



Renewable & Appropriate Energy Laboratory

RAEL

Transformative Technologies and Implications for Energy

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Oslo Energy Forum - February 9, 2017

Takeaway message:

Scientific and technical transformations are critical to enabling a sustainable energy system, but it is the energy-information nexus that provides the 'killer app' for innovation and change

**This is true on-grid *and* off-grid in
developing nations**

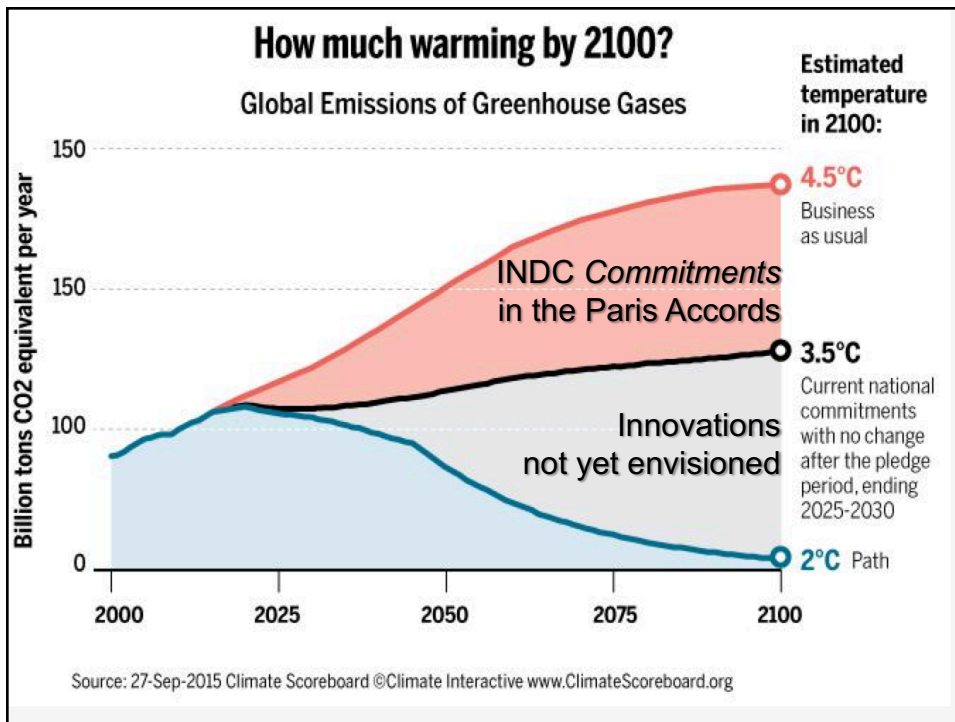
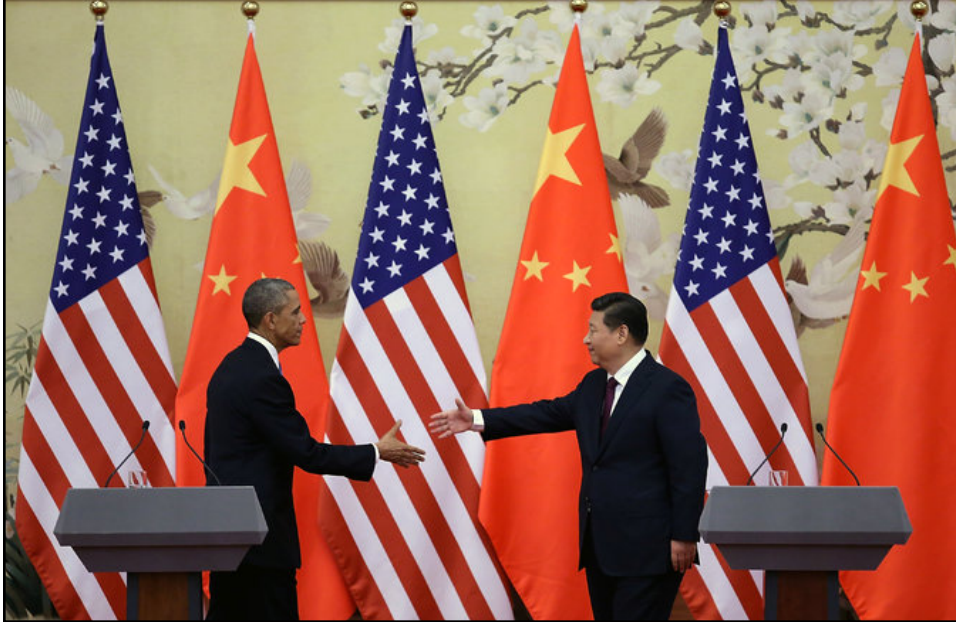


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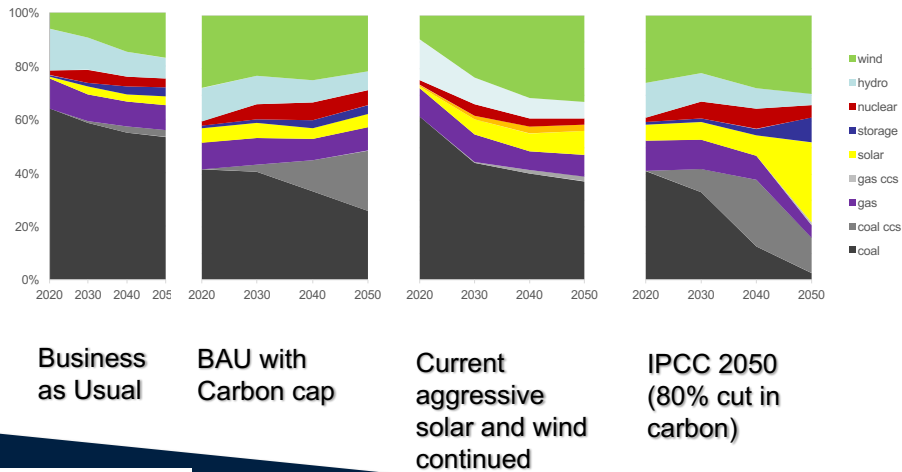
<http://rael.berkeley.edu>

A revolution in climate politics U.S.- China Joint Announcement on Climate Change, 2014



In China even aggressive wind, solar and storage learning alone is not enough to phase out coal

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



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SWITCH-China: A Systems Approach to Decarbonizing China's Power System

Gang He,^{*,†,‡,§} Anne-Perrine Avrin,^{‡,§} James H. Nelson,[⊥] Josiah Johnston,^{‡,§} Ana Mileva,[⊥] Jianwei Tian,[#] and Daniel M. Kammen^{*,‡,§,||}

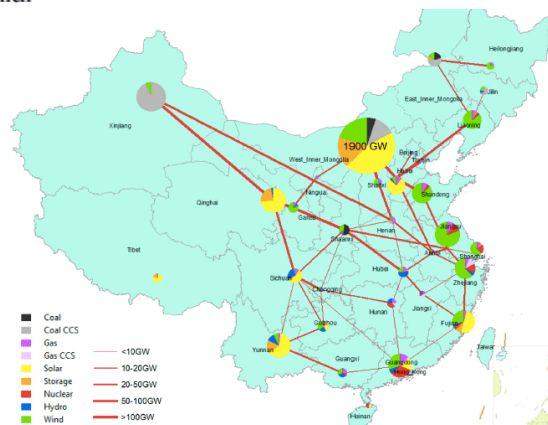
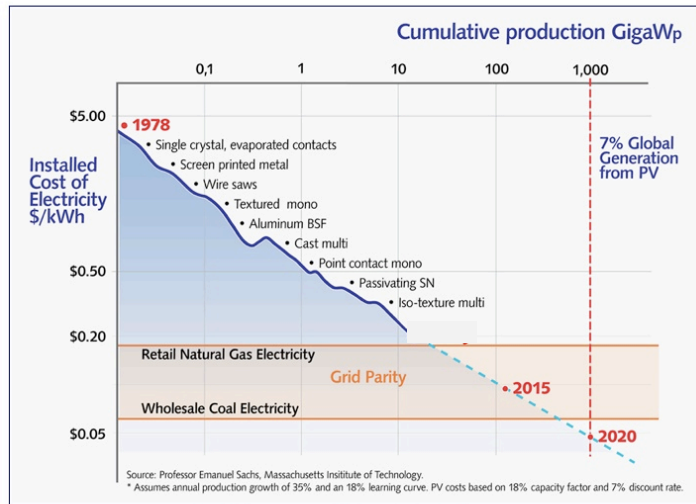


Figure 4. Generation, transmission, and storage capacity needed to achieve an 80% carbon reduction in 2050. All represented lines are new transmission expansion. Inner Mongolia emerges as a major center of clean energy generation thanks to the combination of its location (a few hundred kilometers from major demand centers) and high-quality renewable energy resources.



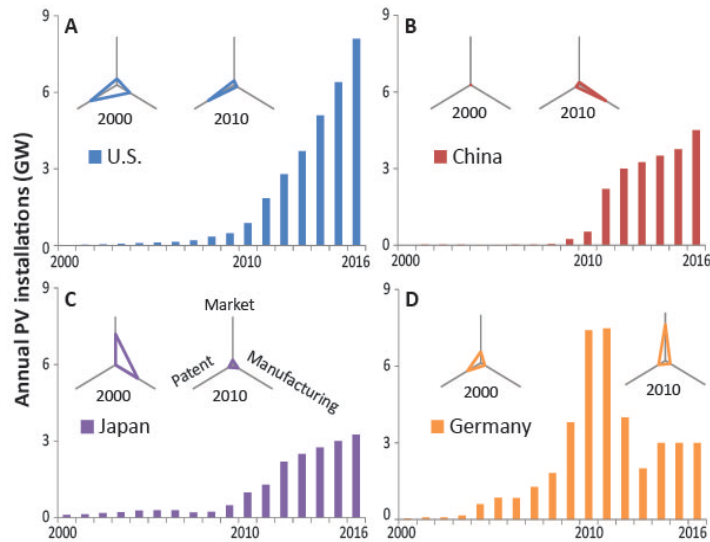
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Solar cost decreases 10% per year

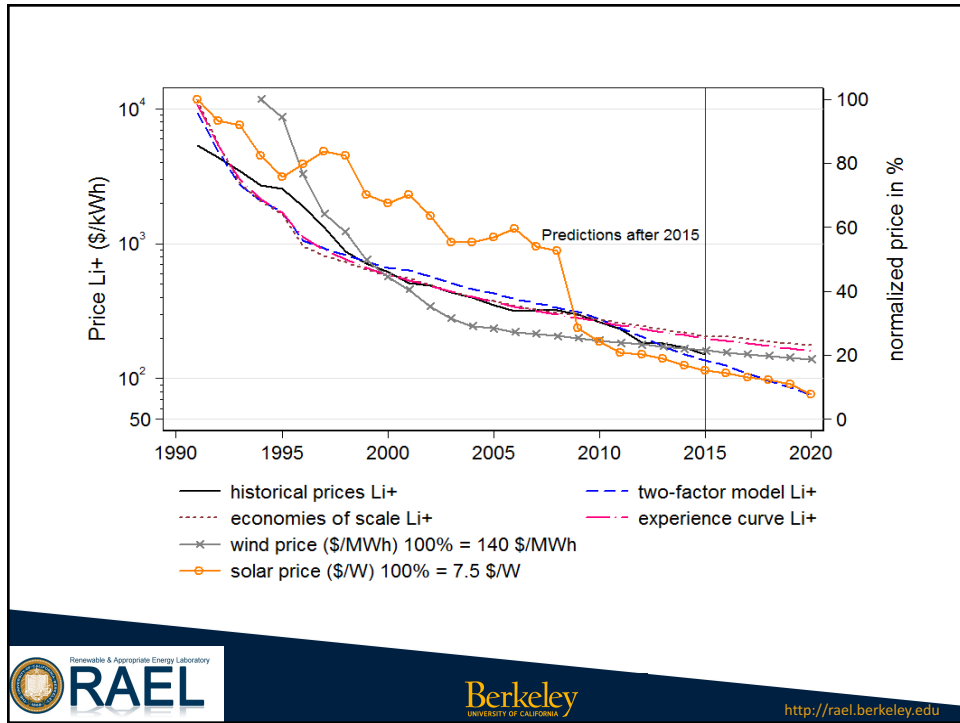


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The Solar Energy Industry is an International Partnership





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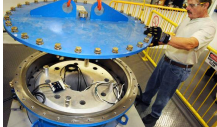



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Energy Storage is Not Just Batteries

Natural gas (without & with storage) 

Traditional and pumped hydropower 

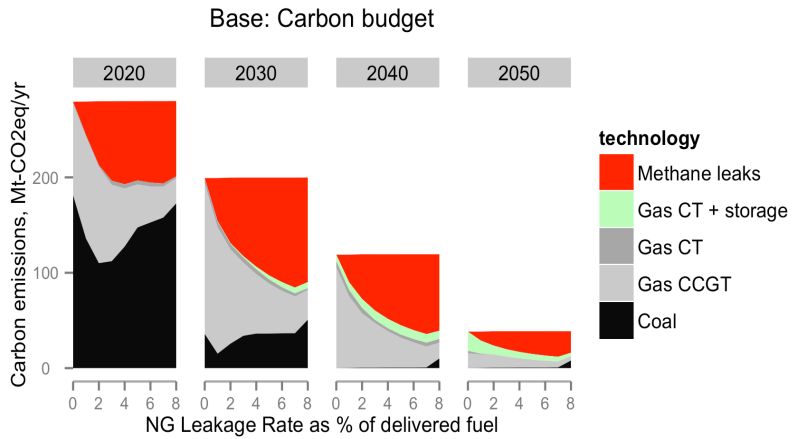
Flywheels 

Flow batteries 



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Example: the impact of Natural Gas Leakage on carbon budgets



Johnstone and Kammen, 2017 in press



<http://rael.berkeley.edu>

Off-grid Electricity Enabled by Storage and Efficient Lights, but ...



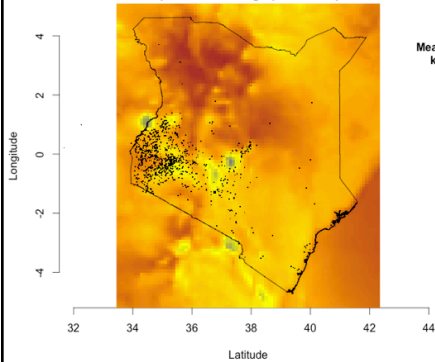
Impossible without secure mobile money



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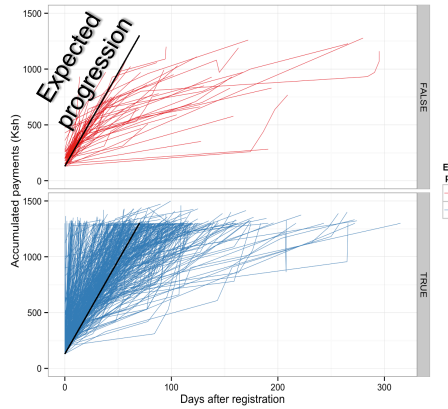
Information Technology Enables Transformative Energy Access Technologies

All SHS with data (n=1025) marked on a map with satellite-derived estimates of solar potential during operations period



Mean Solar Ob:
kWh/m2/day

A vertical color scale legend for Mean Solar Ob: kWh/m2/day, ranging from 4.5 (yellow) to 7.0 (red).



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Policy Analysis

pubs.acs.org/est

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

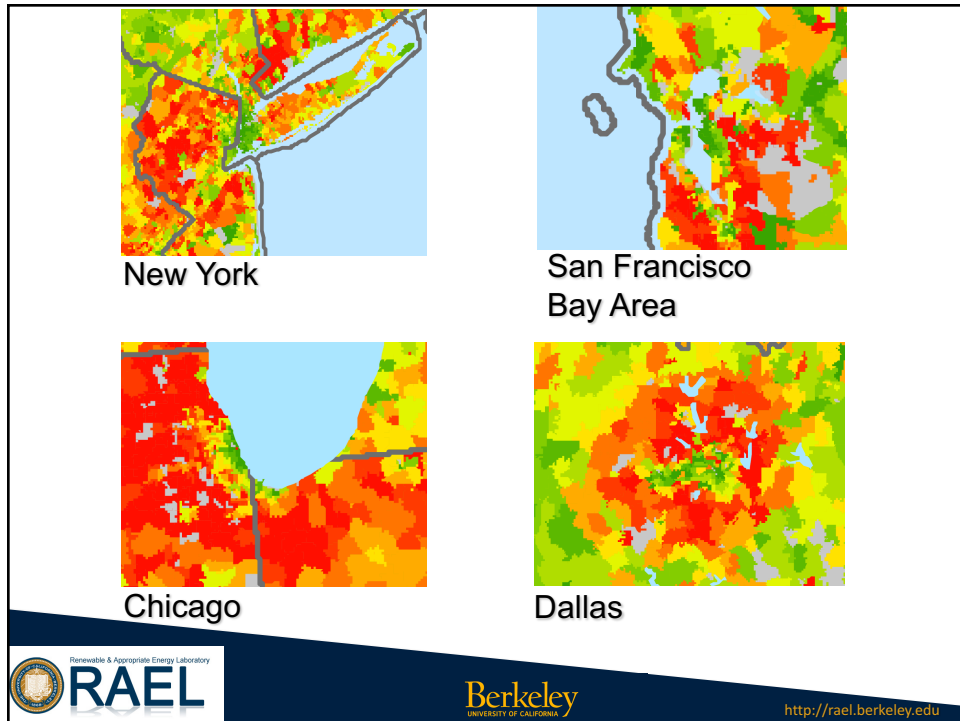
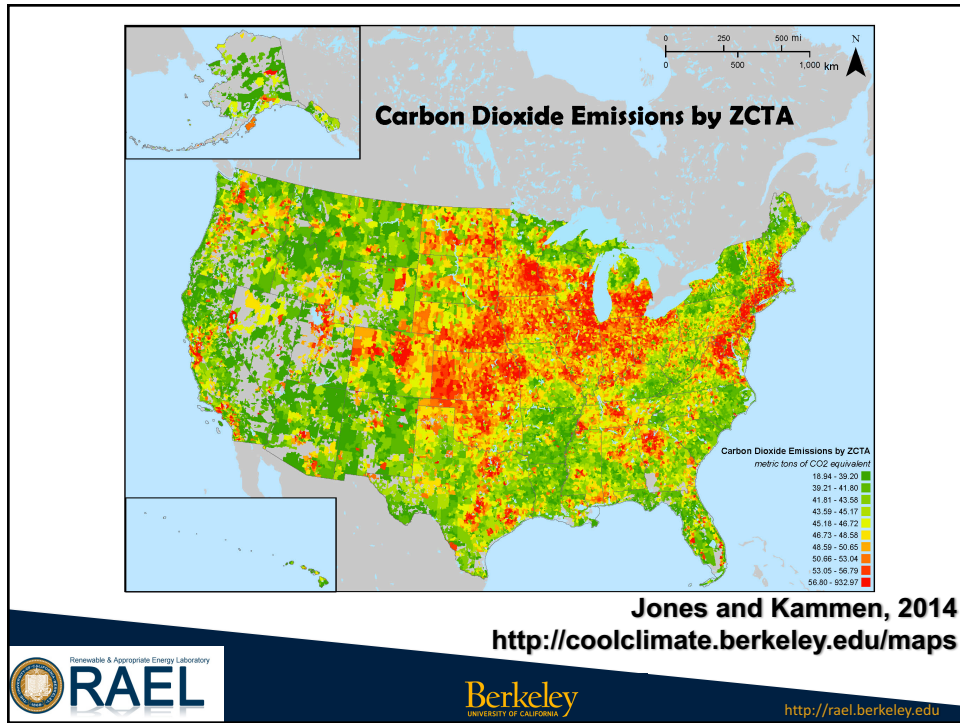
Christopher Jones^{*,†} and Daniel M. Kammen^{*,†,‡,§}

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



<http://rael.berkeley.edu>



Carbon Footprint Summary (tons CO₂e / year)

Category	Footprint
Transportation	14
Housing	2
Food	6
Goods	7
Services	7
Total	36

Climate Action Plan Summary

MY CURRENT FOOTPRINT	41	100%
Pledged reductions	5	12%
Offsets	0	0%
MY NEW FOOTPRINT	36	88%
financial savings per yr	\$2223	
10 year net savings	\$20321	
Payback	0.9	

	mt CO ₂ e/yr reduced	\$ / yr saved	10 year net savings
Buy a More Efficient Vehicle	1.86	\$500	\$3000
Telecommute to Work	1.07	\$528	\$5280
Ride my Bike	0.58	\$156	\$1560
Take Public Transportation	0.47	\$156	\$1560
Practice Eco-Driving	0.93	\$249	\$2490
Maintain my Vehicles	0.71	\$190	\$1900
Reduce Air Travel	0.45	\$100	\$1000
Offset Remaining Transportation Footprint	13.07	-\$261	-\$2610
Switch to CFLs	0.18	\$63	\$721
Turn Down Thermostat in Winter	0.52	\$95	\$950
Turn up Thermostat in Summer	0.15	\$54	\$540
Choose an Energy Star Refrigerator	0.05	\$17	\$140
Dry your Clothes on the Line	0.22	\$75	\$750
Purchase Green Electricity	0	\$0	\$0

Jones and Kammen, 2014
<http://coolclimate.berkeley.edu/maps>

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