael.berkeley.edu**). He was the director of the Transportation Sustainability Research Center from 2007 – 2015**.**

Kammen was appointed by then Secretary of State Hillary Clinton in April 2010 as the first energy fellow of the Environment and Climate Partnership for the Americas (ECPA) initiative. He began service as the Science Envoy for U. S. Secretary of State John Kerry in 2016, but resigned over President Trump's policies in August, 2017. He has served the State of California and US federal government in expert and advisory capacities, including time at the US Environmental Protection Agency, US Department of Energy, the Agency for International Development (USAID) and the Office of Science and Technology Policy.

Dr. Kammen was educated in physics at Cornell (BA 1984) and Harvard (MA 1986; PhD 1988), and held postdoctoral positions at the California Institute of Technology and Harvard. He was an Assistant Professor and Chair of the Science, Technology and Environmental Policy Program at the Woodrow Wilson School at Princeton University before moving to the University of California, Berkeley. Dr. Kammen has served as a contributing or coordinating lead author on various reports of the Intergovernmental Panel on Climate Change since 1999. The IPCC shared the 2007 Nobel Peace Prize.

In 2020 Kammen was elected to the American Academy of Arts & Sciences.

Kammen helped found over 10 companies, including Enphase that went public in 2012, Renewable Funding (Renew Financial) a Property Assessed Clean Energy (PACE) implementing company that went public in 2014. Kammen played a core role in developing the successful bid for the $500 million energy biosciences institute funded by BP.

During 2010-2011 Kammen served as the World Bank Group's first Chief Technical Specialist for Renewable Energy and Energy Efficiency. While there Kammen worked on the Kenya-Ethiopia "green corridor" transmission project, Morocco's green transformation, the 10-year energy strategy for the World Bank, and on investing in household energy and gender equity. He was appointed to this newly-created position in October 2010, in which he provided strategic leadership on policy, technical, and operational fronts. The aim is to enhance the operational impact of the Bank's renewable energy and energy efficiency activities while expanding the institution's role as an enabler of global dialogue on moving energy development to a cleaner and more sustainable pathway. Kammen's work at the World Bank included funding electrified personal and municipal vehicles in China, and the $1.24 billion transmission project linking renewable energy assets in Kenya and Ethiopia.

He has authored or co-authored 12 books, written more than 400 peer-reviewed journal publications, and has testified more than 40 times to U.S. state and federal congressional briefings, and has provided various governments with more than 50 technical reports. For details see http;//rael.berkeley.edu/publications. Dr. Kammen also served for many years on the Technical Review Board of the Global Environment Facility. He has been the Editor-in-Chief of the open access journal *Environmental Research Letters* since its founding in 2006.

Kammen is a frequent contributor and commentator in the international news media, including *Newsweek*, *Time*, *The New York Times*, *The Guardian*, and *The Financial Times*. Kammen has appeared on '*60 Minutes*' (twice), *NOVA*, *Frontline*, and hosted the six-part Discovery Channel series *Ecopolis*. Dr. Kammen is a Permanent Fellow of the African Academy of Sciences, a fellow of the American Academy for the Advancement of Science, and the American Physical Society. In the US, has served on several National Academy of Sciences boards and panels.

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