Pathways to Urban Sustainability: Energy, Water & Climate Drivers

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Pathways to Urban Sustainability:
A National Academies Workshop

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Blueprint for American Prosperity
Unleashing the Potential of a Metropolitan Nation

Shrinking the Carbon Footprint of Metropolitan America

Marilyn A. Brown, Frank Southworth, and Andrea Sarzynski

America's carbon footprint is expanding. With a growing population and an expanding economy, America's settlement area is widening, and as it does, Americans are driving more, building more, consuming more energy, and emitting more carbon. Rising energy prices, growing dependence on imported fuels, and accelerating global climate change make the nation's growth patterns unsustainable.

Metropolitan America is poised to play a leadership role in addressing these energy and environmental challenges. However, federal policy actions are needed to achieve the full potential of metropolitan energy and climate solutions.

America's Challenge

The nation's carbon footprint has a distinct geography not well understood or often discussed. This report quantifies transportation and residential carbon emissions for the 100 largest U.S. metropolitan areas, finding that metro area residents have smaller carbon footprints than the average American. However, metro footprints vary widely. Population density and the availability of public transit are important to understanding carbon footprints, as are the carbon intensity of electricity generation, electricity prices, and weather.

Limitations of Existing Federal Policy

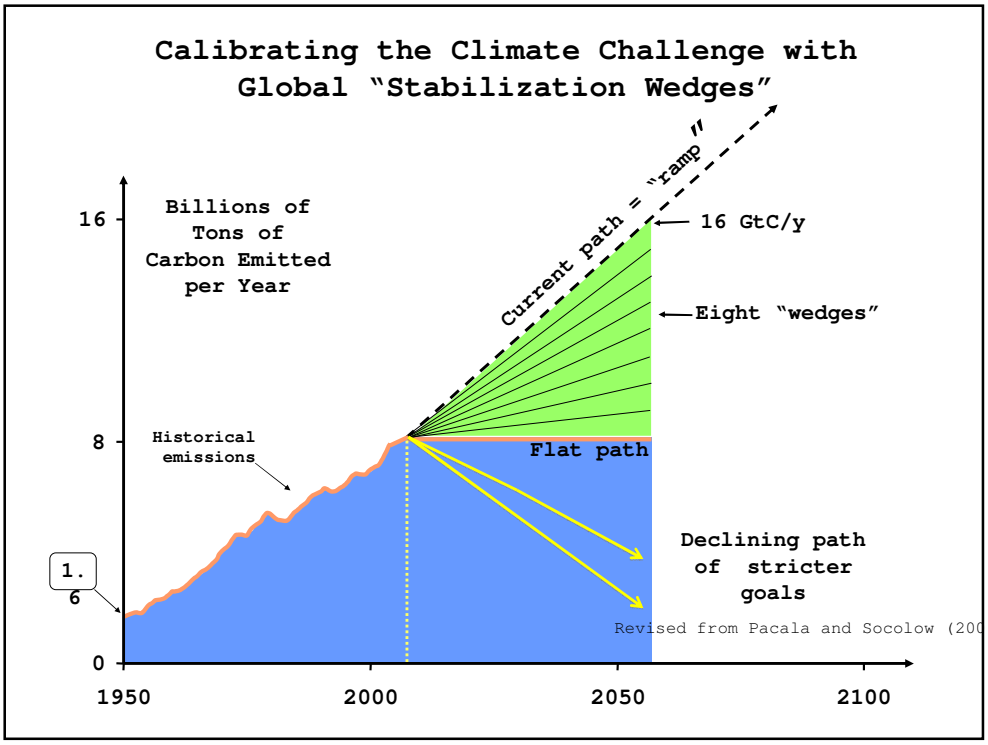
Numerous market and policy distortions inhibit metropolitan actors from more aggressively addressing the nation's climate challenge. Economy-wide problems include underpriced energy, underfunded energy research, missing federal standards, distorted utility regulations, and inadequate information. Policy impediments include a bias against public transit, inadequate federal leadership on freight and land-use planning, failure to encourage energy- and location-efficient housing decisions, and the fragmentation of federal transportation, housing, energy, and environmental policies.

A New Federal Approach

Federal policy could play a powerful role in helping metropolitan areas—and so the nation—shrink their carbon footprint. In addition to economy-wide policies to motivate action, five targeted policies are particularly important within metro areas and for the nation as a whole:

- ***Promote more transportation choices*** to expand transit and compact development options.
- ***Introduce more energy-efficient freight operations*** with regional freight planning.
- ***Require home energy cost disclosure when selling and "up-side" financing*** to stimulate and scale up energy-efficient retrofitting of residential housing.
- ***Use federal housing policy*** to create incentives for energy- and location-efficient decisions.
- ***Issue a metropolitan challenge*** to develop innovative solutions that integrate multiple policy areas.

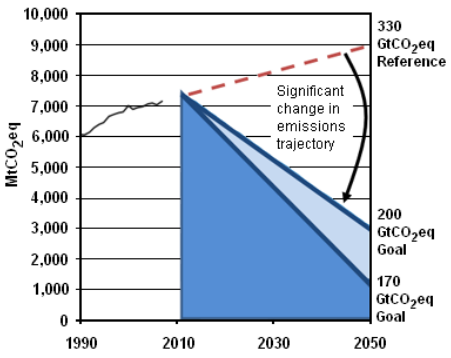
Metropolitan Policy Program



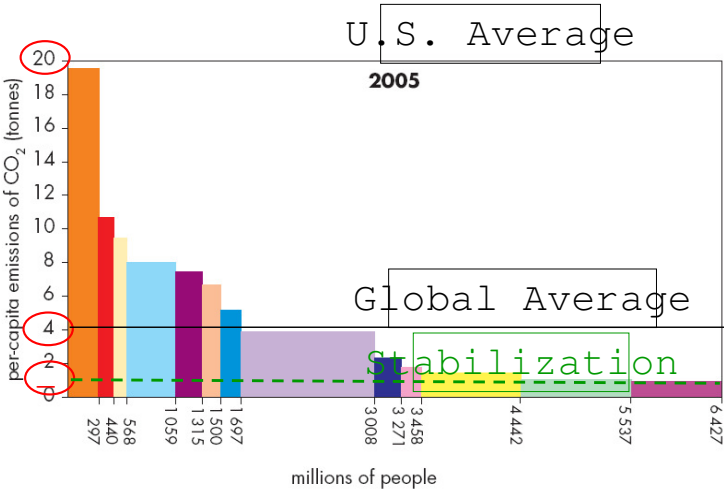
The U.S. Needs to Set a Cumulative GHG Emissions Budget

The National Academies report – "Limiting the Magnitude of Climate Change" – offers a representative range of 170–200 gigatons (Gt) of CO_2-eq for 2012–2050.

Business-as-usual emissions would consume these budgets well before 2050; thus, the case for URGENCY.

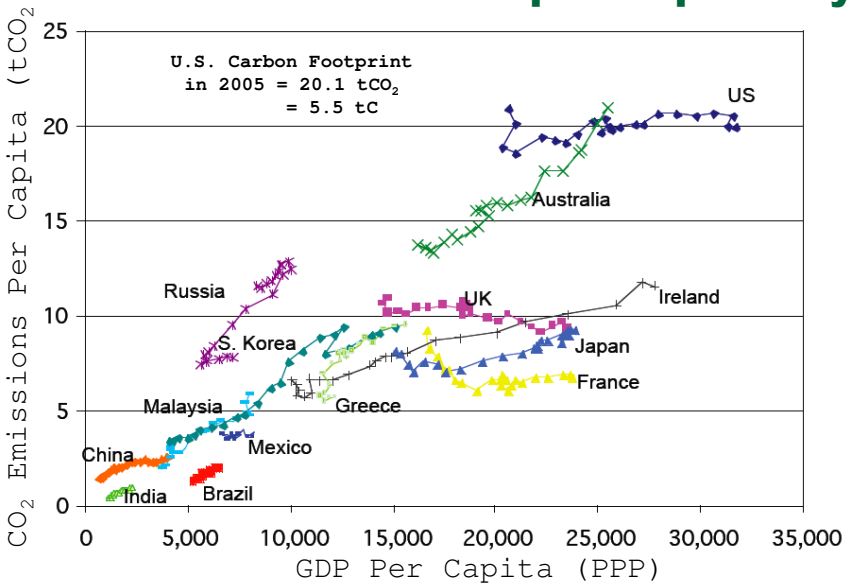


The emissions of the rich eventually must equal the emissions of today's poor



Source: IEA WEO 2007 and Socolow (2009)

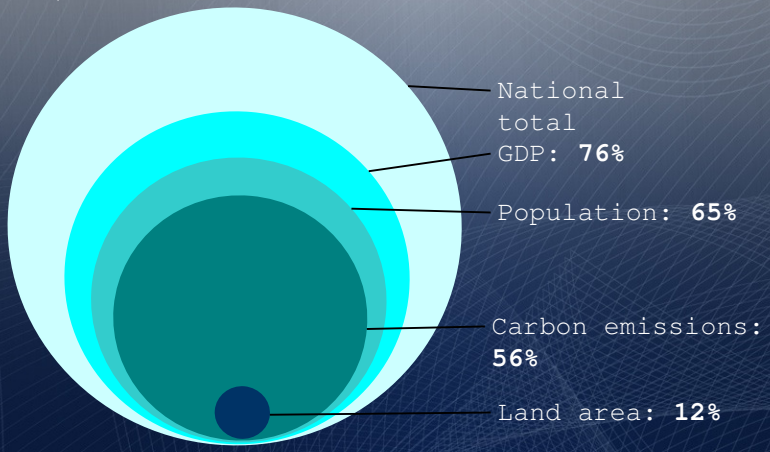
National carbon footprints illustrate the need for alternative development pathways



Sources: Steve Koonin, BP (2007): IEA, 2007, *Key World Energy Statistics*.

Cities can be part of the solution: they offer the potential for great energy and carbon efficiencies

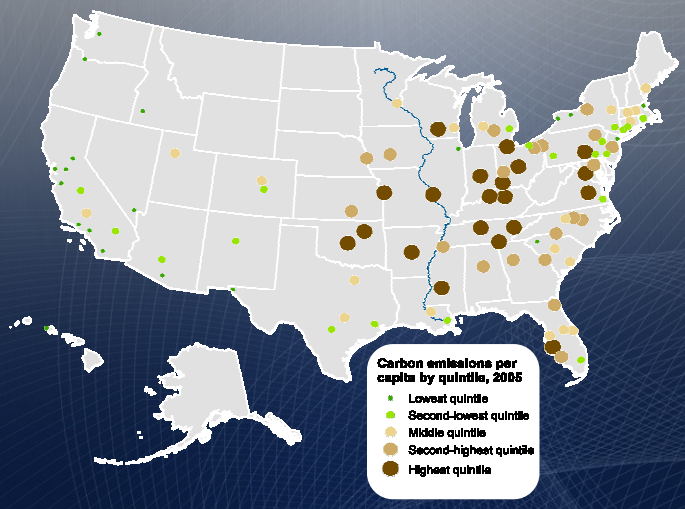
Percentage of national activity in 100 largest metro areas, 2005



Per capita emissions vary substantially, illuminating what works and what doesn't

Largest per capita carbon footprints, 2005	Tons of carbon per capita	Smallest per capita carbon footprints, 2005	Tons of carbon per capita
Lexington, KY	3.455	Honolulu, HI	1.356
Indianapolis, IN	3.364	Los Angeles, CA	1.413
Cincinnati, OH	3.281	Portland, OR	1.446
Toledo, OH	3.240	New York, NY	1.495
Louisville, KY	3.233	Boise City, ID	1.507
Nashville, TN	3.222	Seattle, WA	1.556
St. Louis, MO	3.217	San Jose, CA	1.573
Oklahoma City, OK	3.204	San Francisco, CA	1.585
Harrisburg, PA	3.190	El Paso, TX	1.613
Knoxville, TN	3.134	San Diego, CA	1.630

The Mississippi River roughly divides the country into high and low emitting metropolitan areas



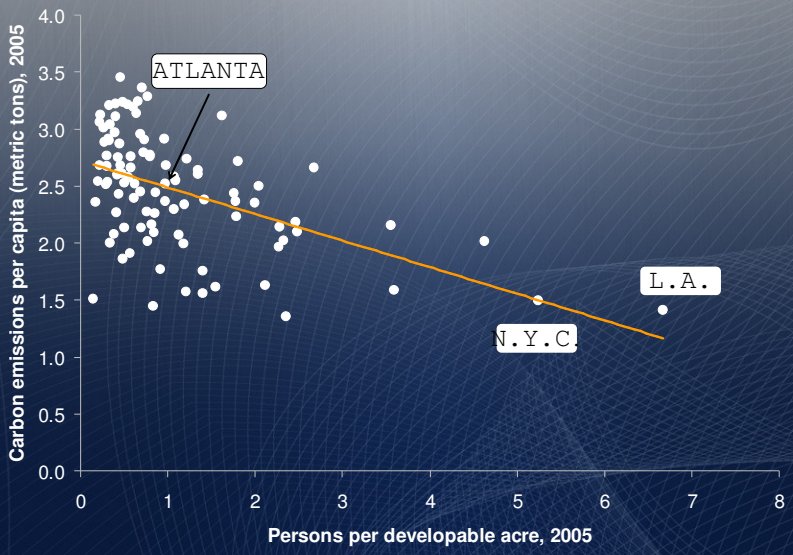
Fuel mix and electricity prices are important determinants of emissions

- The fuel mix used to generate electricity matters in residential footprints
- Lower electricity prices are correlated with larger residential footprints
- Areas with lower residential building carbon footprints tend to be located in mild climates with low heating and cooling requirements

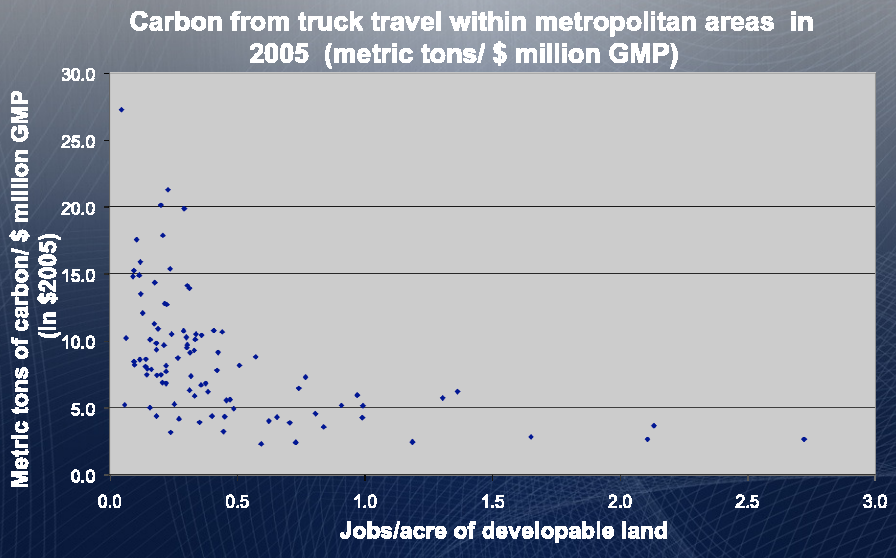
Development patterns and rail transit play an important role in determining carbon emissions

- Density and concentration of development tend to be higher in the lowest-emitting metro areas
- Many metro areas with small per capita carbon footprints also have sizeable rail transit ridership
- Dispersed employment causes high car and truck carbon emissions

Denser metro areas tend to have lower per capita carbon footprints

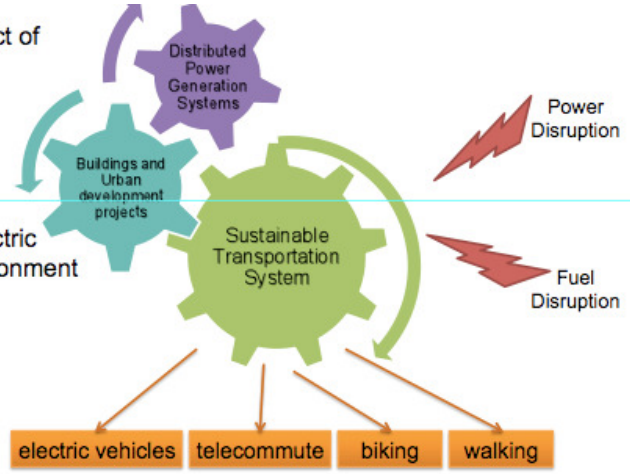


persed Employment Increases Truck Emissi



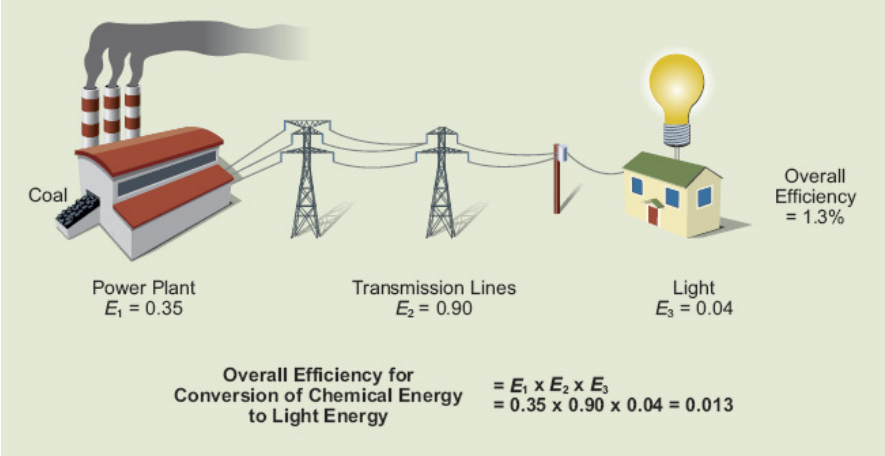
Sustainable, Resilient Transportation

- Transportation effect of densification
- Integration across infrastructures (electric vehicles, built environment design)



Source: Valerie Thomas and Efrain O'Neal (2010)

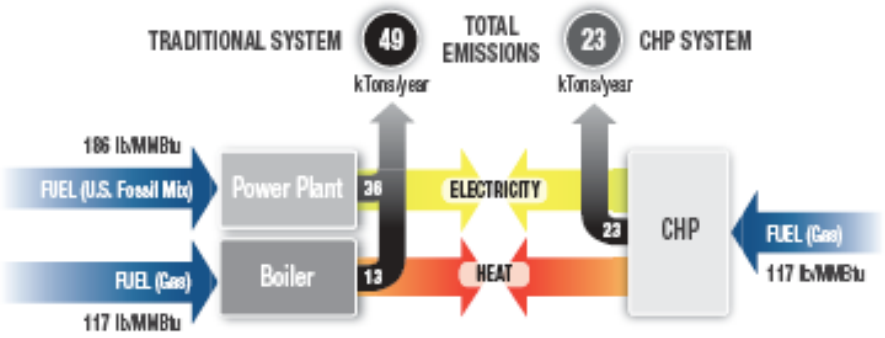
U.S. Energy System is Highly Inefficient



Source of calculations: Suplee, Curt, Allen Bard, Marilyn Brown, Mike Corradini, and Jeremy Mark. 2008. "What you Need to Know About Energy," National Academy of Sciences, http://sites.nationalacademies.org/energy/Energy_043338

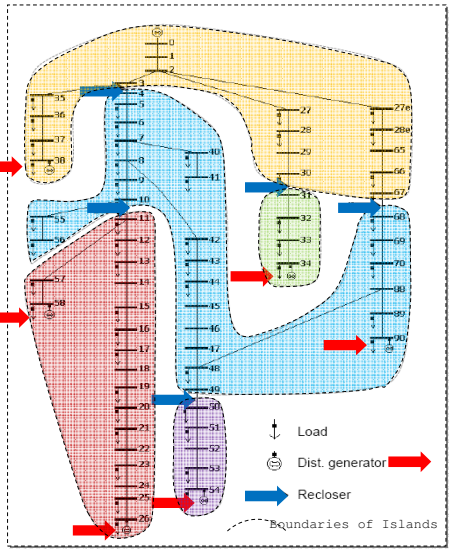
The Benefits of Infrastructure Ecology

- Reorganizing the linkage among individual infrastructure systems is like changing food chains in ecology.
- Co-locating power production and productive uses of heat can double resource efficiencies and cut pollution in half.
- This ***infrastructure ecology*** has a high potential to significantly contribute to solving the gigaton problems.



Source: ORNL, 2008, p. 11

Reliability and Resilience with Distributed Electricity Resources



Source: Begovic, M; GT

Optimal topologies of feeders, substations, and microgrids for the infusion of distributed generation

↓

Reclosers allow the possibility of system separation into islands (outlined by dashed lines) to isolate disturbances

↓

Result: positive impact on overall reliability and resilience of feeders, but requires optimization of topologies

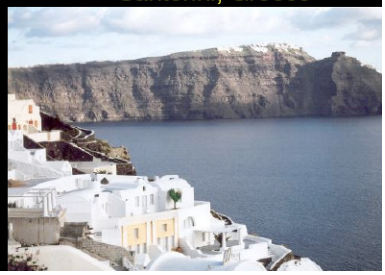
Mitigating and Adapting to Climate Change

Dallas, Texas

White roofed buildings:

Sunlight energy is reflected back into space rather than heating up buildings and homes in the summer.

Santorini, Greece

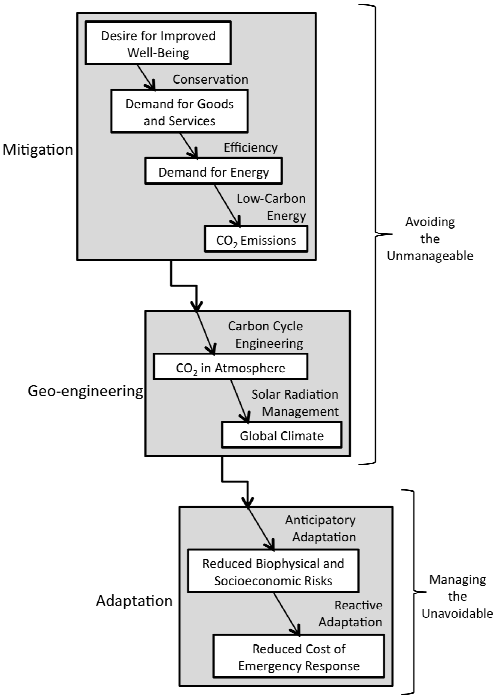


Retrofitting urban roofs and pavements with solar-reflective materials is equal to eliminating carbon emissions from all automobiles for 11 years.

Source: Secretary Steven Chu. 2010. *Driving Global Progress on Clean,* Clean Energy Ministerial, July 20, 2010, Washington, DC

Three general approaches for dealing with global climate change:

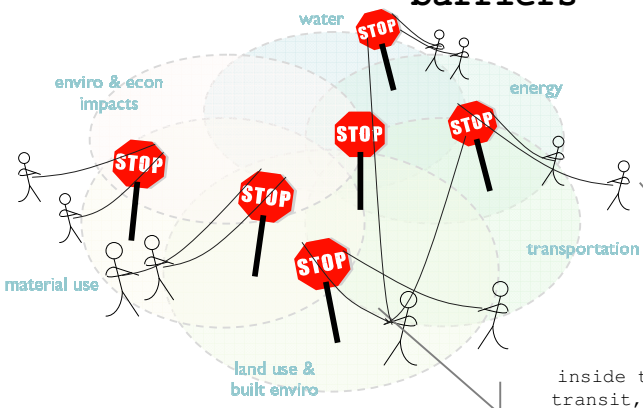
✓Mitigation
✓Geo-engineering
✓Adaptation



Source: Marilyn Brown and Benjamin Sovacool 2011.
Climate Change and Global Energy Security: Technology and Policy Options (MIT Press).

Adoption and Diffusion Barriers

Interrelated urban systems means interrelated **barriers**



outside the system: culture, innovation, federalism

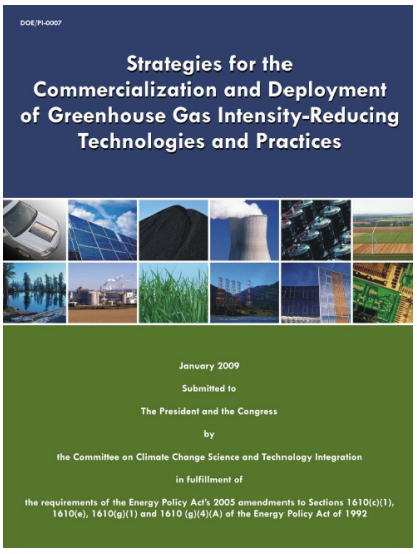
inside the system: lack of transit, zoning, old pipes, ineffective incentives, lack of information, inertia, organizational flaws, etc.

~~N.V. positive investments~~ in energy efficiency face numerous barriers.

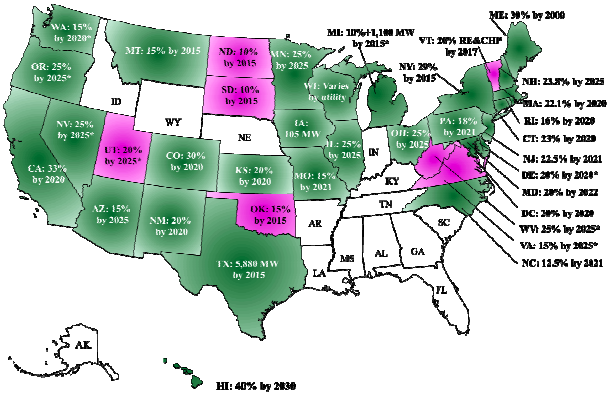
This report has an excellent description of these (www.cliimatetechnology.gov)

For further details, see:

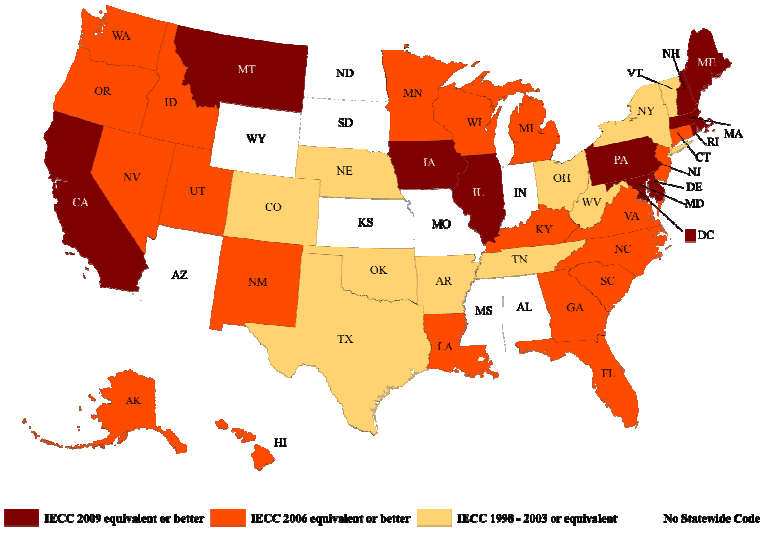
Brown, Marilyn A. and Sharon (Jess) Chandler, 2008. "**Governing Confusion**: How Statutes, Fiscal Policy, and Regulations Impede Clean Energy Technologies," *Stanford Law and Policy Review, (19) 3: 472-509.*



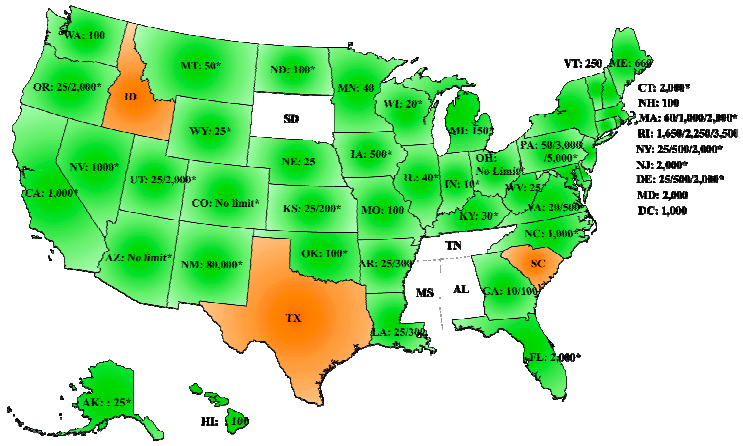
Renewable Electricity Standards: Few Exist in the South



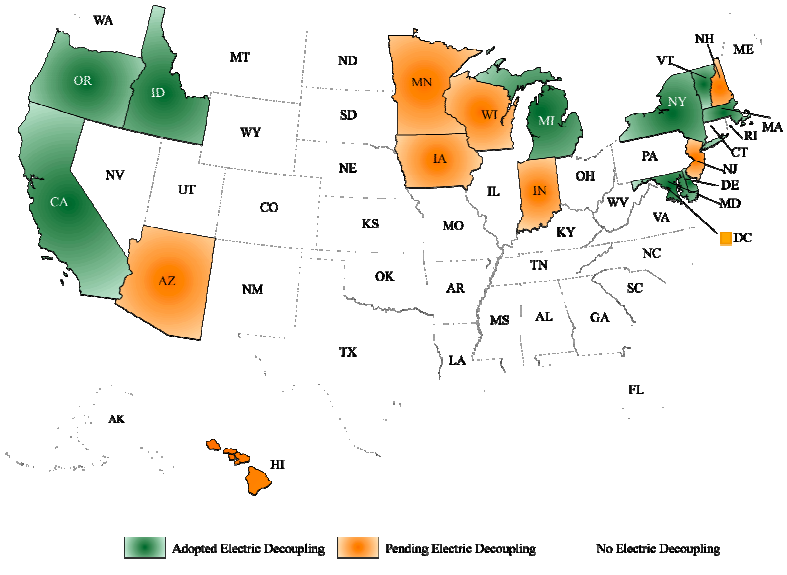
State Building Codes: A Chaotic Policy Landscape



Net Metering: Variable and Limiting

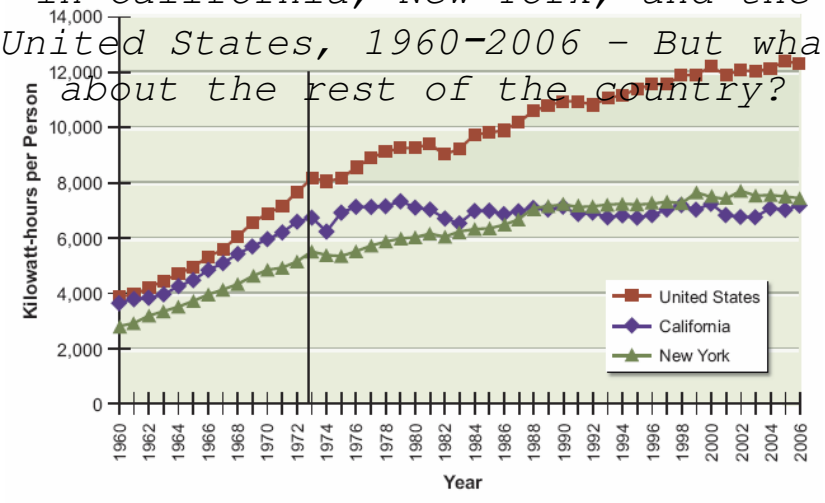


Electricity Decoupling: Utility Profits Remain Tied to Electricity Sales



State Policies Can Make a Difference

Per capita electricity consumption in California, New York, and the United States, 1960-2006 – But what about the rest of the country?



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Energy Efficiency in the South

Marilyn Brown, Etan Gumerman, Xiaojing Sun, Youngsun Baek, Joy Wang, Rodrigo Cortes, and Diran Soumonni

www.seealliance.org

The Energy Foundation

THE KRESGE FOUNDATION

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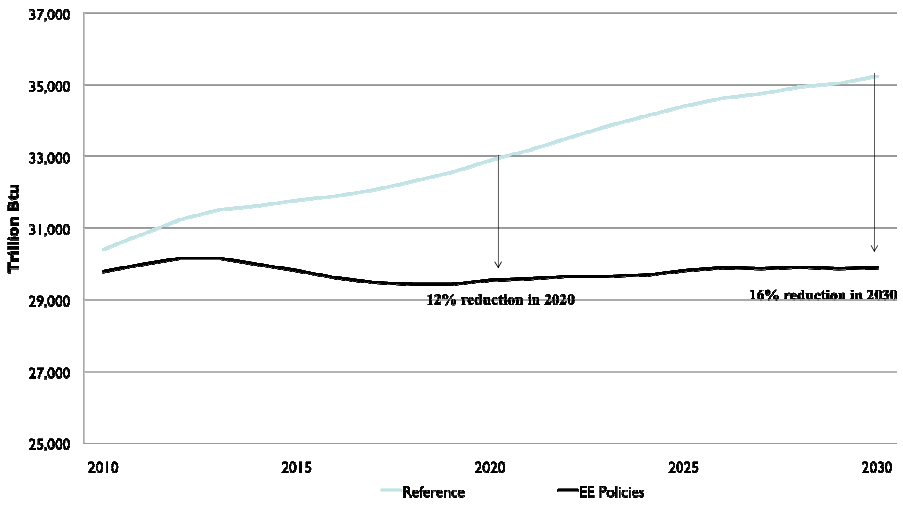
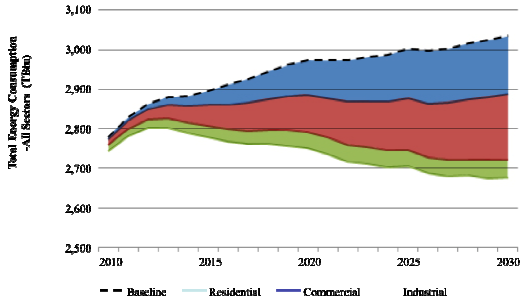
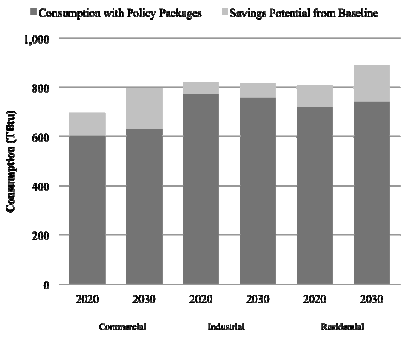
Primary Energy Consumption Projections (RCI Sectors) in the South



Georgia

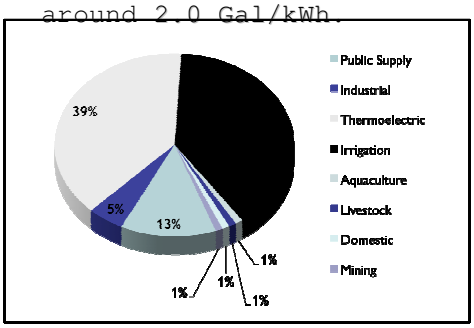




Indicator	2020	2030
Public Sector Policy Financial Incentives (in million $2007)	882	1,299
Private Sector/Household Productive Investment (in million $2007)	349	391
Change in Electricity Costs (in million $2007)	-2,070	-3,824
Change in Natural Gas Costs (in million $2007)	-341	-513
Annual Increased Employment (ACEEE Calculator)	32,200	43,100
Change in Gross State Product (in million $2007)	70	94

Water for Energy in the U.S.: A Co-Benefit of Saving Electricity

- Thermoelectric power generation accounts for approximately 39% of total freshwater consumption and 52% of fresh surface water withdrawals..
- The average (weighted) evaporative consumption of water for power generation over all sectors is around 2.0 Gal/kWh.



US Freshwater withdrawals by sector
(Total withdrawal: 345

Energy Source	Gal/kWh (Water Consumption)
Hydro	18.27
Nuclear	0.62
Coal	0.49
Oil	0.43
PV Solar	0.030
Wind	0.001

Source: US DOE, *Energy Demand on Water Resources*, 2006

Historic Energy/Environment Regulatory Focus on Industry

- Since the explosion of environmental regulation in the early 1970s, policymakers have focused most regulatory prescriptions on large industrial sources.
- Thus, controlling emissions from cars = adoption of fuel economy standards for manufacturers.
- Controlling emissions from residential electricity use = regulating the building industry + rate reform for utilities.

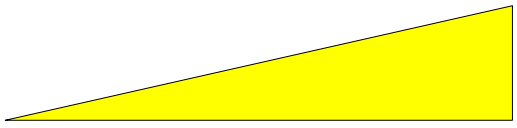
Yet Consumers are Increasingly the Driving Force of Domestic Energy/Carbon

- Schipper, et al. (1989) = 45-55% of energy use
- Vandenergh and Steinemann (2007) = 32% of carbon emissions
- Bin and Bin, S. and H. Dowlatabadi (2005) = More than 80% of the energy used and the CO2 emitted in the U.S. are a consequence of consumer demands and the economic activities to support these demands.

The Behavioral Wedge

"Household Actions Can Provide a Behavioral Wedge to Rapidly Reduce U.S. Carbon Emissions"

Dietz, T., G. T. Gardner, J. Gilligan, P. C. Stern, and M. P. Vandenbergh. 2009. *Proceedings of the National Academy of Sciences.* http://www.pnas.org/content/106/44/18452.



17 types of household actions can reduce energy consumption with available technology, low cost, and without appreciable lifestyle changes.

Grounds for Optimism

- Carbon emissions are just beginning to be priced – "market signals" will spur innovation.
- Most of the 2050 physical plant is not yet built – with growth comes opportunity.
- Our urban energy systems could be made much more efficient – reducing emissions and creating jobs.

✓ Can barriers be overcome and behavior be changed at