Emerging Green Technology and Economic Growth: A Landscape of Action?

Daniel M. Kammen

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school of law
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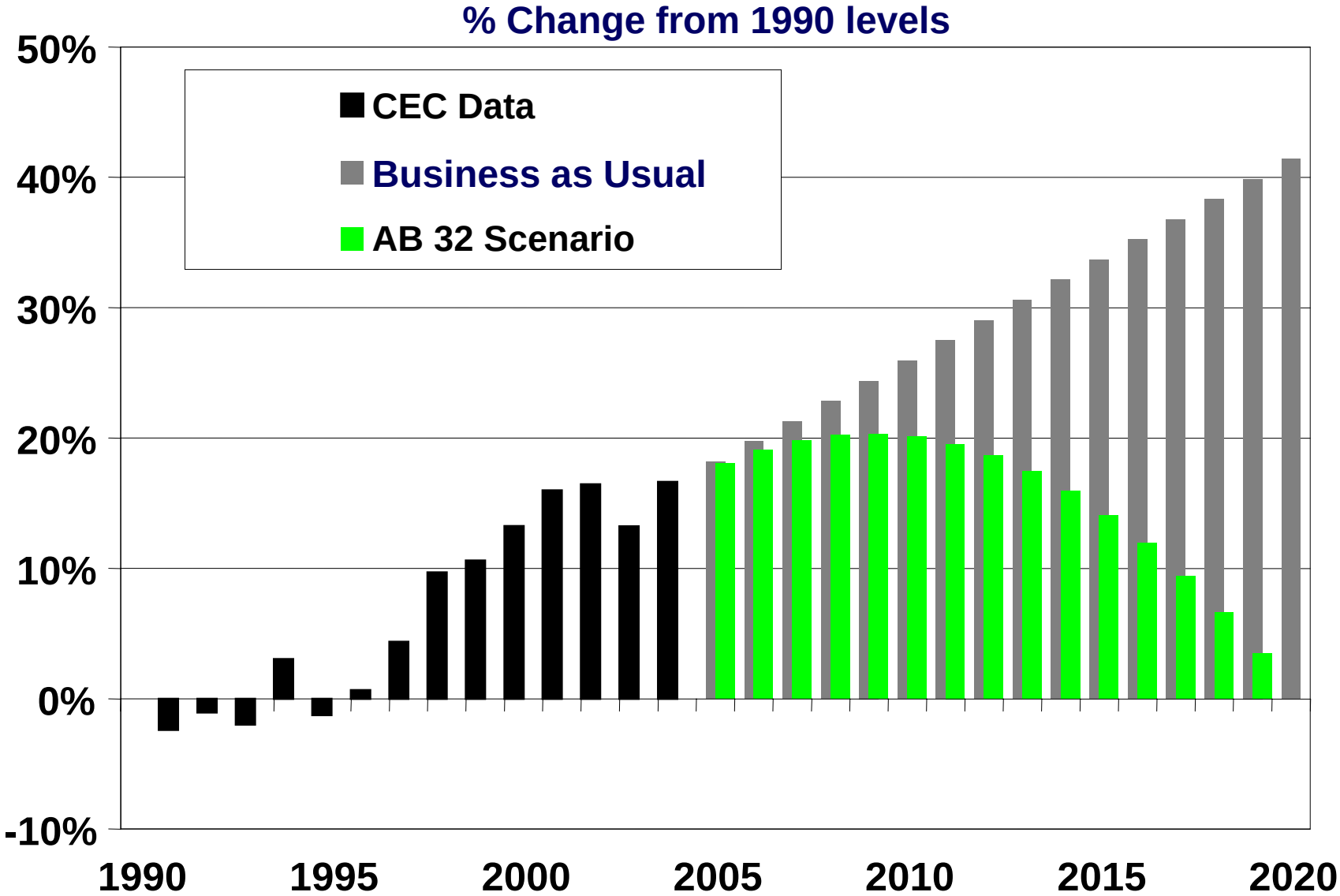
UNIVERSITY OF CALIFORNIA, BERKELEY

AB 32 Emissions Reductions

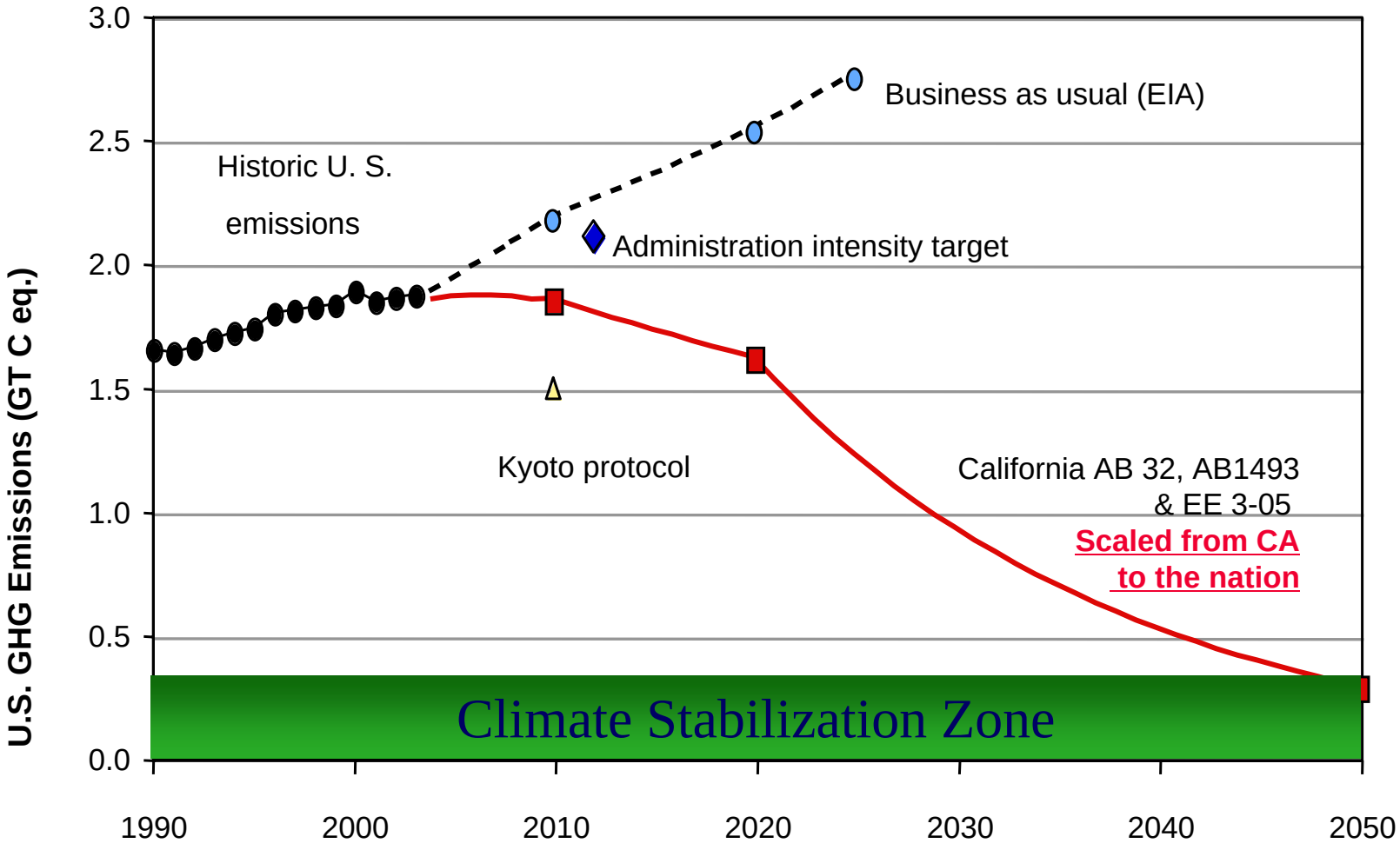


Source: Center for Energy Efficiency and Renewable Technologies, January 2007

$CH_4 \rightarrow H_2S$ separation, then H_2 & elemental sulfur separation

PLT.36
SULFUR BLOCK & TANK AREA
RESTRICTED ACCESS
PERMITS CALL SECONDARY U/G
EMERGENCY CALL
FLAME RESISTANT COVERALLS REQUIRED
NO SMOKING, NO BEARDS

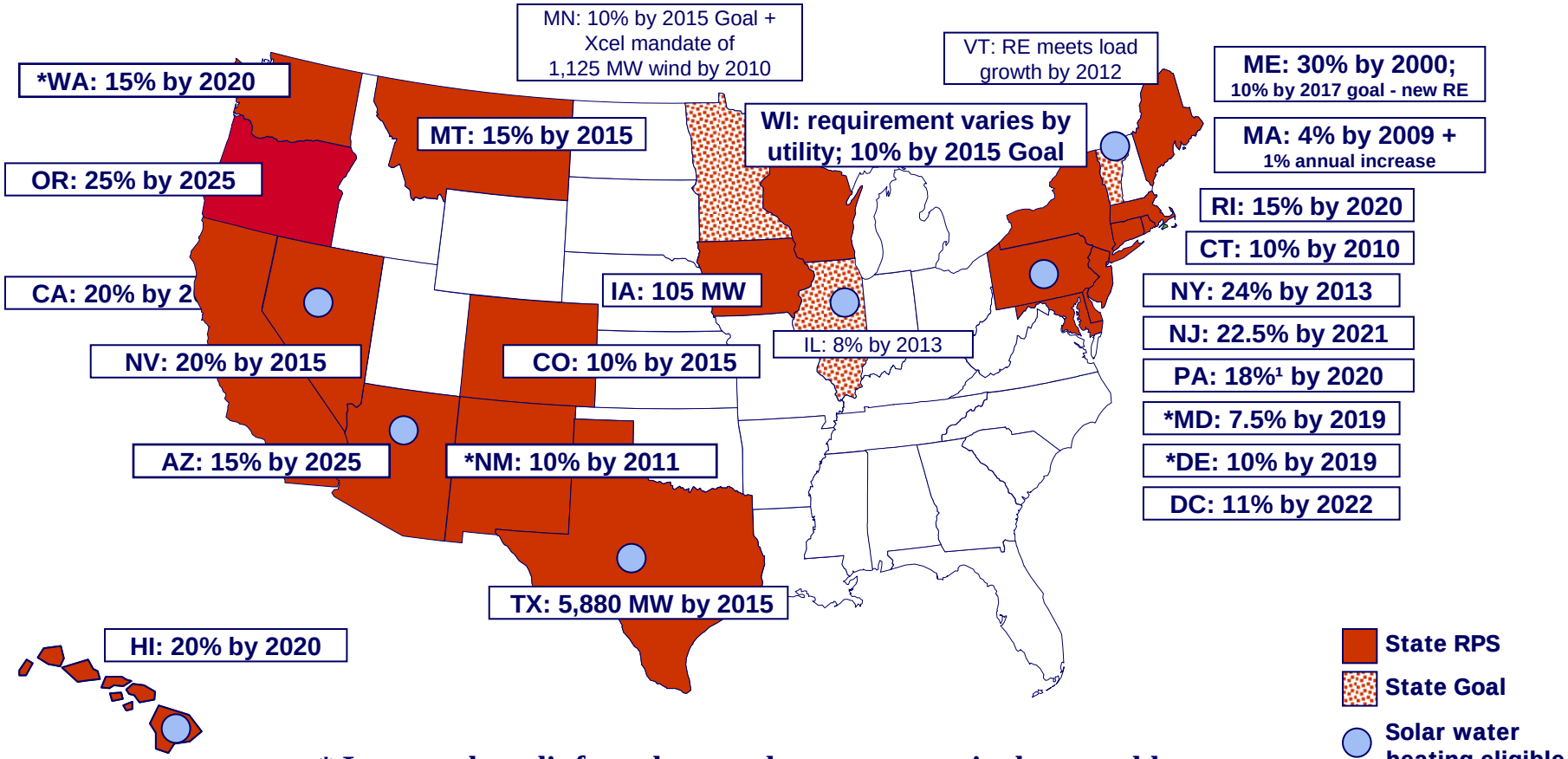
The California commitment - scaled to the nation



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

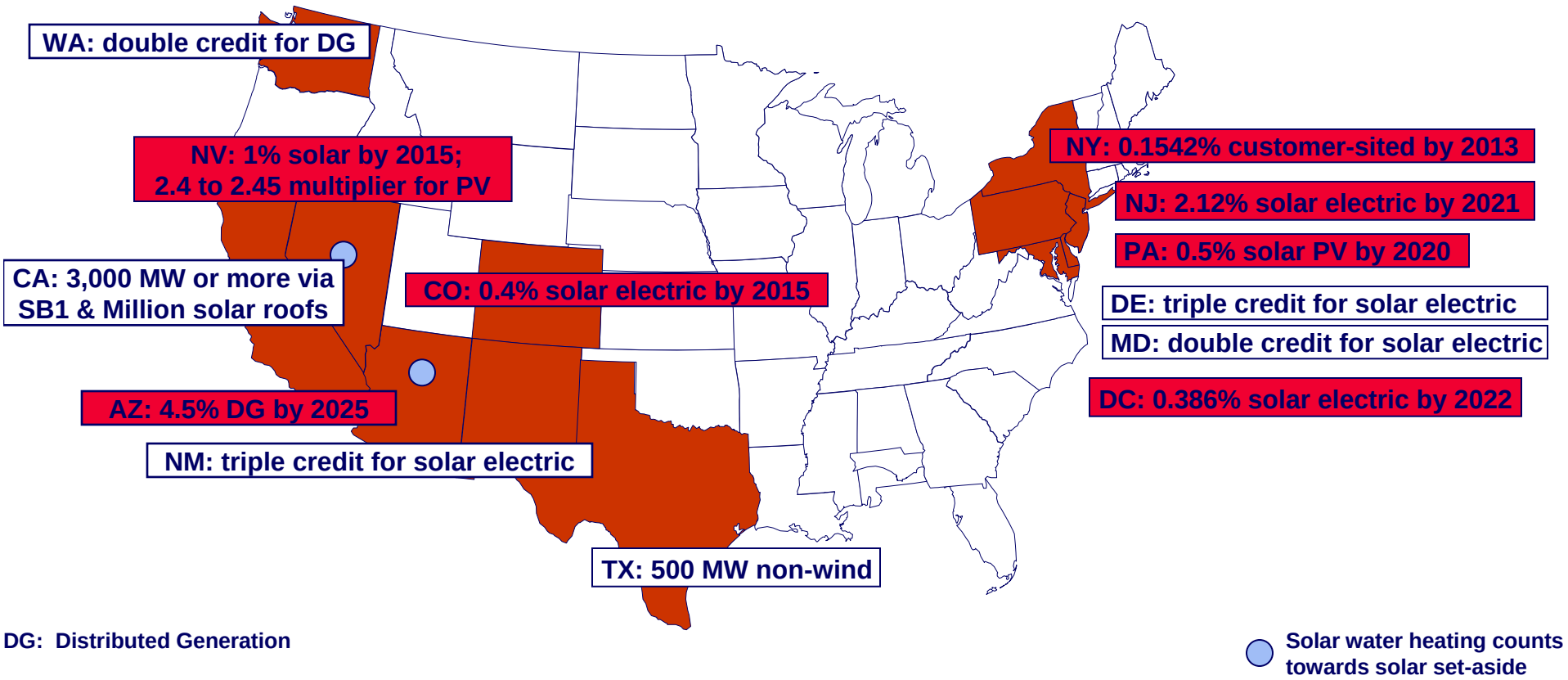
Renewable Energy Portfolio Standards

24 states + DC, and counting



*** Increased credit for solar or other customer-sited renewables**
PA: 8% Tier I (renewables)

Solar & Distributed Generation Provisions in RPS Policies

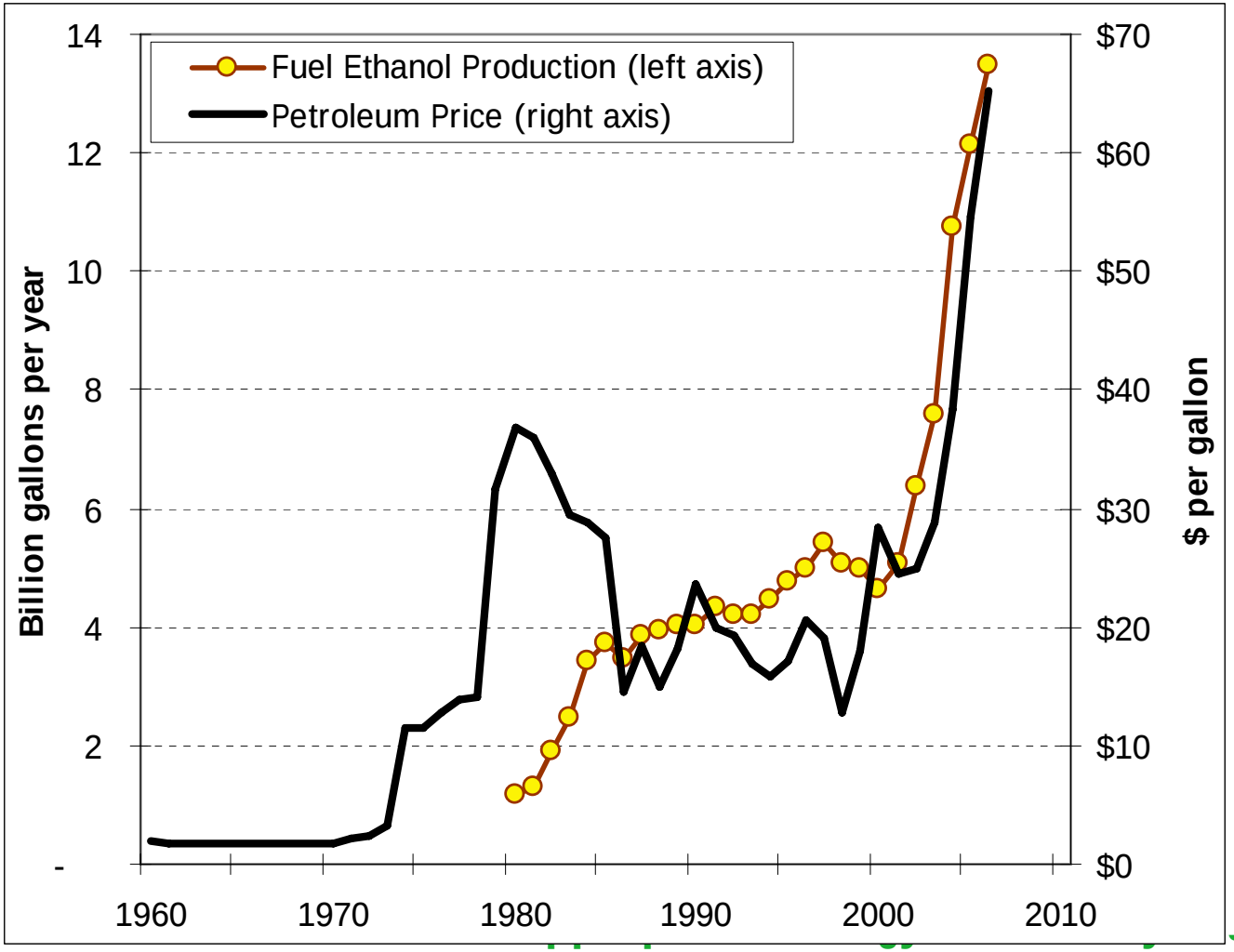


DG: Distributed Generation

Solar water heating counts towards solar set-aside

Today's Biofuel Industry

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



Sources: US EIA, BP, RFA

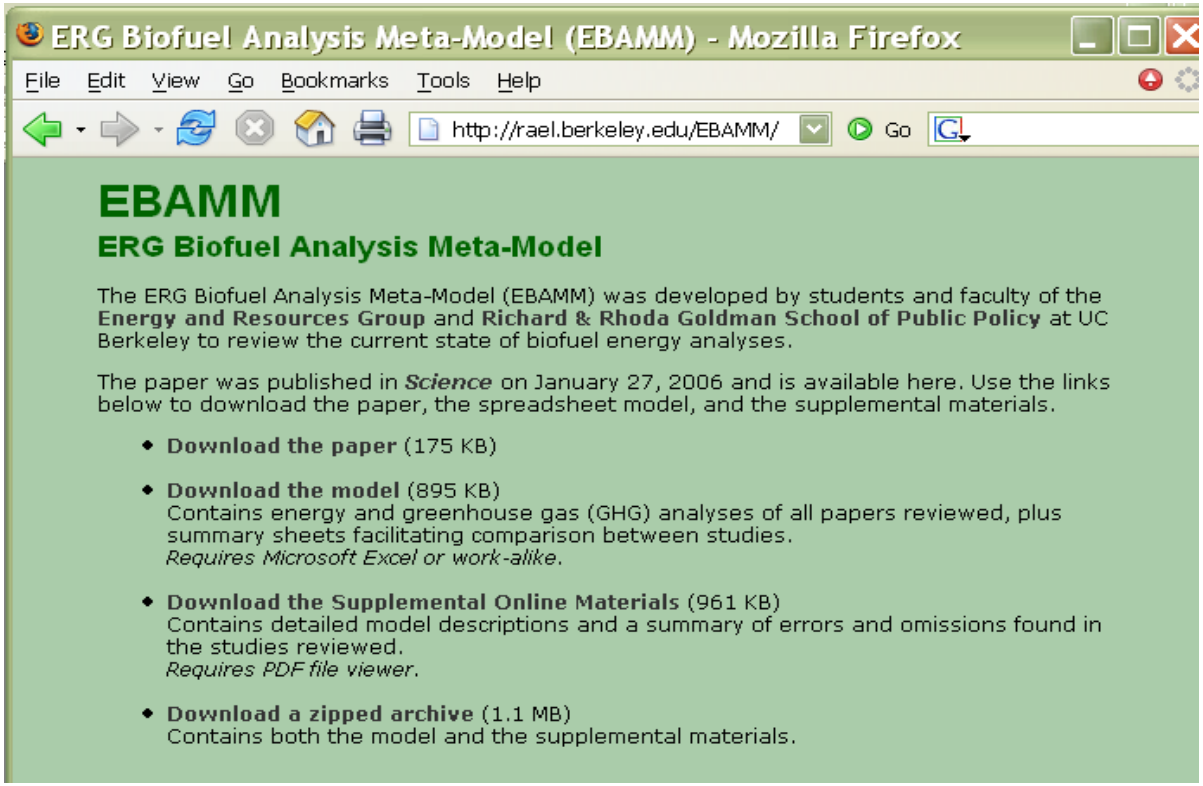
REPORTS

27 JANUARY 2006 VOL 311 SCIENCE www.sciencemag.org

Ethanol Can Contribute to Energy and Environmental Goals

Alexander E. Farrell,[1*] Richard J. Plevin,[1] Brian T. Turner,[1,2] Andrew D. Jones,[1] Michael O'Hare,[2] Daniel M. Kammen[1,2,3]

Open access, online, biofuel calculator tools: http://rael.berkeley.edu/ebamm



Overview

- **<u>Feedstock-to-fuel</u> choices have profound impacts far beyond the energy sector**
- **Carbon is a start, but *sustainable fuel* standards are needed**

- **Markets provide a key tool**

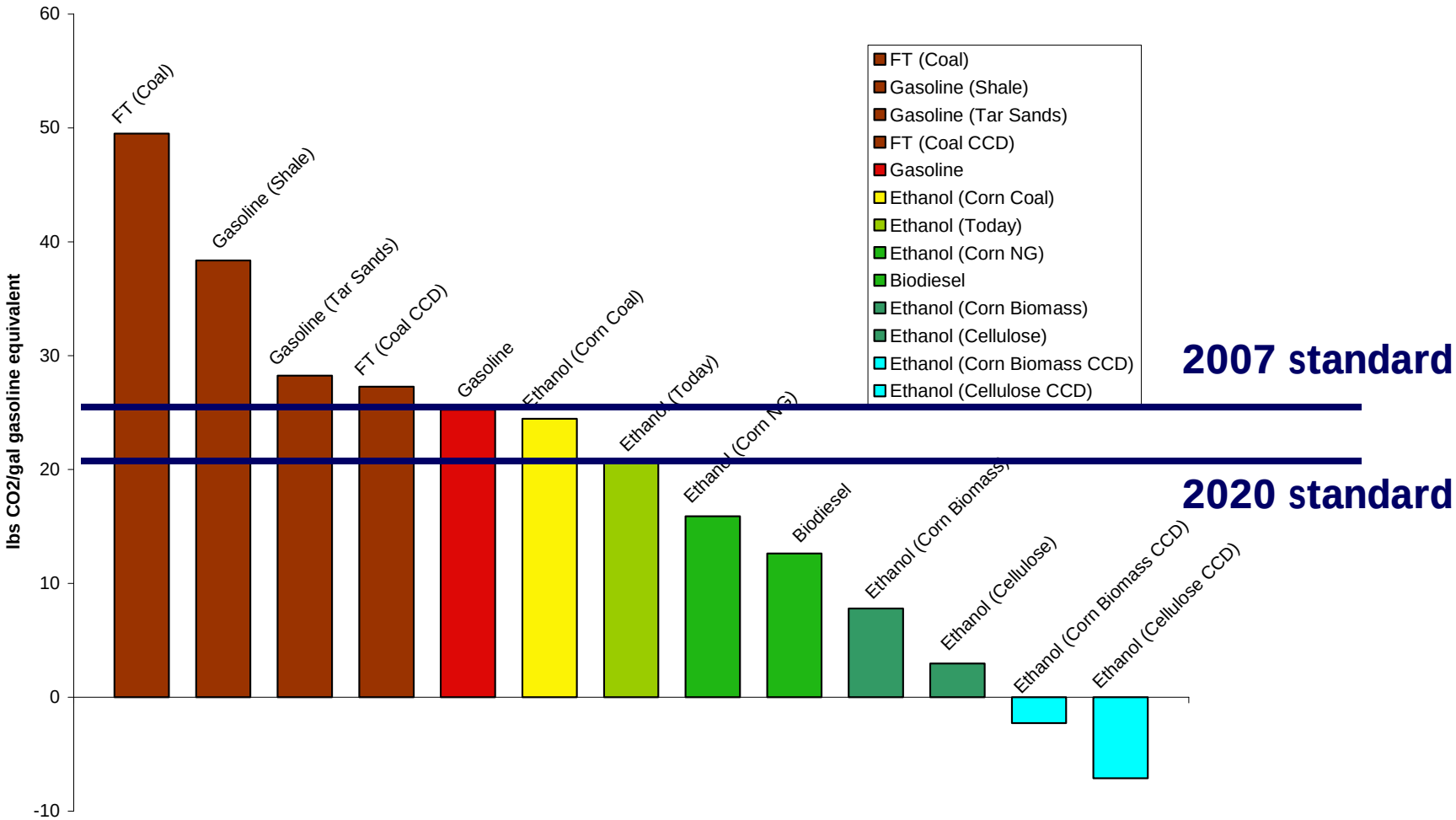
- **The poor are the most at risk, but have much to gain if biofuels are made tools to achieve sustainable societies**

- **Biofuel research and demonstration must be integrated with policy development**
- **Biofuels link energy and globalization**

Energy Biosciences Institute

University of California, Berkeley
Lawrence Berkeley National Laboratory
University of Illinois at Urbana-Champaign
BP (partner and $500 million funder)

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



Feedstocks that use degraded land or no land require advanced technologies

- **Ligno-cellulosic fermentation**
- **Gasification & synthesis**
- **Fast Pyrolysis**
- **Algae**

A promising crop: *Miscanthus X Giganticus*

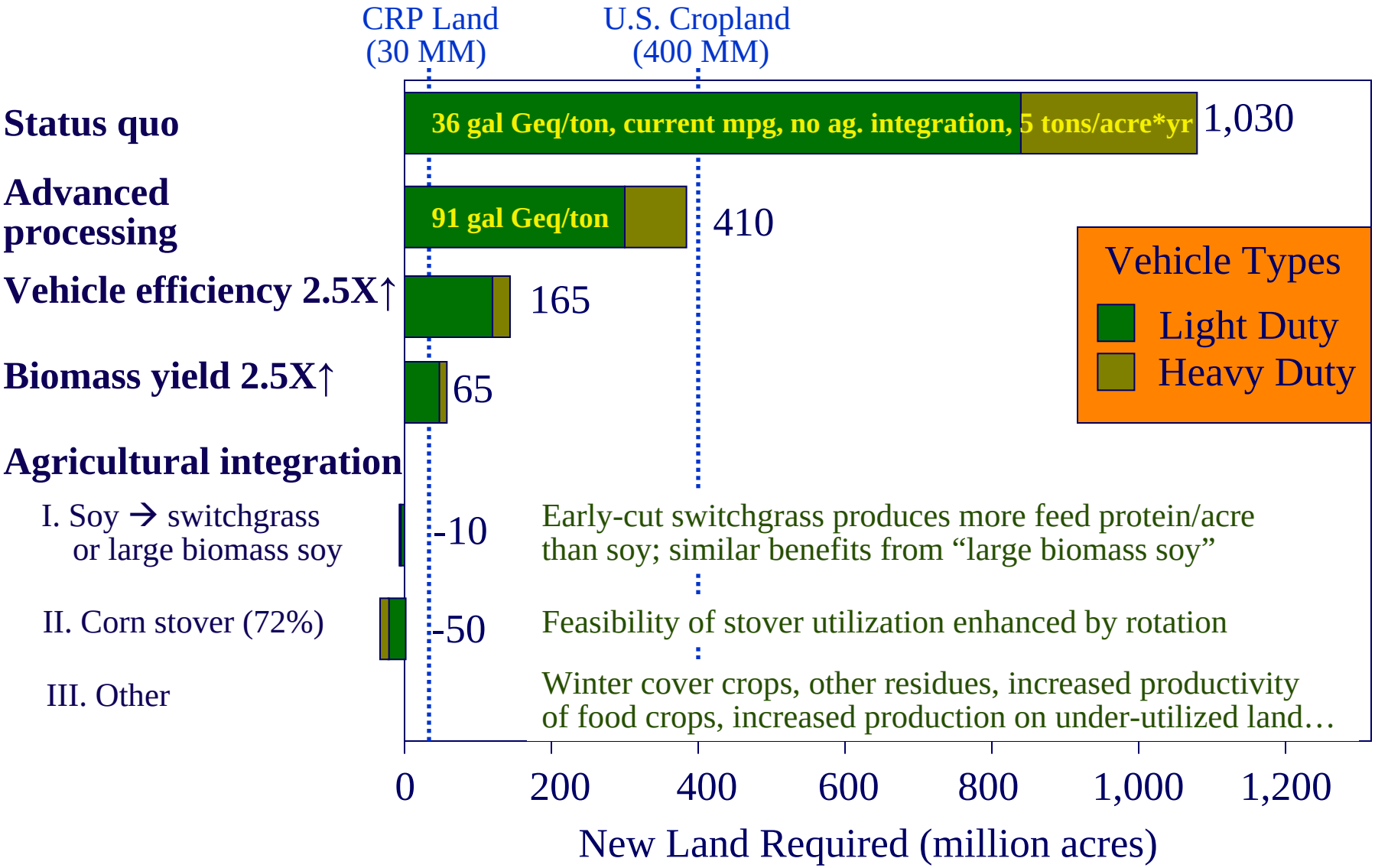
Top left: summer Miscanthus growth (sterile)

Top right: Miscanthus stands (UK)

Right: winter harvest of the C4 plant, Miscanthus after growing season and nutrients and water returned to the soil

Photo credits: S. Long (U. of Illinois/EBI)

Land Required to Satisfy Current U.S. Mobility Demand

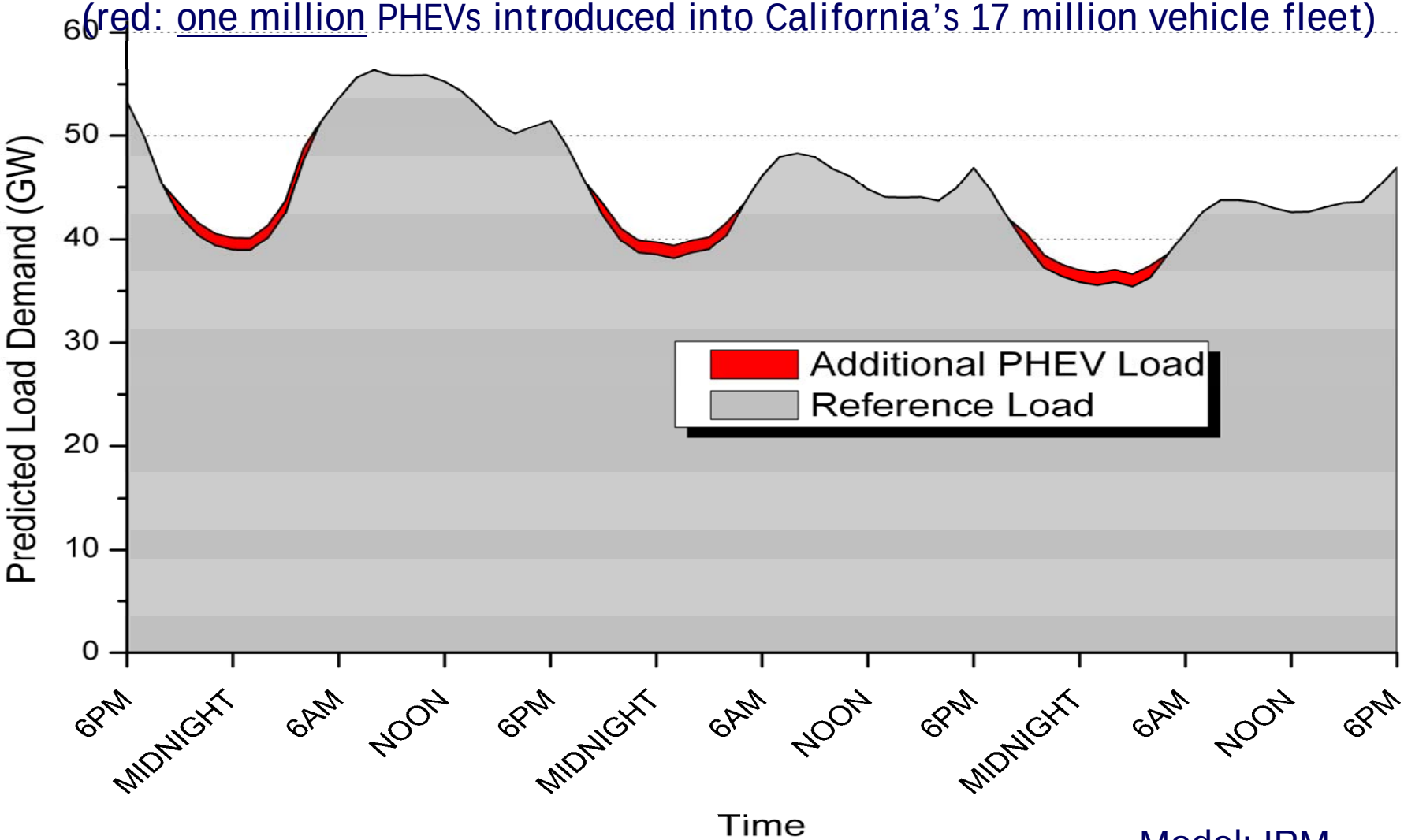


U.S. mobility demand, the largest per capita in the world, could be met from land now used for agriculture while maintaining food production (L. Lynd)

Plug In Partners / e.g. CalCars.org

Plug-in Hybrid (PHEV) Off-Peak Electricity Demand

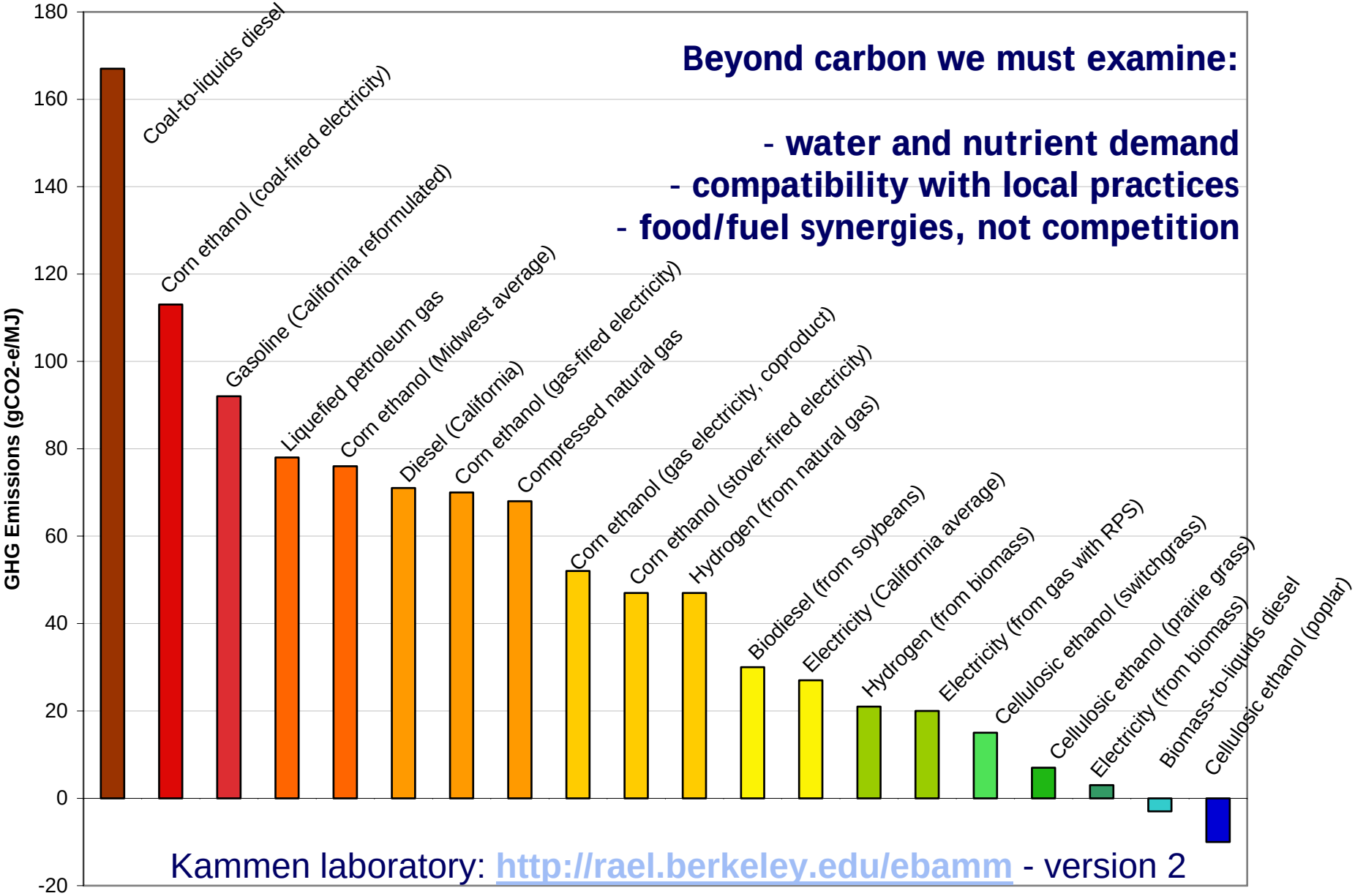
(red: one million PHEVs introduced into California's 17 million vehicle fleet)



Model: IPM

- Additional load from PHEVs is small
- PHEVs could be charged mostly via base-load filling during evenings and nights, when electricity costs are low

From a Low Carbon Fuel Standard to a Sustainable Fuel Standard



Beyond carbon we must examine:

- **water and nutrient demand**
- **compatibility with local practices**
- **food/fuel synergies, not competition**

Kammen laboratory: http://rael.berkeley.edu/ebamm - version 2

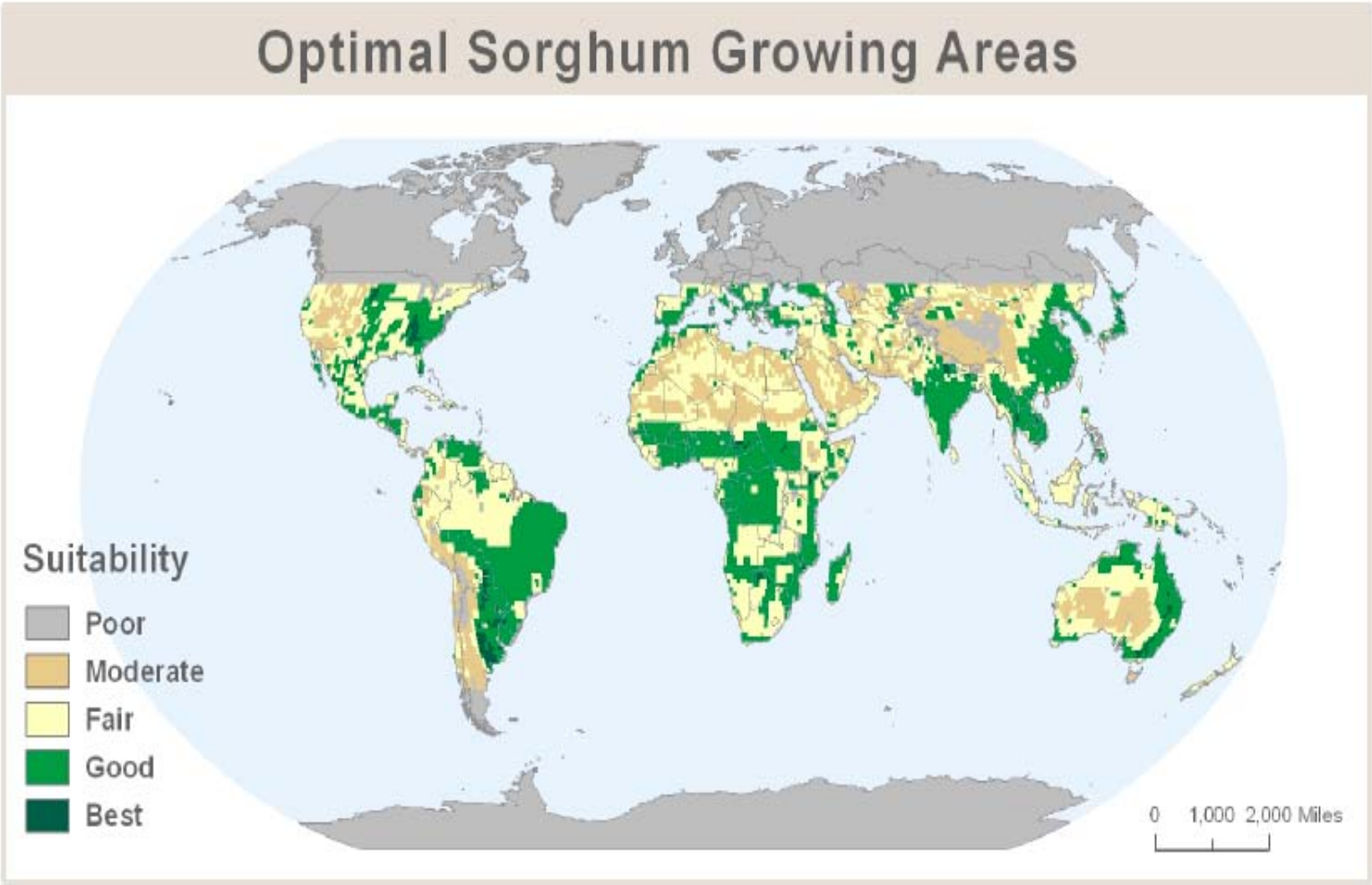
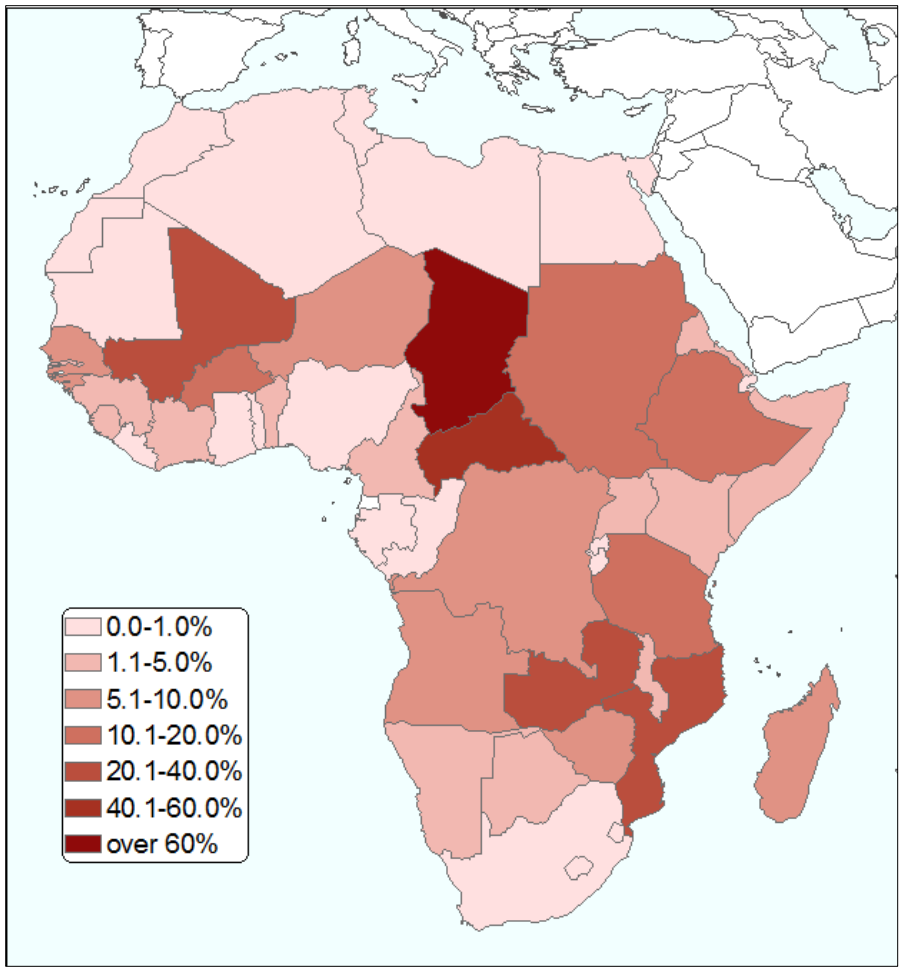


Figure 1. Optimal sorghum growing areas are based on solar radiation, minimum, maximum, and monthly temperature, annual precipitation, and soil texture. Produced by the UC-Berkeley Geospatial Imaging and Informatics Facility (GIIF) as an early demonstration of the data methods available for this study.

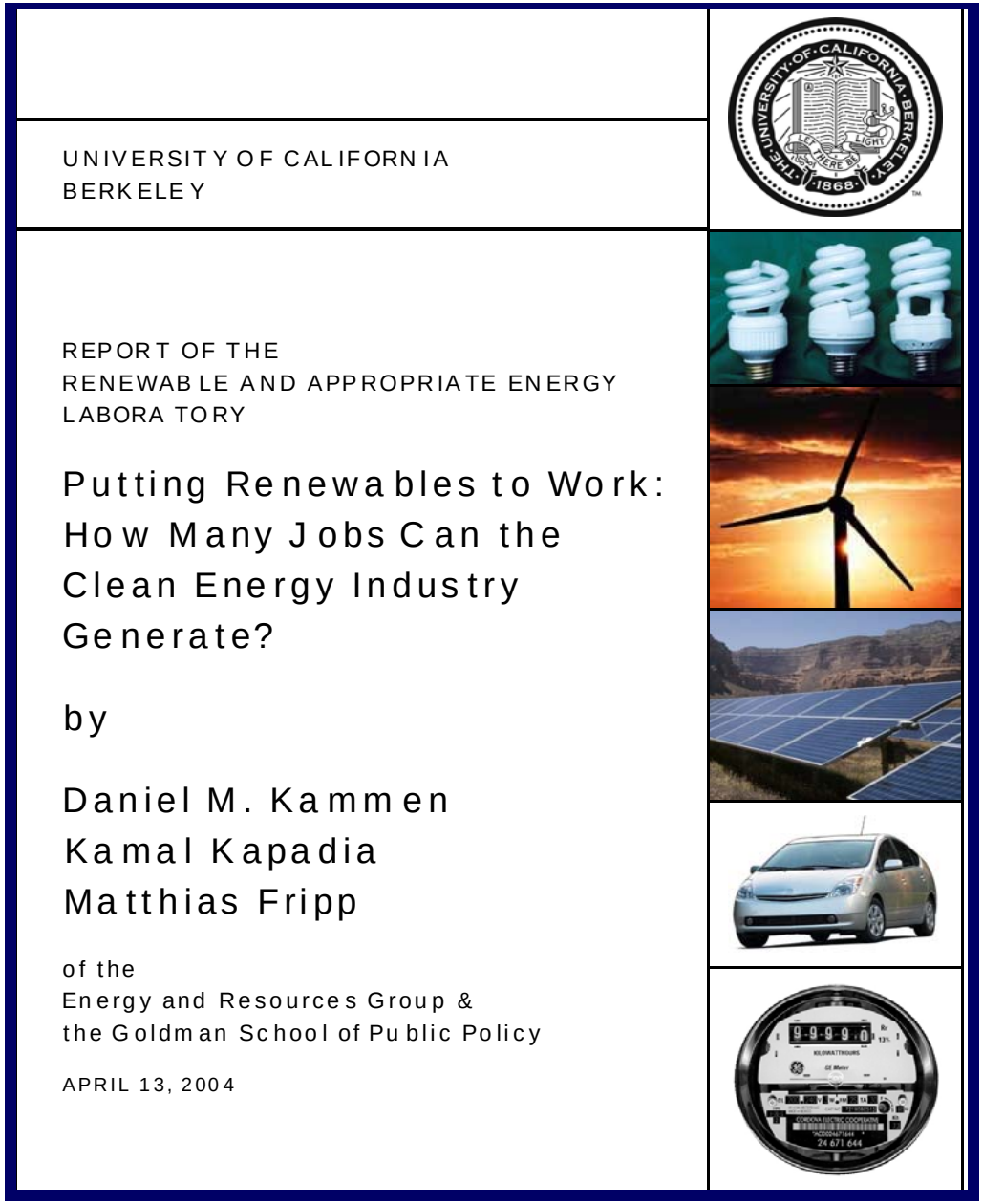
William Collins, LBNL

Ethanol can Displace Gasoline Consumption in Africa

- 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

Report available at:

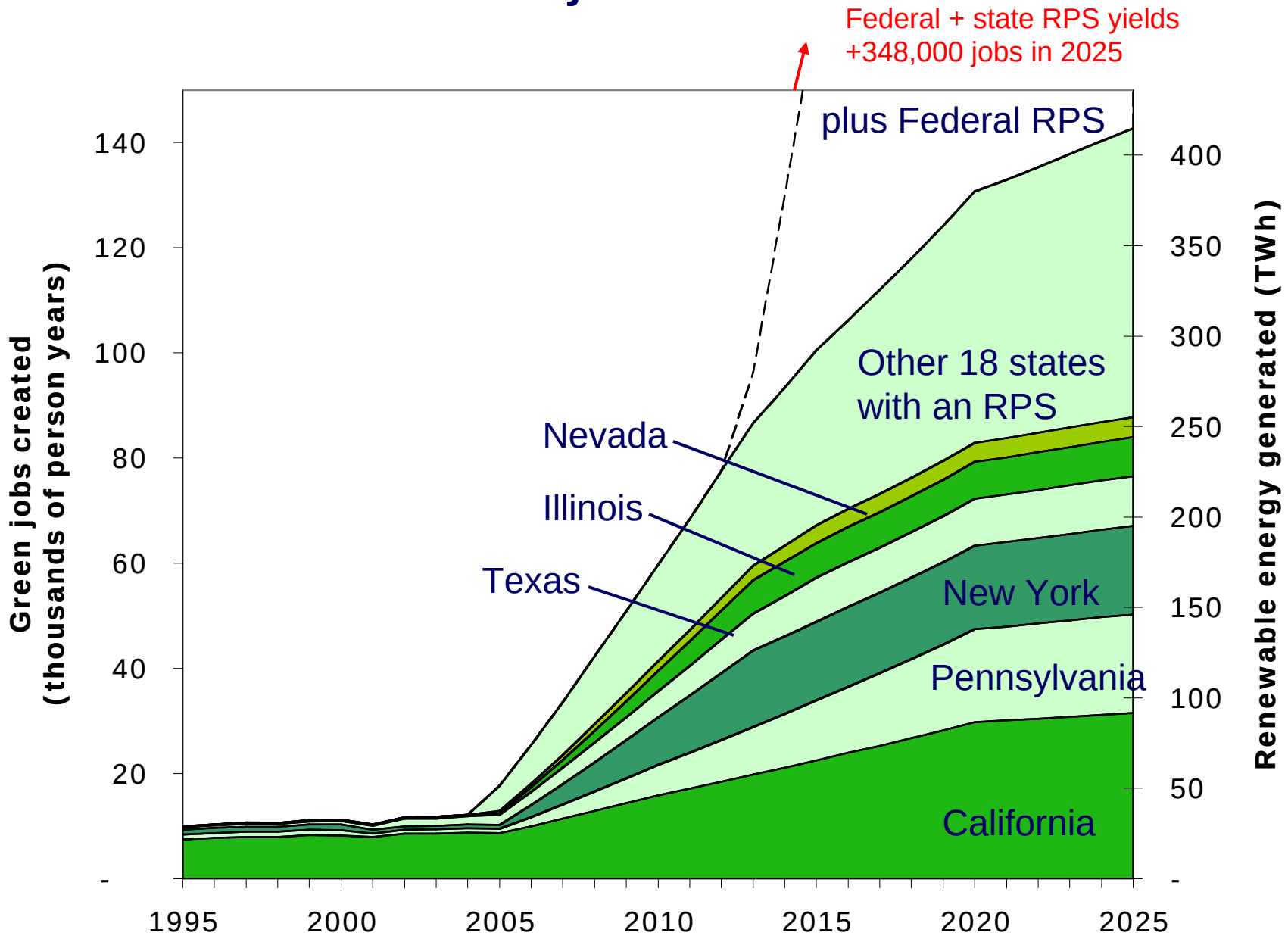
Green job creation

More renewables = more jobs

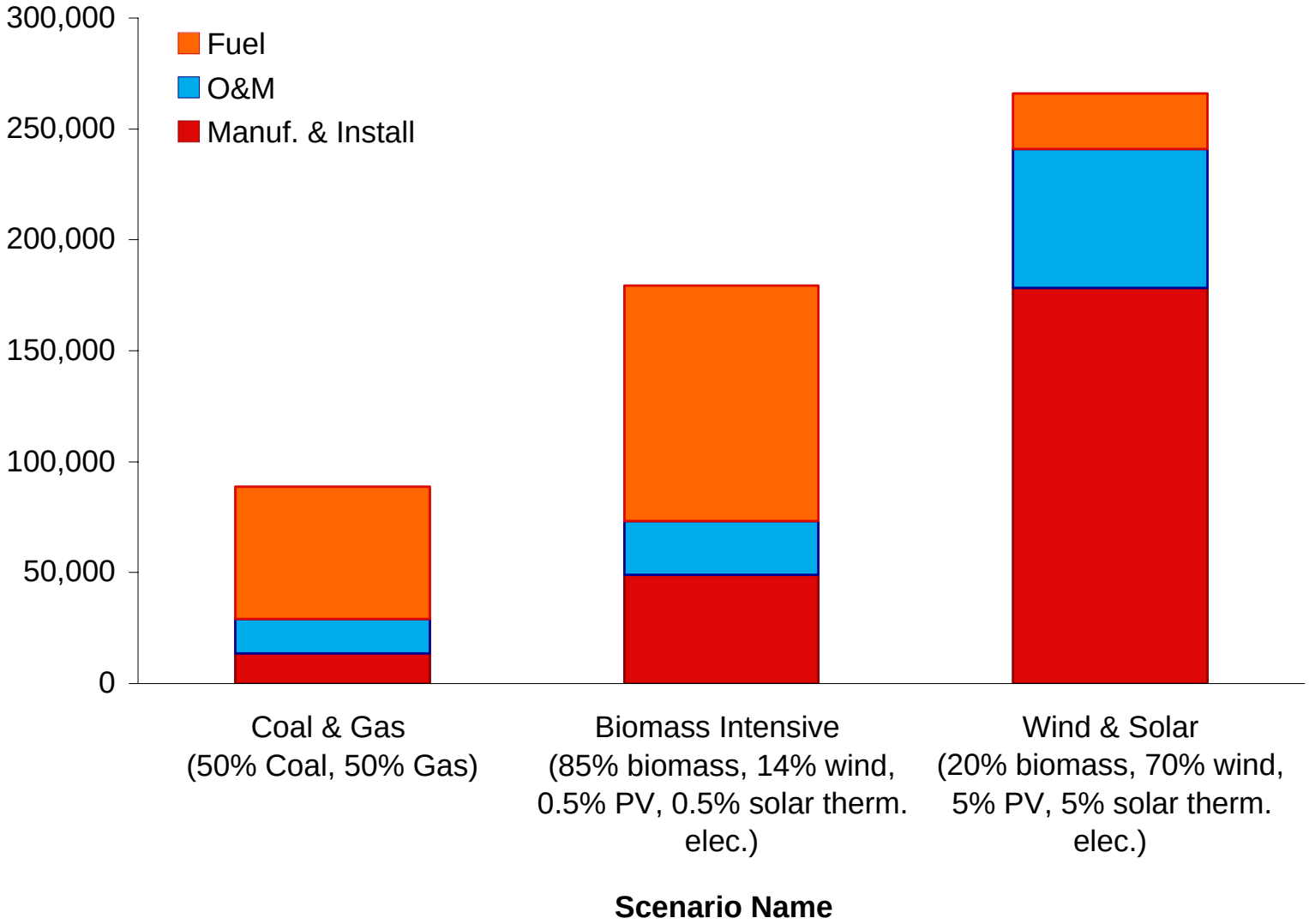
Energy Technology	Jobs (total person-yrs/TWh)		Equipment lifetime (years)	Capacity Factor	Employment Components			Source of Numbers
	Construction, Manufacturing, Installation	O&M and fuel processing			Construction, Manufacturing and Installation (person-yr/MWp)	Operation and Maintenance (jobs/MWp)	Fuel 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

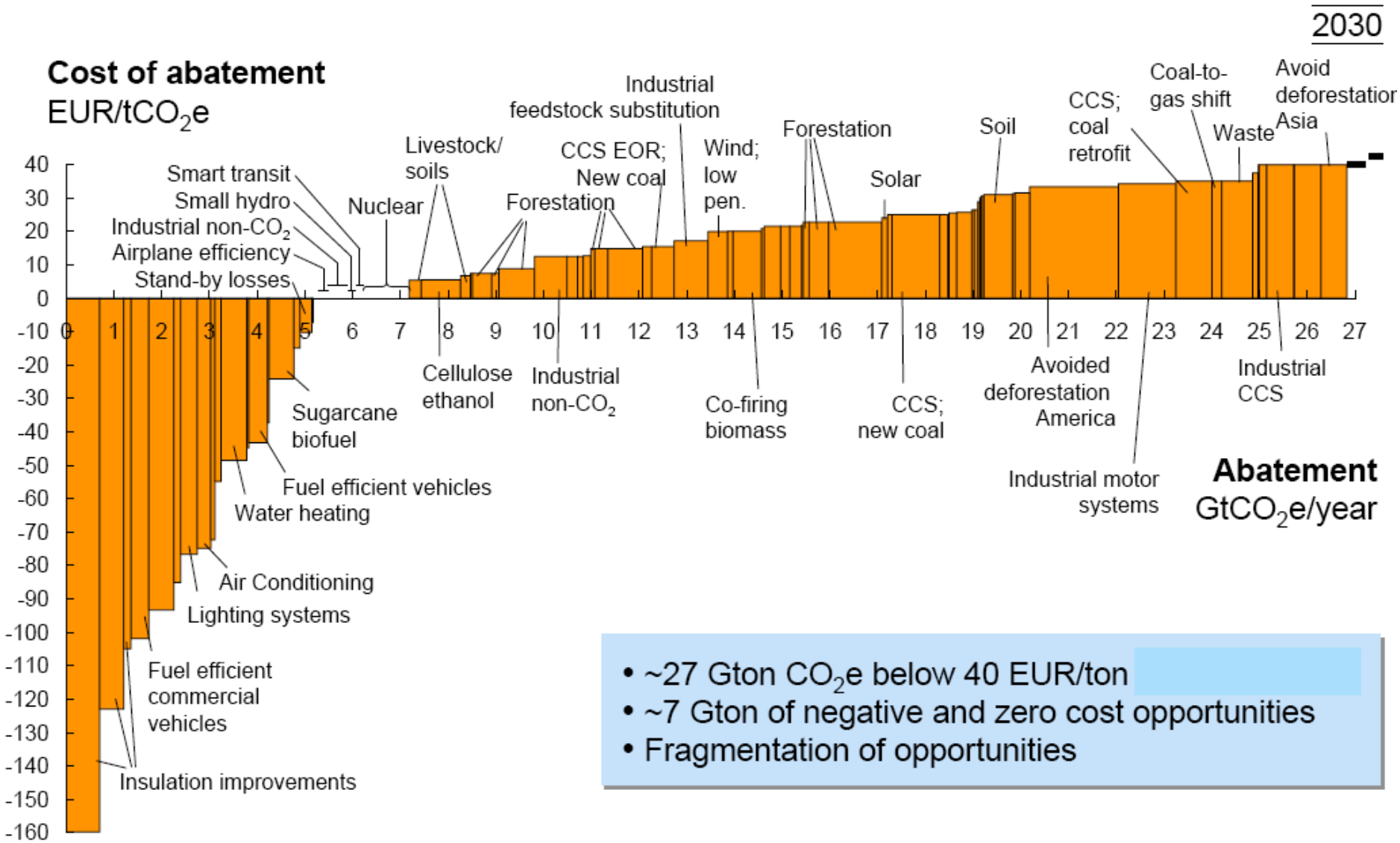
Green job creation



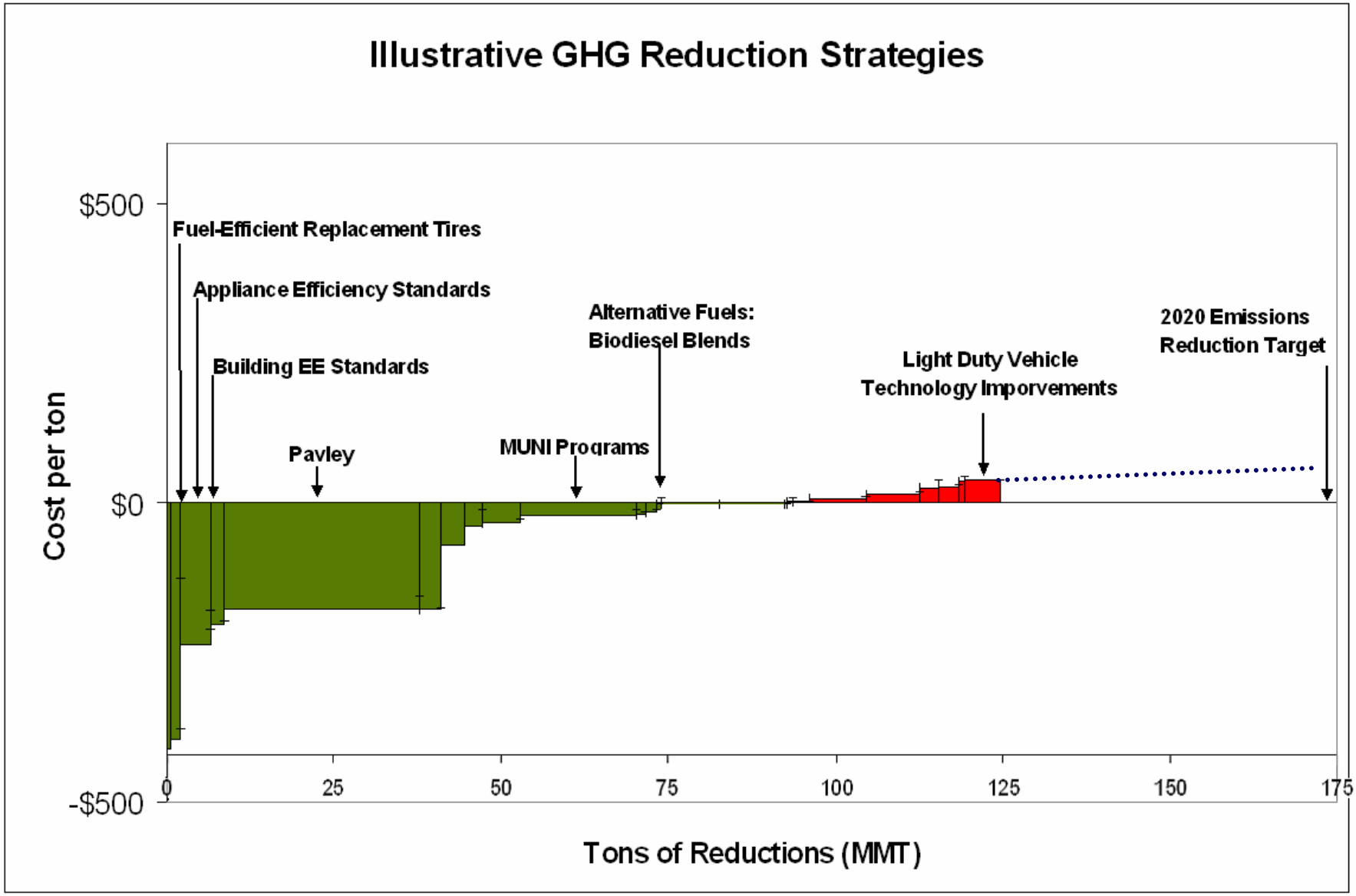
Scenario Results (800 TWh/yr, 91 GWa)



Global CO_2 Abatement Opportunities

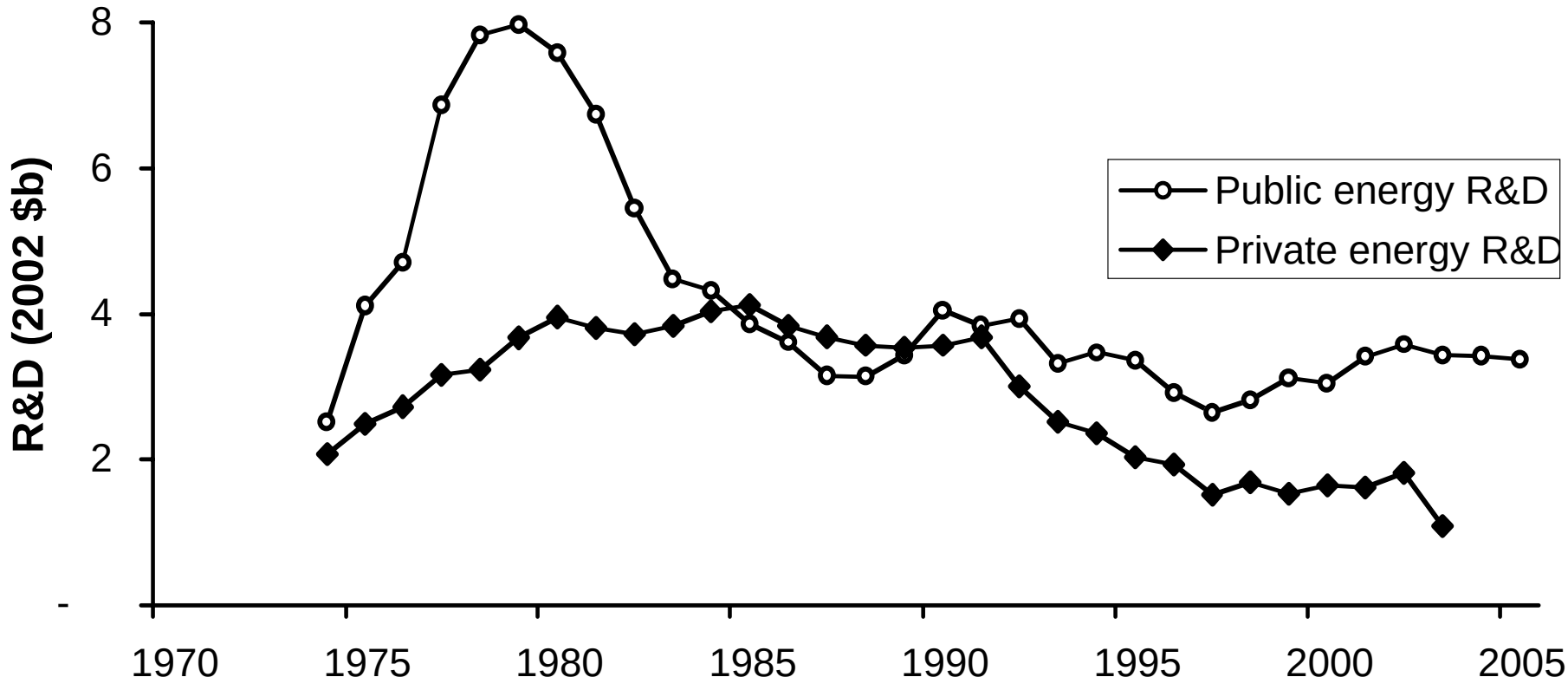


- ~27 Gton CO_2e below 40 EUR/ton
- ~7 Gton of negative and zero cost opportunities
- Fragmentation of opportunities



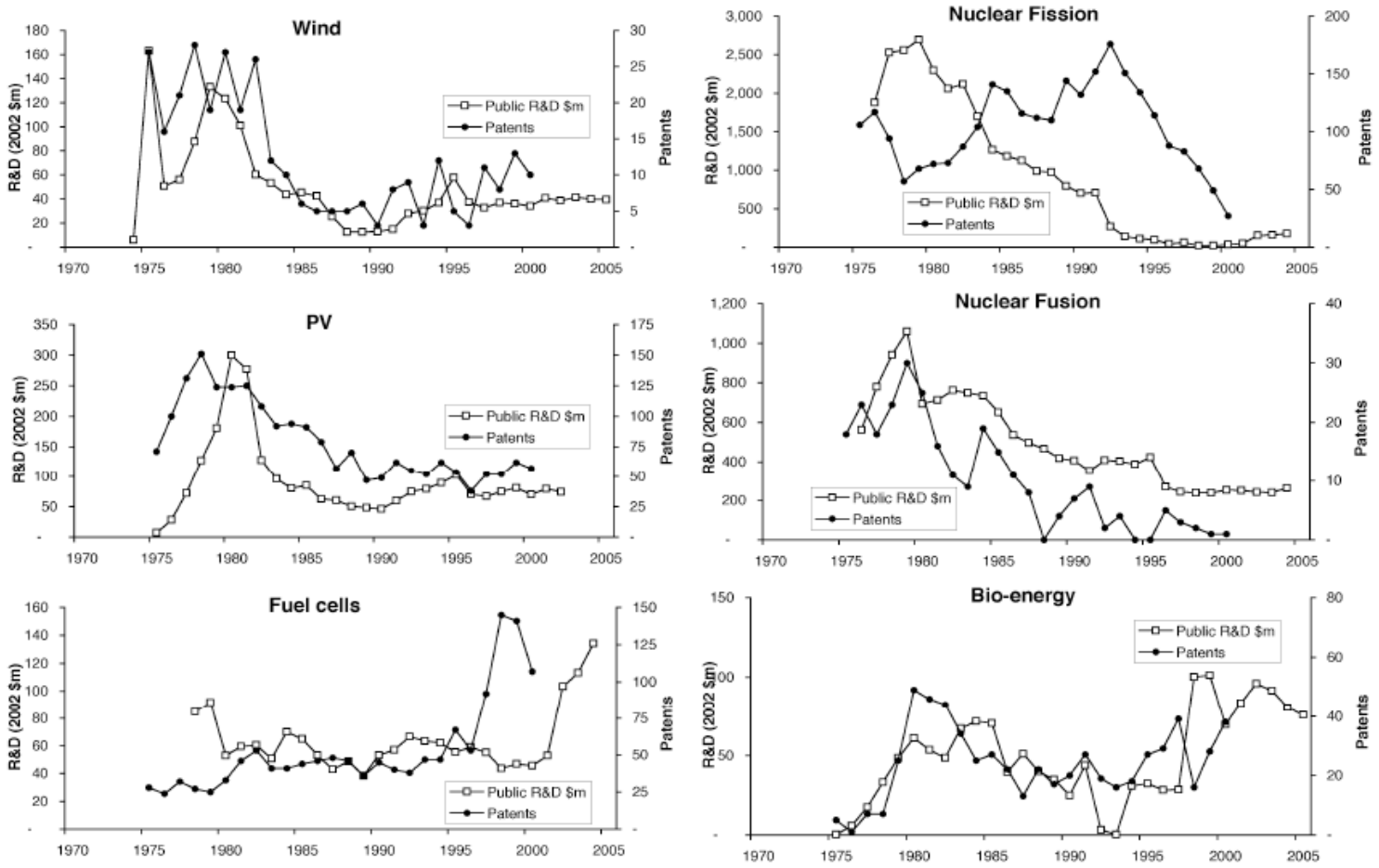
Based Upon Exhibit 11: Updated Estimates for 2020 for the Climate Strategies Included in the 2006 CAT Report UPDATED MACROECONOMIC ANALYSIS OF CLIMATE STRATEGIES …

If you think US public sector energy R&D funding is doing poorly …



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

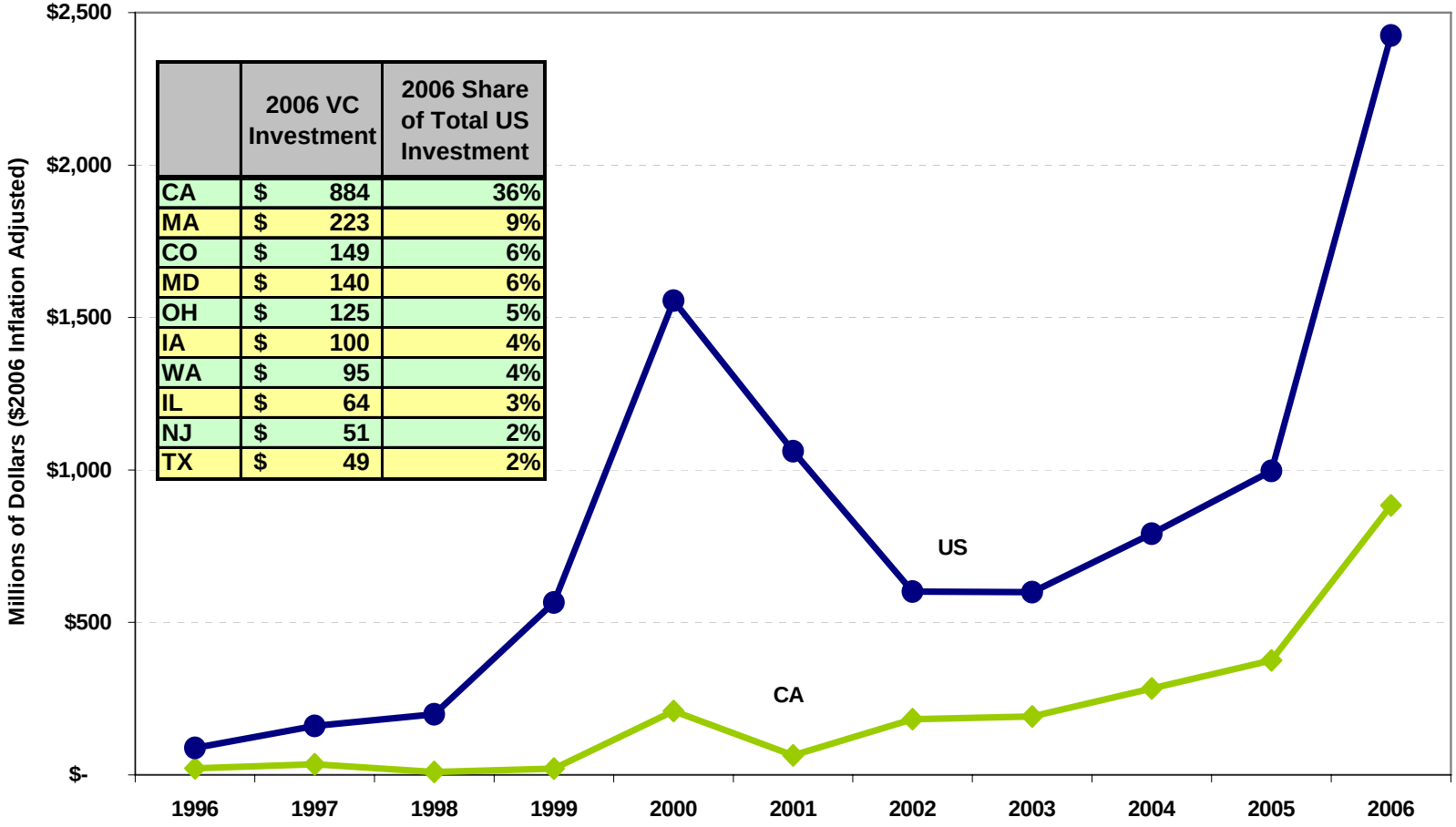
Patents and R&D Funding Correlated



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

California Public Utilities Commission
505 Van Ness Ave., San Francisco, CA

PRESS RELEASE

PROPOSAL: $620 MILLION, 10 YEAR PROGRAM
THE INSTITUTE WILL BE A HUB FOR GLOBAL PARTNERSHIPS

FOR IMMEDIATE RELEASE

Media Contact: Terrie Prosper, 415.703.1366, news@cpuc.ca.gov

PUC CONSIDERS UC PROPOSAL CREATING CLIMATE SOLUTION INSTITUTE

SAN FRANCISCO, September 20, 2007 - The California Public Utilities Commission (PUC), as part of its continuing effort to aggressively pursue ways for California to reduce greenhouse gas emissions, today said it will analyze and act upon a proposal by the University of California to create the California Institute for Climate Solutions.

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

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.

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 6: CA Berkeley city council votes 8- 0 in support

June 2008: operational date

SOLAR AMERICA CITY 2007

Summary / Conclusions

- Sound technology policy combines technology push and demand-pull
  - AB32 provides vital, technology-neutral, demand pull
  - Market design is equally vital to sustaining demand (the Market Advisory Committee report is an excellent start)
  - A sufficient technological base exists, particularly in California
- An ongoing commitment to R&D will be needed
- A price for pollution is a vital next step

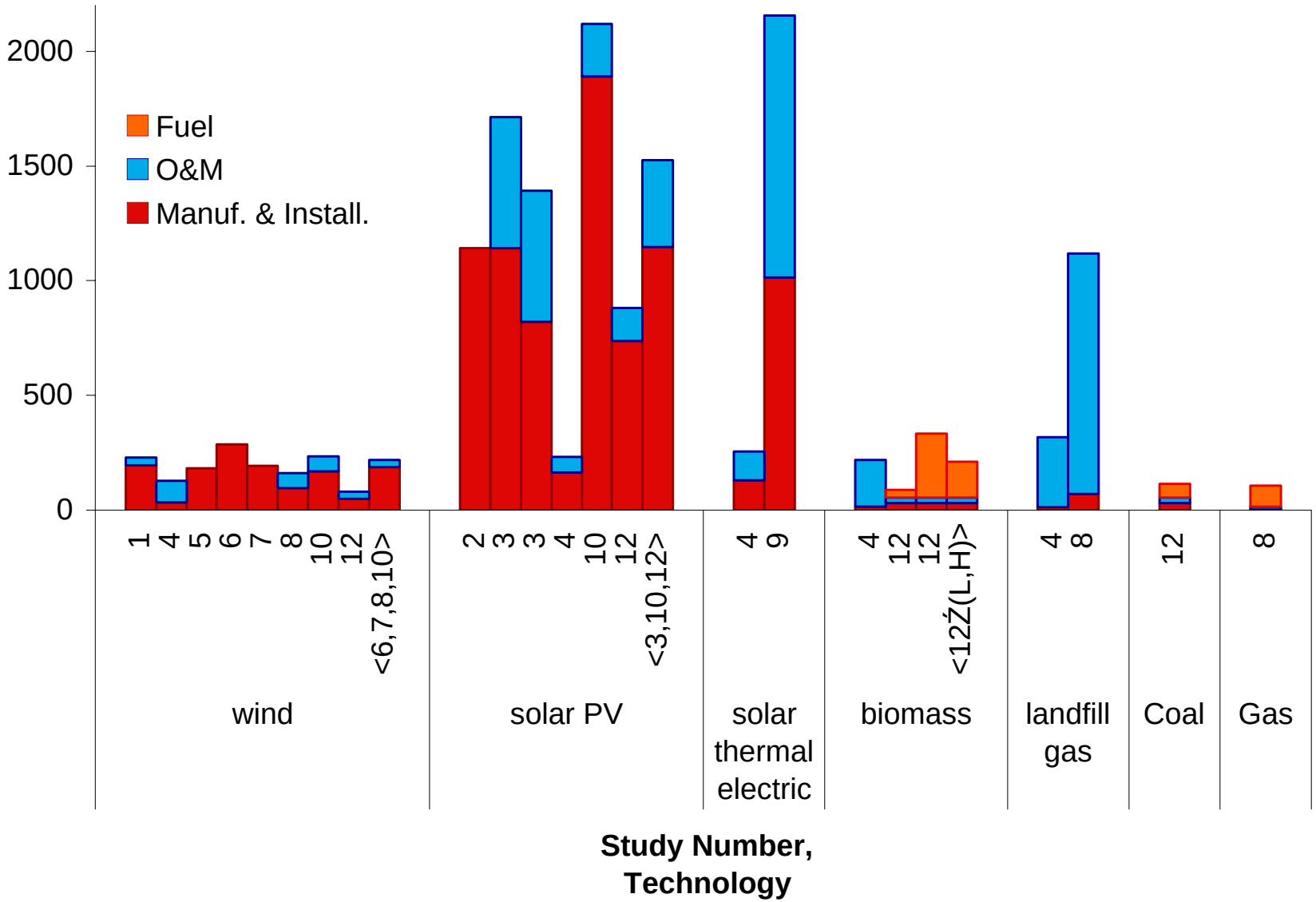
Extra / supplemental slides

Lifetime Average Employment per TWh

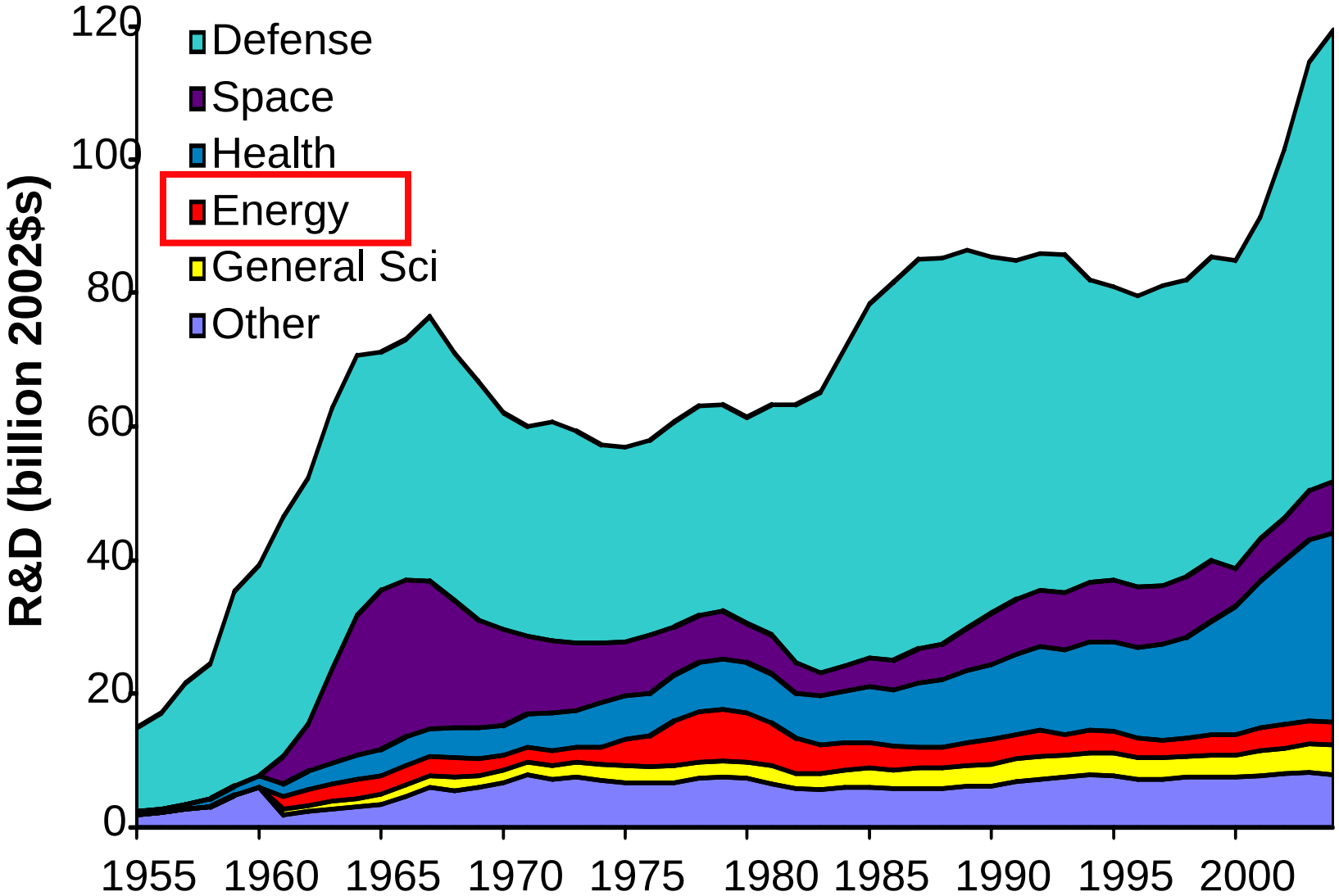
Study #	Technology	Employment Data			Annualized Data		Average Power Production		Average Employment (person-year / TWh)			
		Construction, Manufacturing, Installation (person-year / MWp)	Operation and Maintenance (jobs / MWp)	Fuel extraction and processing (person-year / TWh)	Equipment Lifetime (years)	Lifetime Average Employment for Const, Manuf., Inst. (person-year / MWp-year	Capacity Factor	Average Electricity Output (TWh / MWp-year)	Const., Manuf. & Inst.	O&M	Fuel extraction and processing	Total
1	wind	15.00	0.10	0.00	25	0.600	35%	0.00307	196	33	0	228
4	wind	2.57	0.29	0.00	25	0.103	35%	0.00307	34	95	0	128
5	wind	14.00	0.00	0.00	25	0.560	35%	0.00307	183	0	0	183
6	wind	22.00	0.00	0.00	25	0.880	35%	0.00307	287	0	0	287
7	wind	14.80	0.00	0.00	25	0.592	35%	0.00307	193	0	0	193
8	wind	7.40	0.20	0.00	25	0.296	35%	0.00307	97	65	0	162
10	wind	13.00	0.20	0.00	25	0.520	35%	0.00307	170	65	0	235
12	wind	3.80	0.10	0.00	25	0.152	35%	0.00307	50	31	0	81
13	wind	6.00	0.00	0.00	25	0.240	35%	0.00307	78	0	0	78
2	solar PV	50.00	0.00	0.00	25	2.000	20%	0.00175	1,142	0	0	1,142
3	solar PV	50.00	1.00	0.00	25	2.000	20%	0.00175	1,142	571	0	1,712
3	solar PV	36.00	1.00	0.00	25	1.440	20%	0.00175	822	571	0	1,393
4	solar PV	7.14	0.12	0.00	25	0.286	20%	0.00175	163	68	0	232
10	solar PV	82.80	0.40	0.00	25	3.312	20%	0.00175	1,890	228	0	2,119
12	solar PV	32.33	0.25	0.00	25	1.293	20%	0.00175	738	143	0	881
4	solar thermal electric	5.71	0.22	0.00	25	0.228	20%	0.00175	130	126	0	256
9	solar thermal electric	44.40	2.00	0.00	25	1.776	20%	0.00175	1,014	1,142	0	2,155
4	biomass	4.29	1.53	0.00	40	0.107	85%	0.00745	14	205	0	220
12	biomass cofiring	9.30	0.18	33.50	40	0.233	85%	0.00745	31	24	34	89
12	biomass cofiring	9.30	0.18	279.00	40	0.233	85%	0.00745	31	24	279	334
4	landfill gas	3.71	2.28	0.00	40	0.093	85%	0.00745	12	306	0	319
8	landfill gas	21.30	7.80	0.00	40	0.533	85%	0.00745	72	1,048	0	1,119
12	Coal	8.50	0.18	59.00	40	0.213	80%	0.00701	30	26	59	115
8	Gas	1.02	0.10	90.00	40	0.026	85%	0.00745	3	13	90	107

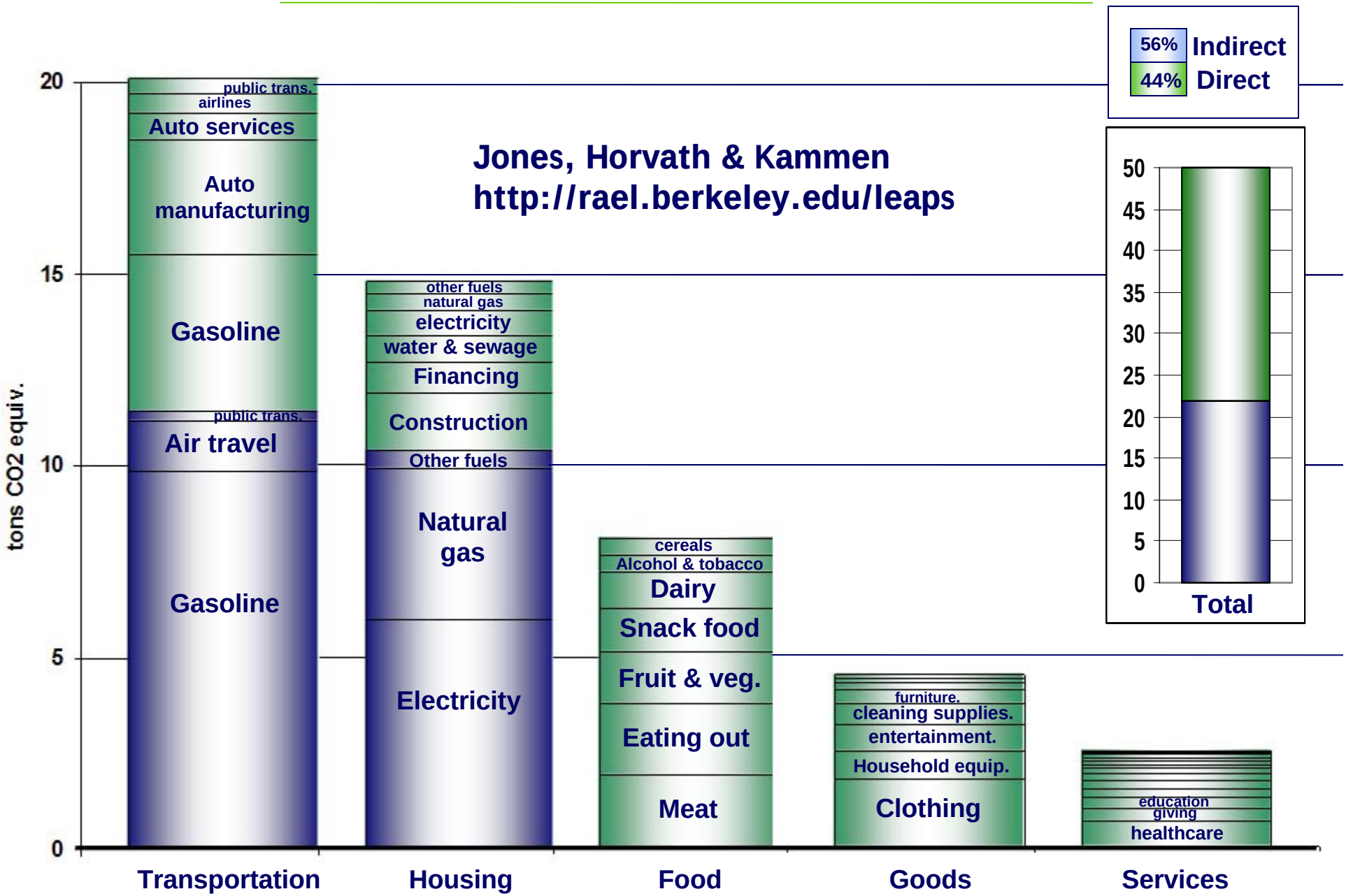
easier to see as a graph...

Employment from Each Technology



Federal R&D Investments, 1955 - 2004



Margolis & Kammen, *Science*, 1999

State of California to Adopt and Support Carbon Calculator Tool for Municipal Use