Science and Policy for Deep Cuts in Carbon Emissions

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

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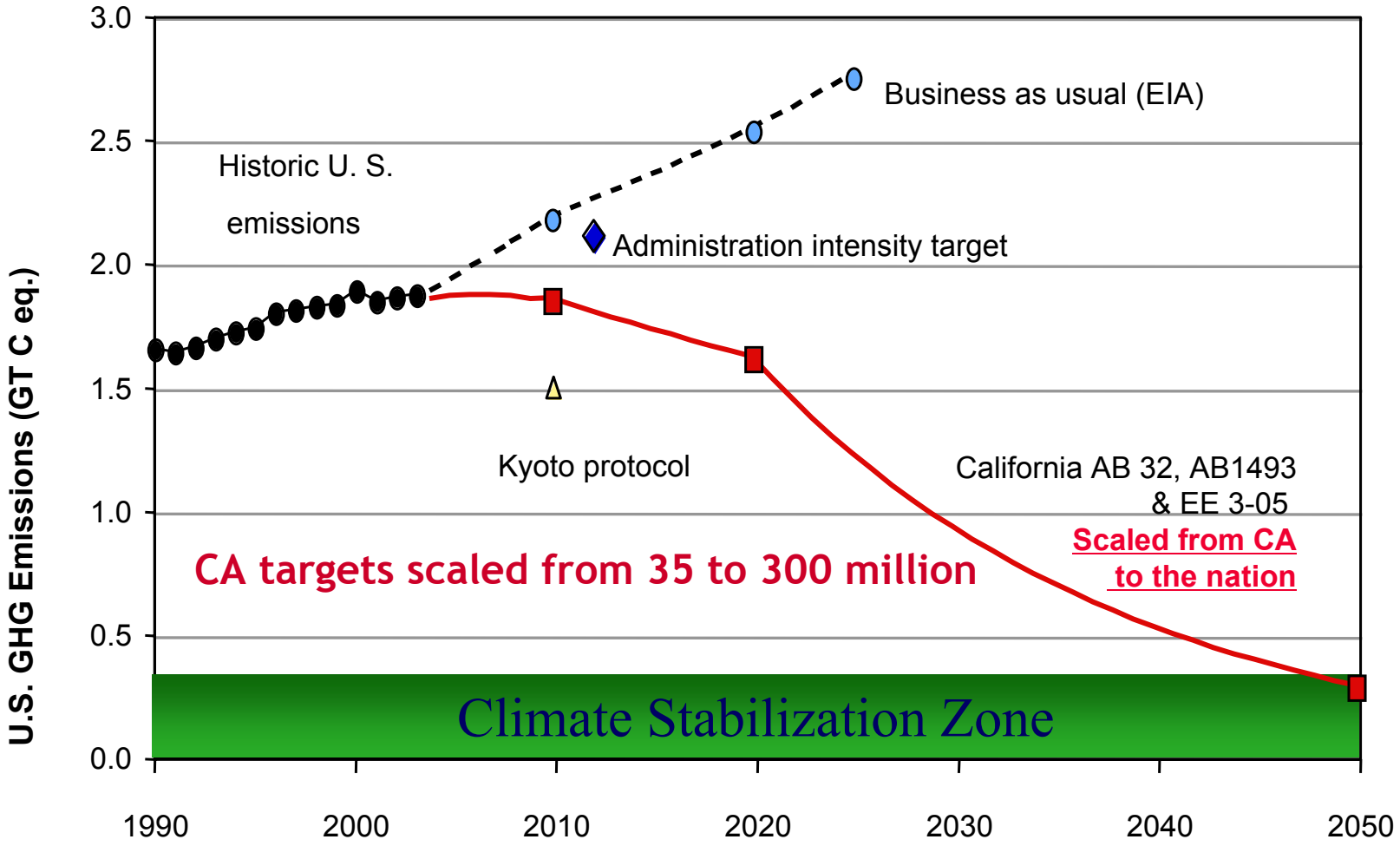
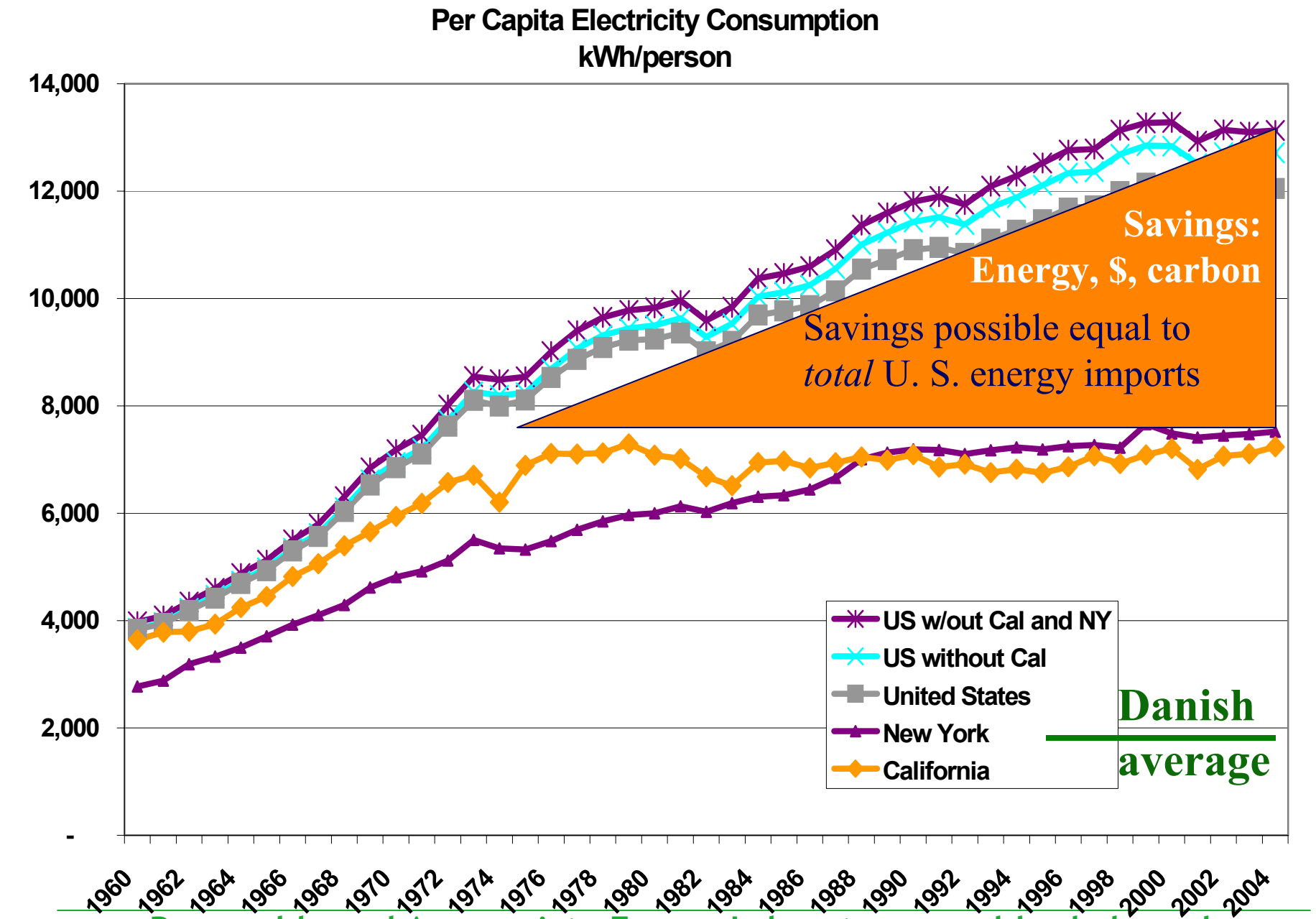
Outline

- The most common call for a new energy economy is for diversity
  - Operationally, what does this mean?
- Energy efficiency has been the greatest success, more is needed
- Carbon accounting and pricing is essential
- A foundation for a new wave of research and development requires investment

The California commitment - scaled to the nation

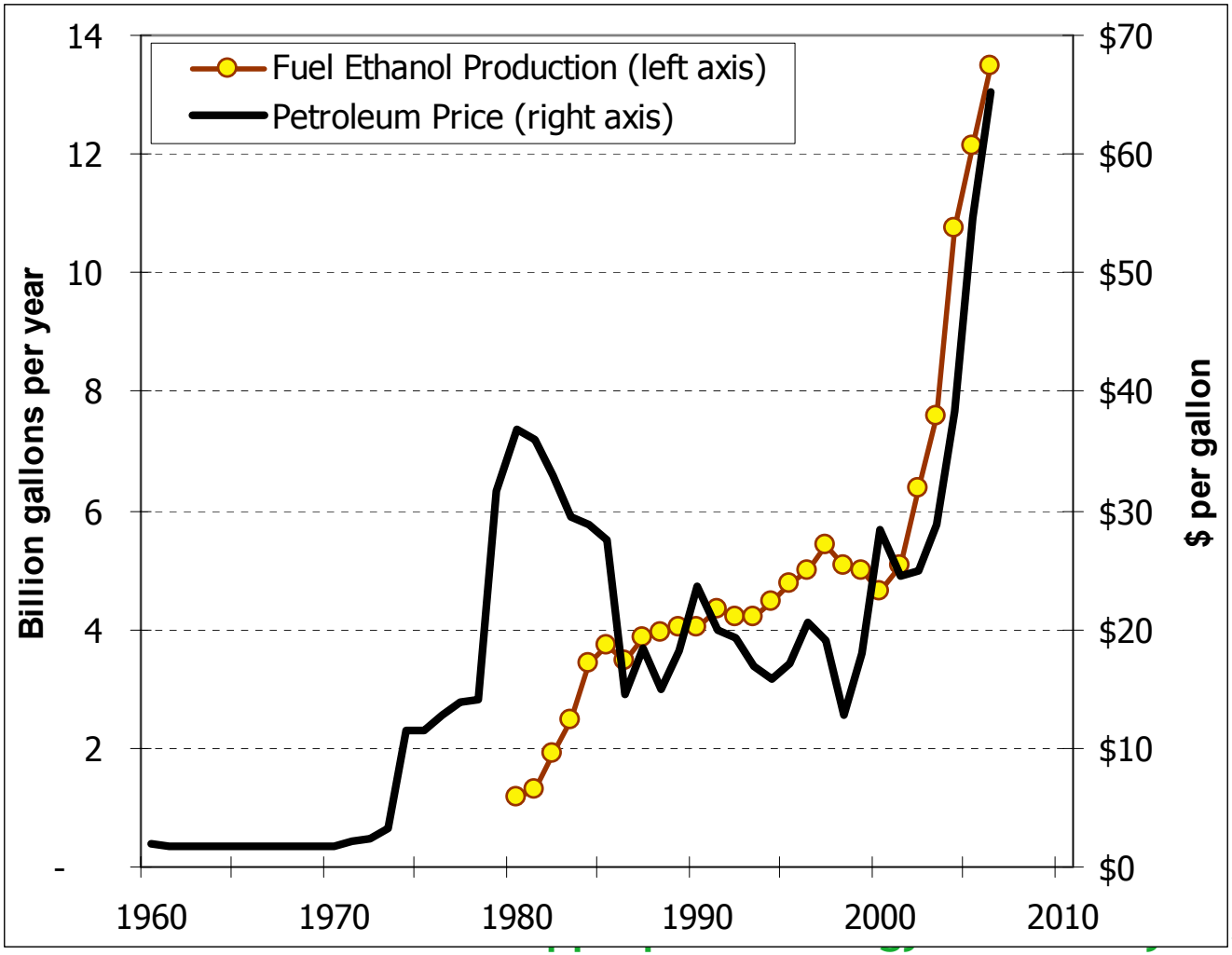


Kammen, "September 27, 2006 – A day to remember", *San Francisco Chronicle*, September 27,


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

Today's Biofuel Industry

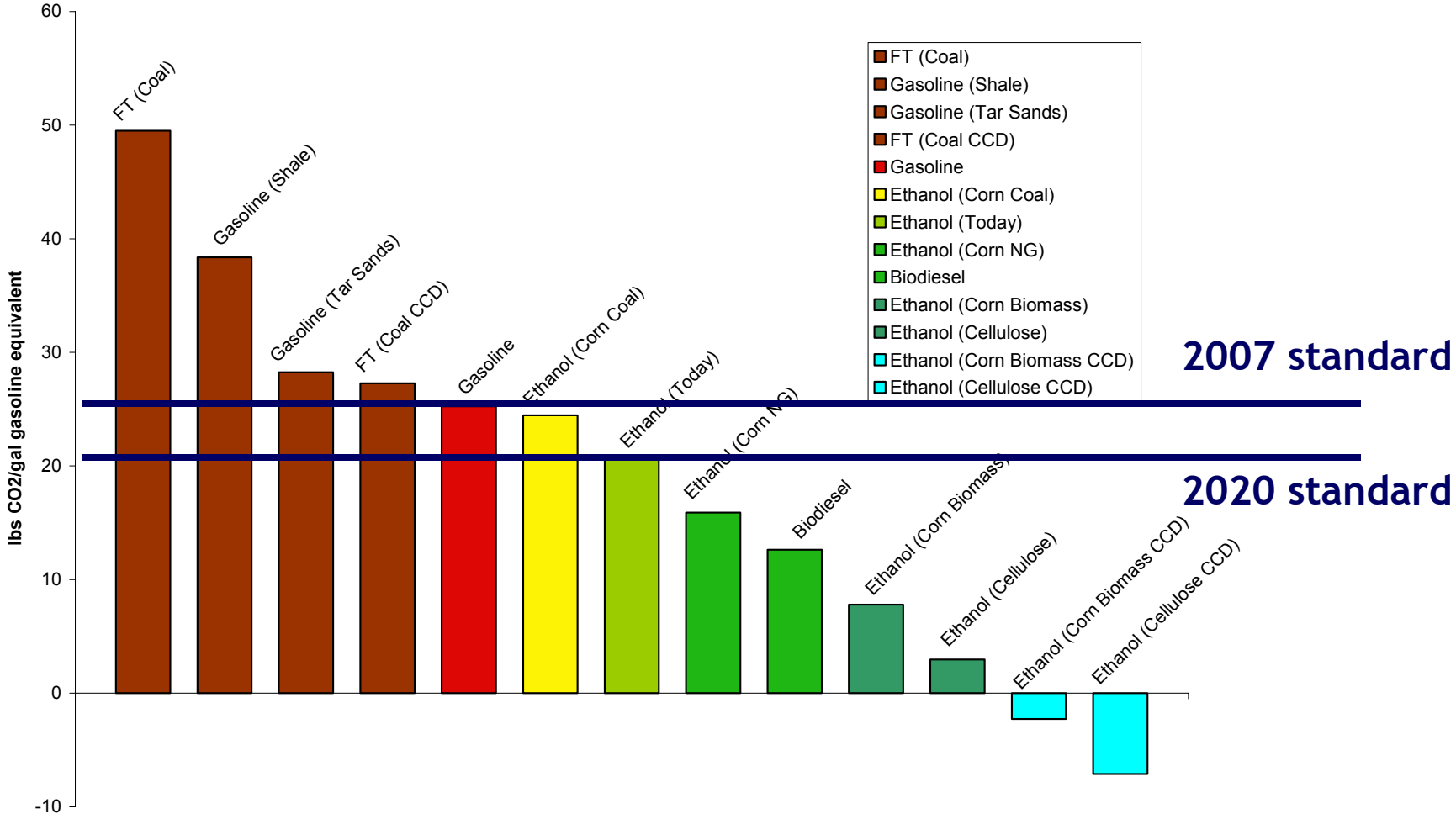
- Feedstocks largely food commodities
- Fuels are traditional substances
- Success depends on subsidies and mandates
- Small, but profitable and growing rapidly



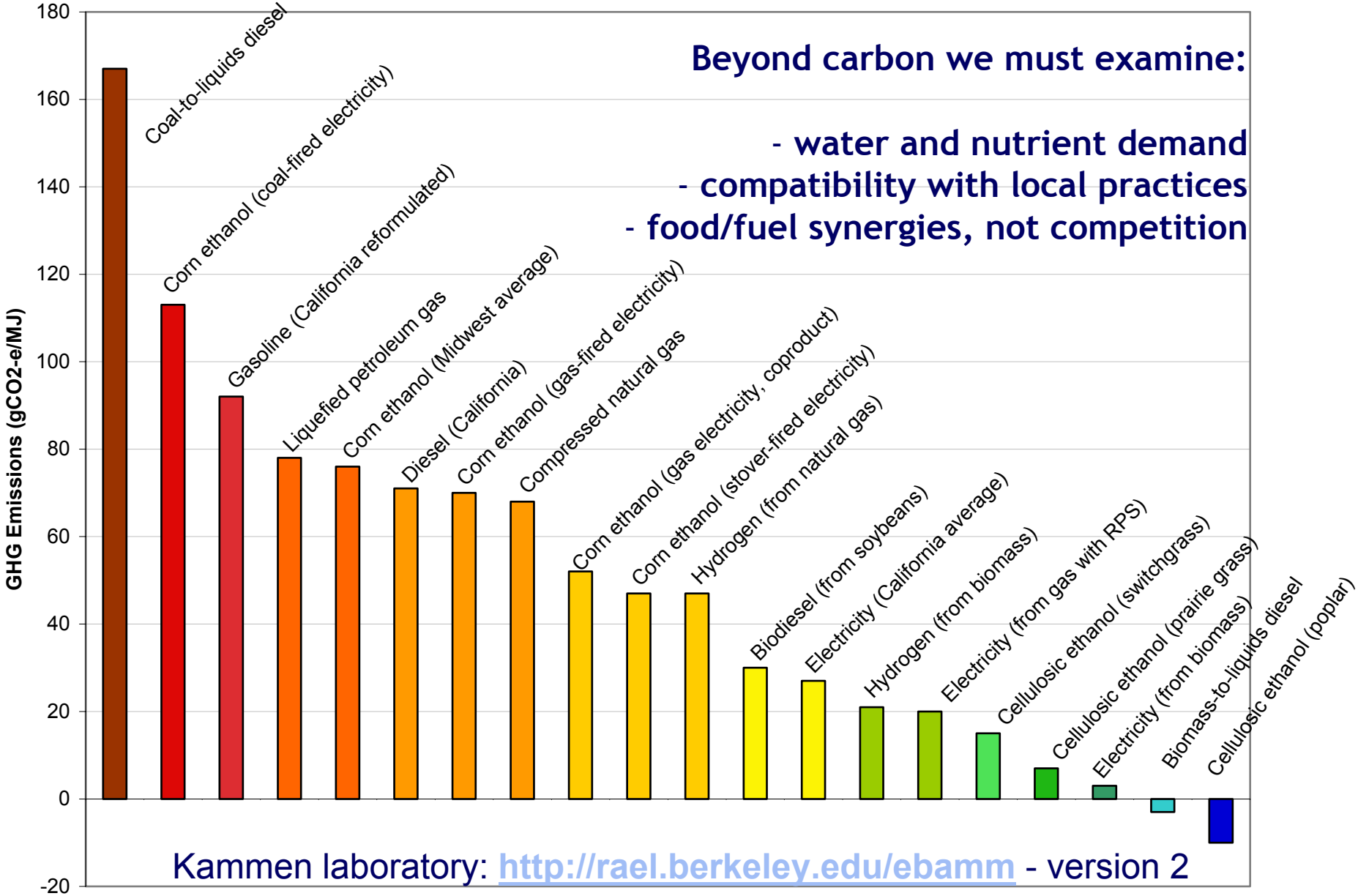
Sources: US EIA, BP, RFA

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

(California Executive Order S-7-01)



From a Low Carbon Fuel Standard to a Sustainable Fuel Standard



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

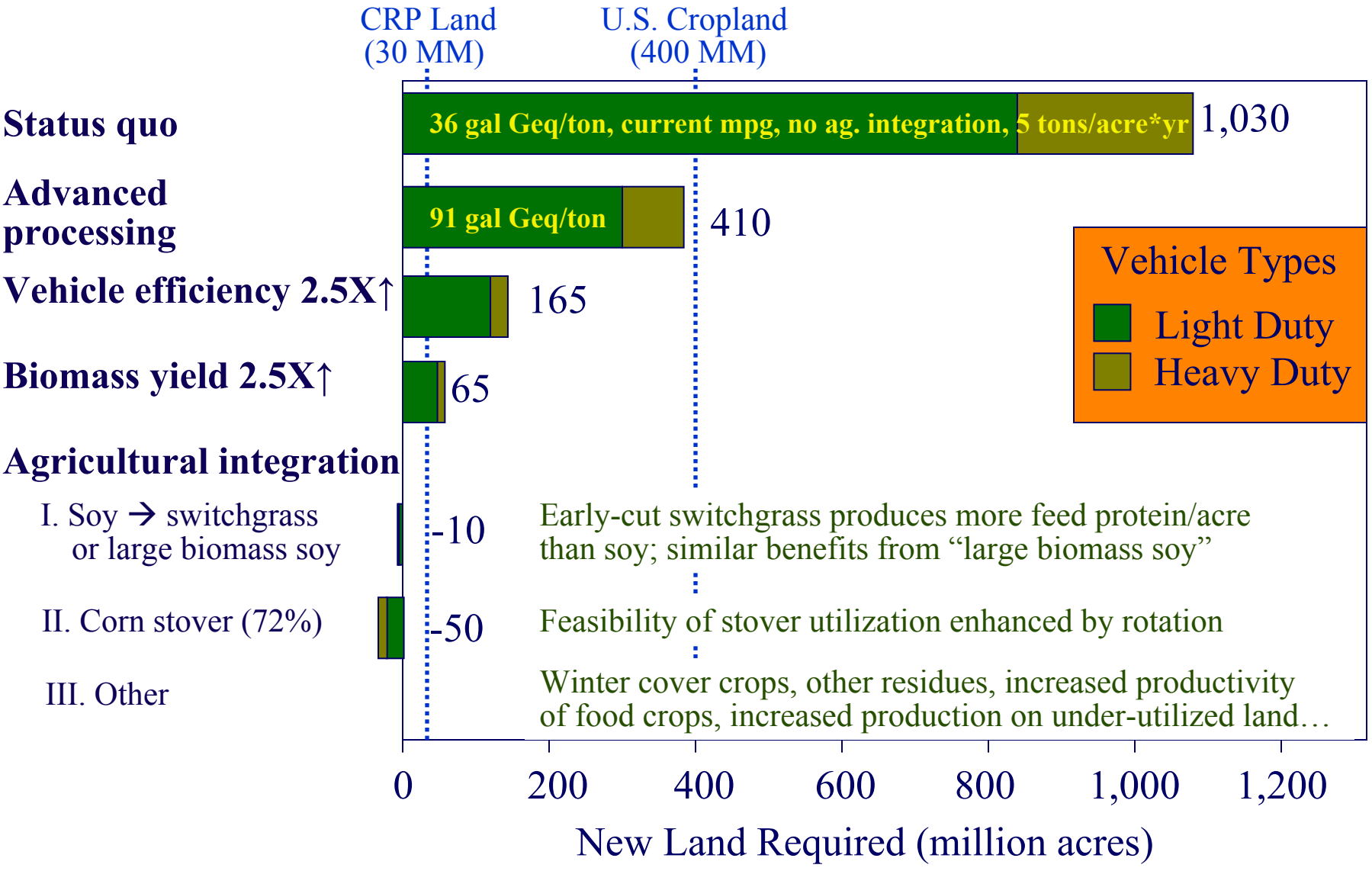
Slides to follow (too large to email):

Plug-in hybrid costs/impacts

Feedstocks that use degraded land or no land require advanced technologies

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

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)

Solar Energy for Many Applications

Moscone Center, SF: 675,000 W

Residential Solar: 1000 - 4000 Watts/home

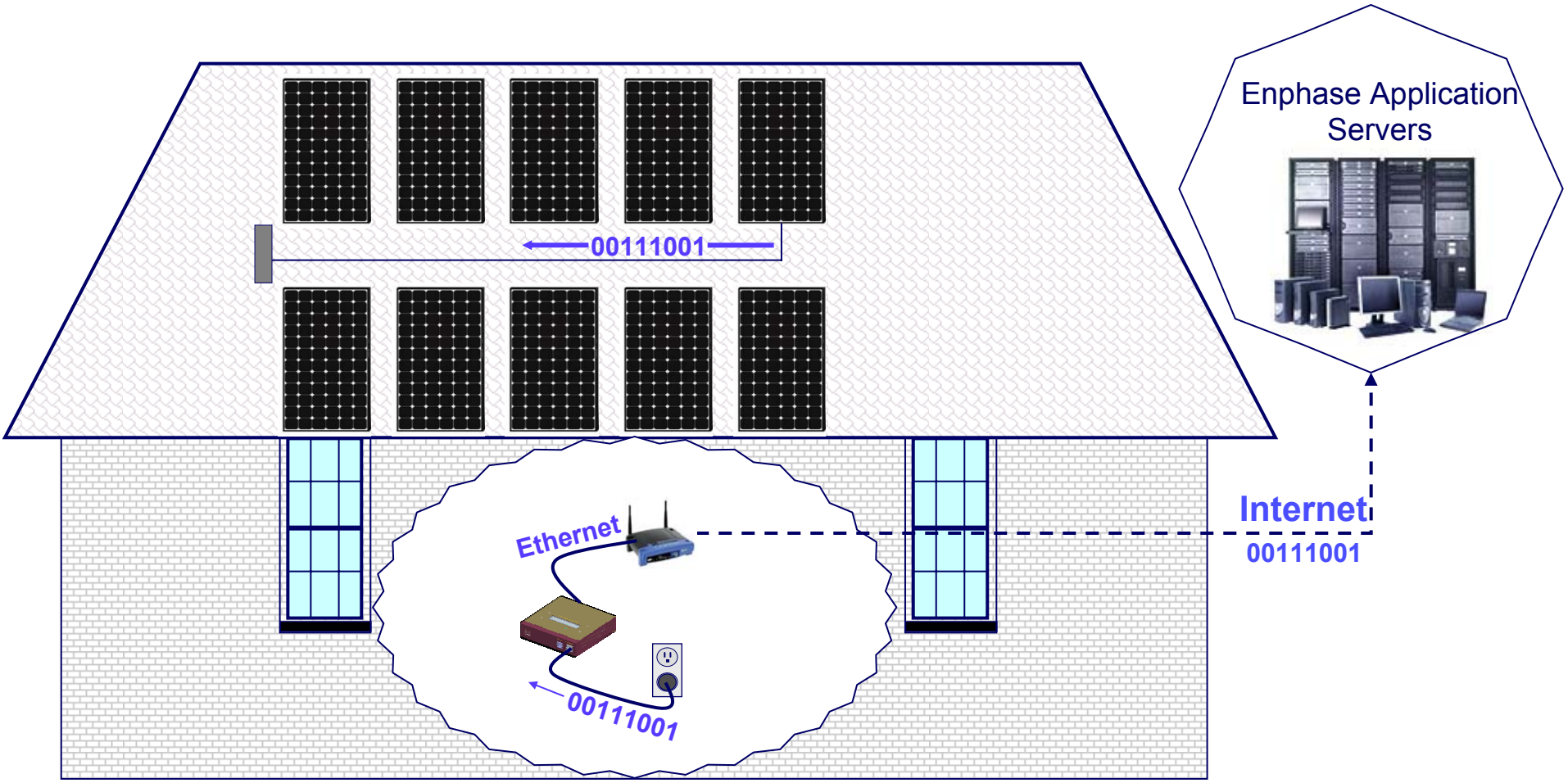
CA Million Solar Roofs Program:
3,000 - 10,000 MW of solar to be built

Kenyan PV market: Average system: 18W

Largest penetration rate of any nation

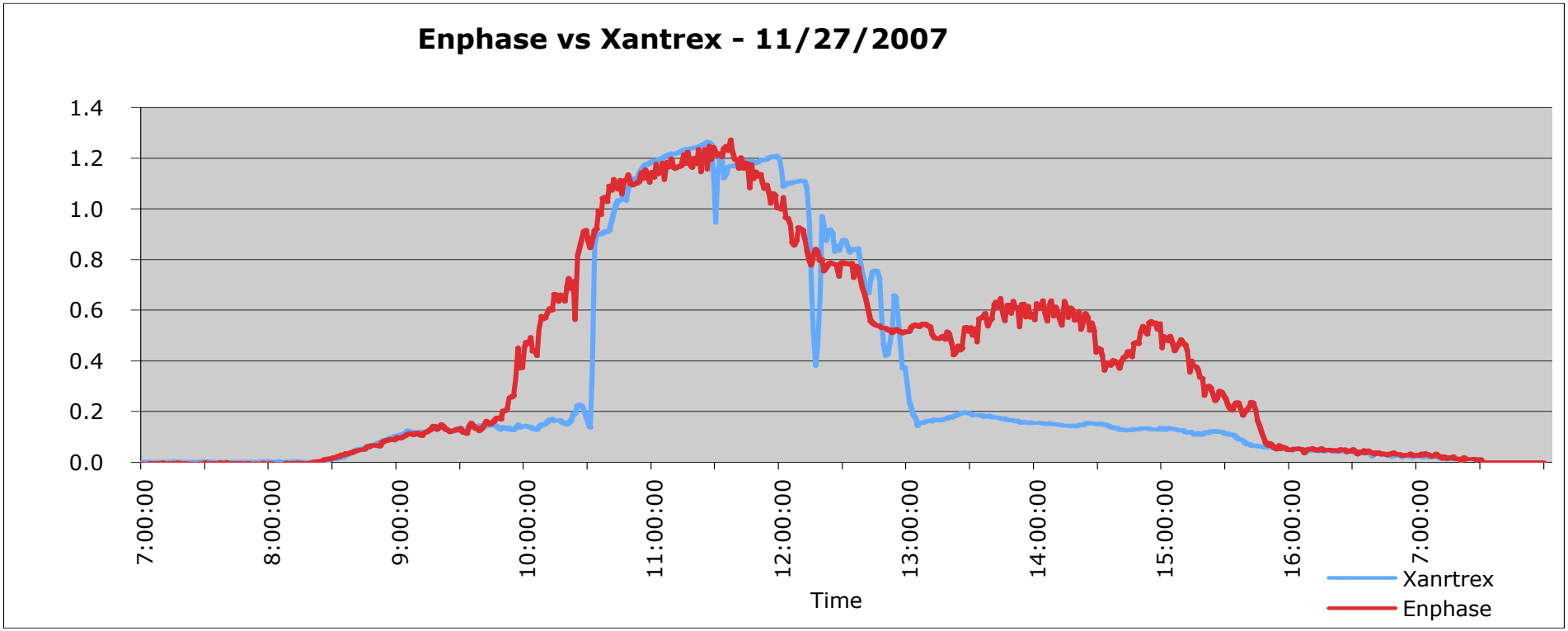
	California	Japan
2005 Annual PV Installations	50 MW	290 MW
Average Cost for Residential System	$8.8/Wac	$7.4/Wac
Average Cost Reduction from 99-04	5.2%/year	8.9%/year

Information Technology Meets Solar Technology: Performance Monitoring

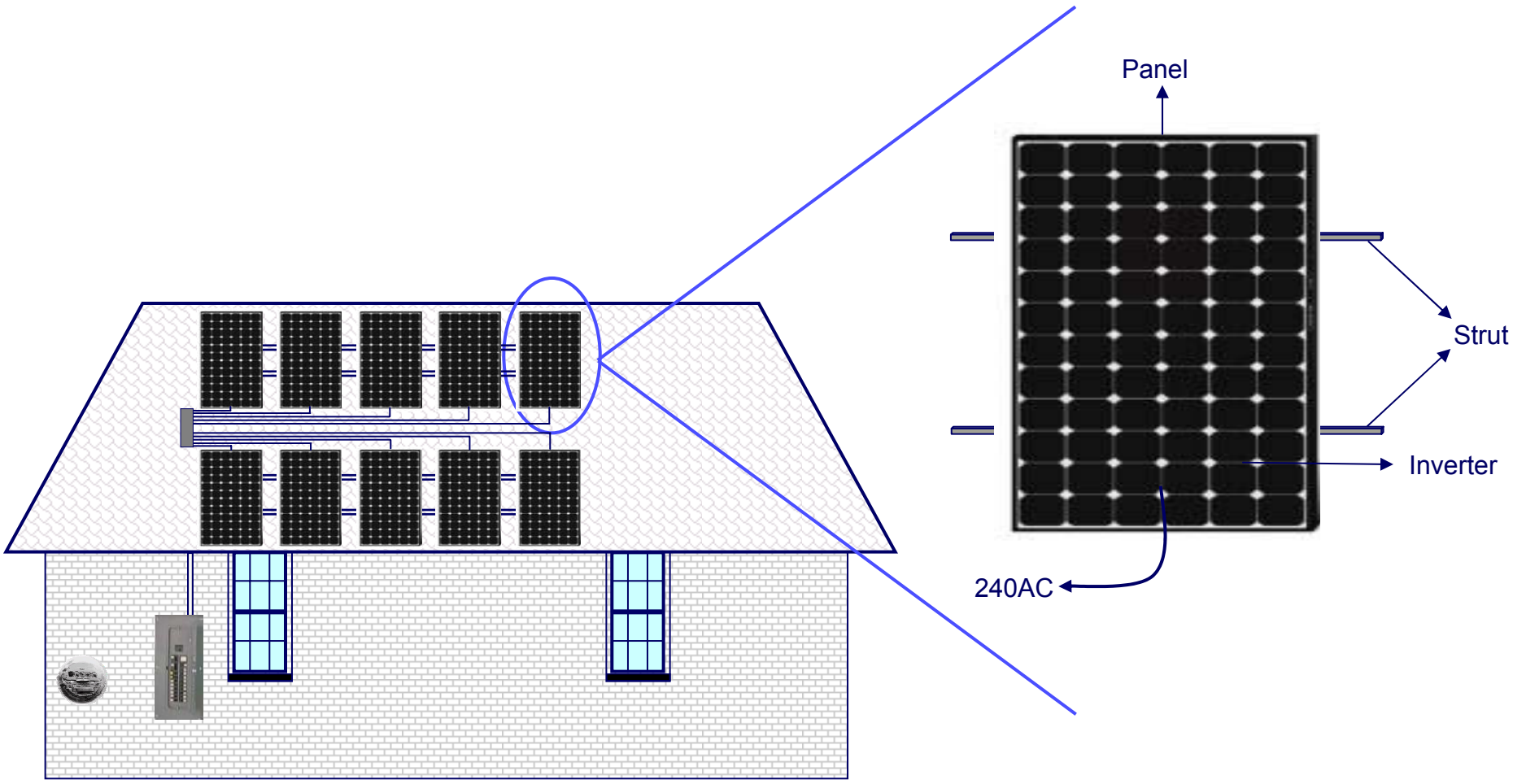


Micro-interter versus Conventional

- Xantrex GT3.0 versus Enphase 175W Micro-inverter
- 24 175W Suntech panels
- Panels connected in a checkerboard pattern (every other panel connected to the Xantrex and Enphase)
- Enphase energy production is greater by 20 - 34%

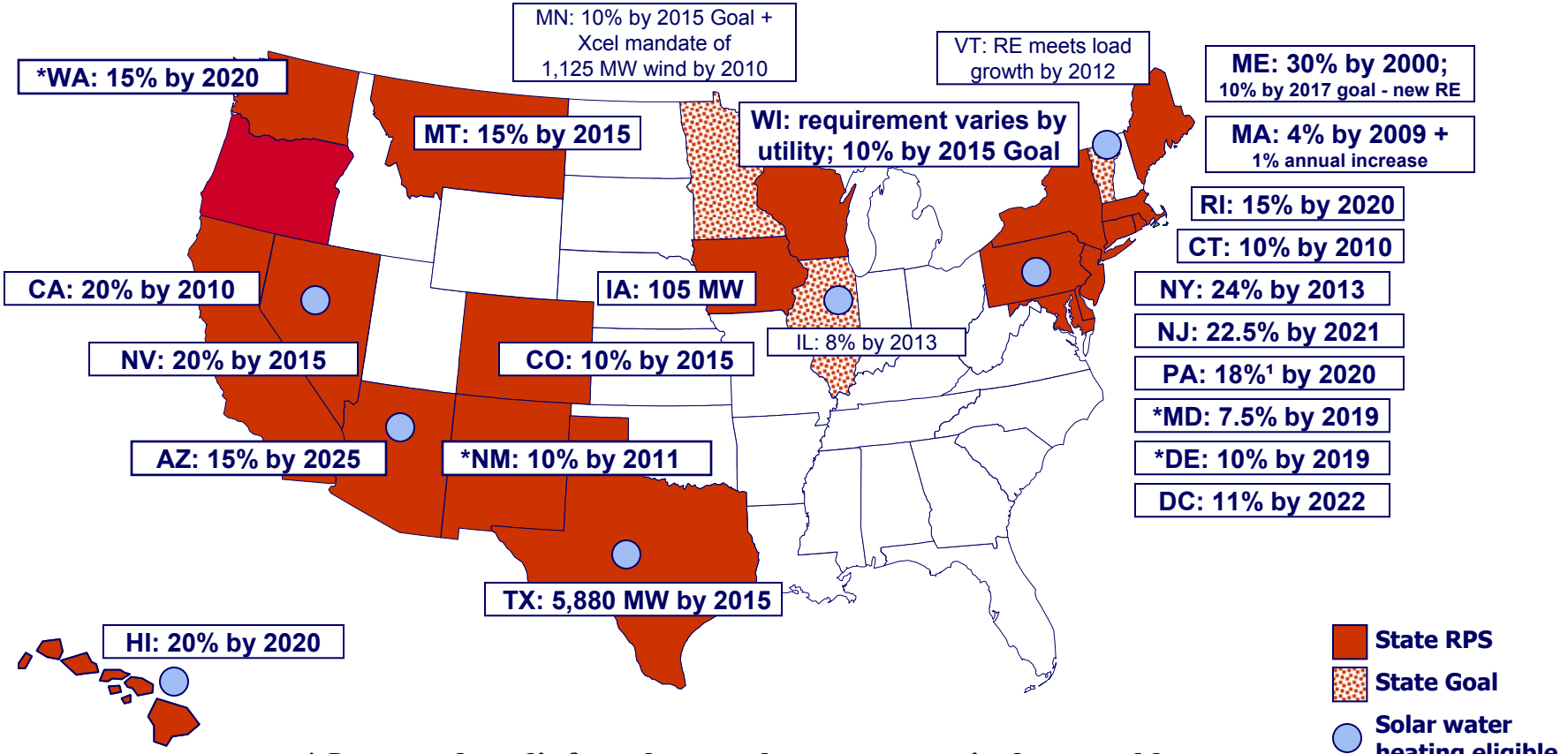


Enphase Micro-Inverter Solution



Renewable Energy Portfolio Standards (RPS)

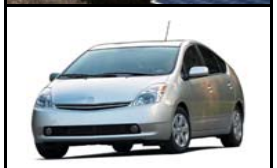
29 states + Washington, DC, and counting



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

PA: 8% Tier I (renewables)

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

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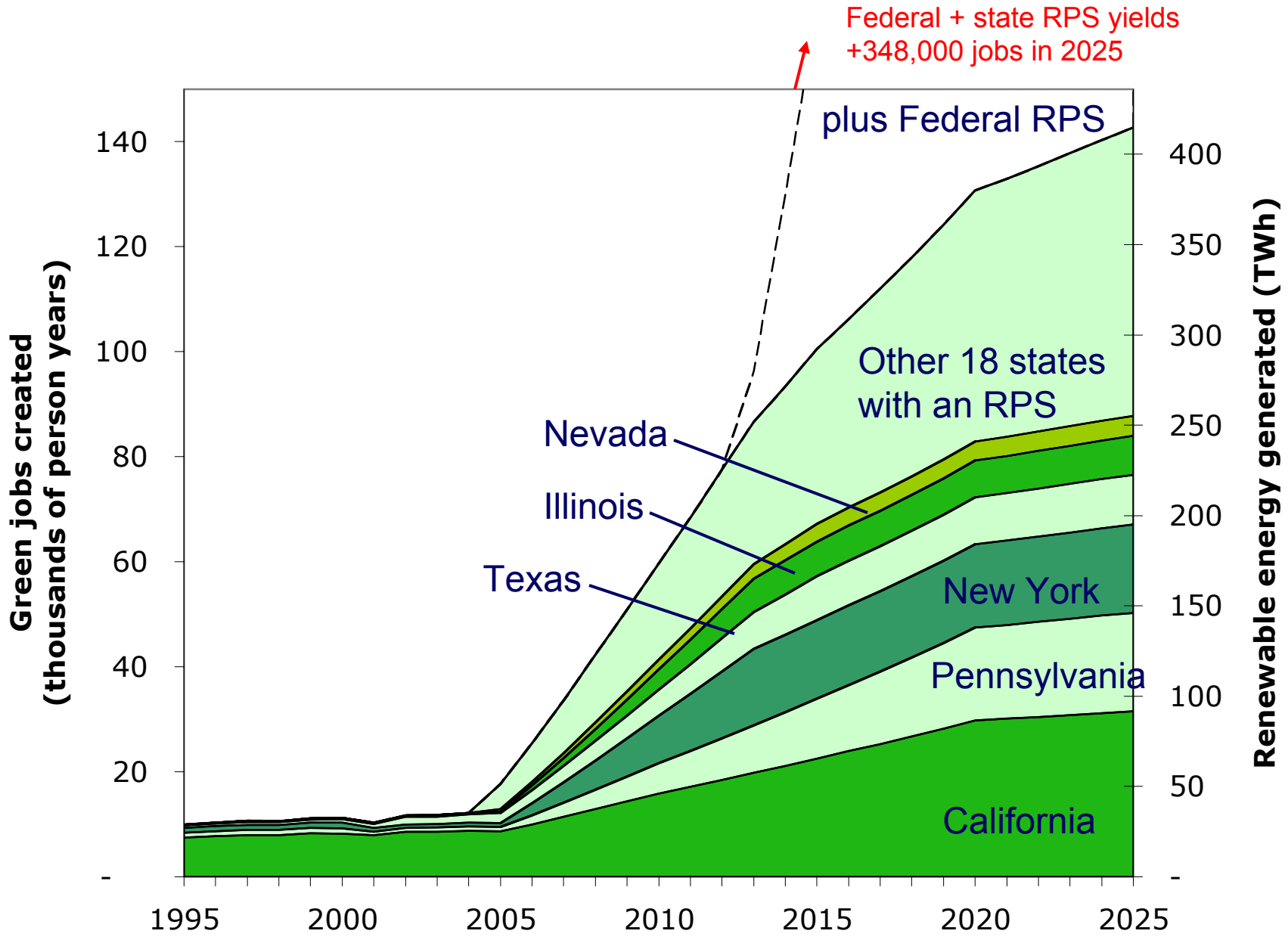
APRIL 13, 2004

Study reviews:

- 13 studies of job creation
- 3 - 5 *times* More jobs per dollar invested in the renewables sector than in fossil fuels

Green Collar Job Creation



Green job creation

More renewables = more jobs

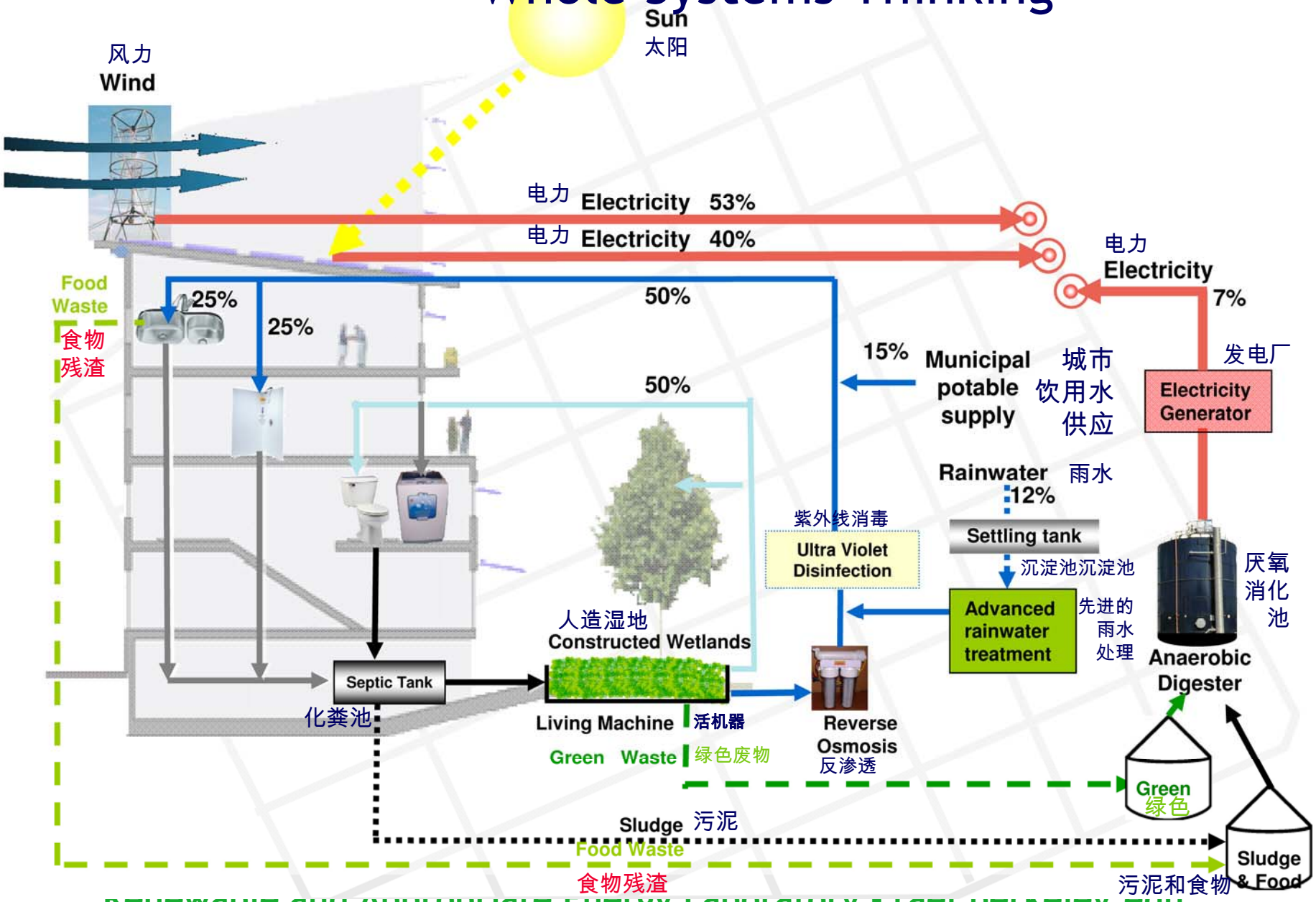
Energy Technology	Jobs (total person-yrs/TWh)		Equipment lifetime (years)	Capacity Factor	Employment Components			Source of Numbers
	Construction, Manufacturing, Installation	O&M and fuel processing			Construction, Manufacturing and Installation (person-yr/MWp)	Operation and Maintenance (jobs/MWp)	Fuel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

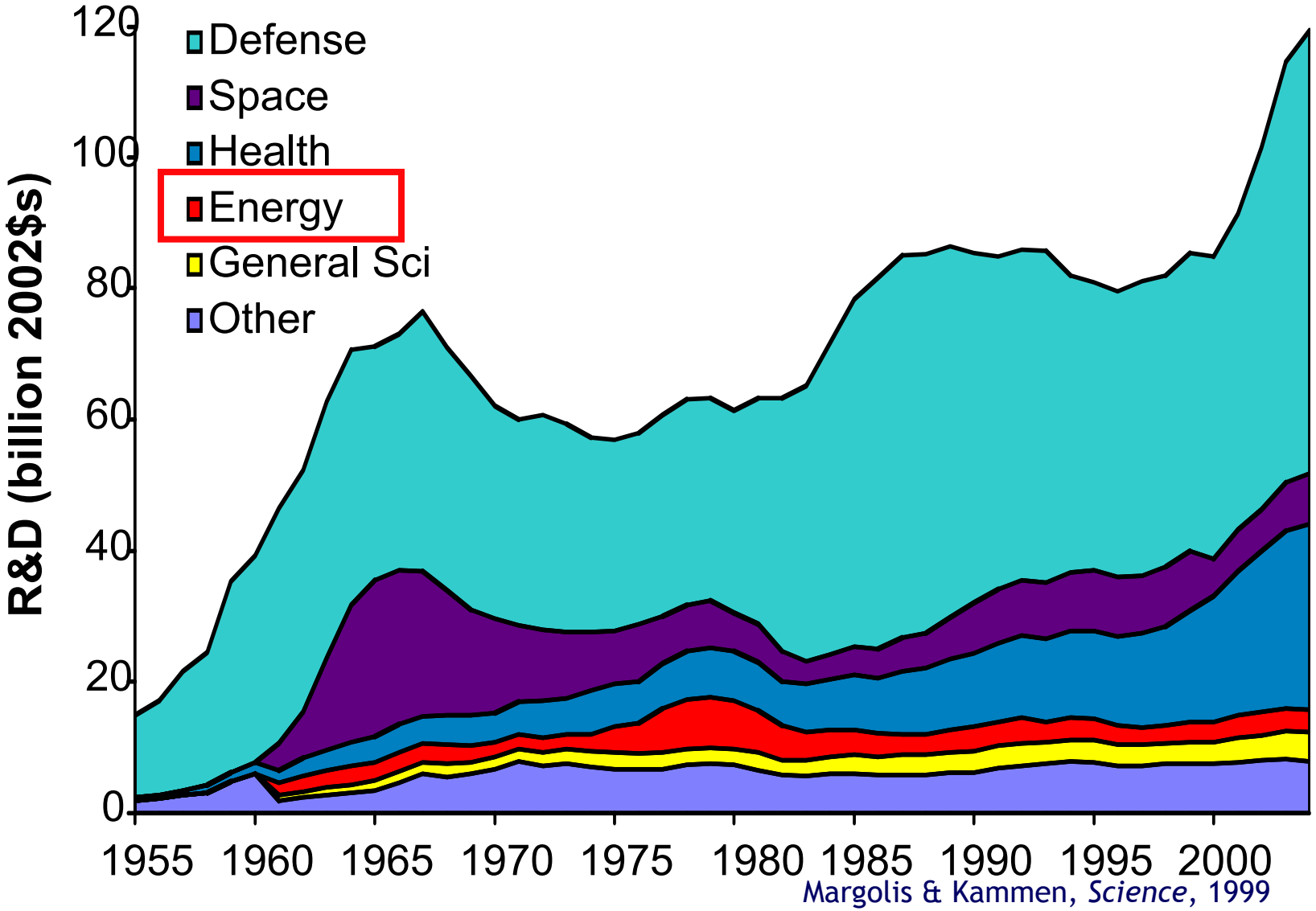
[1] REPP, 2001
[2] EWEA/Green-peace, 2003
[3] Greenpeace, 2001
[4] Kammen, from REPP, 2001; CALPIRG, 2003; BLS, 2004

自足，
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

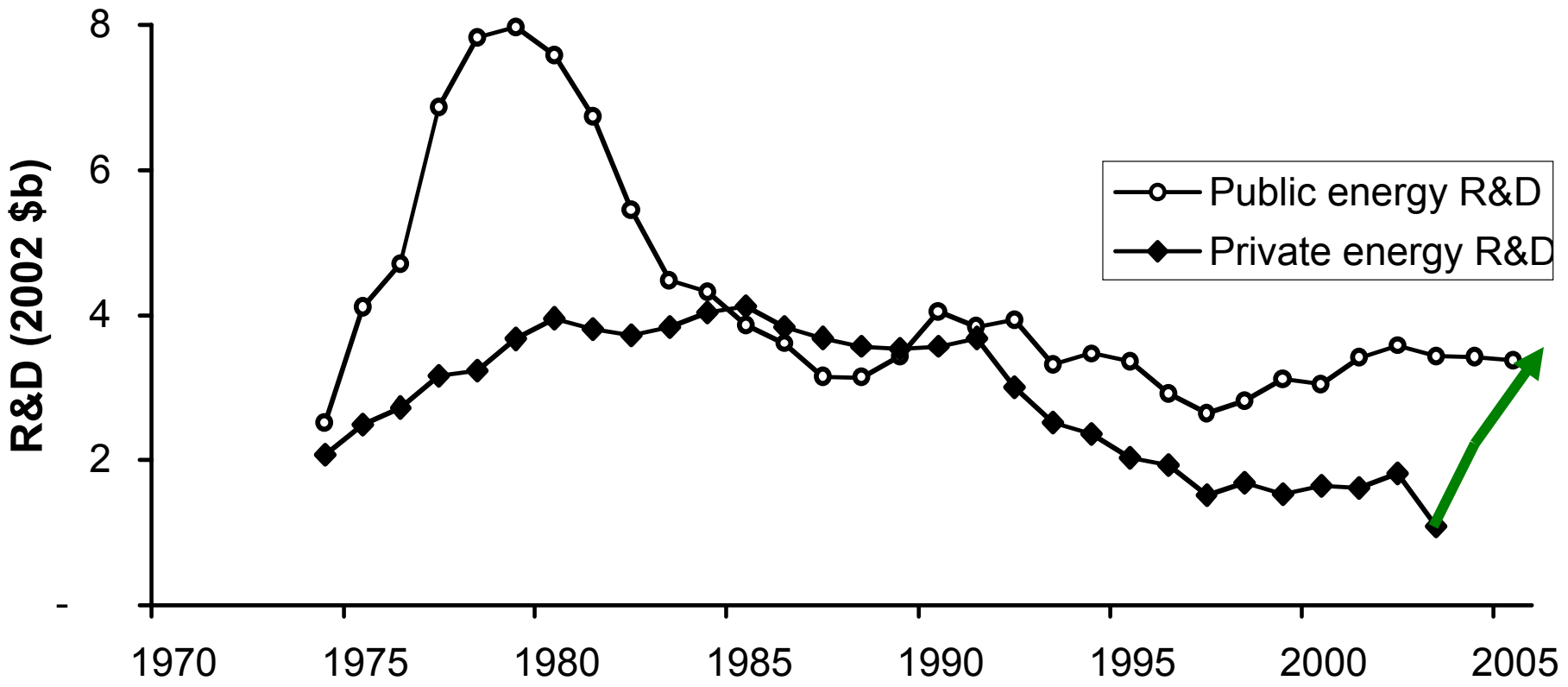


Federal R&D Investments, 1955 - 2004



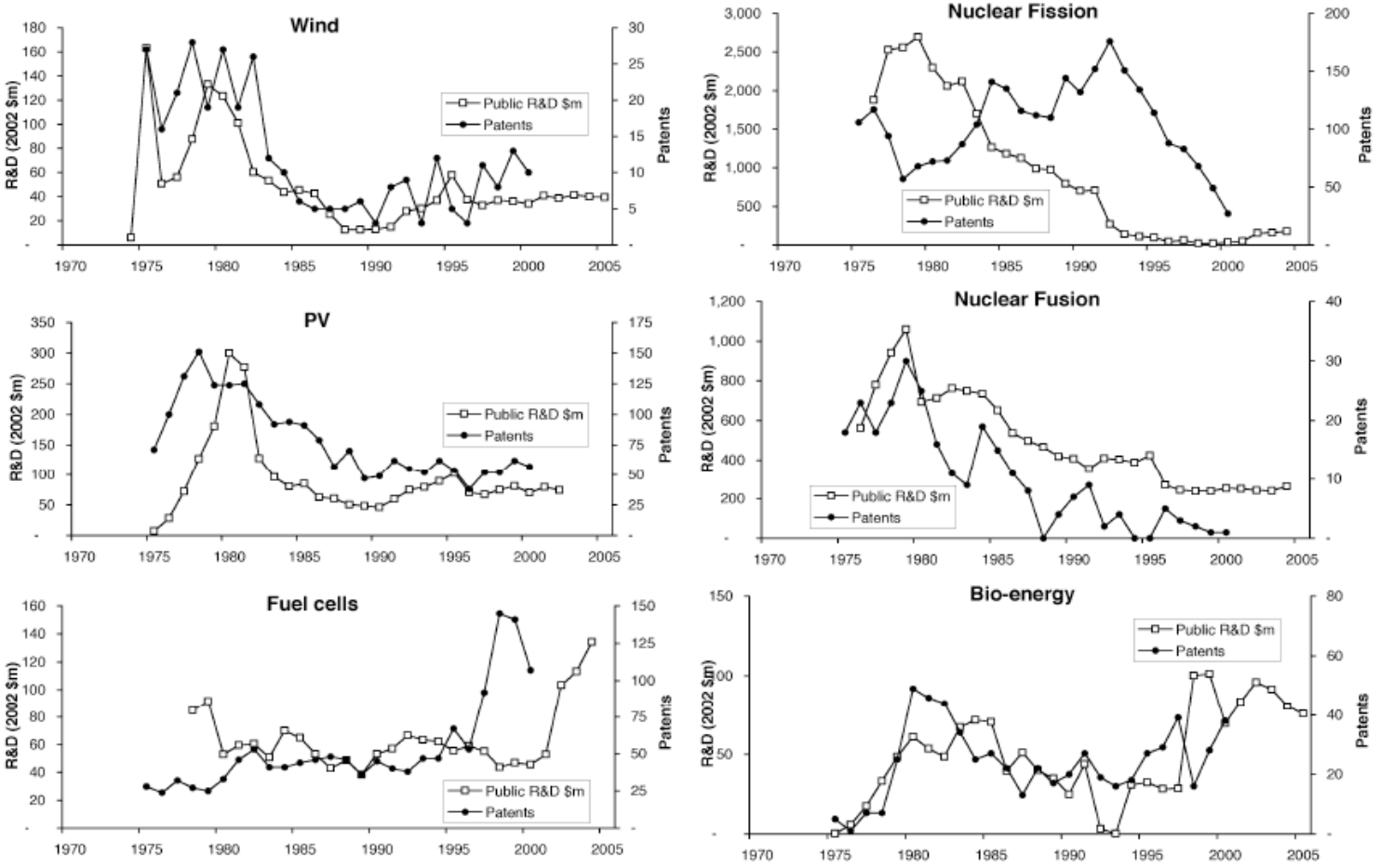
Margolis & Kammen, *Science*, 1999

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



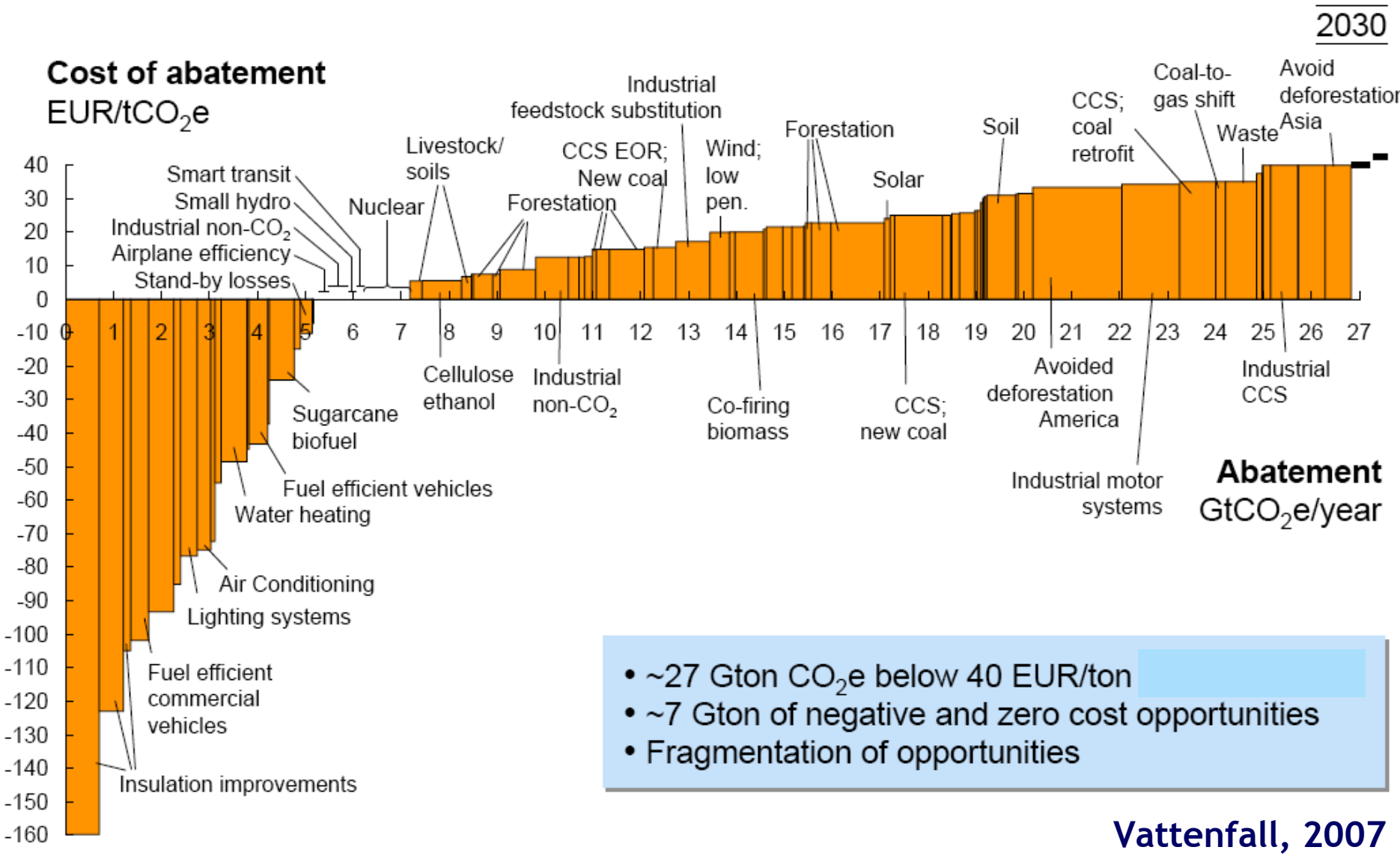
Kammen and Nemet (2005)
"Reversing the incredible shrinking energy R&D budget," *Issues in Science & Technology*, **Fall**, 84 – 88.

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

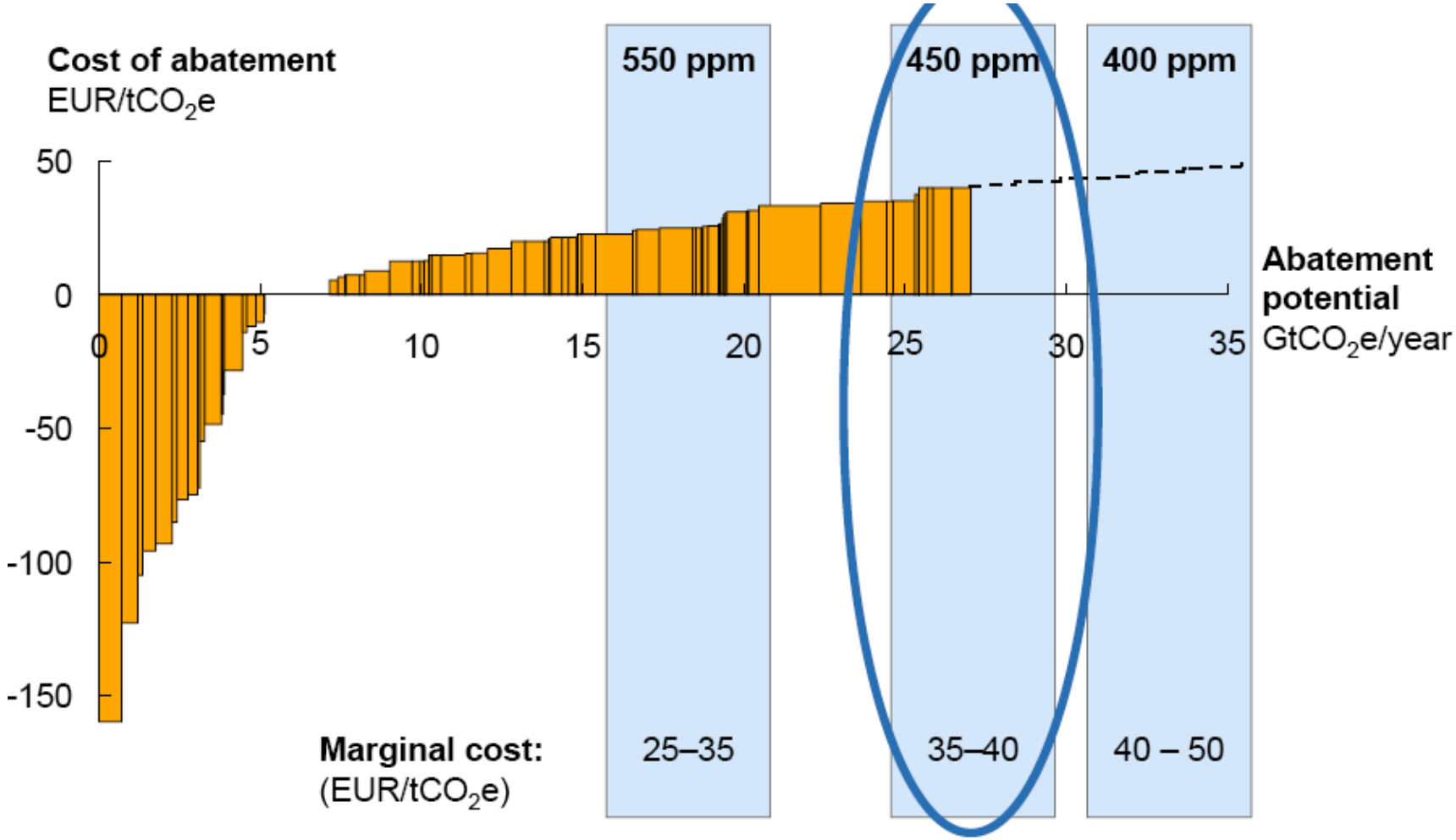
Global CO_2 Abatement Opportunities



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

Vattenfall, 2007

Global CO_2 Abatement Opportunities



Vattenfall, 2007

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