Science and Policy for Deep Cuts in Carbon Emissions

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Materials online at: http://rael.berkeley.edu

APS, UC Berkeley, February 29, 2008

Outline

- The most common call for a new energy economy is for diversity
  - Operationally, what does this mean?
- Energy efficiency has been the greatest success to date, more are needed, and fast
- Carbon accounting and pricing is essential
- Developing nations will be the locus of many of the largest impacts and opportunities to build the clean-energy economy, or to exert the most social and environmental damage
- A foundation for a new wave of research and development requires investment and a outlet for implementation

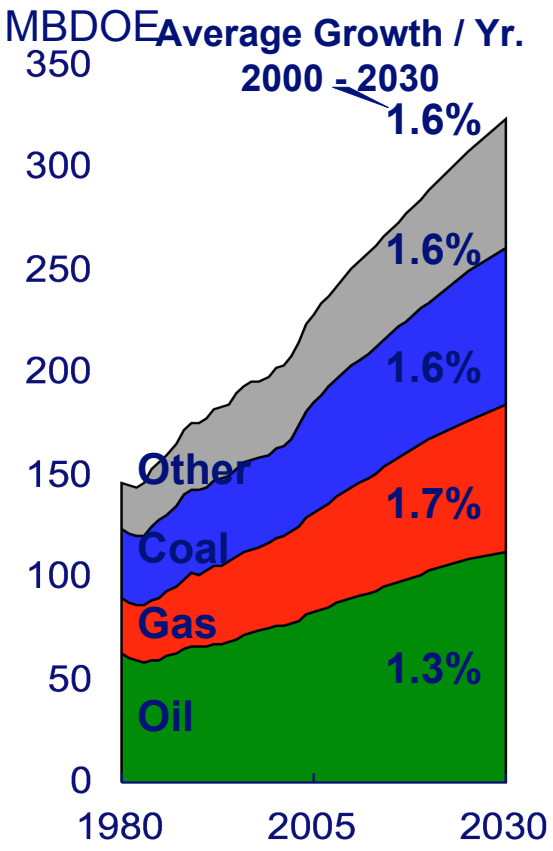
Global Energy Supply by Fuel

A massive carbon Baseline & inertia

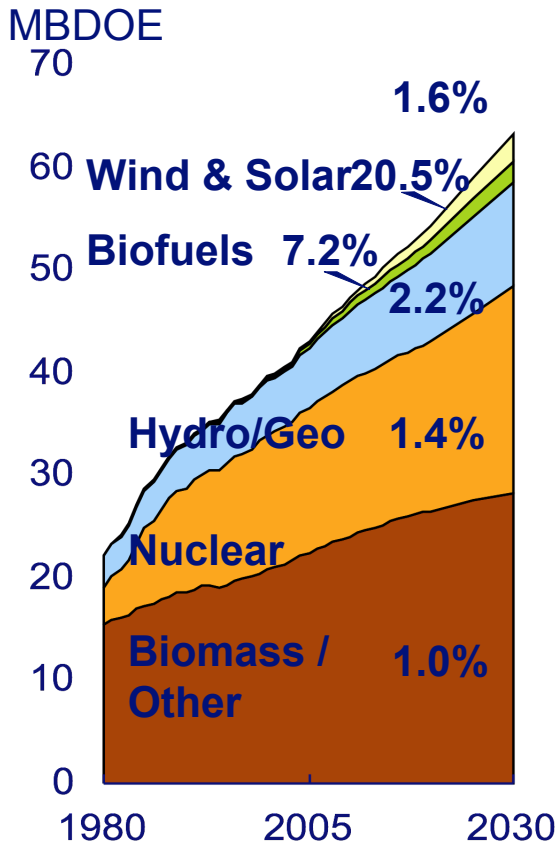
Sufficient opportunities exist

Fastest growth, smallest sectors

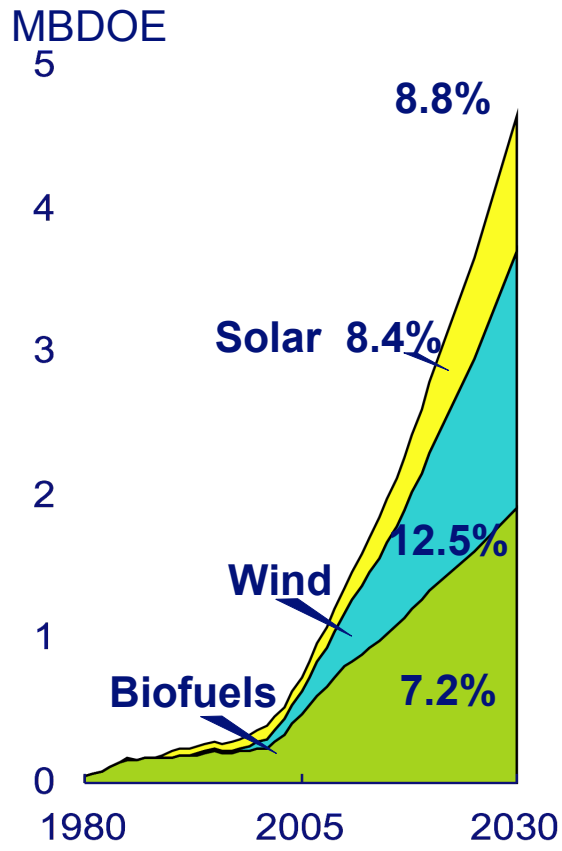
Fossil Energy



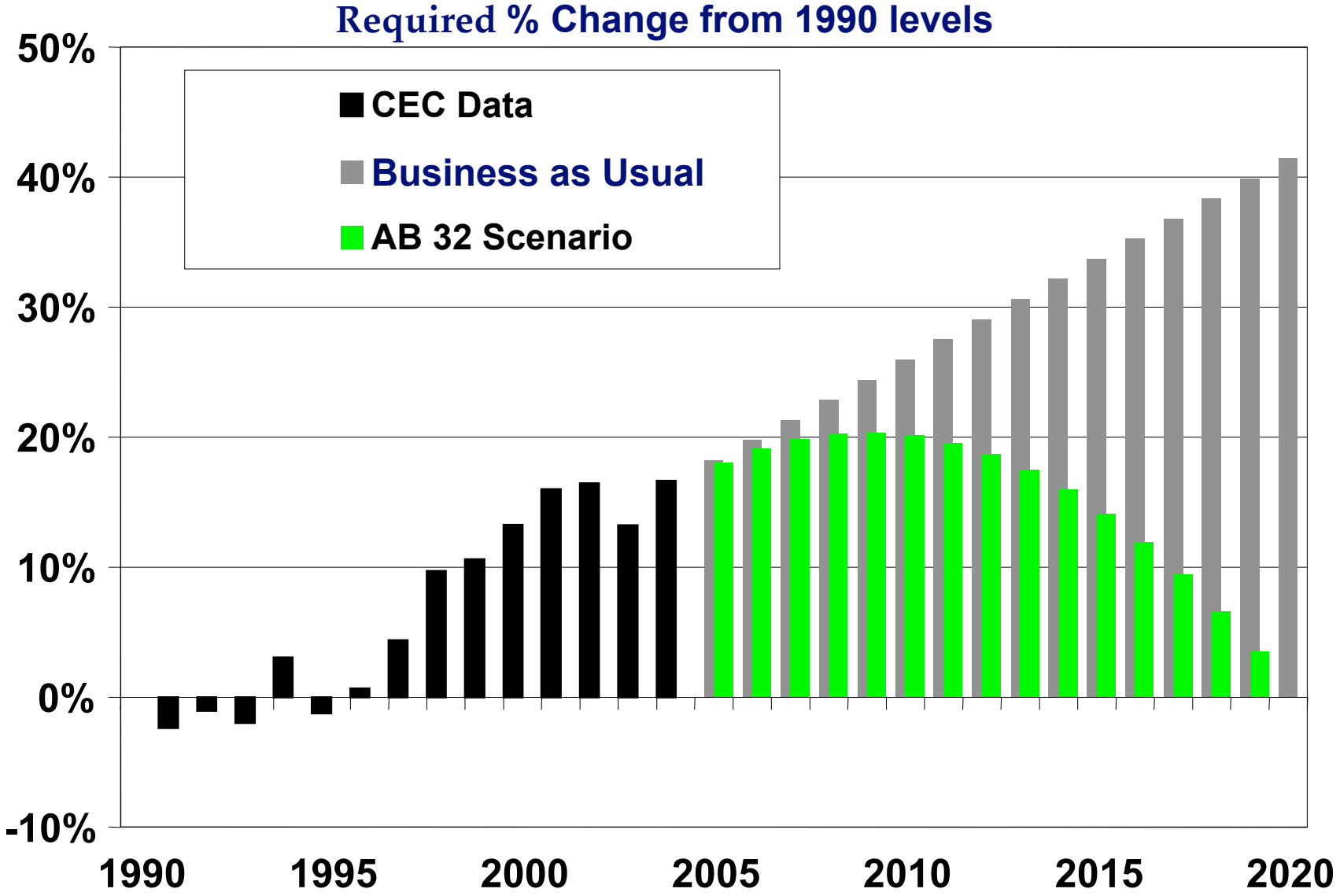
Other Energy



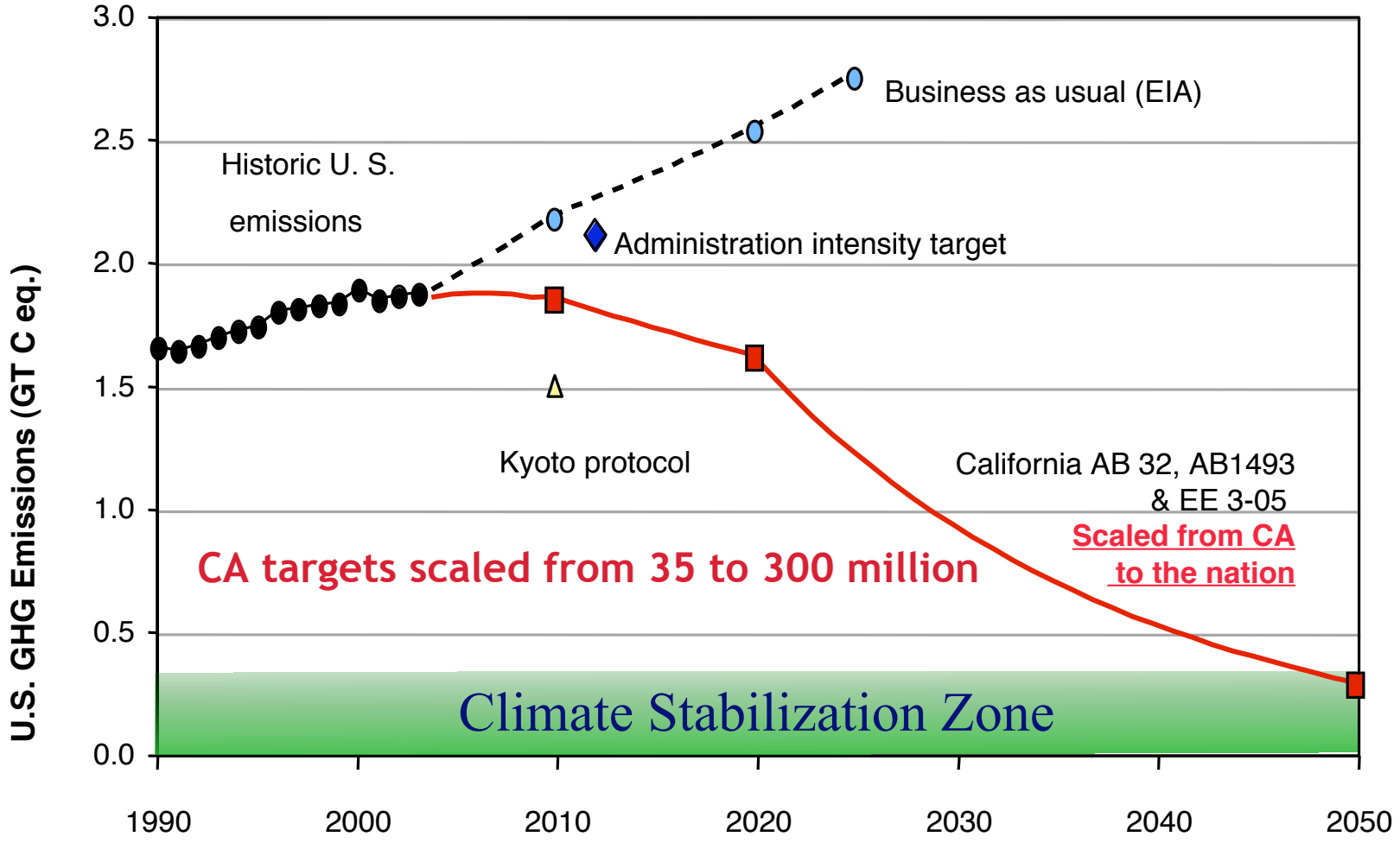
Wind, Solar & Biofuels



Calif.: AB 32 Emissions Reductions

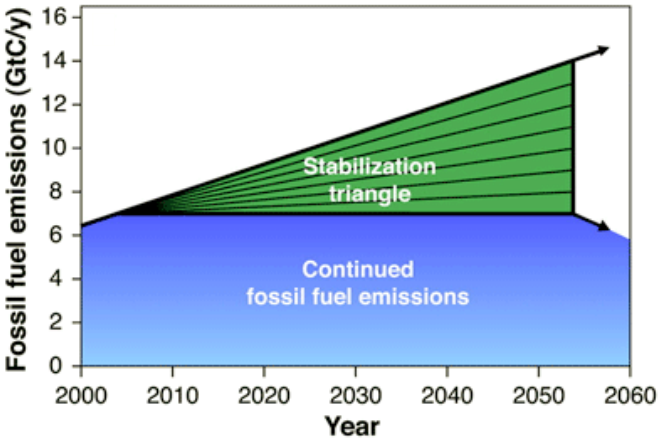


The California commitment - scaled to the nation

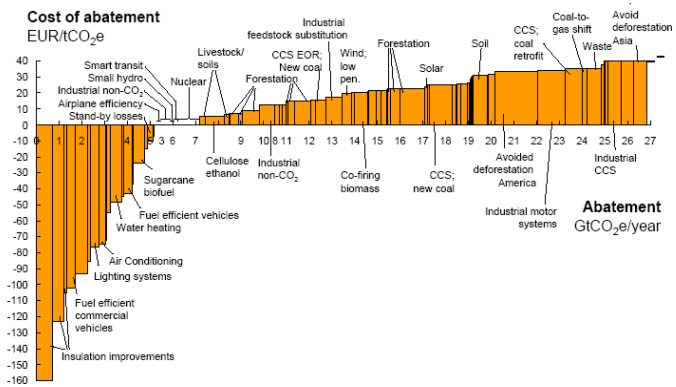


Kammen, "September 27, 2006 – A day to remember", *San Francisco Chronicle*, September 27,

C^3: taking the next step



and/or

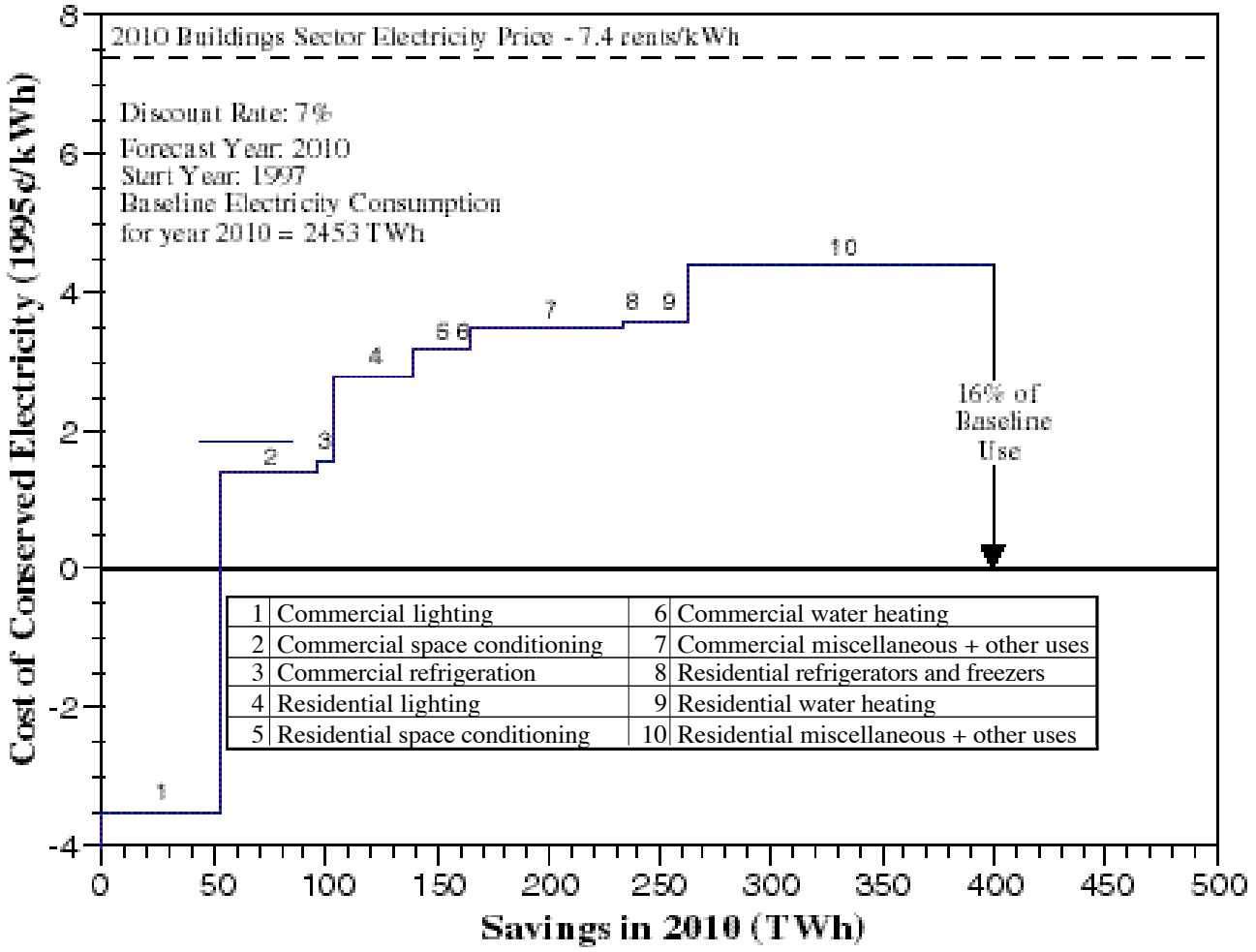


C^3

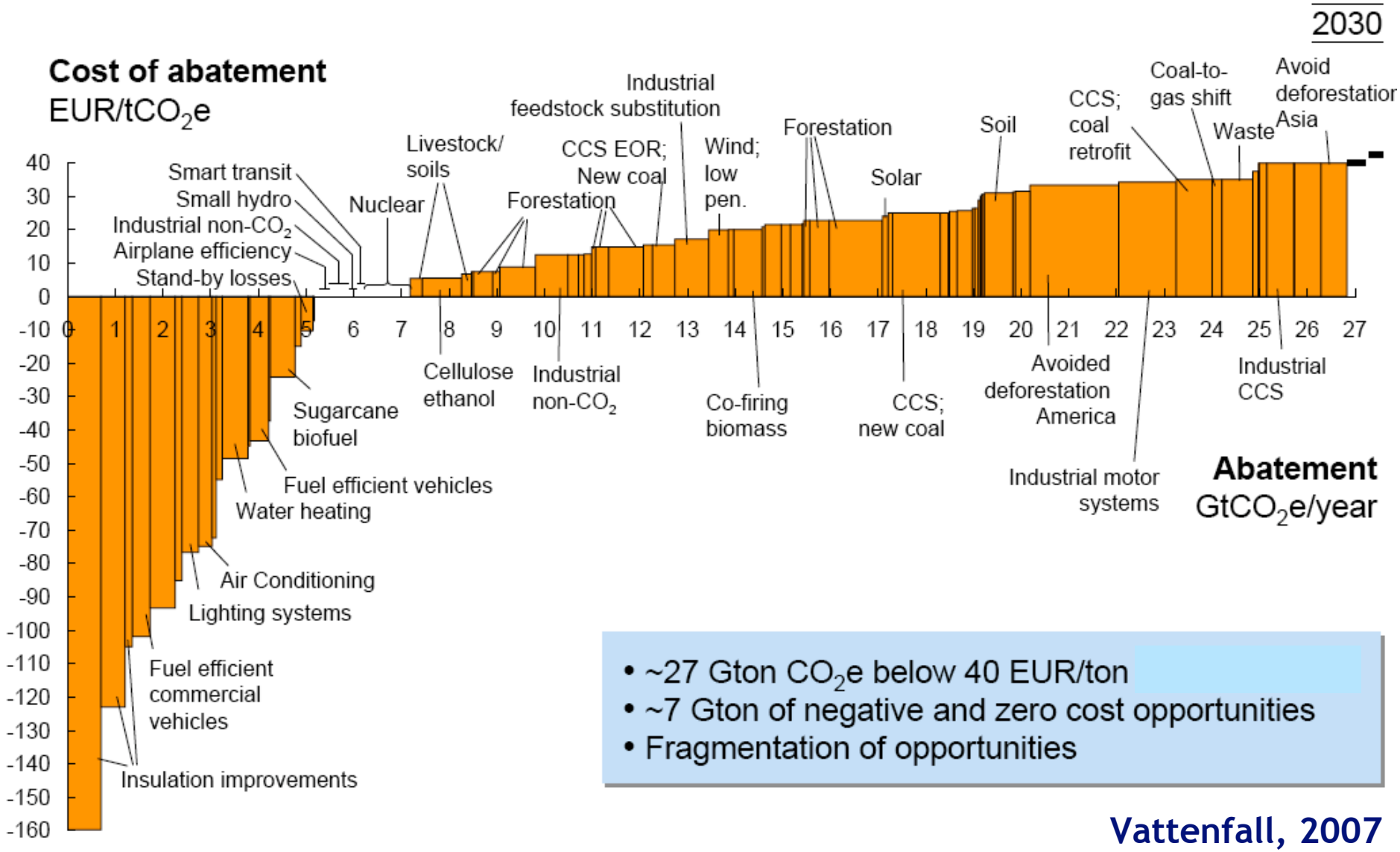
Dynamic ◆ Up-to-date ◆ Flexible ◆ Transparent ◆ Open

Costs of Conserved Energy

Potential Electricity Savings from High-Efficiency Case in 2010 (**5 Labs study**: many authors in this room today)



Global CO_2 Abatement Opportunities



- ~27 Gton CO_2e below 40 EUR/ton
- ~7 Gton of negative and zero cost opportunities
- Fragmentation of opportunities

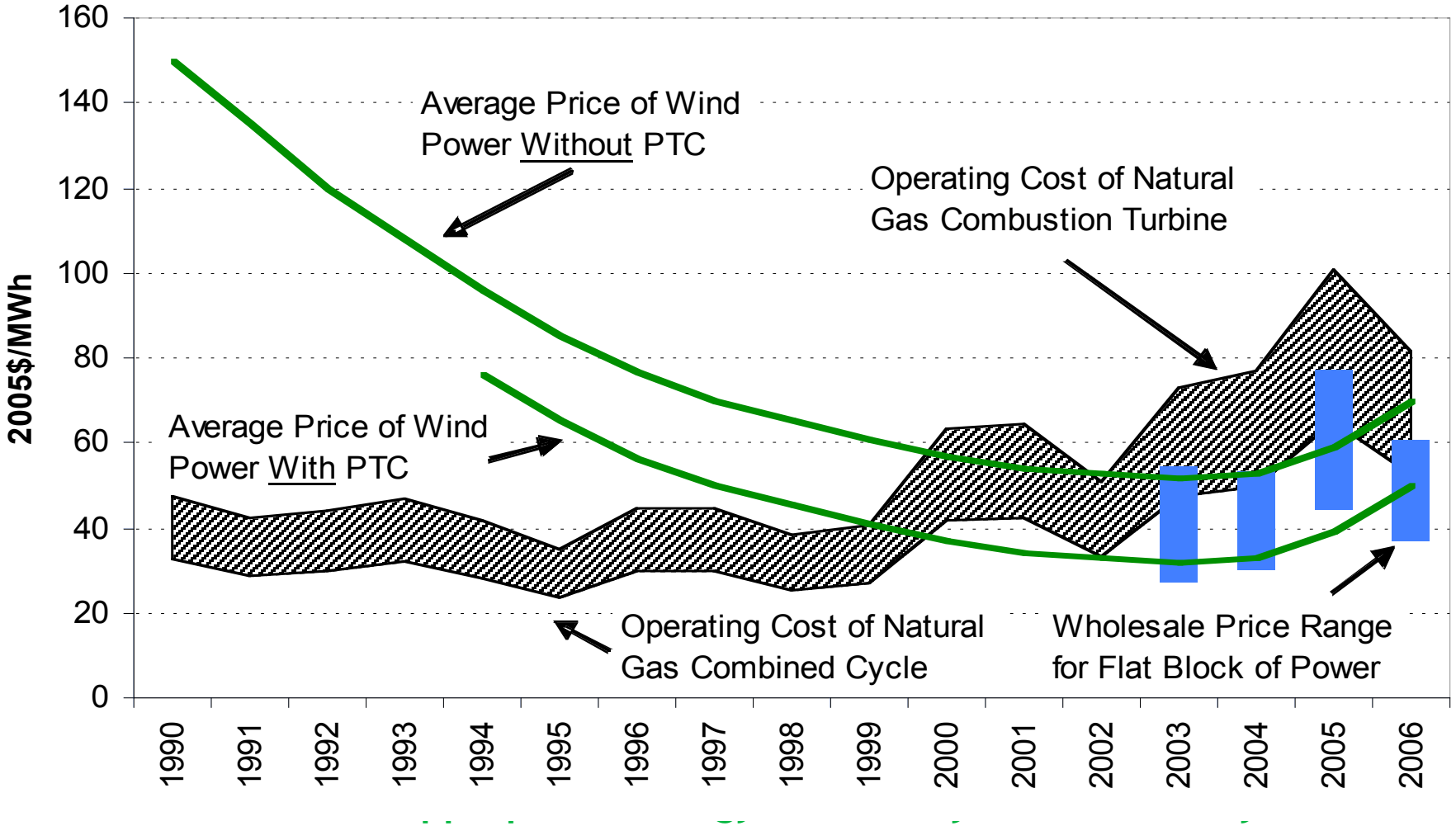
Vattenfall, 2007

C3/GtT Team

- Prof. Dan Kammen, ERG/GSPP/Nuc. Eng -- Advisor
- Joe Kantner, ERG – Team Co-Leader; Presentations; Linkages; Solar PV
- Ian Hoffman, ERG – Team Co-Leader; Nuclear; Solar Thermal; Wind; Qualitative Indices
- Jon Mingle, ERG – Energy Efficiency
- Eric Gimon, LBL – Nuclear; Solar Thermal
- Joe Levin, GSPP – Nuclear; Integration/Standardization
- Anna Motschenbacher, ERG – Presentations; Linkages; Biophysical Feedbacks
- Suzie Shin, ERG – Presentations; Integration/Standardization
- Jameel Alsalam, GSPP – Solar Thermal
- Josiah Johnston, ERG – Integration/Standardization; Wiki/Open Collaboration
- Sam Borgeson, ERG/ARCH – Energy Efficiency
- Alexia Byrne, ME -- Wind
- Ryoichi Komiyama, LBL – LDNE Model
- Thomas Goerner, Haas – Solar Thermal
- Zack Norwood, ME – Solar Thermal
- Kat Saad, CE – Integration/Standardization; Solar PV
- Anand Gopal, ERG -- Biomass

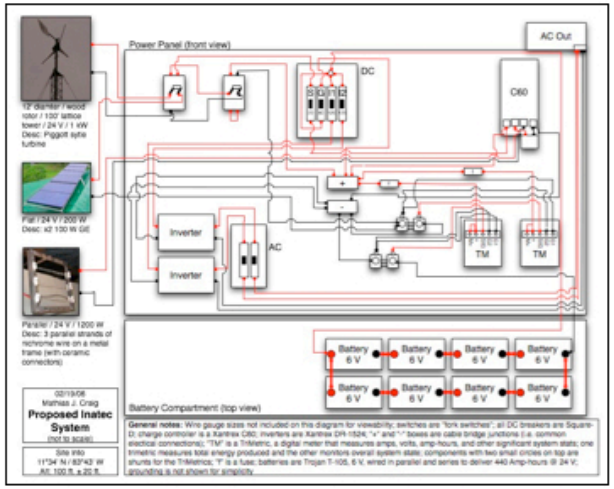
Low-carbon technologies as least-cost, fast-deployment, technology options: wind

(ptc: US production tax credit)



80% of rural Nicaragua lacks electricity

blueEnergy – an example NGO energy service provider based on the tlantic Coast

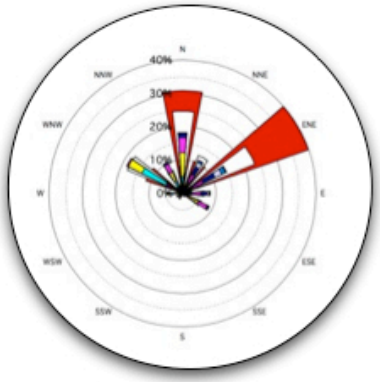


Turbine

Tower

Solar

Power Center



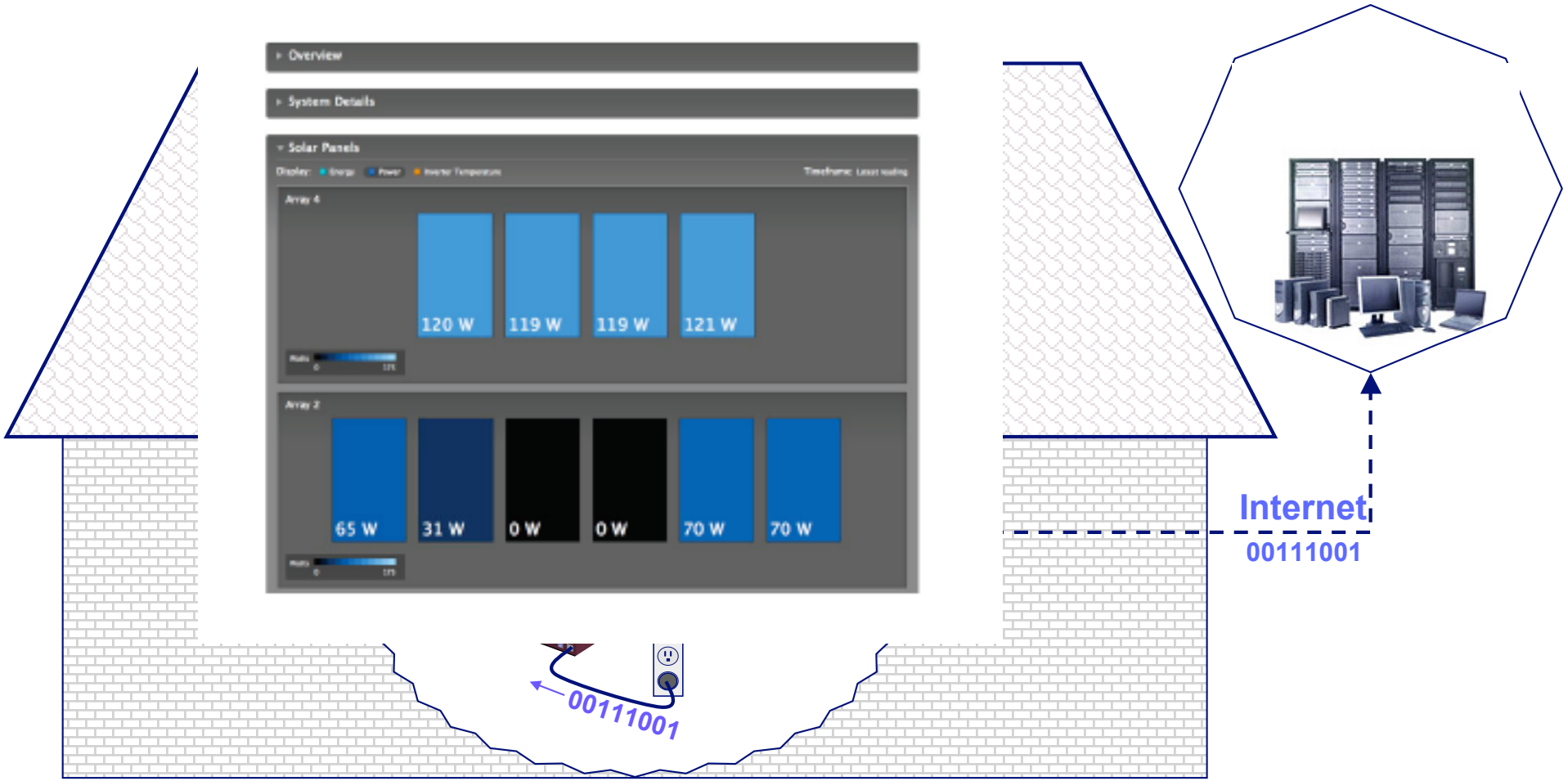
Site Evaluation

Installation

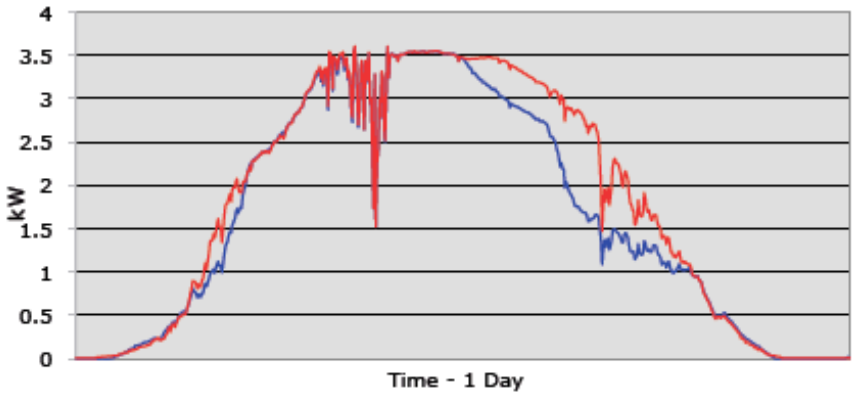
Operator Training

Maintenance

Information Technology Integrated with Solar Technology: Performance Monitoring

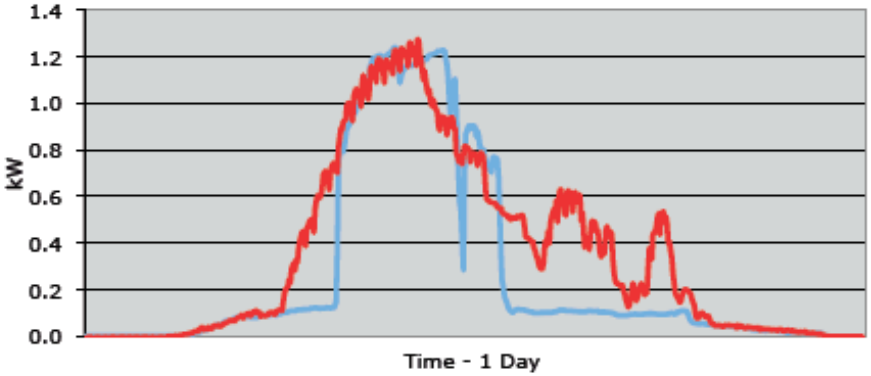


Micro-inverters versus traditional designs



Energy Advantage: 10.24%

- ⇨ SMA SB6000US (95.5%) - Blue
- ⇨ Enphase – Red
- ⇨ Location: Petaluma, CA
- ⇨ Date: November 2007



Energy Advantage: 33.63%

- ⇨ Xantrex GT3 (94.5%) - Blue
- ⇨ Enphase – Red
- ⇨ Location: Grass Valley, CA
- ⇨ Date: December 2007

October 23, 2007

Berkeley Breakthrough on Financing Solar Energy and Energy Efficiency

Berkeley, CA – Berkeley is set to become the first city in the nation to allow property owners to pay for energy efficiency improvements and solar system installation as a long-term assessment on their individual property tax bill.

This makes energy efficiency + solar PV an investment at $0.0 - $0.10 cents/kWh

TIMELINE:

October 23: Berkeley, California, press release

October 30: State Attorney General & Treasurer to work for statewide version

November 1: US DoE pledges support

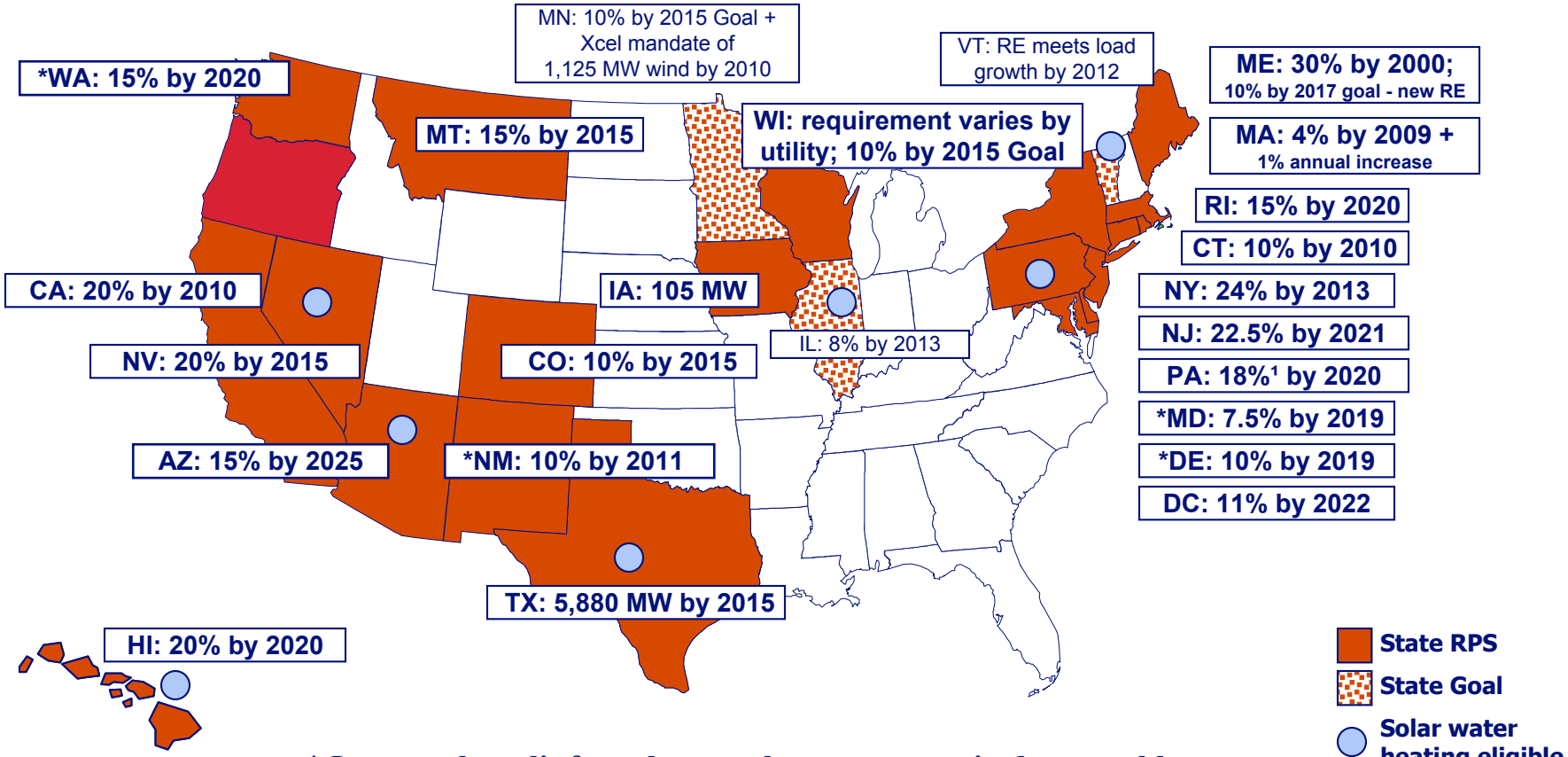
November 8: Approved by the city council, up for review as a statewide initiative

June 2008: operational date

SOLAR AMERICA CITY 2007

Renewable Energy Portfolio Standards (RPS)

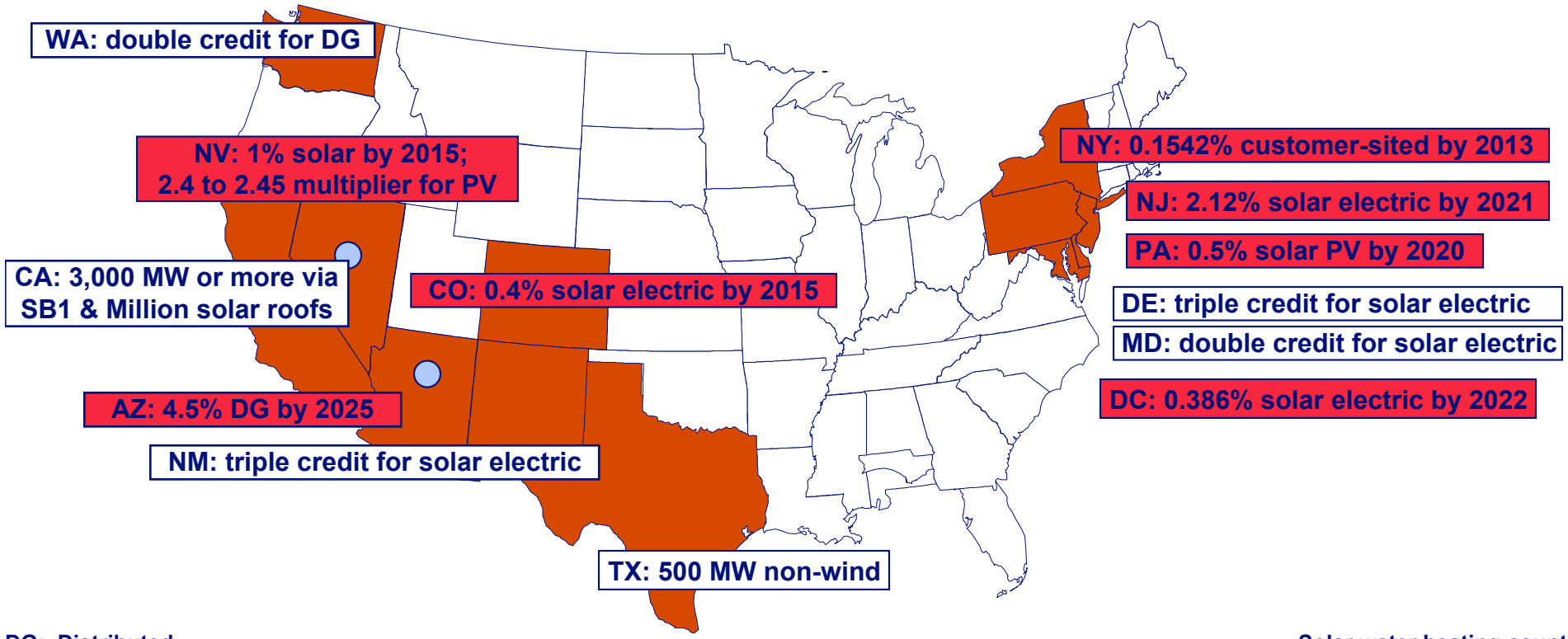
29 states + Washington, DC, and counting



*** Increased credit for solar or other customer-sited renewables**

PA: 8% Tier I (renewables)

Solar & Distributed Generation Provisions in RPS Policies

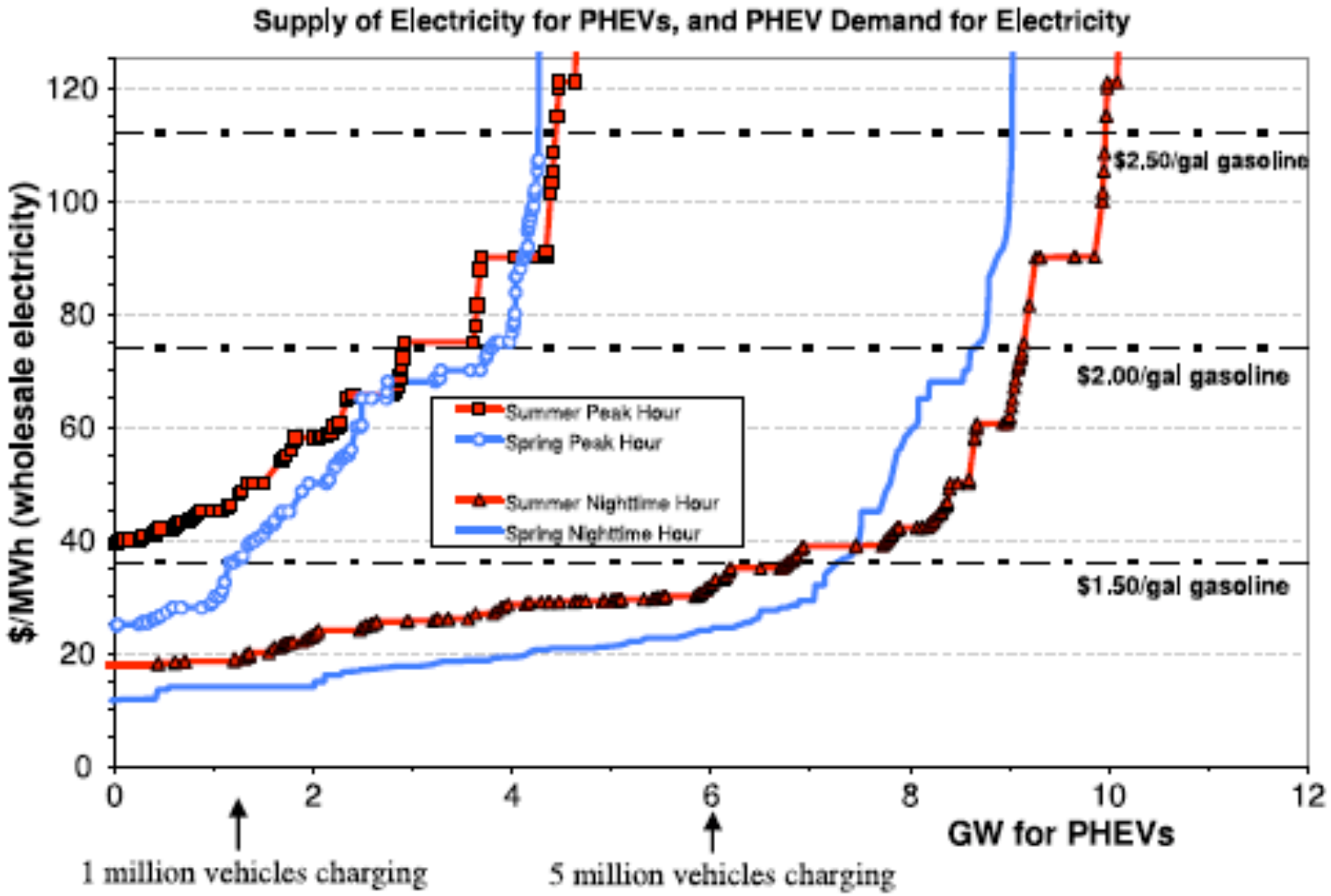


DG: Distributed Generation

Solar water heating counts towards solar set-aside

Plug-in Hybrids: Can they move rapidly to scale?

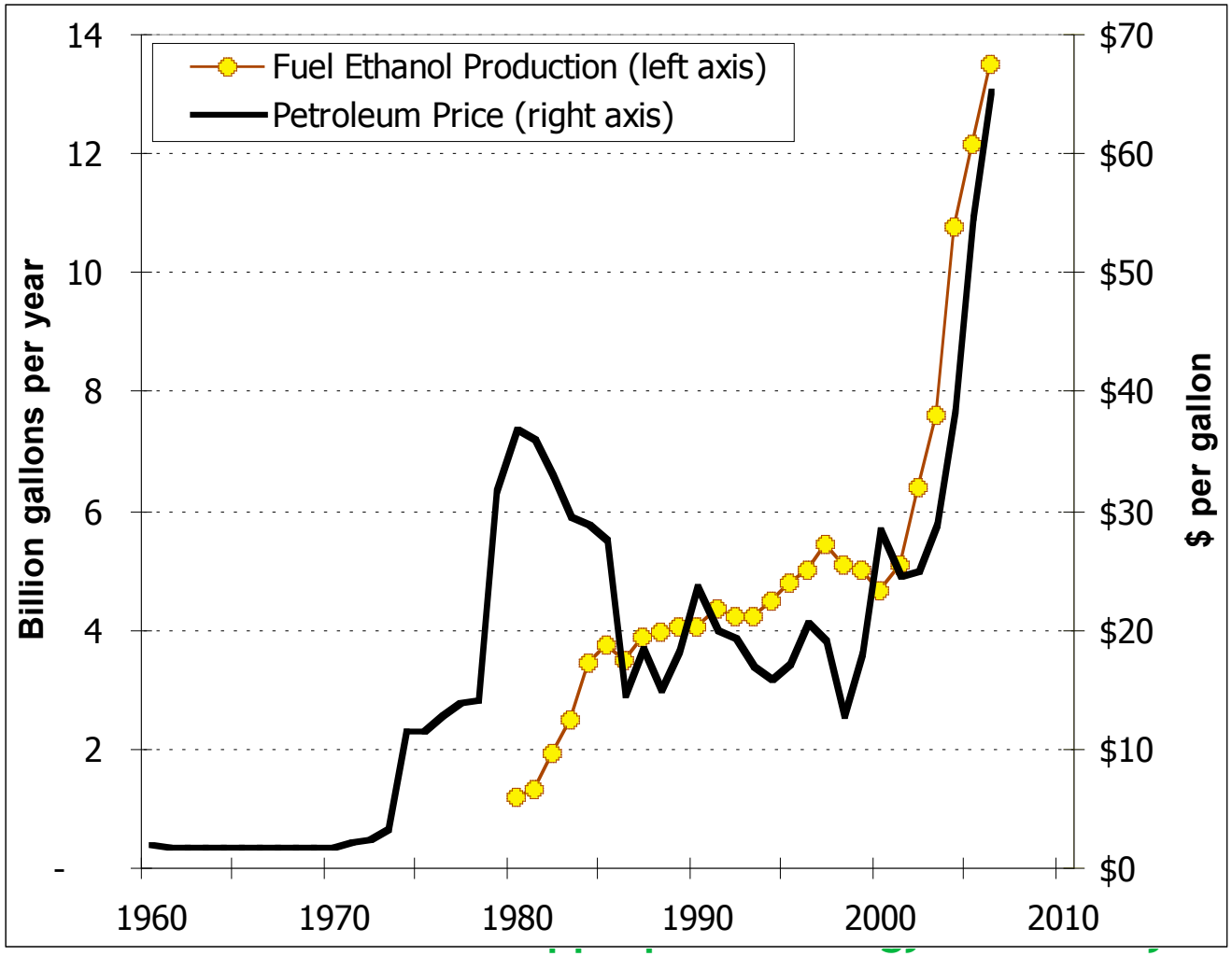
Electricity Demand (additional) to supply a PHEV fleet in CA



Lemoine, Farrell & Kammen, *Env. Research Letters* (2008)

Today's Biofuel Industry

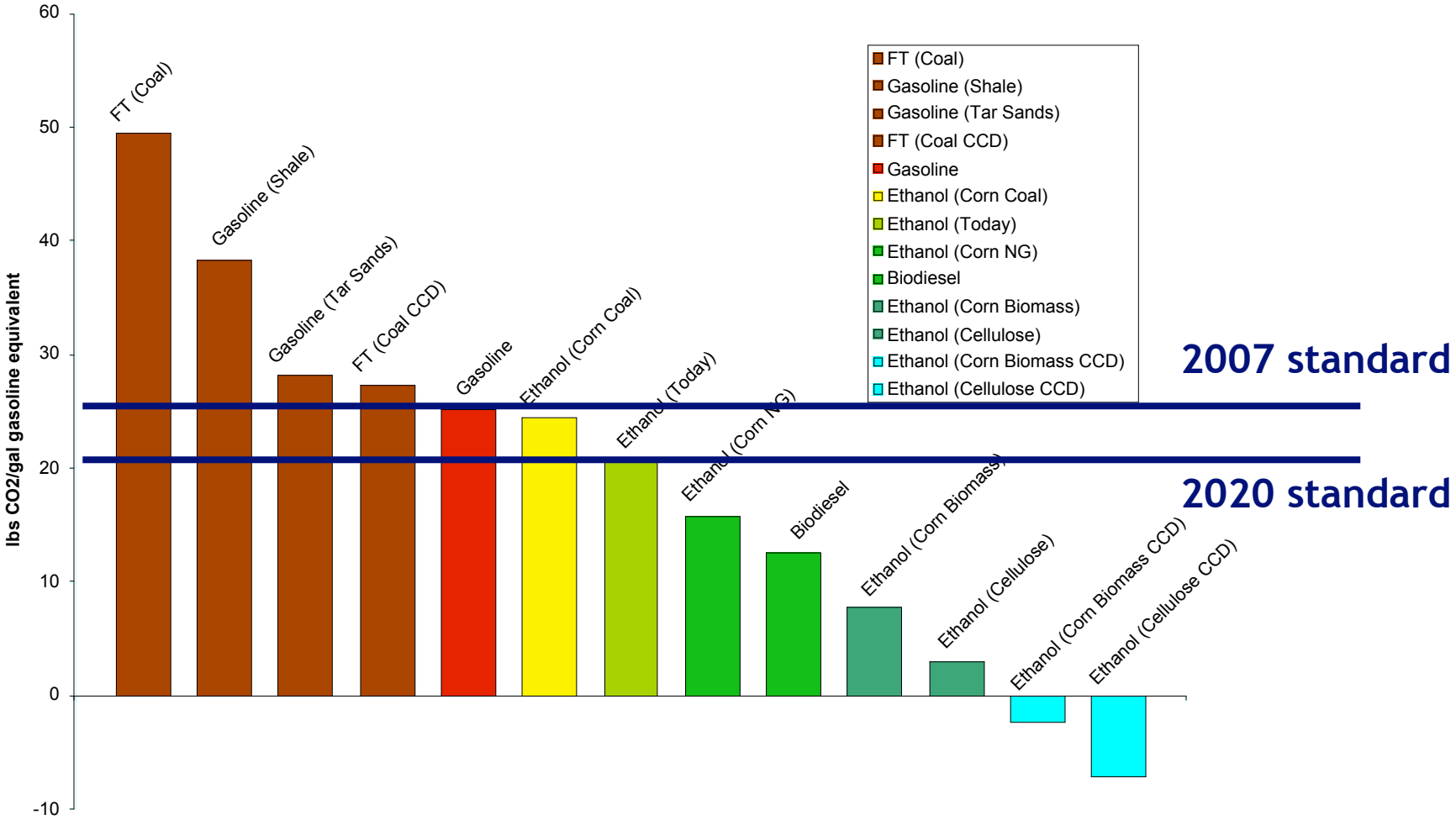
- Feedstocks largely food commodities
- Fuels are traditional substances
- Success depends on subsidies and mandates
- Small, but profitable and growing rapidly



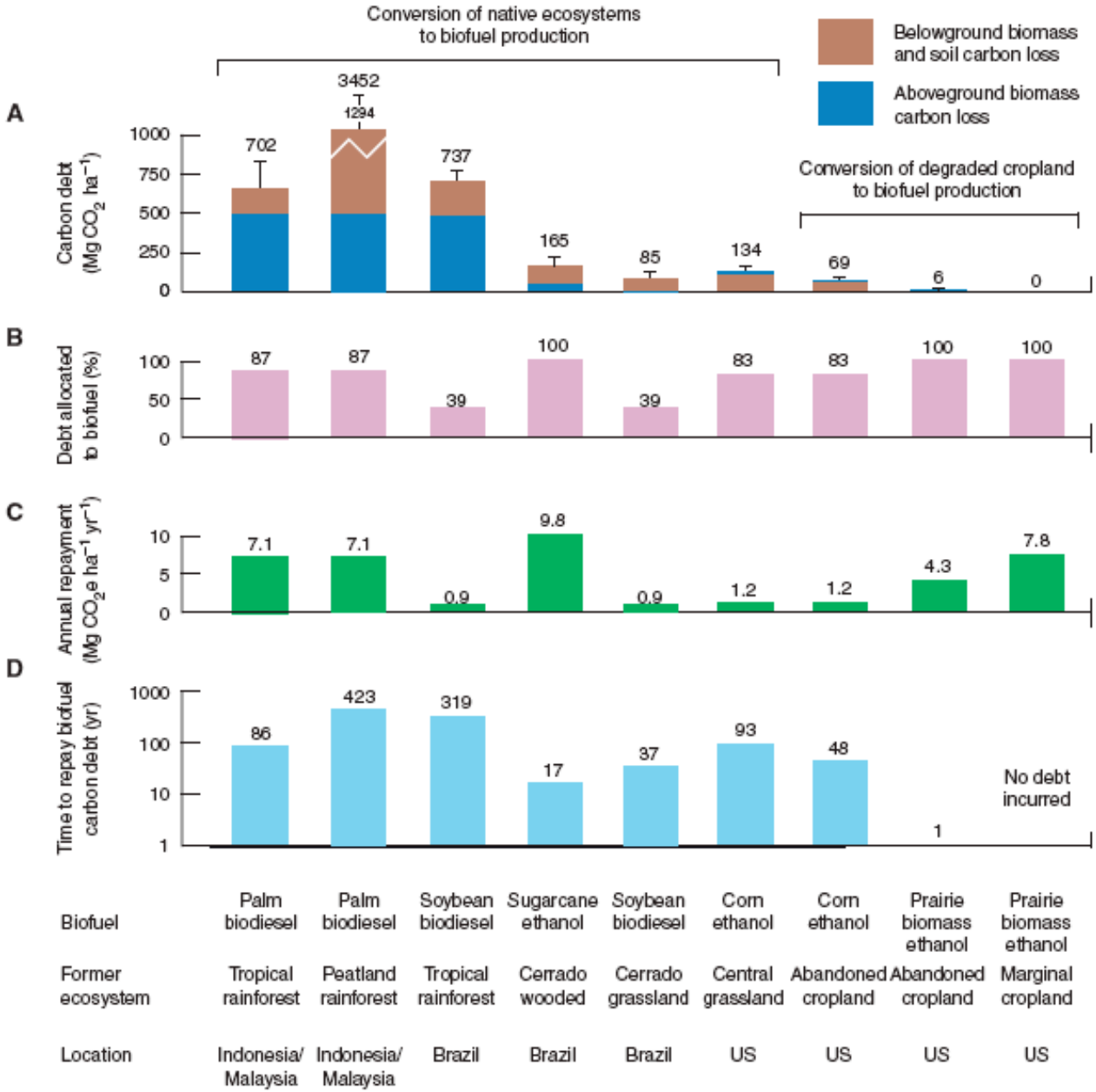
Sources: US EIA, BP, RFA

An Alternative Fuel is Not Necessarily a Low-Carbon Fuel, but it can be

(California Executive Order S-7-01)

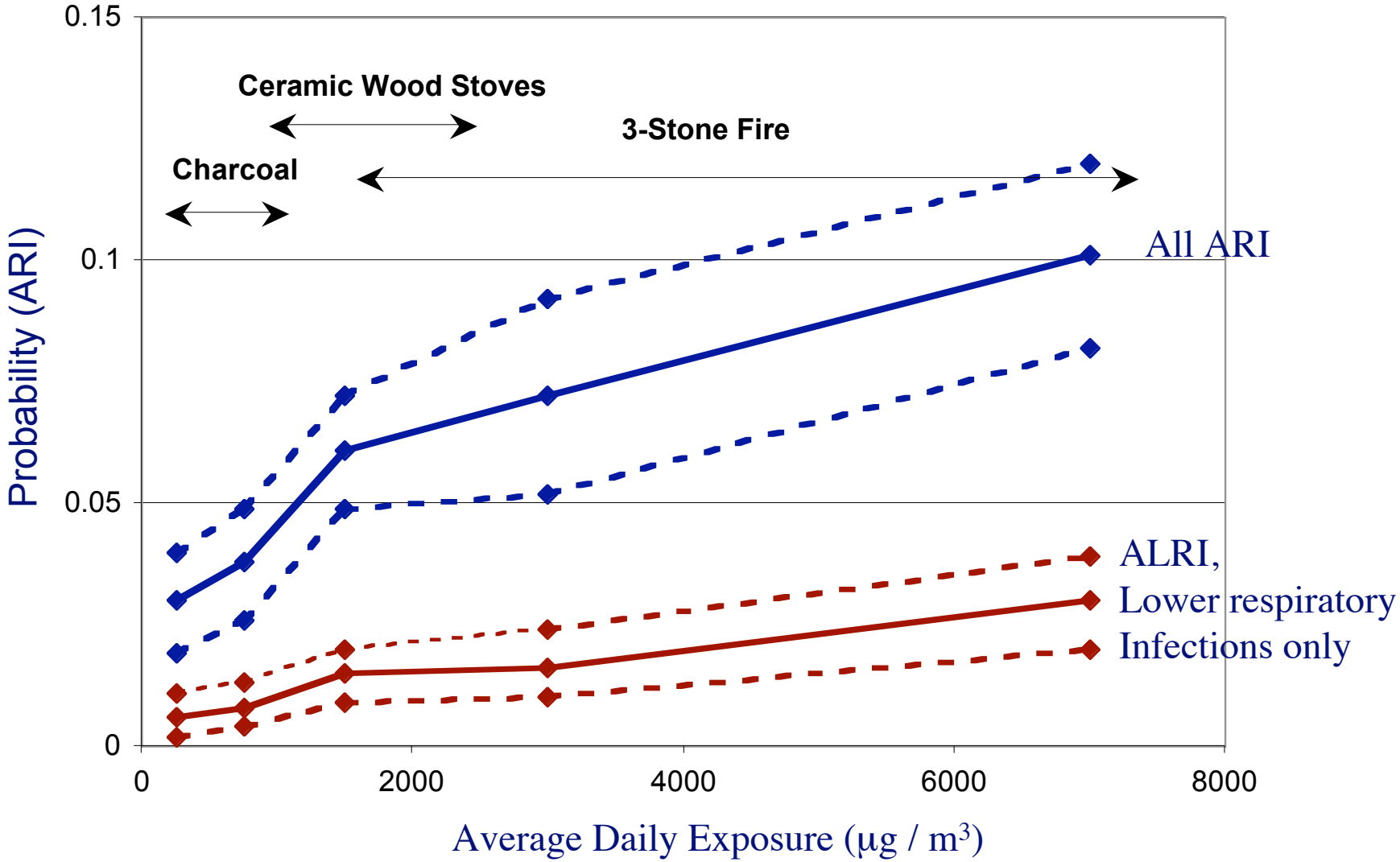


Land use, GHG emissions, and 'carbon debt'

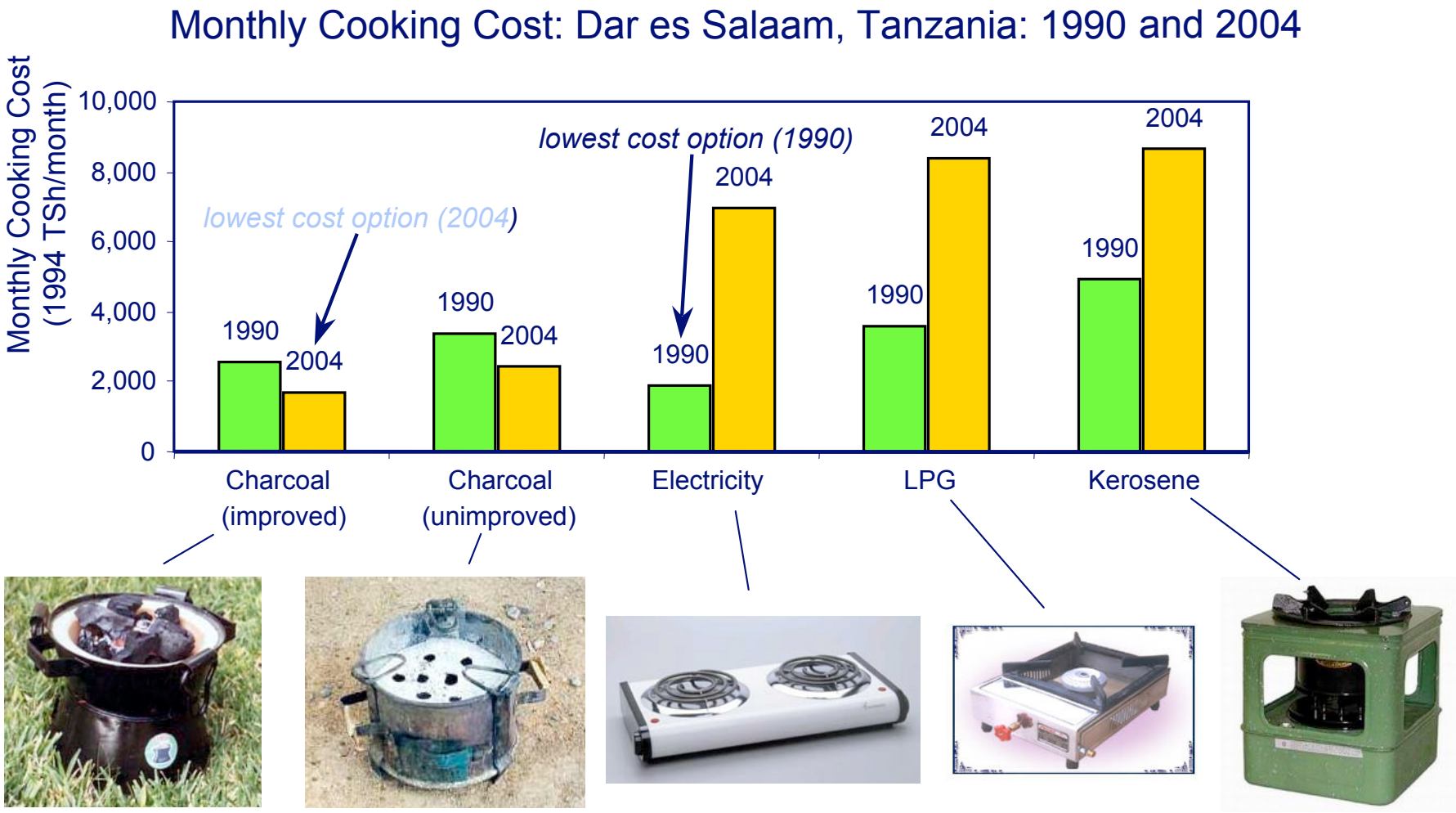


Fargione, *et al*, Science, *Feb 8, 2008*

Illness Reduction Observed in Kenya
(ARI = acute respiratory infection)
Ezzati and Kammen, *The Lancet*, 2001



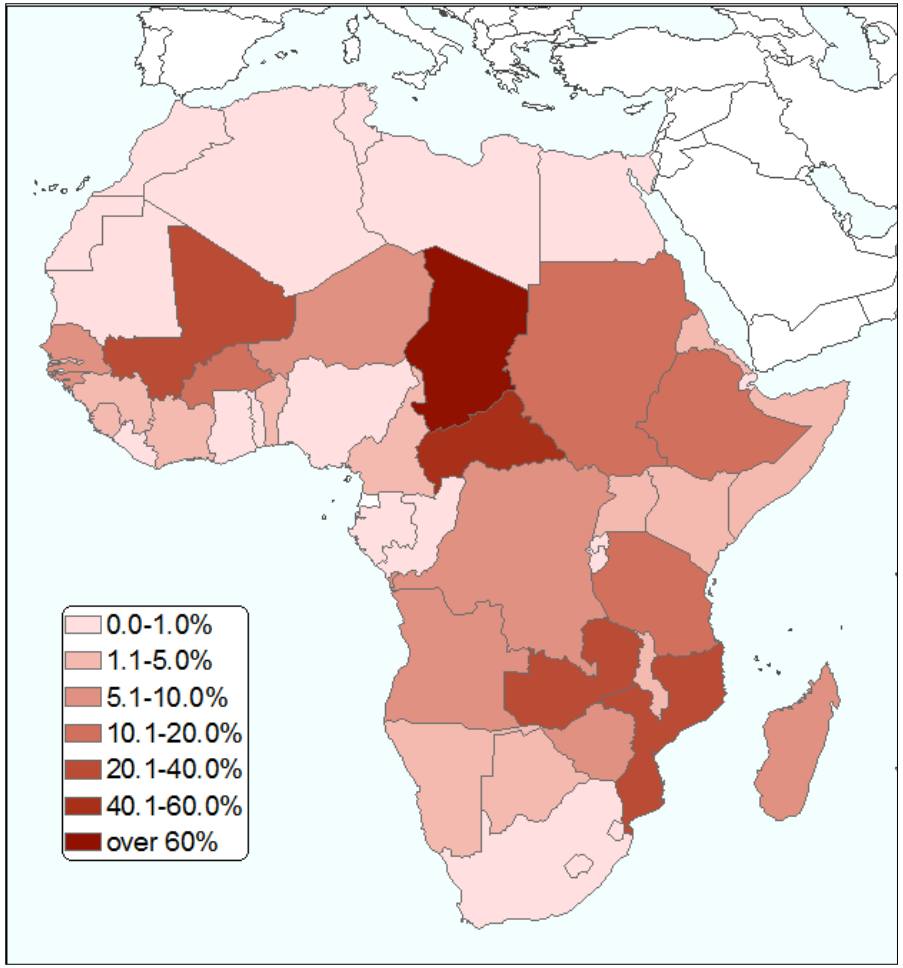
Rising energy prices have made charcoal the most economical cooking option



Data Source: Hosier, R.H. and W. Kipondya, *Urban household energy use in Tanzania*. Energy Policy, 1993. May: p. 454-473. (1990); R. Ghanadan, unpublished (2004)

Ethanol can Displace Gasoline Consumption in Africa (N. Dargouth and Kammen, in prep.)

- Using only post-harvest crop losses as inputs (up to 50 percent of yields), biofuels can play a significant role
- Implications for poverty alleviation, job creation, urban health, and foreign currency savings
- Metrics for ecological and cultural sustainability must be part of the planning process



Source: FAO/IIASA 2002, EIA 2007, ICRISAT 2007

UNIVERSITY OF CALIFORNIA
BERKELEY

REPORT OF THE
RENEWABLE AND APPROPRIATE ENERGY
LABORATORY

Putting Renewables to Work: How Many Jobs Can the Clean Energy Industry Generate?

by

Daniel M. Kammen
Kamal Kapadia
Matthias Fripp

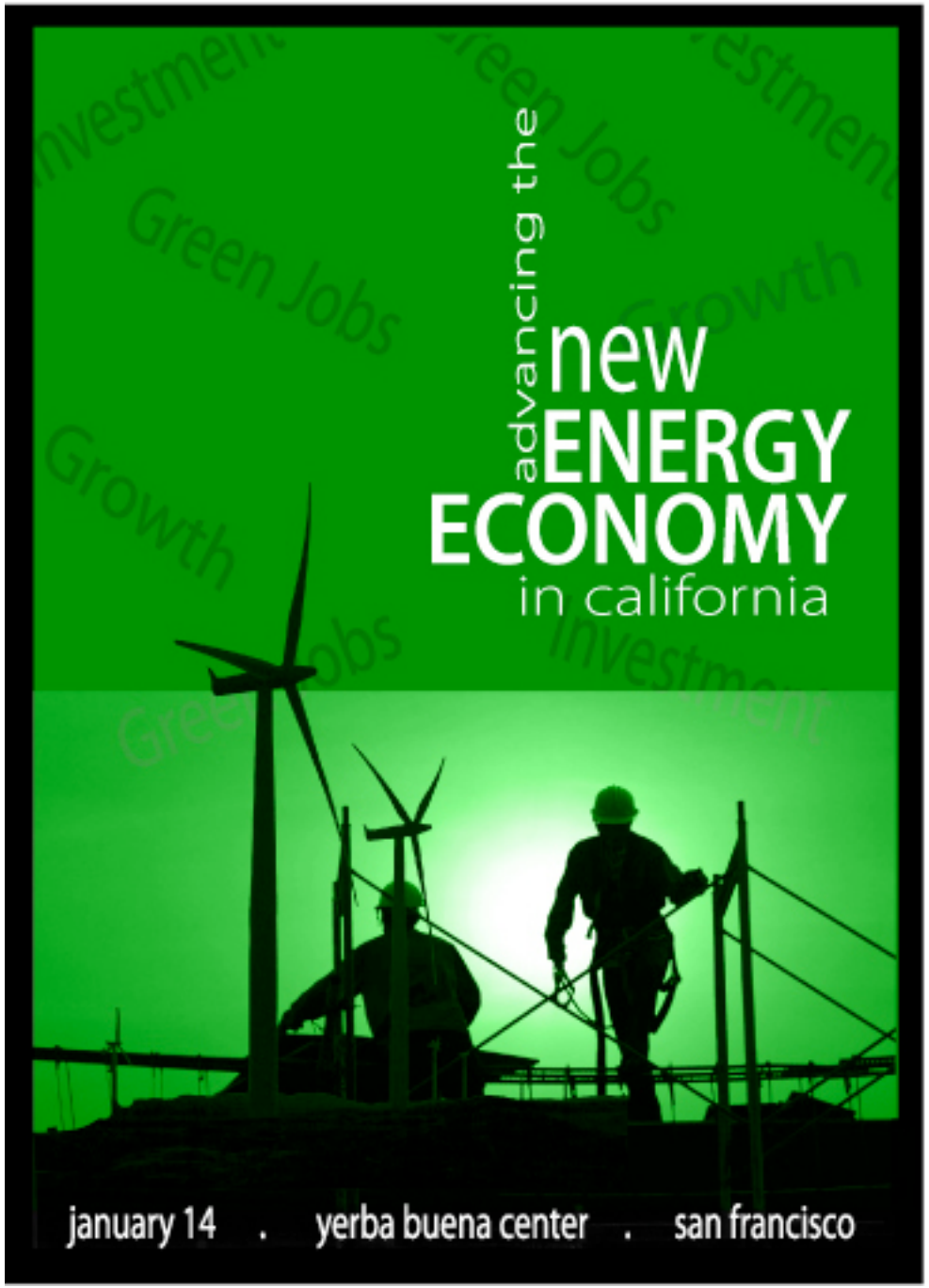
of the
Energy and Resources Group &
the Goldman School of Public Policy

APRIL 13, 2004

Study reviews:

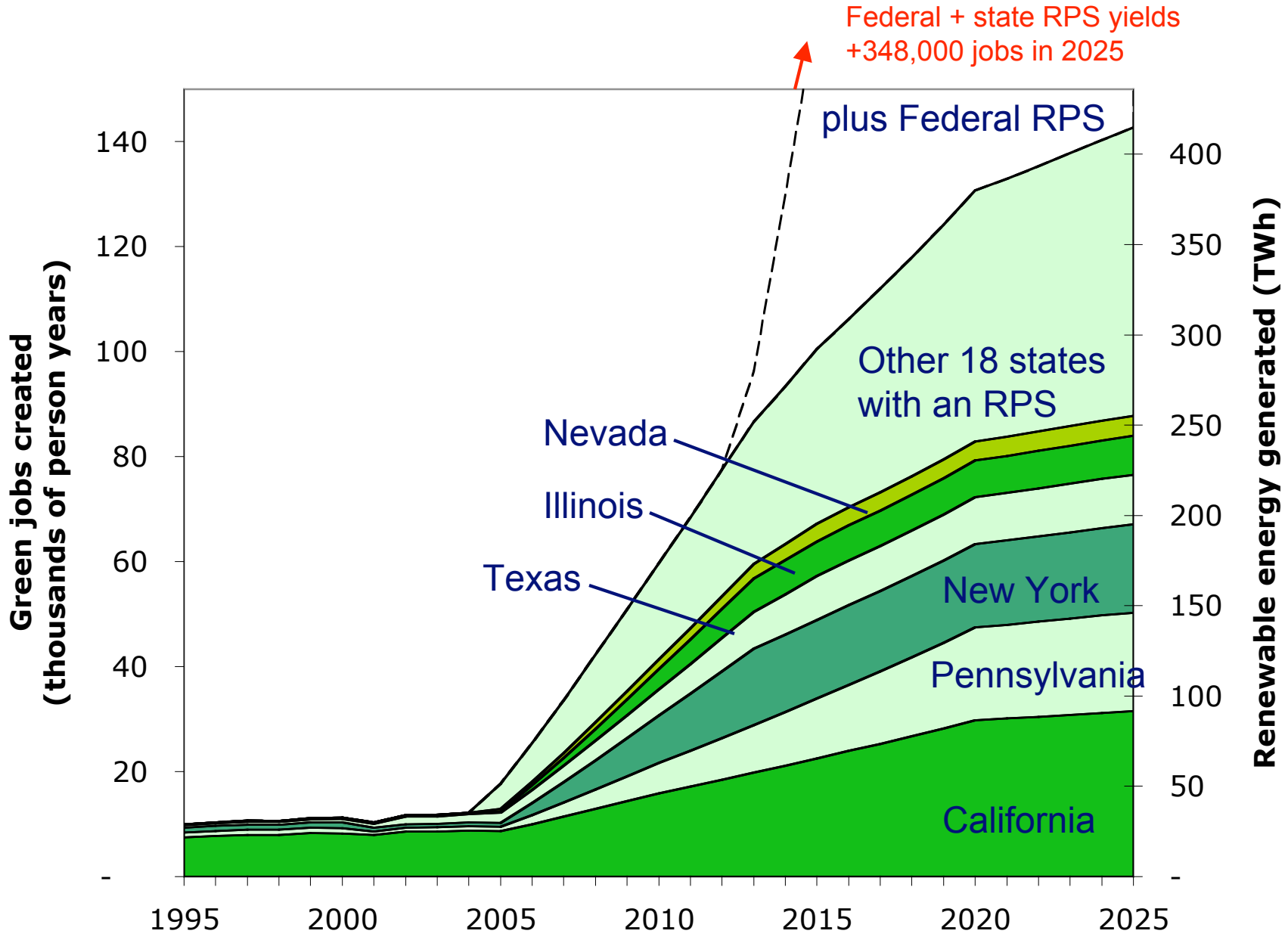
- 13 studies of job creation

- 3 - 5 *times* More jobs per dollar invested in the renewables sector than in fossil fuels



http://docs.cpuc.ca.gov/eeworkshop/CPUC-new/summit.html

Green Collar Job Creation



Green job creation

More renewables = more jobs

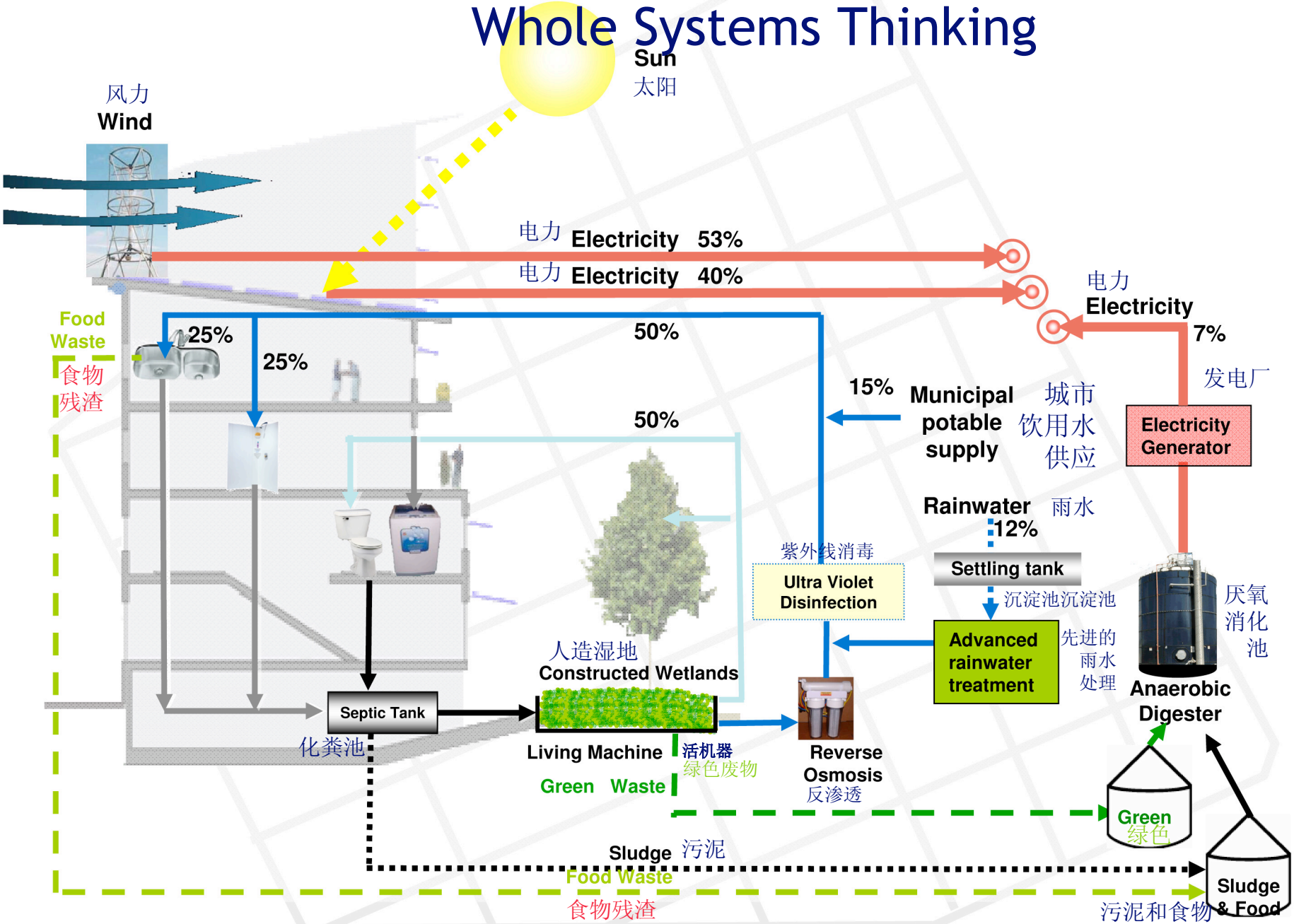
Energy Technology	Jobs (total person-yrs/TWh)		Equipment lifetime (years)	Capacity Factor	Employment Components			Source of Numbers
	Construction, Manufacturing, Installation	O&M and fuel processing			Construction, Manufacturing and Installation (person-yr/MWp)	Operation and Maintenance (jobs/MWp)	Fuel extraction and processing (person-yrs/TWh)	
PV 1	710	140	25	21%	32	0.3	0	1
PV 2	660	550	25	21%	30	1.0	0	3
Wind 1	50	30	25	35%	4	0.1	0	1
Wind 2	290	30	25	35%	22	0.1	0	2
Biomass - high estimate	50	280	25	85%	9	0.4	220	1
Biomass - low estimate	50	40	25	85%	9	0.04	40	1
Coal	30	80	40	80%	9	0.2	60	1
Gas	30	80	40	85%	9	0.1	70	4

Sources

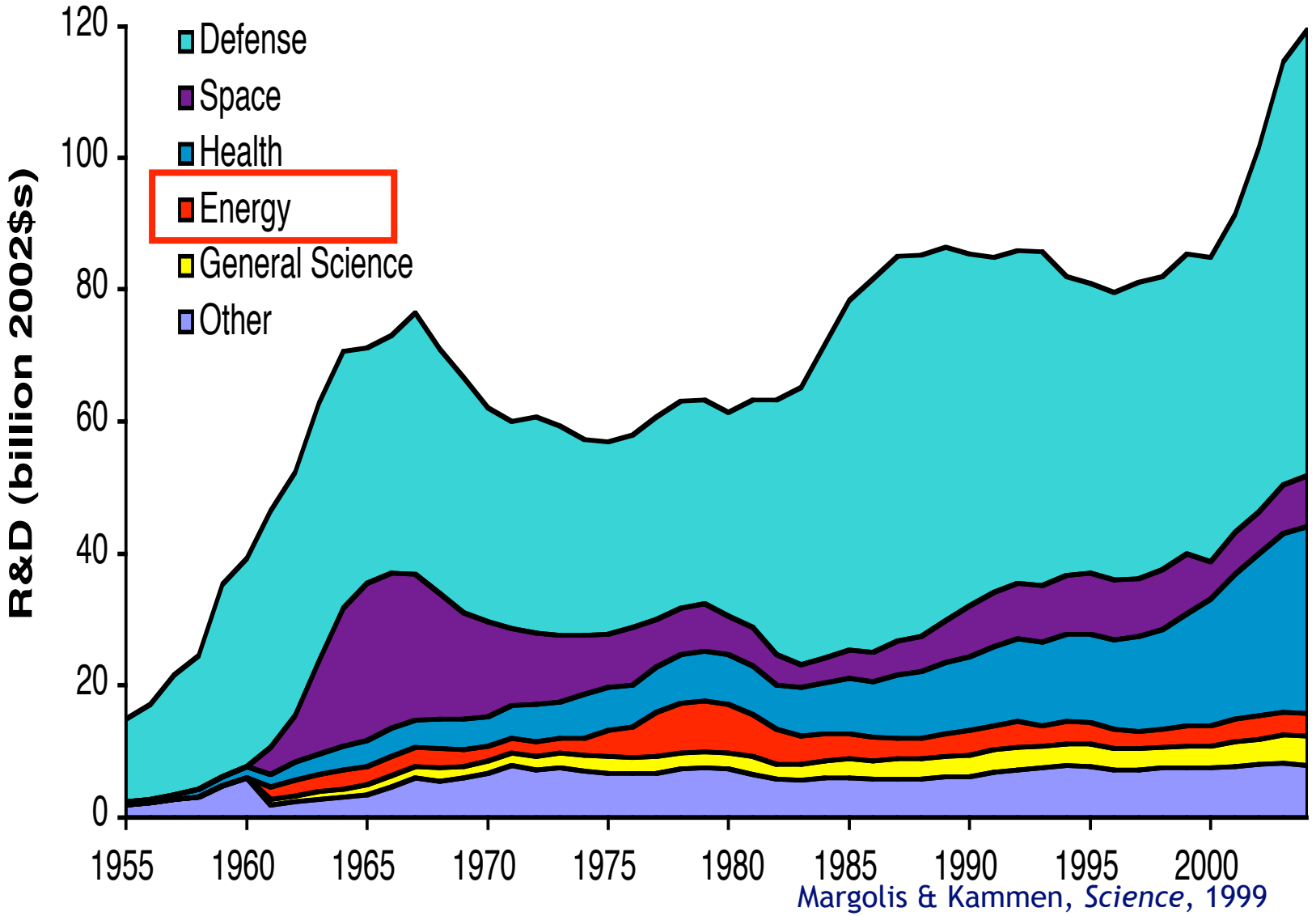
[1] REPP, 2001
[2] EWEA/Green-peace, 2003
[3] Greenpeace, 2001
[4] Kammen, from REPP, 2001; CALPIRG, 2003; BLS, 2004

目定，
则中国基础设施和自然资源的需求将大幅降低
If SuperBlocks could be self-sufficient with respect to energy, water and waste, demand on China's infrastructure and natural resources could be significantly reduced

全面系统思考
Whole Systems Thinking

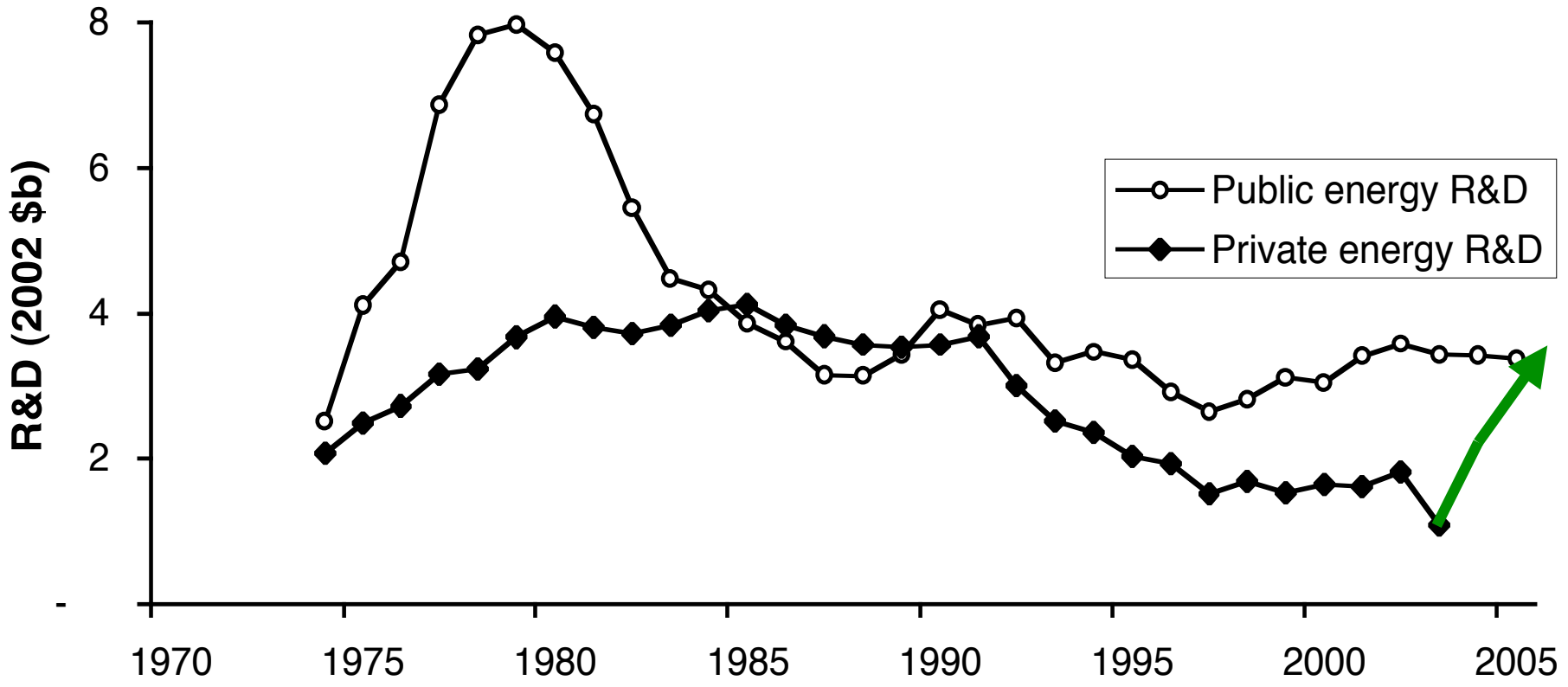


Federal R&D Investments, 1955 - 2004



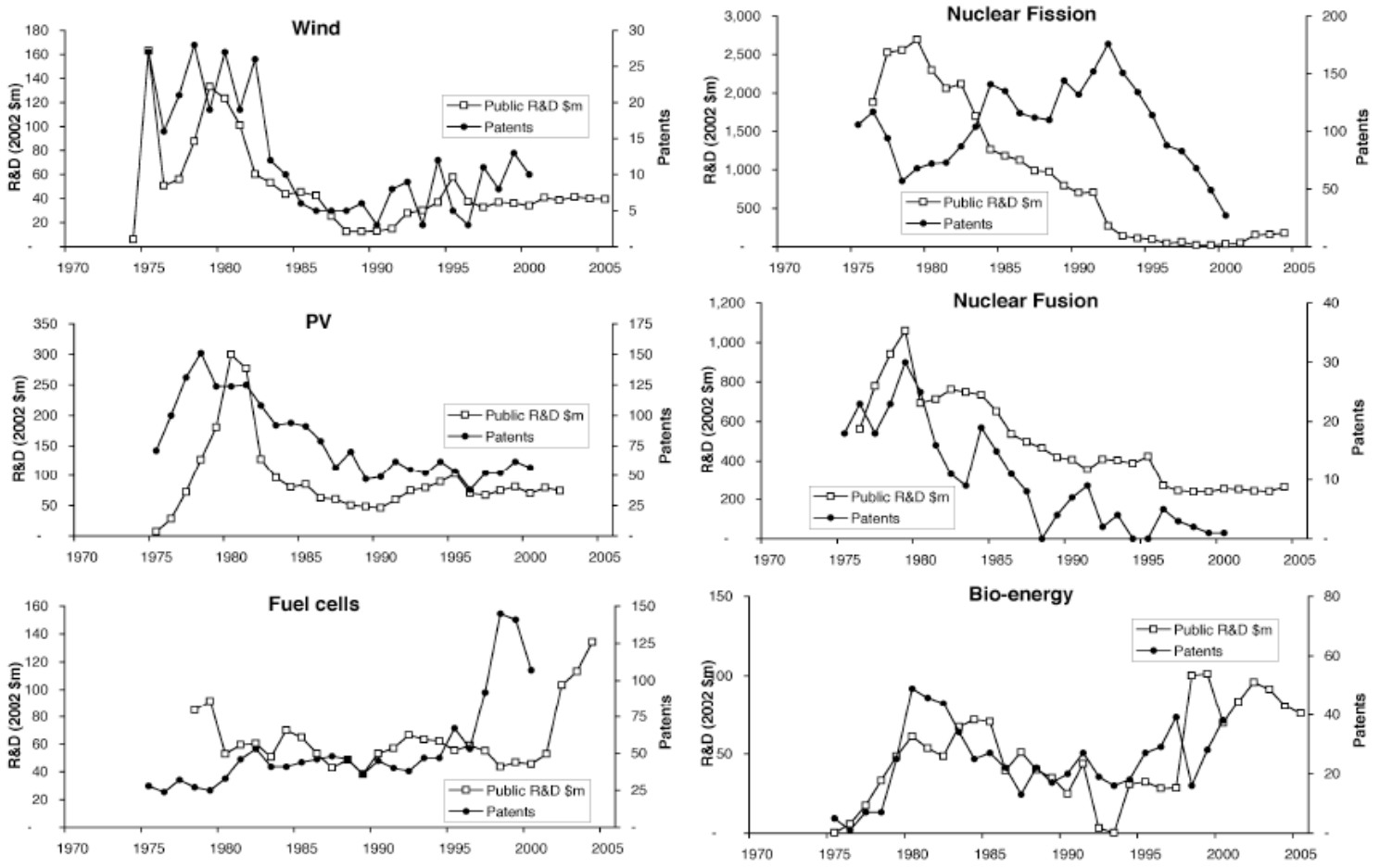
Margolis & Kammen, *Science*, 1999

United States' Public and Private Sector Energy Research and Development Spending



Kammen and Nemet (2005)
"Reversing the incredible shrinking energy R&D budget," *Issues in Science & Technology*, **Fall**, 84 – 88.

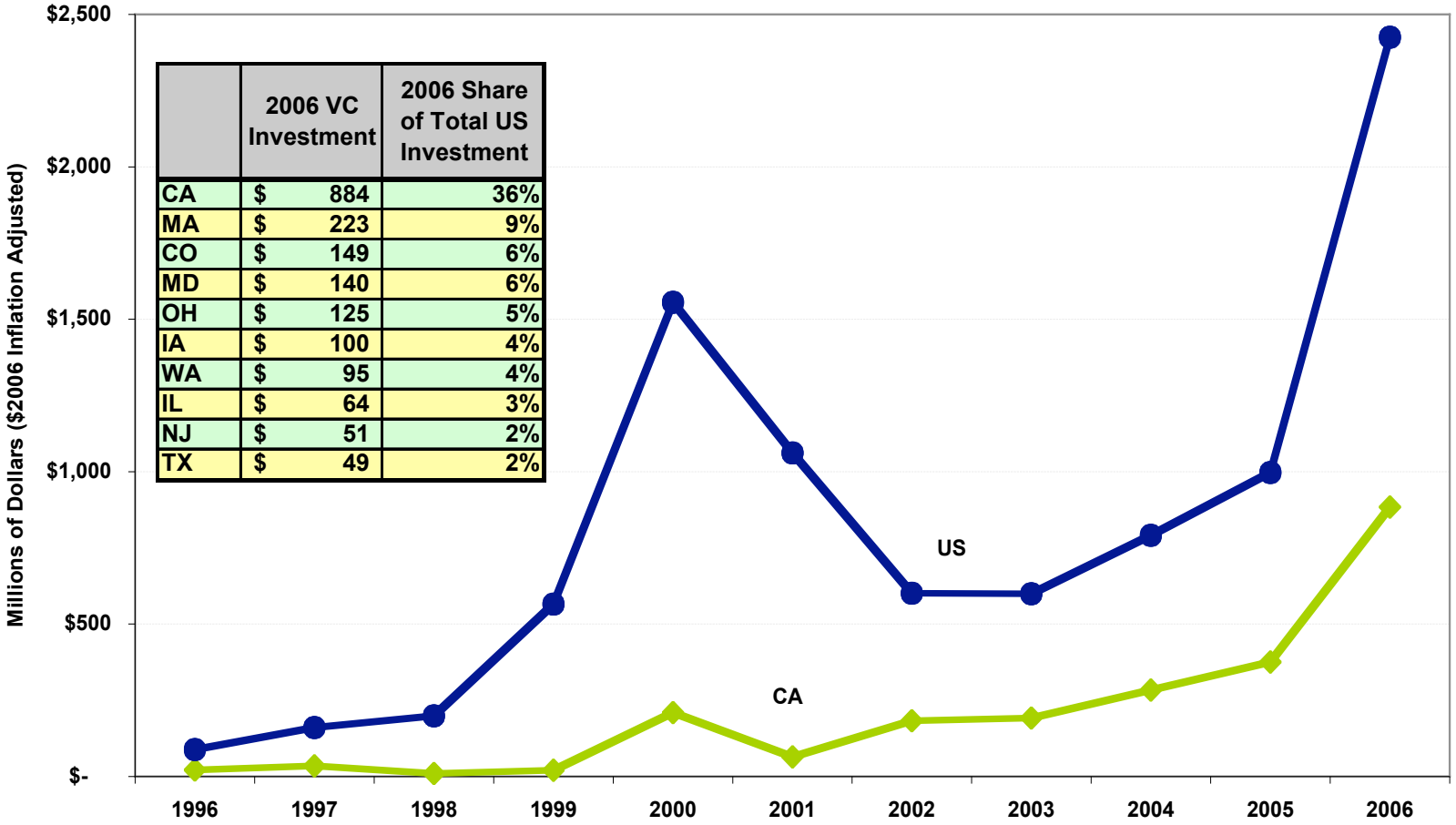
Patents and R&D Funding Correlated



Kammen and Nemet (2005)
"Reversing the incredible shrinking energy R&D budget," *Issues in Science & Technology*, **Fall**, 84 – 88.
And Nemet, dissertation, 2007

VENTURE CAPITAL INVESTMENT IN ENERGY TECHNOLOGY

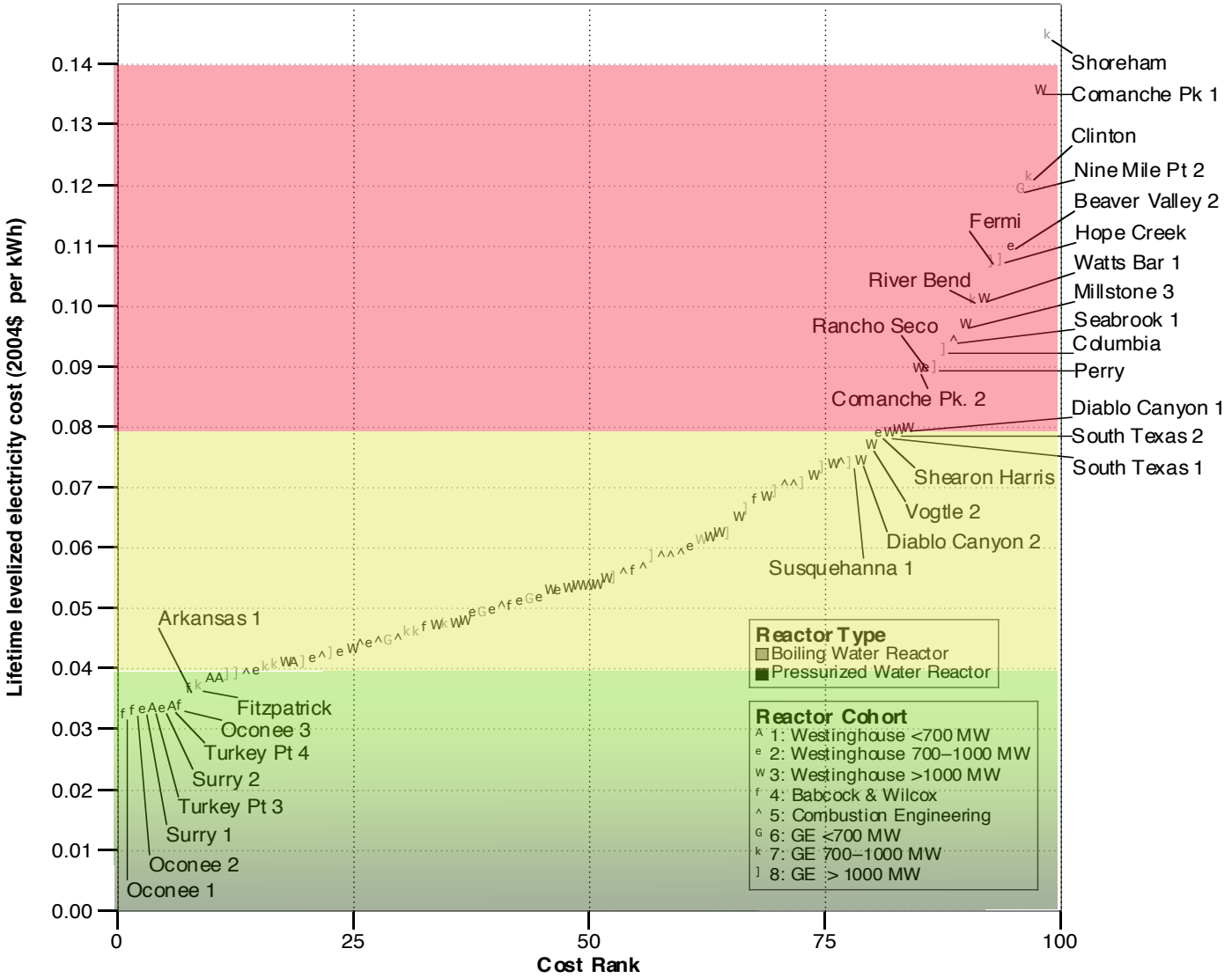
Total Venture Capital Investment in Energy Technology
California and the U.S.
1996-2006



	2006 VC Investment	2006 Share of Total US Investment
CA	$ 884	36%
MA	$ 223	9%
CO	$ 149	6%
MD	$ 140	6%
OH	$ 125	5%
IA	$ 100	4%
WA	$ 95	4%
IL	$ 64	3%
NJ	$ 51	2%
TX	$ 49	2%

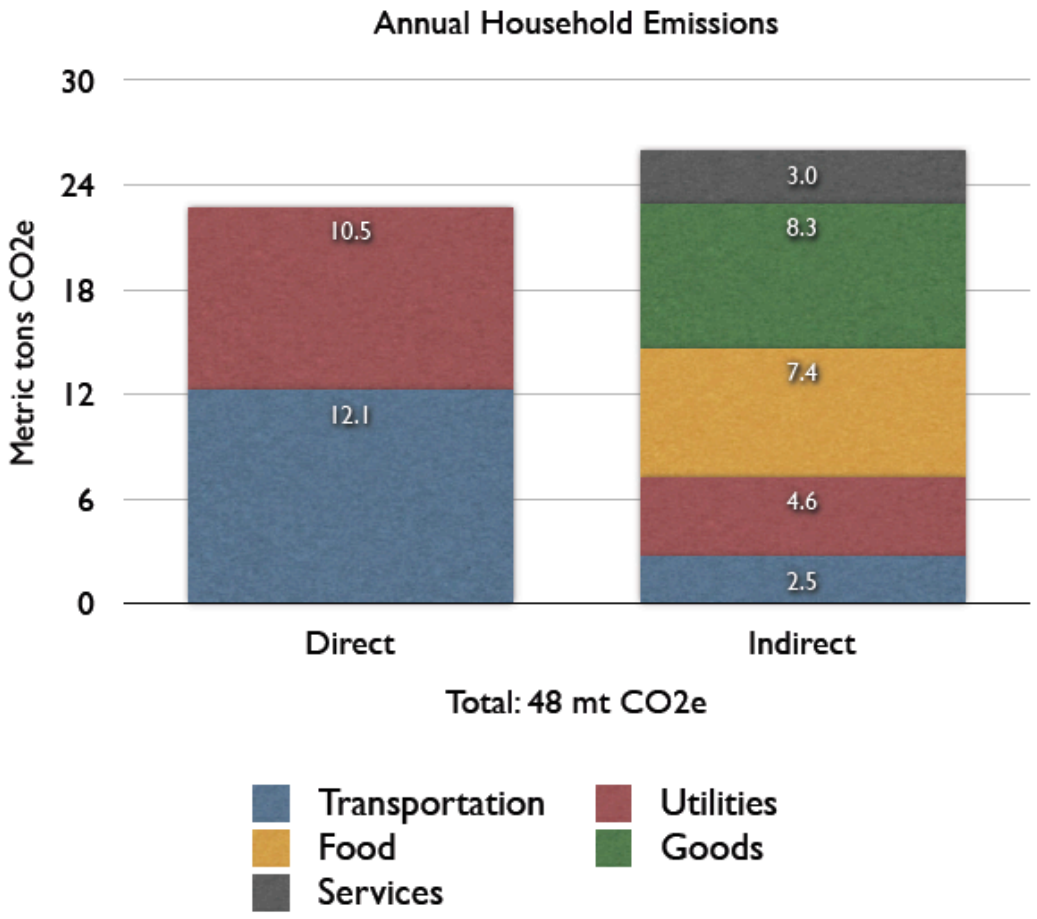
Source: Nth Power

The Cost of Nuclear Power from the U. S. Civilian Reactor Fleet



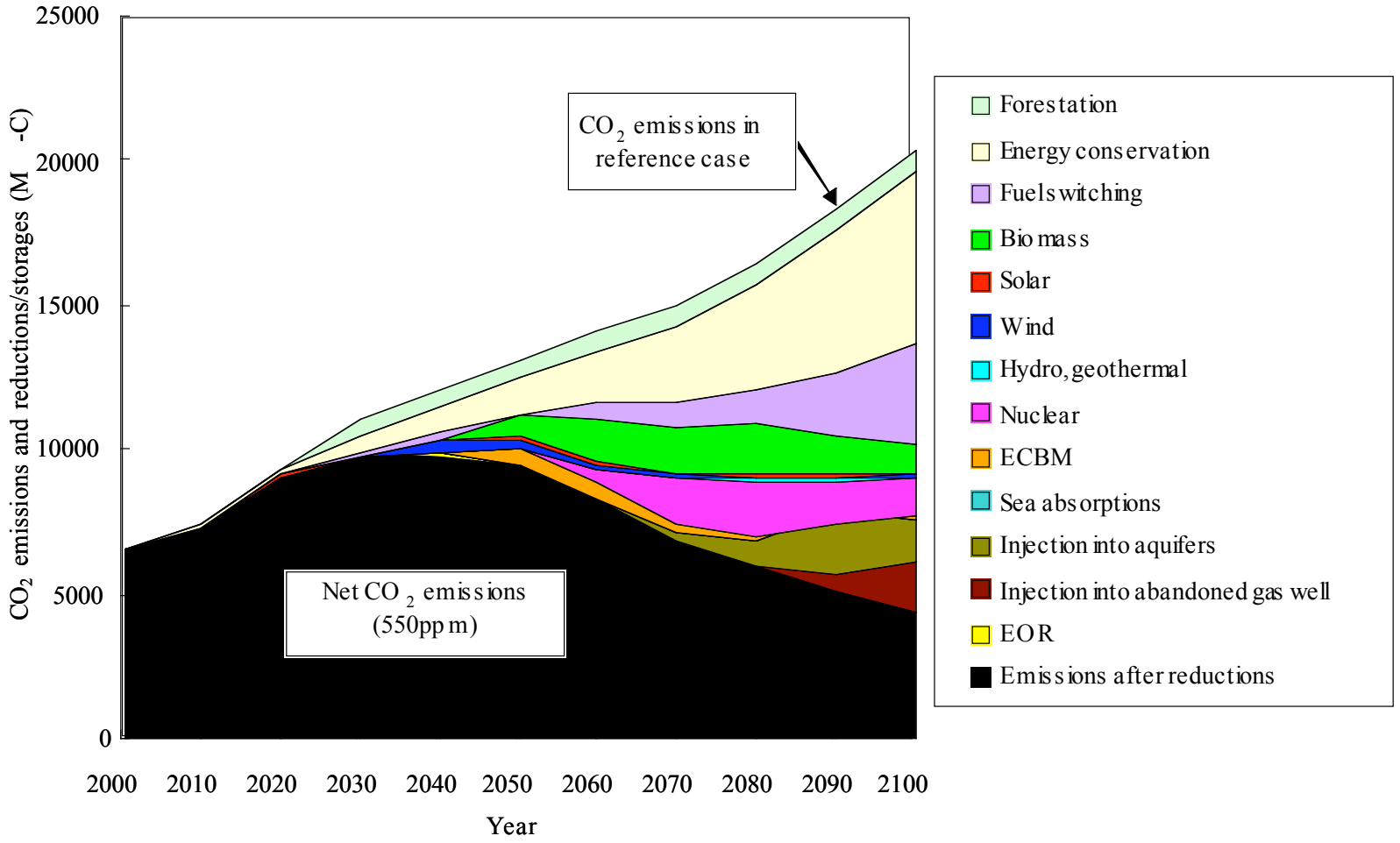
Hultman, Koomey & Kammen (2007) *ES&T*

http://www.coolcalifornia.org **AND http://bie.berkeley.edu**

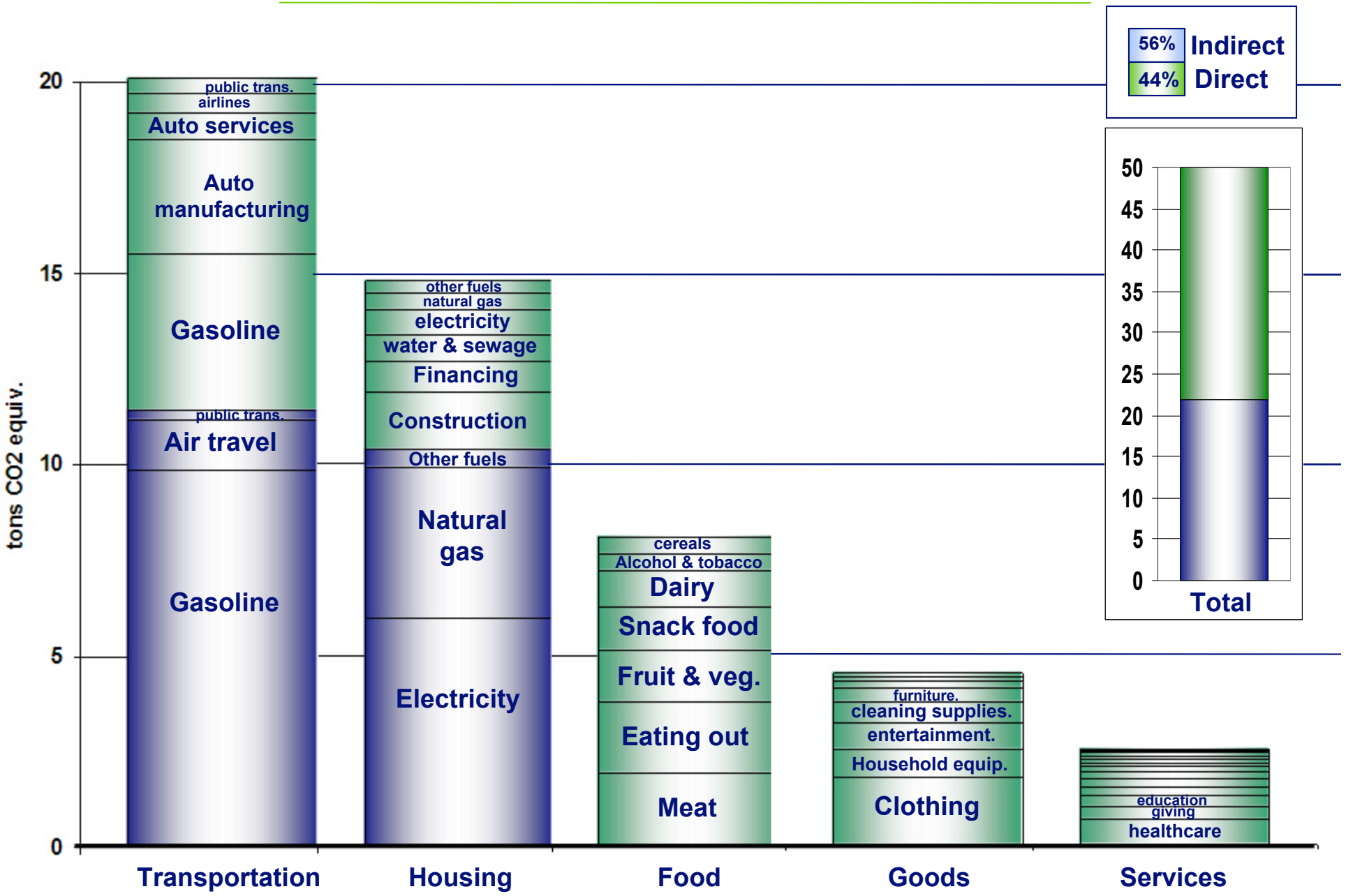


Source: Berkeley LEAPS Model: http://bie.berkeley.edu

CO_2 Emission Reduction Effects by Technology (550ppm)



Summary of GHG Emissions for Typical U.S. Household
(LEAPS Results) 50 Metric tons of CO_2 equivalent gases



California Institute for Climate Solutions

CLIMATE CHANGE

California Stirs a $600 Million Pot of Solutions

California researchers could soon be able to tap a 10-year, $600 million climate initiative. The project would create the California Institute for Climate Solutions to foster research so the state can meet strict greenhouse gas emissions limits enacted over the past 2 years. The president of the state's public utilities commission (PUC), Michael Peevey, recently announced that PUC is looking at the proposed institute as a way to help meet the new targets. The commission is weighing a plan to finance it through a $1-a-month hike in electricity rates.

"This is really exciting to see," says Daniel Kammen, an energy policy expert at the University of California (UC), Berkeley, who views the institute as a way to translate climate goals to action. "It will really put financial muscle behind the climate-change laws." Omar Yaghi, a chemist at UC Los Angeles, who works on materials capable of separating carbon dioxide from power-plant emissions, likes the idea that utility commissioners are paying attention to more than just the industry's bottom line. "I'm really happy to hear the PUC is taking the initiative on this," Yaghi says.

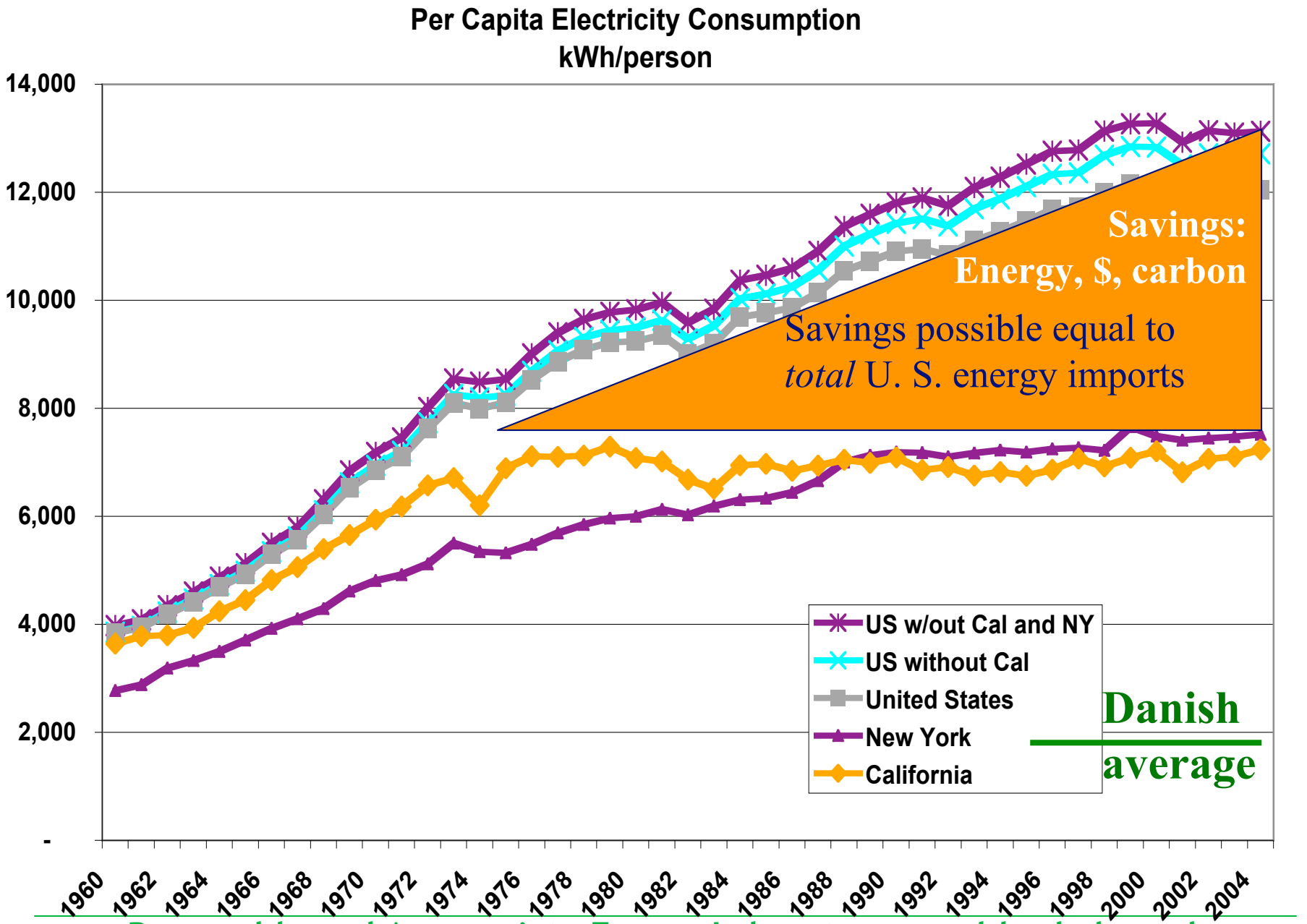
The institute's design is still in flux. But Kammen and others say it's likely to focus on a range of projects that offer near-term energy savings. A preliminary list, Kammen says, includes research centers for energy efficiency, solid-state lighting, carbon sequestration, and green buildings, and a policy center to mesh California's climate regulations with those of other states and countries.

California needs technological advances to meet its new greenhouse gas emission standards. The first standard, enacted last year, requires a 25% reduction in greenhouse gas emissions, to 1990 levels, by 2020. Two years ago, Governor Arnold Schwarzenegger signed an executive order targeting 80% reductions by 2050.

The new institute is not expected to fund new buildings, Kammen says, but rather will support and extend existing campus research efforts across the state. "Coordination is key here," says Ellen Auriti, executive director for research policy at UC's Office of the President. A public comment period closes next week, followed by hearings early next year. If all goes smoothly, the institute could have money to spend by next summer.

–ROBERT F. SERVICE

CREDIT: COALITION FOR DEFENSE RESEARCH


Per Capita Electricity Consumption
kWh/person
14,000
12,000
10,000
8,000
6,000
4,000
2,000
-
1960
1962
1964
1966
1968
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
Savings:
Energy, $, carbon
Savings possible equal to
total U. S. energy imports
US w/out Cal and NY
US without Cal
United States
New York
California
Danish
average