University of California, Berkeley

Renewable and Appropriate Energy Laboratory UC Berkeley

Jobs in a Clean Energy Economy: Science, Engineering, and Policy Perspectives

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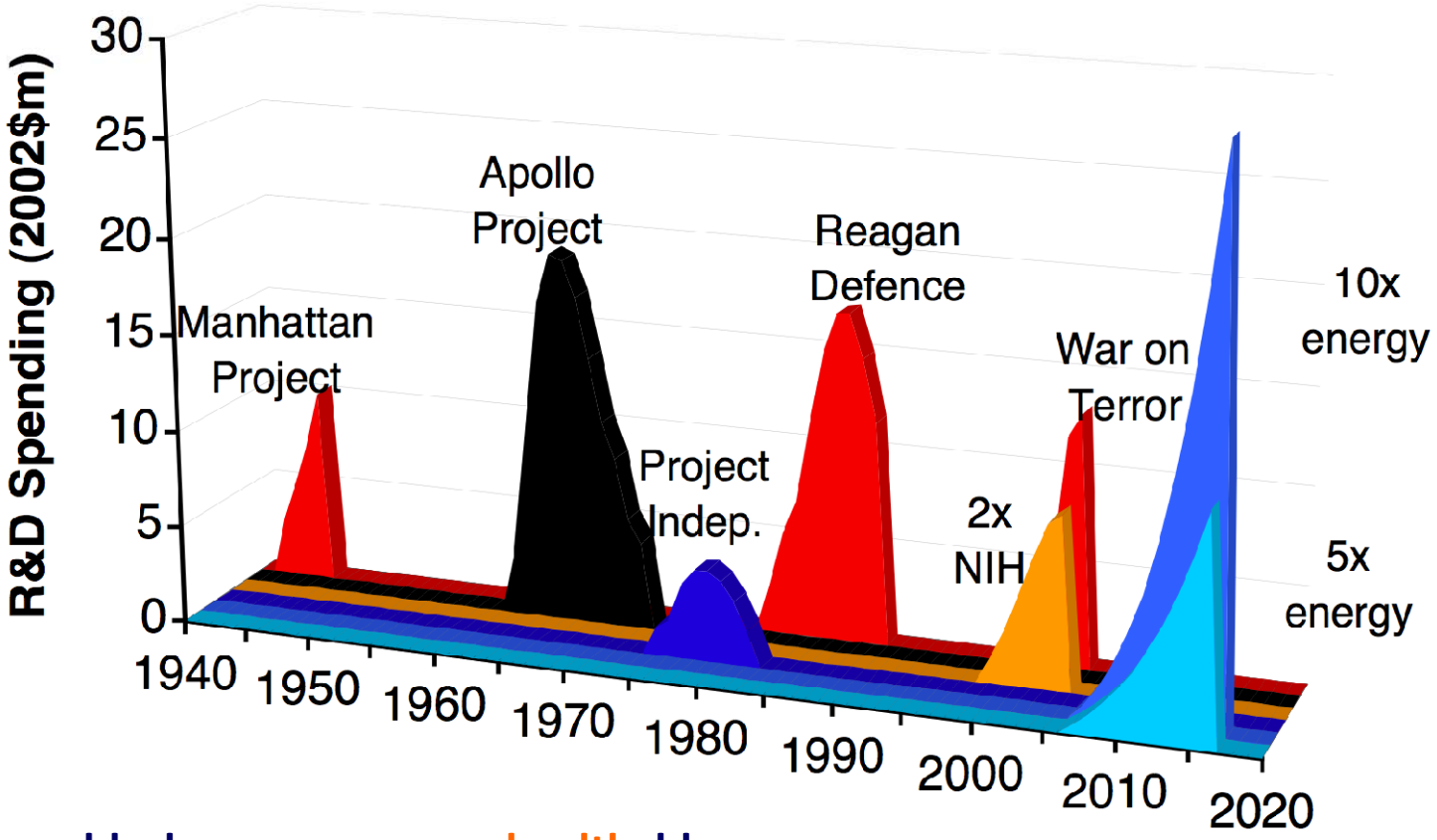
University of California, Berkeley

http://rael.berkeley.edu

February 4, 2010, Madison, WI

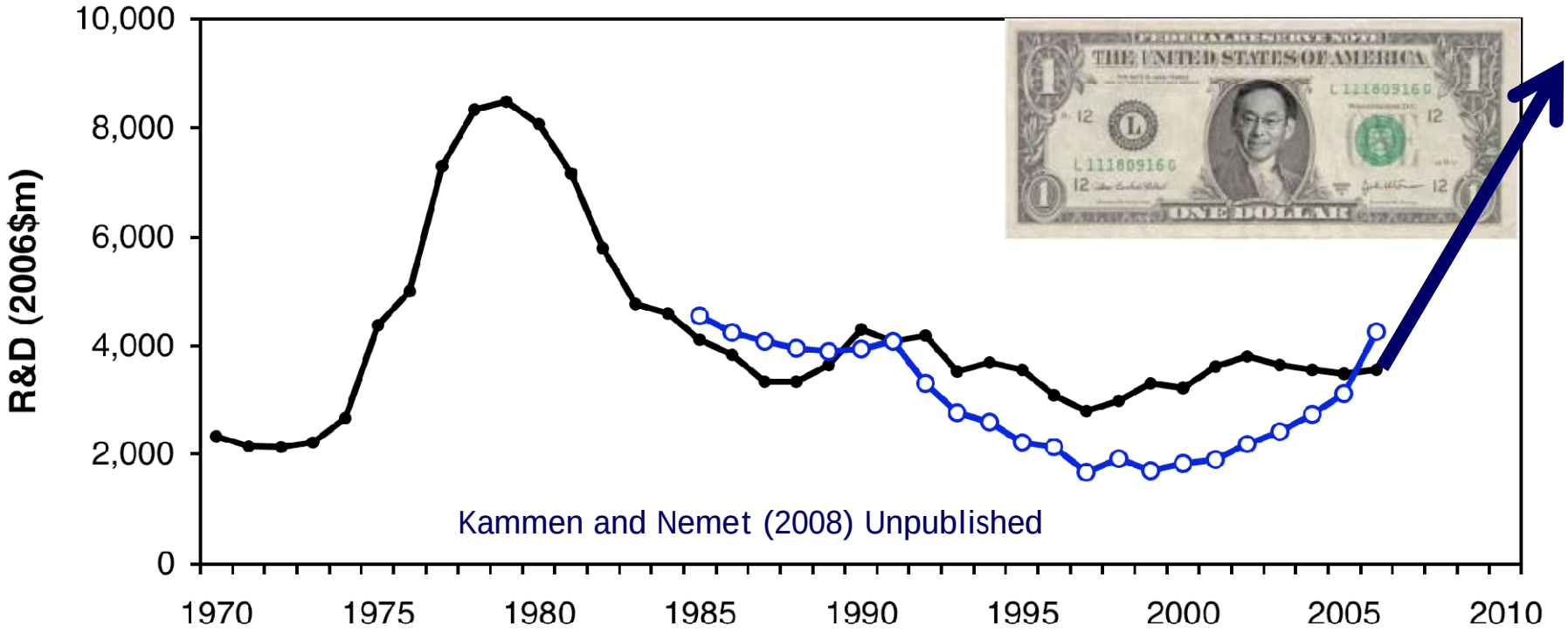
Major U.S. Public Research and Development Programs



red=defense, black=space, orange=health, blue=energy

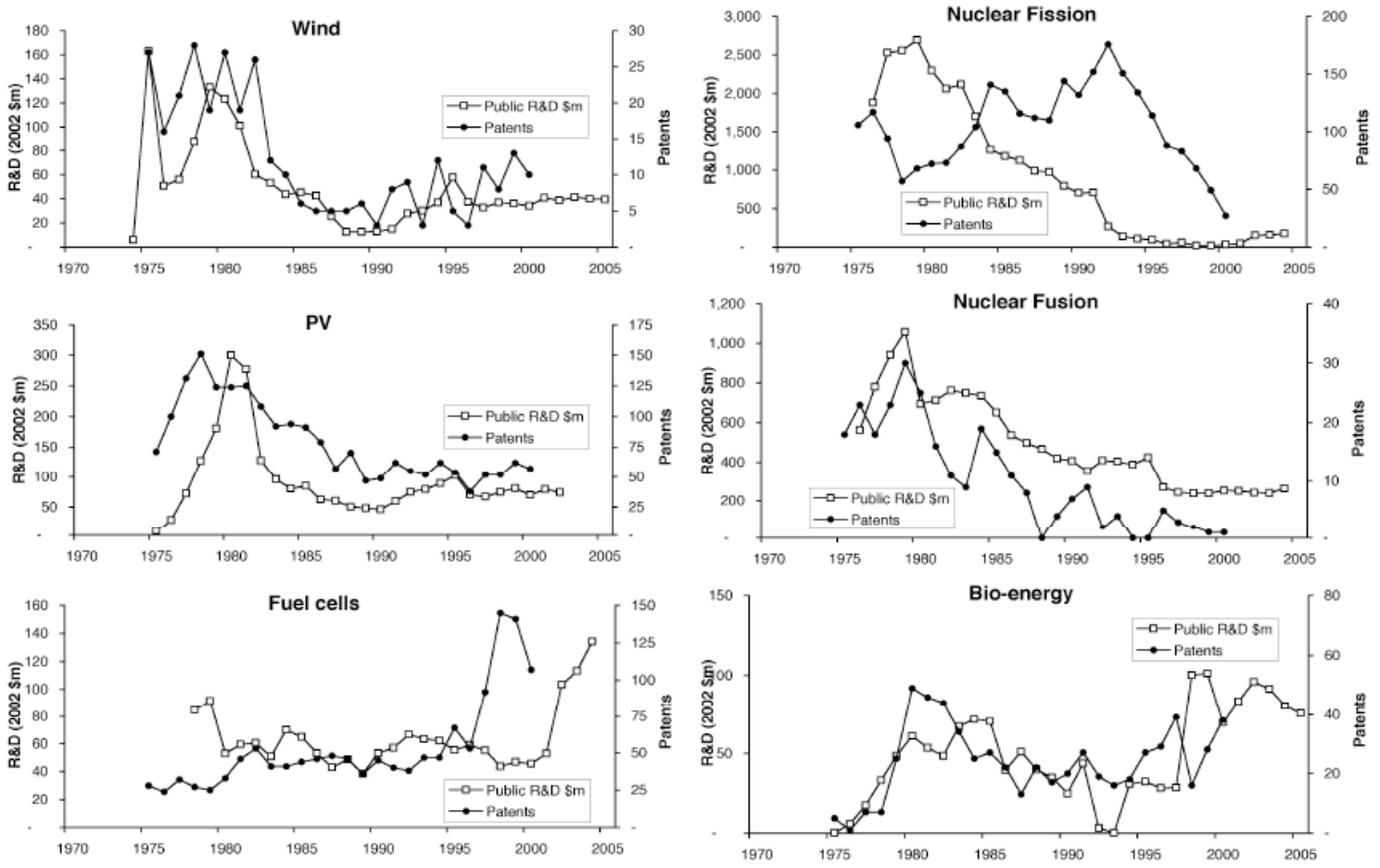
Nemet, 2007; Nemet and Kamen 2007; Kammen and Nemet, 2005

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



- **We are at a critical moment - momentum exists for change of direction**
- **Carbon cost/benefit assessments needed for federal programs**
- **Energy efficiency and transmission/storage goals and roadmaps needed**
- **Tremendous economic benefits possible in a low-carbon economy**

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, Ph.D. dissertation, 2007

The battle of tipping points

- The clean jobs economy is real, and provides a route to build a new industrial base
- Developing innovative technical and social 'tipping points' is vital
- Energy 'Systems science' and implementation requires an integration of basic research and a state enabling environment and workforce

UNIVERSITY OF CALIFORNIA
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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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Matthias Fripp

of the
Energy and Resources Group &
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APRIL 13, 2004

Green Jobs and the Clean Energy Economy

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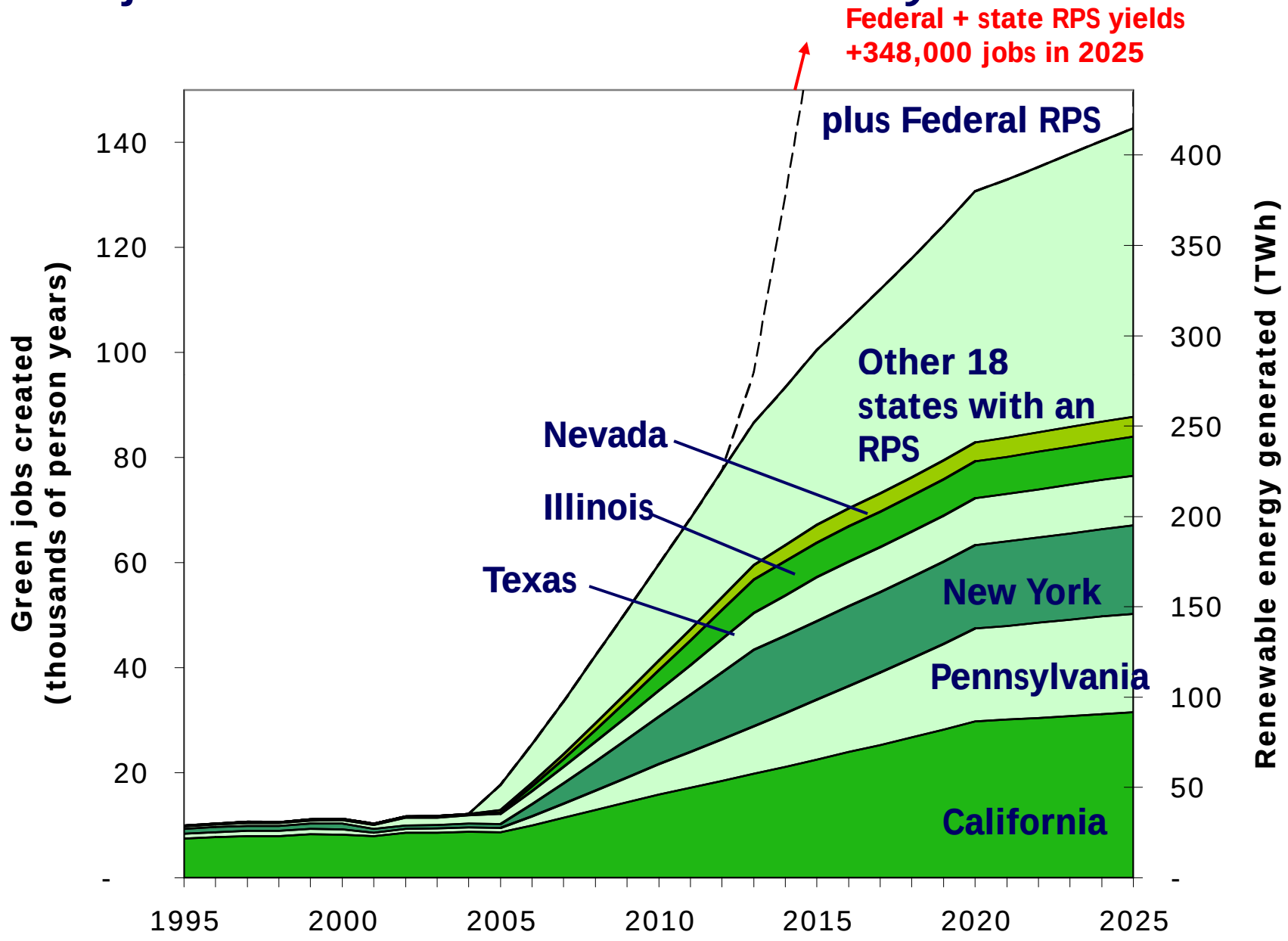
Professor and Co-Director,
Berkeley Institute of the Environment

04

THOUGHT LEADERSHIP SERIES

COPENHAGEN CLIMATE COUNCIL

Green job creation: Obama 25% by 2025 Plan



Better, Cheaper Lighting - Convention Center

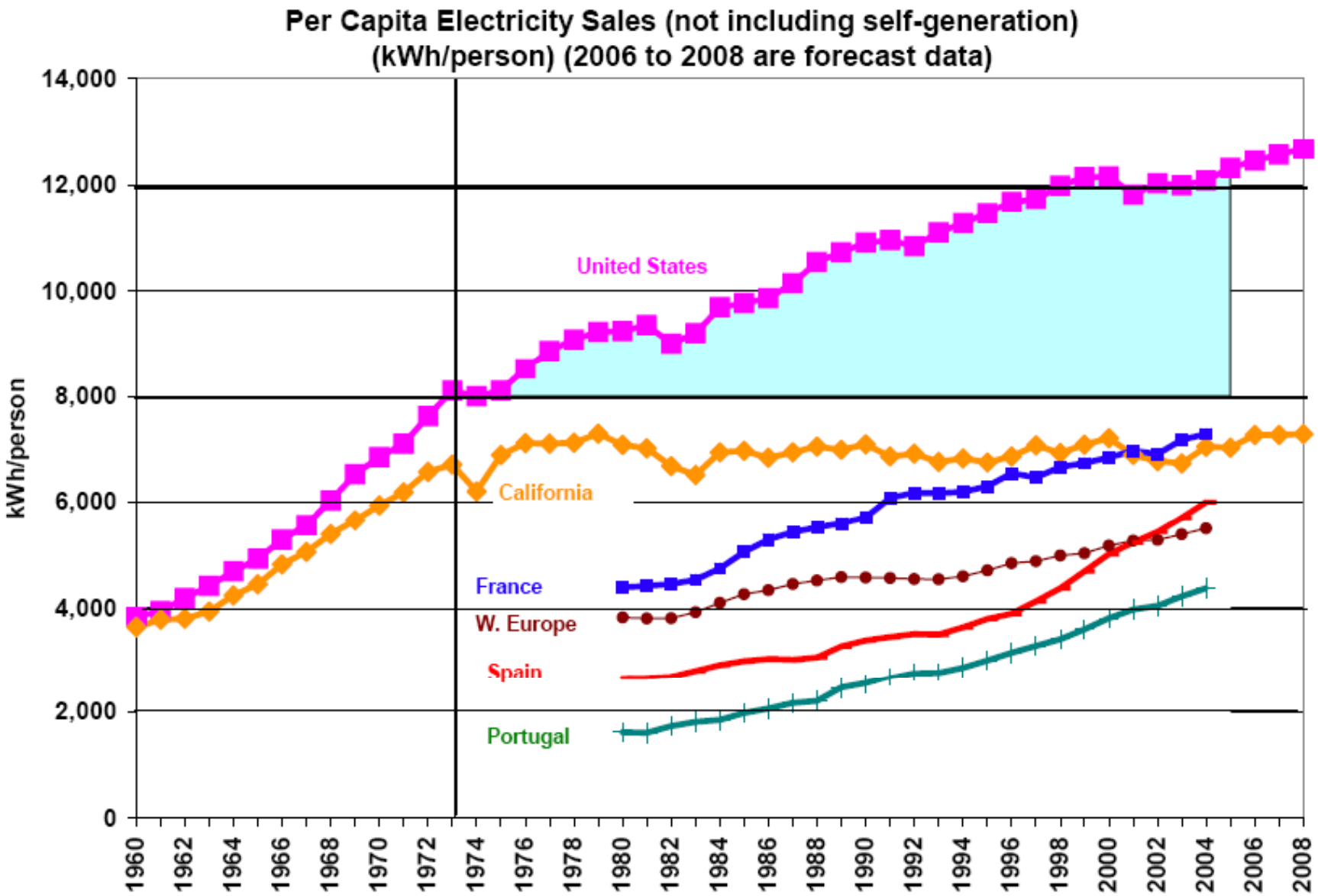
The Many Values of Efficiency:

$400,000 saved per year with new lights

Energy Efficiency Strategies

Residential New Construction

- **All new residential construction in California will be zero net energy by 2020.**

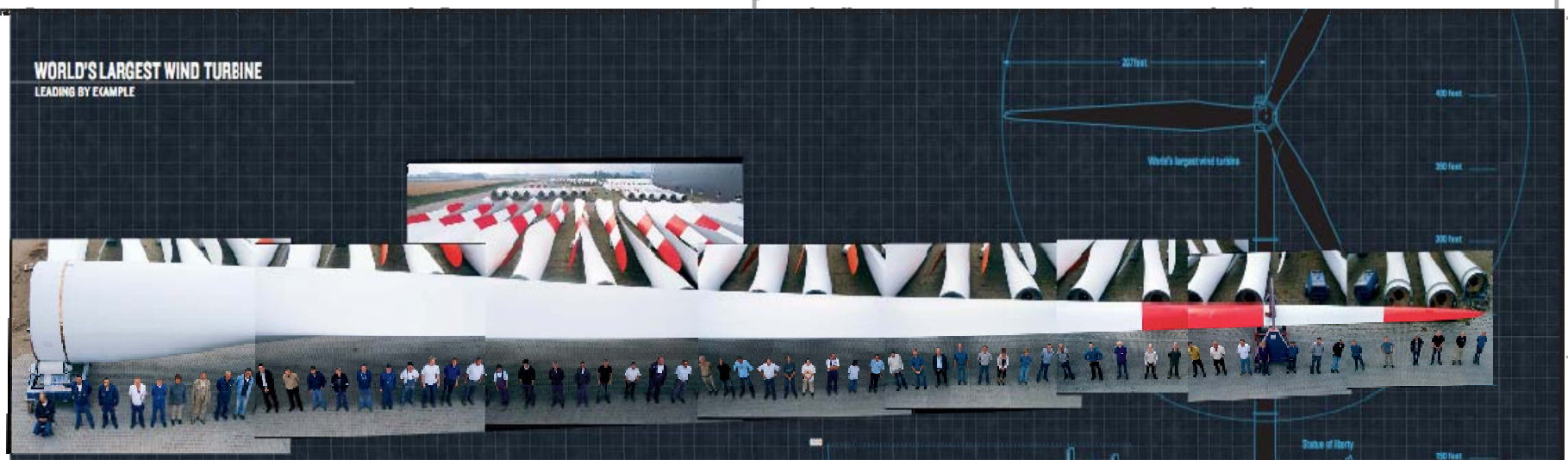

Per Capita Electricity Sales (not including self-generation)
(kWh/person) (2006 to 2008 are forecast data)
kWh/person
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
1960
1962
1964
1966
1968
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
United States
California
France
W. Europe
Spain
Portugal

Technological Innovation: solar


Vestas is the largest Wind Turbine manufacturer in the world
Employing approx. 20,500 people
24 countries worldwide
Just opened the world's biggest R&D center
Install a new wind turbine every 5 hours
80 x V80-2.0 MW, HornReef, Denmark

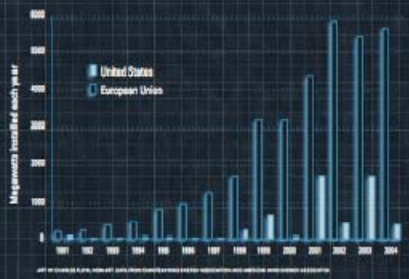
WORLD'S LARGEST WIND TURBINE

LEADING BY EXAMPLE

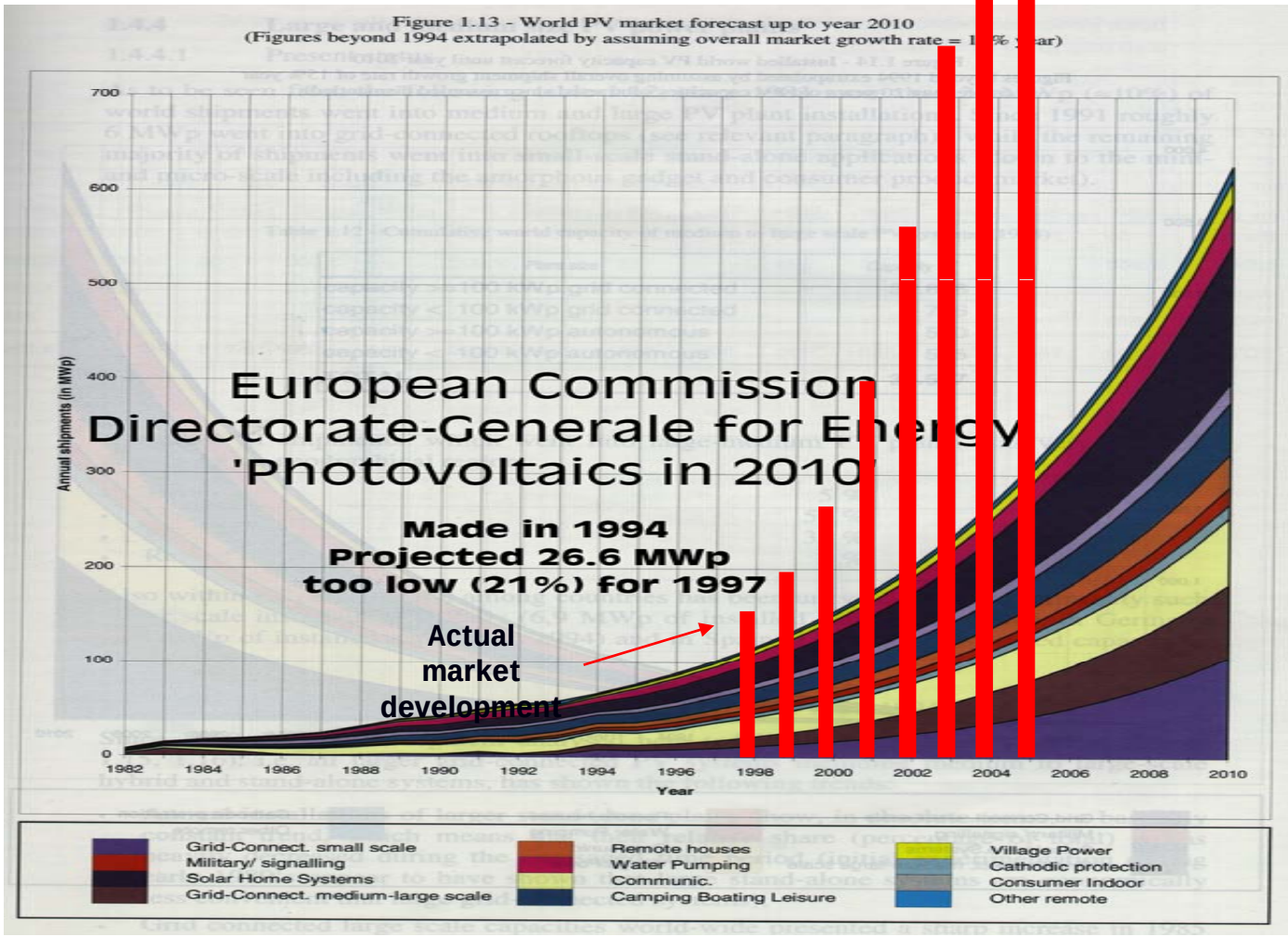


MIGHTY WINDMILL

Eighteen tons of fiberglassand carbon fiber went into a 201-foot blade built in Denmark for the world's largest wind turbine. The titanwill stand 390 feet tall and generate five megawatts, enough power for asset 5,000 homes. The turbine embodies the European Union's enthusiasm for alternative energy—and the size of its subsidies. The U.S. lacks such focus, lagging far behind the EU in wind-power capacity installed each year (chart right). One energy-policy professor compares the U.S. to a hunter-gatherer, constantly scouting for new fossil-fuel sources when "we should probably be more like farmers. Energy farming is the future."



Actual PV Growth vs. Historic Forecasts



The New York Times

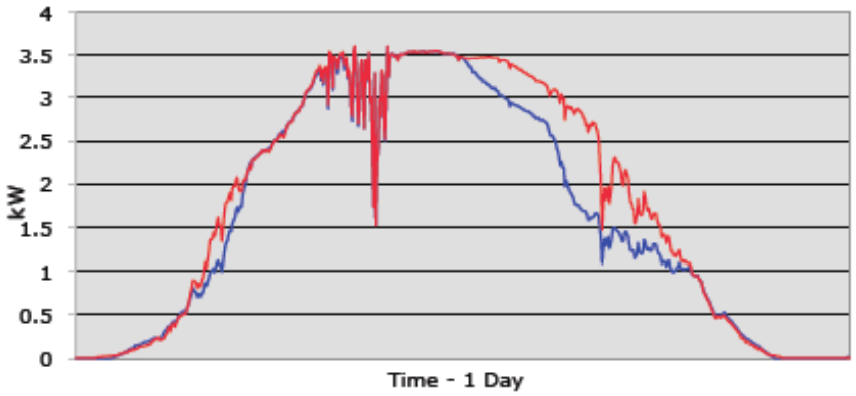
China Racing Ahead of U.S. in the Drive to Go Solar

By KEITH BRADSHER

Published: August 24, 2009

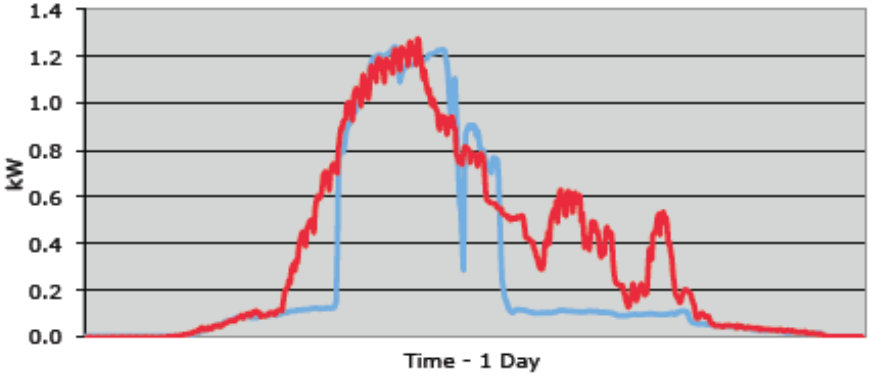
Information Technology Integrated with Solar Technology: Performance Monitoring

Micro-inverters versus traditional designs: A household and building electronics strategy



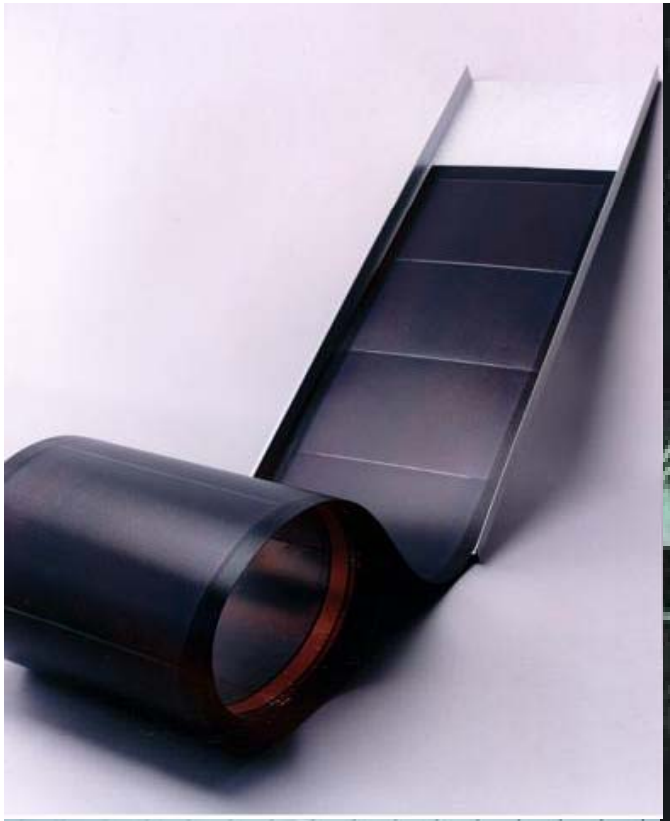
Energy Advantage: 10.24%

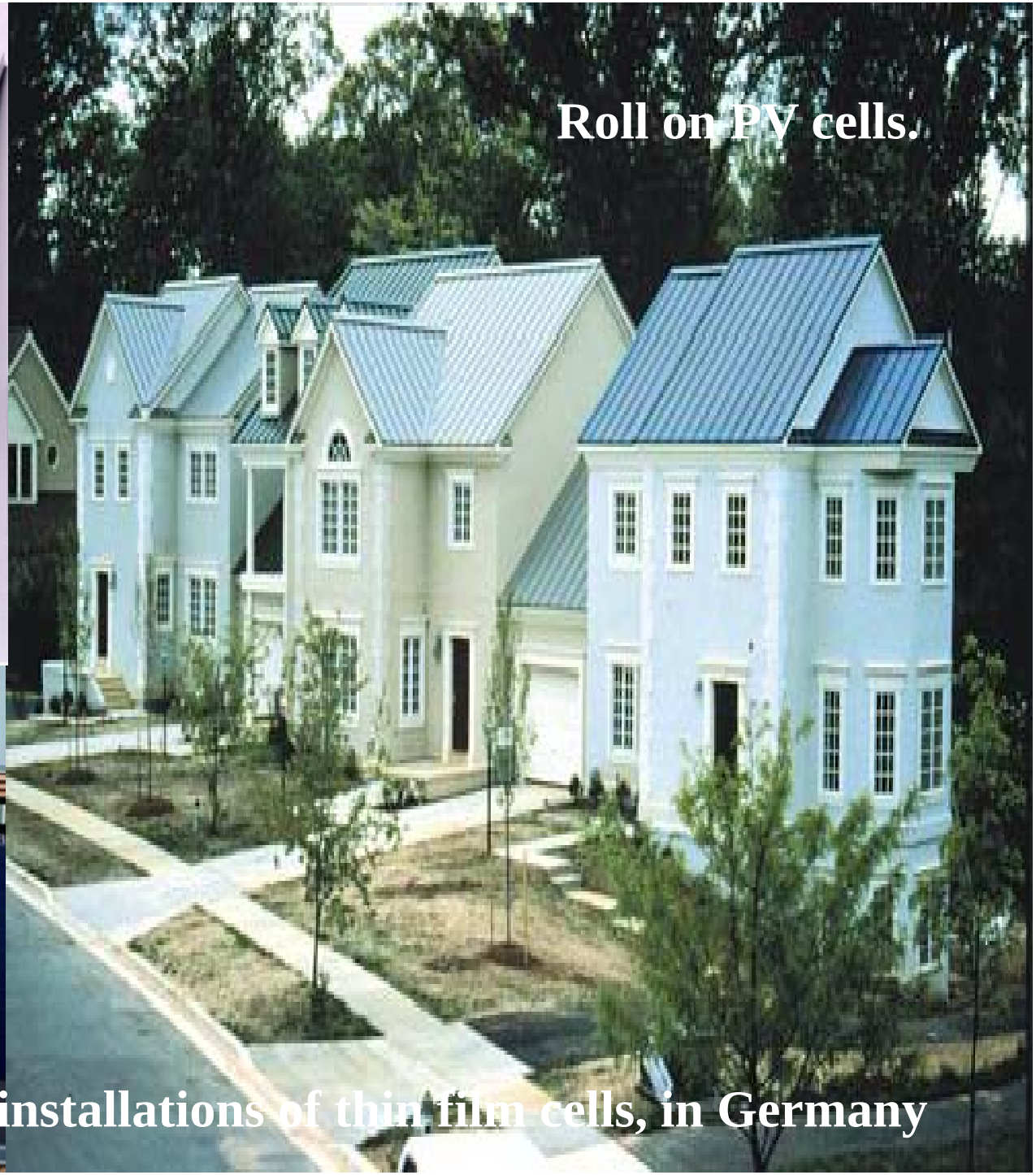
- ⇨ SMA SB6000US (95.5%) - Blue
- ⇨ Enphase – Red
- ⇨ Location: Petaluma, CA
- ⇨ Date: November 2007



Energy Advantage: 33.63%

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





Roll on PV cells.

Solar photovoltaic installations of thin film cells, in Germany

Market Innovation: Financial tools

Clean Energy Municipal Financing

(PACE: Property Assessed Clean Energy)

see Fuller, Portis and Kammen (2009) *Environment*, **51** (1), 22 - 32,

and **http://rael.berkeley.edu/financing**

$$ Upfront

$$ Repaid on tax bill

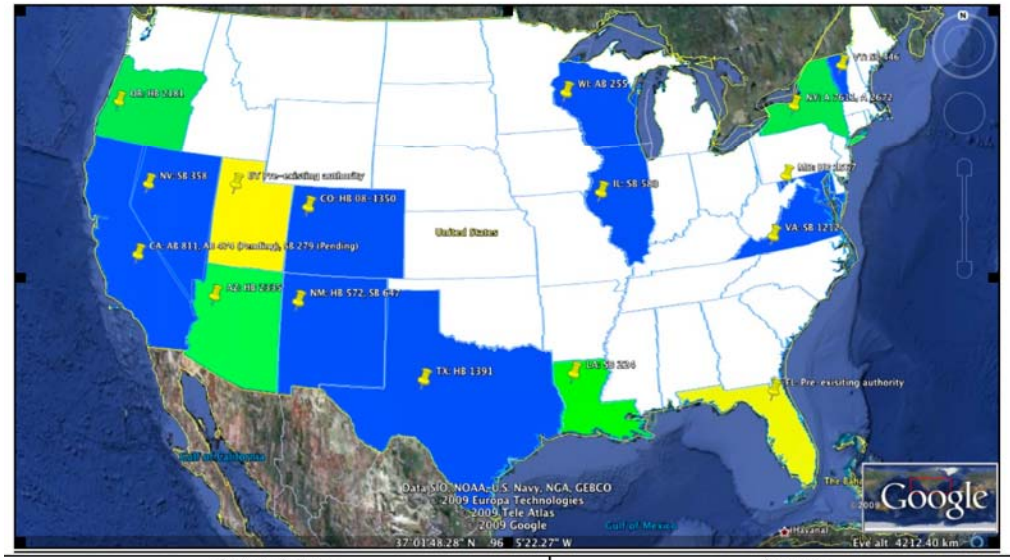
- **Creates financing district & approval process**
- **Provides upfront capital**
- **Attaches repayment obligation to the building**

- **Identifies work & chooses contractor**
- **Repays financing as a line item on the property tax bill**
- **Repayment obligation transfers with ownership**
- **Builds clean energy equity**

Property Assessed Clean Energy (PACE): State Actions

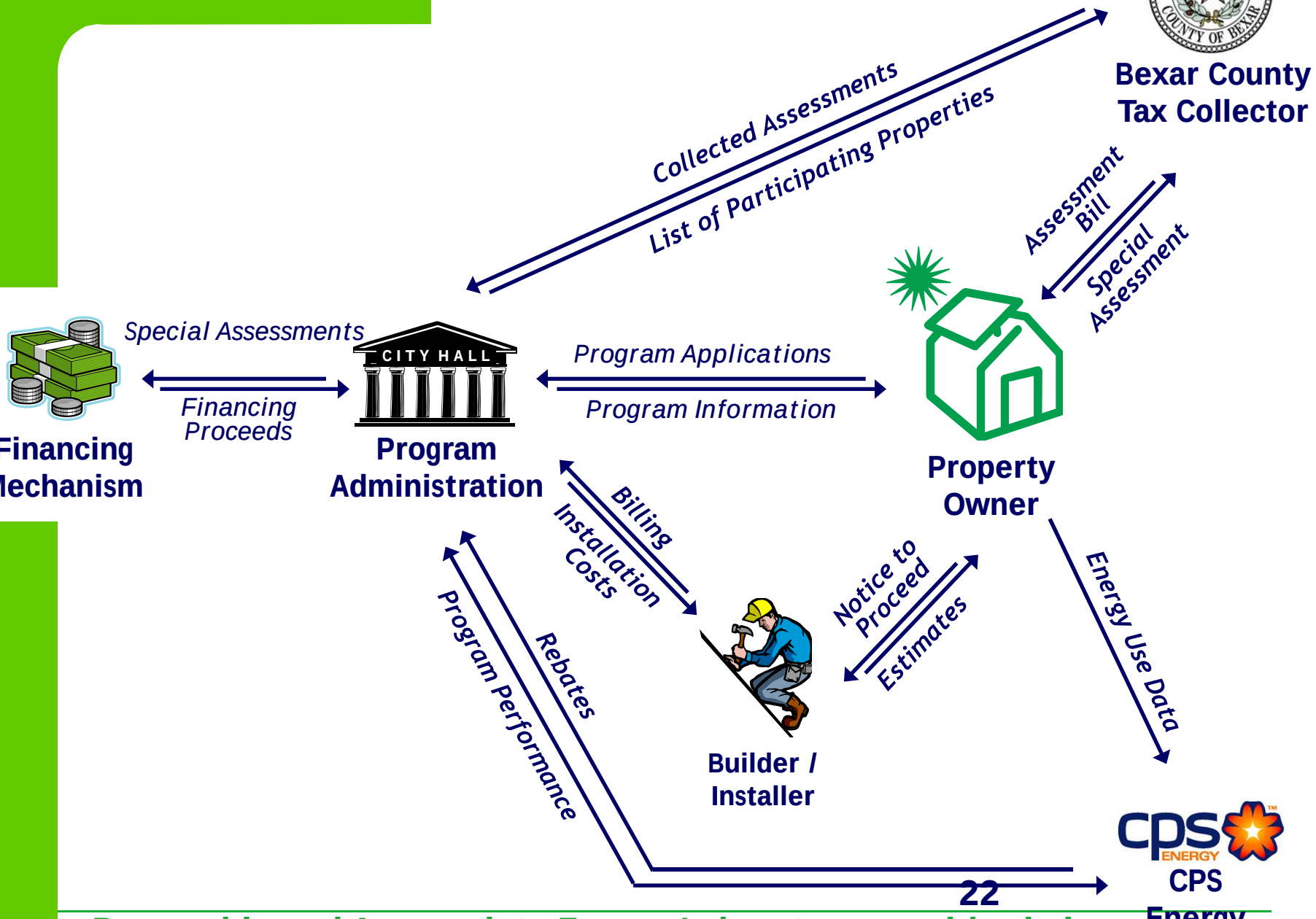
PACE financing has now been adopted by the White House for support and appears in the US House Climate Bill (Waxman-Markey)

Clean Energy Municipal Financing Legislation



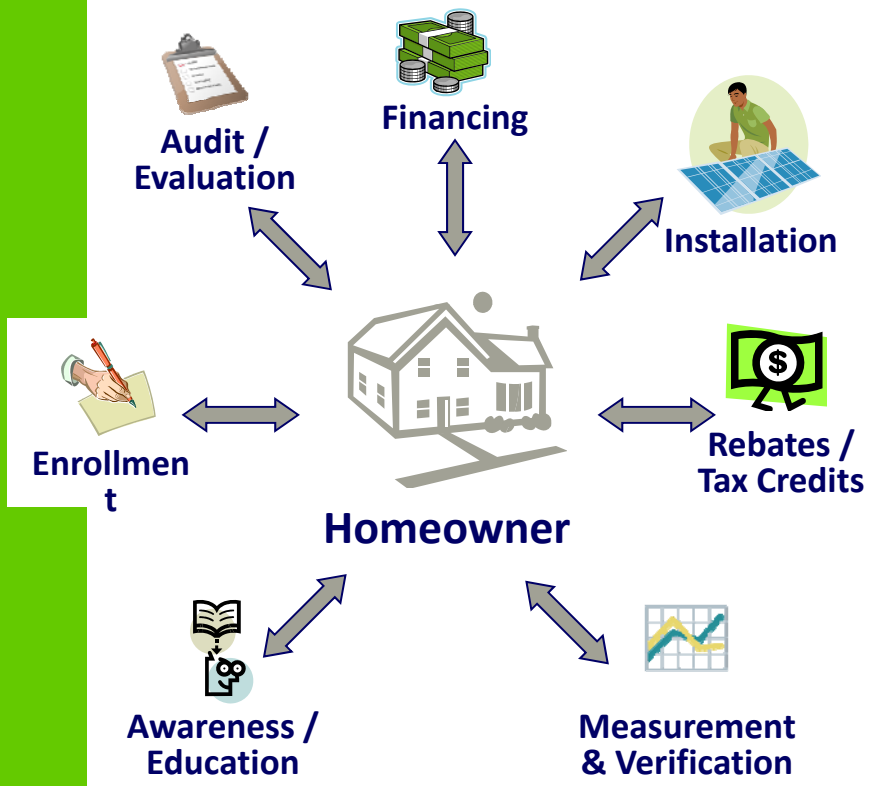
State & Bill	Status
Federal – National Home Energy Savings Revolving Fund Act – HR 1573 Inslee HR 2212 Bingaman S 949 Waxman Markey HR 2454 Dingell Amendment	In committee – House Energy and Commerce (3/17/09) HR 2212 House Energy and Environment Subcommittee (5/5/09) S 949 Committee on Energy and Natrl Resources (4/30/09)
Arizona – HB 2335	Passed House-In Senate (6/16/09)
California – SB 279; AB 811; AB 474	SB 279: In committee Passes Senate, in Assembly, Re-referred to com. On L. Gov (5/27/09) AB 811: Signed into law (2008) AB 474: Passed Assembly; in Senate (5/21/09)
Colorado – HB 08-1350	Signed into law (5/08)
Florida existing authority	Pre-existing Authority
Hawaii – existing authority	Existing county legal authority
Illinois-SB 583	Passed both houses 5/19/09
Louisiana – SB 224	Pending House Final Passage (6/15/09)
Maryland – HB 1567	Signed into law (4/09)
Nevada – SB 358	Approved by Governor (5/28/09)
New Mexico – HB 572 SB 647	Signed into law (4/9/09)
New York – A 7611; A 2672	A 7611 referred to ways and means as of 6/16/09 A 2672 no action since intro on 1/29/09
Oregon – HB 2181	In committee – Subcommittee on Natural Resources (5/18/09)
Texas - HB 1391	Pending Governor's signature (5/11/09)
Utah	May have pre-existing authority
Vermont – H.161 (subsumed into H. 446)	Passed as part of the VT Renewable Energy & Energy Efficiency Act of 2009 – HB 446 (5/28/09)
Virginia – SB 1212	Signed into law (3/30/09)
Wisconsin AB 255	Enacted 5/15/09

PACE details: Program Coordination



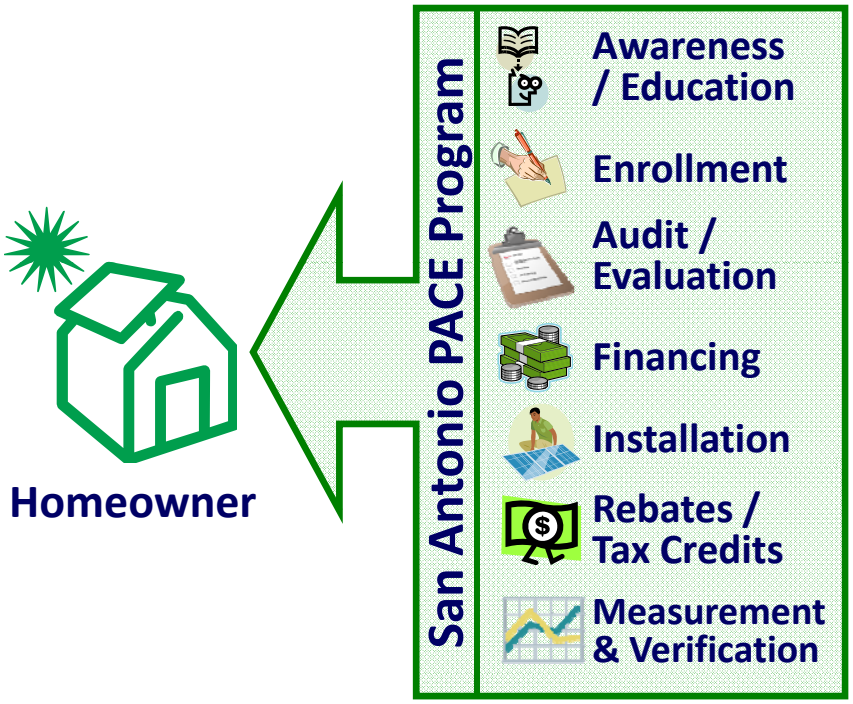
PACE details: Program Coordination

Current Situation



- Lack of awareness & participation
- Citizen responsible for project coordination
- Unknown impact & results

PACE Implementation

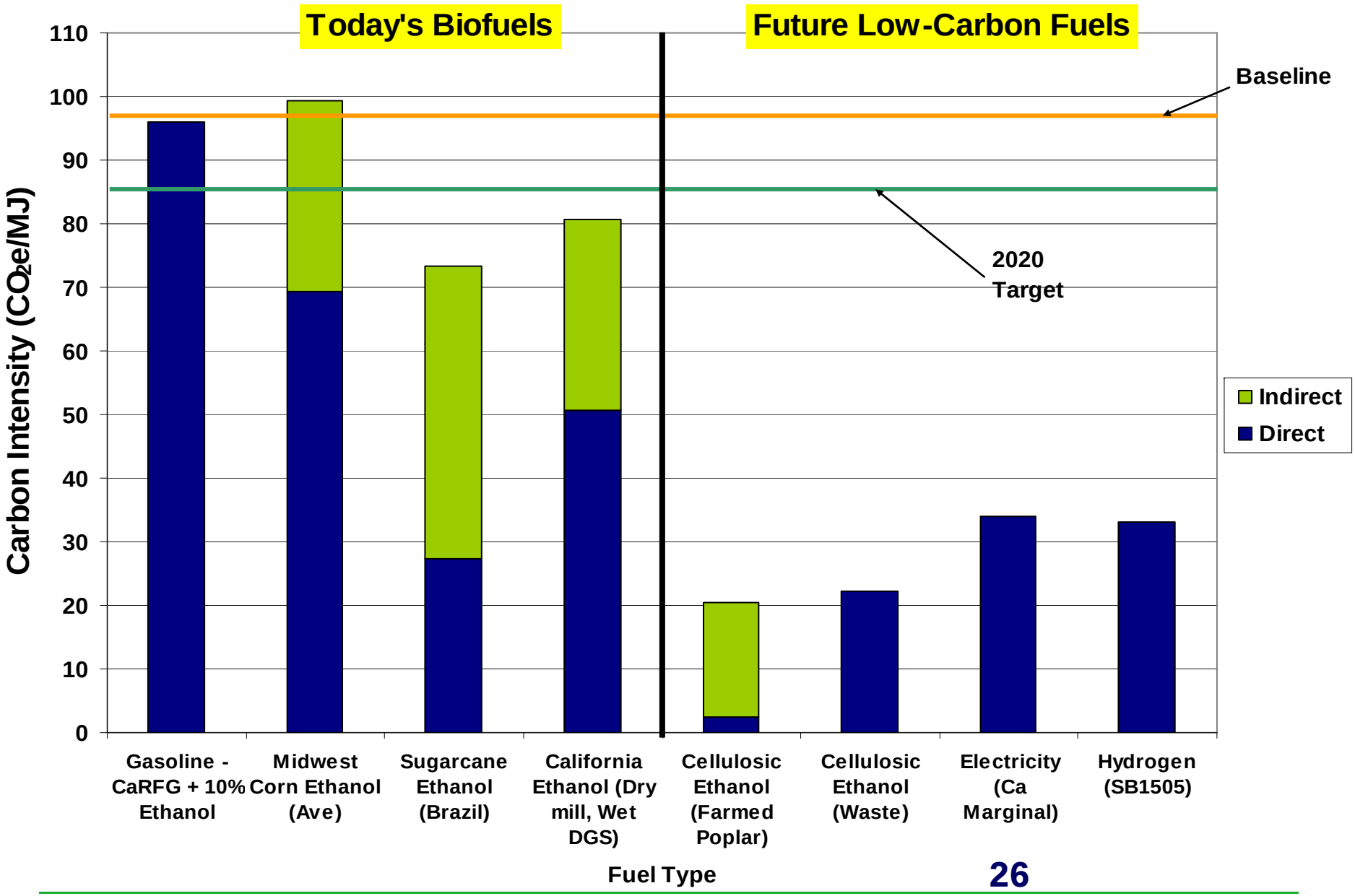


- Increased market participation
- One-stop coordination of projects from enrollment through implementation
- Measured impacts & results

Technological & market Innovation: biofuels

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

Carbon Intensity of Fuels



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]

To study the potential effects of increased biofuel use, we evaluated six representative analyses of fuel ethanol. Studies that reported negative net energy incorrectly ignored coproducts and used some obsolete data. All studies indicated that current corn ethanol technologies are much less petroleum-intensive than gasoline but have greenhouse gas emissions similar to those of gasoline. However, many important environmental effects of biofuel production are poorly understood. New metrics that measure specific resource inputs are developed, but further research into environmental metrics is needed. Nonetheless, it is already clear that large-scale use of ethanol for fuel will almost certainly require cellulosic technology.

27 JANUARY 2006 VOL 311 SCIENCE www.sciencemagazine.org

CLIMATE CHANGE

Fixing a Critical Climate Accounting Error

Timothy D. Searchinger,[1]* Steven P. Hamburg,[2]* Jerry Melillo,[3] William Chameides,[4] Petr Havlik,[5] Daniel M. Kammen,[6] Gene E. Likens,[7] Ruben N. Lubowski,[2] Michael Obersteiner,[5] Michael Oppenheimer,[1] G. Philip Robertson,[8] William H. Schlesinger,[7] G. David Tilman[9]

Rules for applying the Kyoto Protocol and national cap-and-trade laws contain a major, but fixable, carbon accounting flaw in assessing bioenergy.

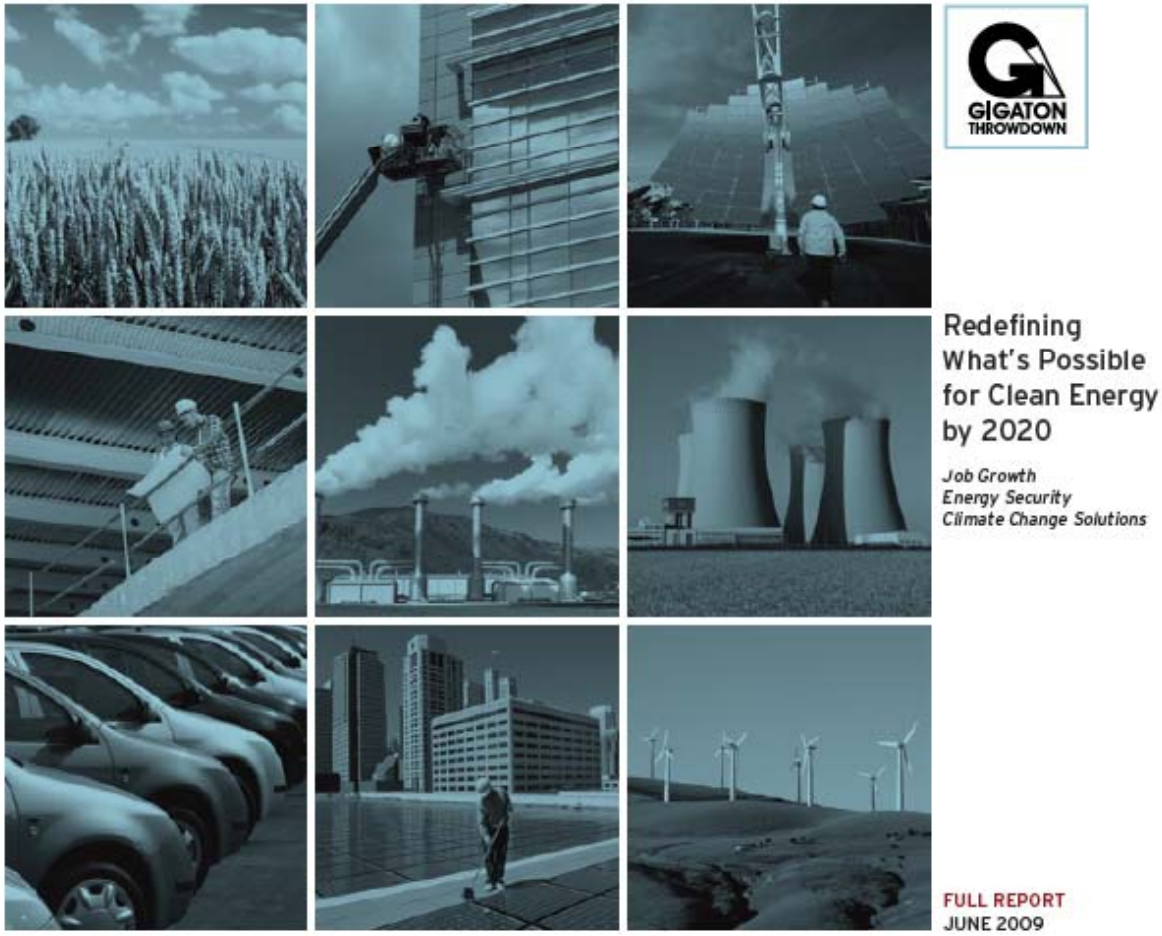
www.sciencemag.org SCIENCE VOL 326 23 OCTOBER 2009

A $500 million biofuel development grant from BP

Technology Assessments

Project coordinator: Sunil Paul

Scientific advisor: Dan Kammen



http://www.gigatonthrowdown.org/

Information innovation: Policy and environmental accounting

The SWITCH West Energy System Model:

The Switch model is a geo-referenced model of the WECC region that:

- Matches conventional, nuclear, and renewable energy supply to demand.
- Utilizes energy efficiency and demand-side management (to be completed)
- Does so with the construction of transmission and distribution infrastructure

(major task)

Objective: Minimize *Total System* Cost, Subject to GHG Constraints

New Plants

Fixed Costs of all New Plants

$$\sum_{p,i} InstallGen\_MW_{p,i} \cdot fixed\_cost_{p,i}$$

Variable Costs of New Dispatchable Plants

$$+\sum_{p,t} DispatchGen\_MWh_{p,t} \cdot (variable\_cost_{p,t} + carbon\_cost_{tech_p,t})$$

Variable Costs of New Baseload Plants

$$+\sum_{p,i,t} InstallGen\_MW_{p,i} \cdot (variable\_cost_{p,t} + carbon\_cost_{tech_p,t}) \cdot (1 - forced\_outage\_rate_p) \cdot (1 - scheduled\_outage\_rate_p)$$

Existing Plants

Fixed Costs of Existing Plants (contingent on not mothballing)

$$+\sum_{ep,period} OperateInPeriod_{ep,period} \cdot fixed\_cost_{ep,period}$$

Variable Costs of Existing Baseload Plants (contingent on not mothballing)

$$+\sum_{ep,period,t} OperateInPeriod_{ep,period} \cdot size\_mw_{ep} \cdot (variable\_cost_{ep,t} + carbon\_cost_{ep,t}) \cdot (1 - forced\_outage\_rate_{ep}) \cdot (1 - scheduled\_outage\_rate_{ep}$$

Variable Costs of Existing Dispatchable Plants

$$+\sum_{ep,t} Dispatch\_MWh_{ep,t} \cdot (variable\_cost_{ep,t} + carbon\_cost_{ep,t})$$

Variable Costs of Existing Intermittent Plants

$$+\sum_{ep,t} OperateInPeriod_{ep,period_t} \cdot variable\_cost_{ep,t} \cdot size\_mw_{ep} \cdot cap\_factor_{ep,t} \cdot (1 - forced\_outage\_rate_{ep})$$

T & D

Cost of New Transmission

$$+\sum_{a_1,a_2,i} InstallTrans\_MW_{a_1,a_2,i} \cdot transmission\_cost\_per\_mw_{a_1,a_2,i}$$

Cost of New Distribution

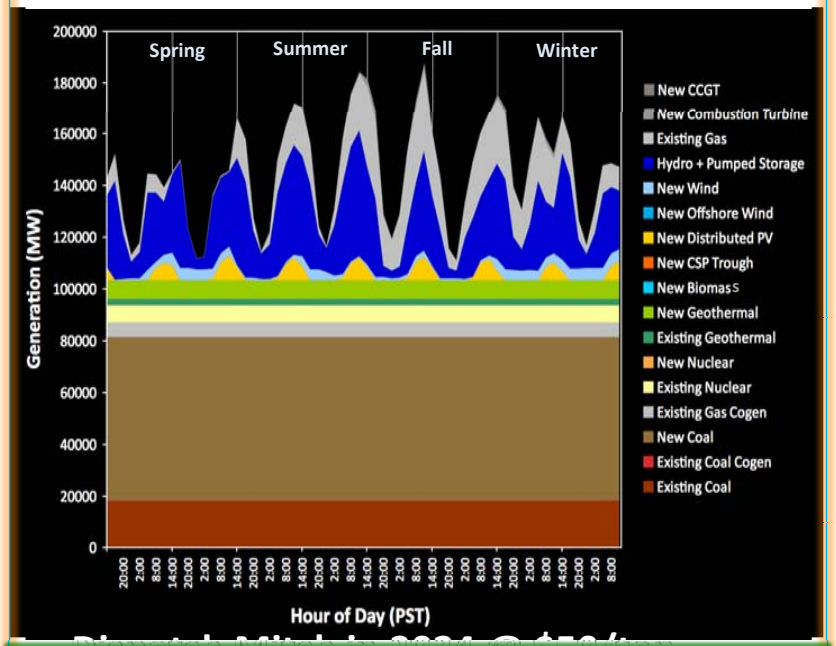
$$+\sum_{a,i} InstallLocalTD\_MW_{a,i} \cdot local\_td\_cost\_per\_mw_{i,a}$$

Sunk

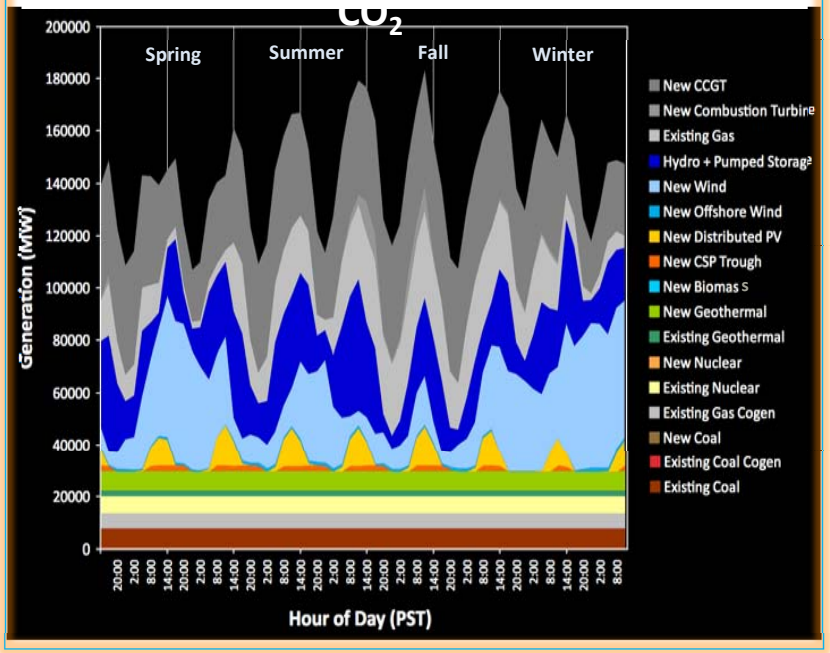
Sunk Costs (to obtain the correct price of power)

$$+\sum_{ep,a} sunk\_system\_costs$$

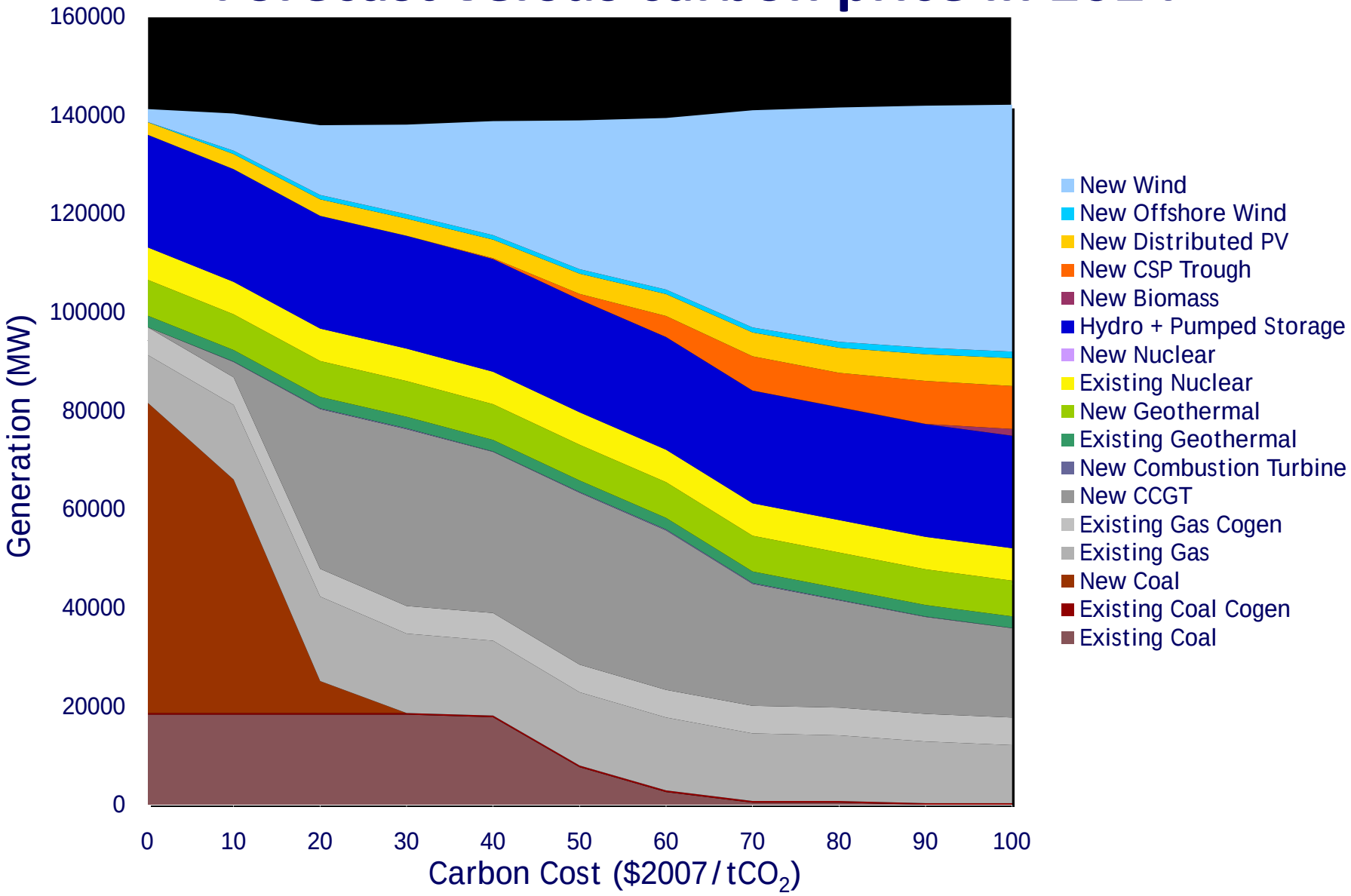
Dispatch Mix in 2024 @ $0/ton CO_2



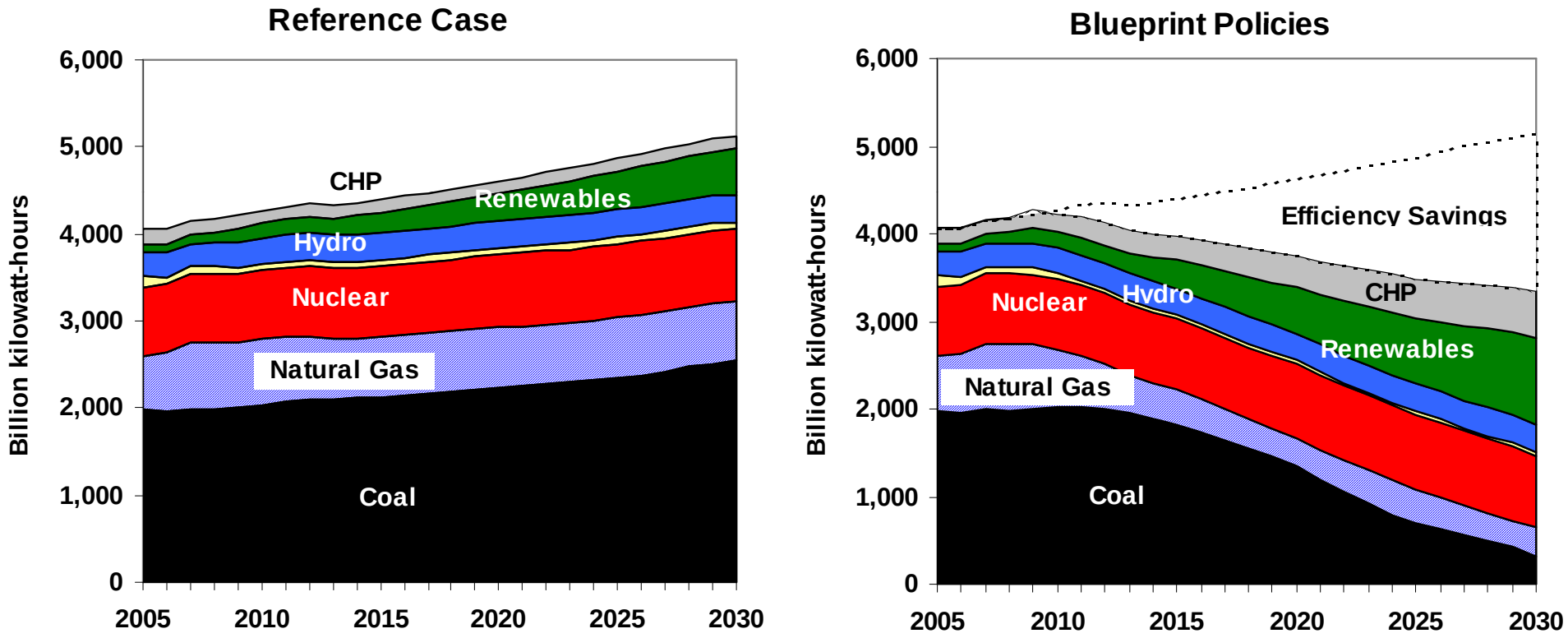
CO_2



Electricity Supply in Western North American Forecast versus carbon price in 2024



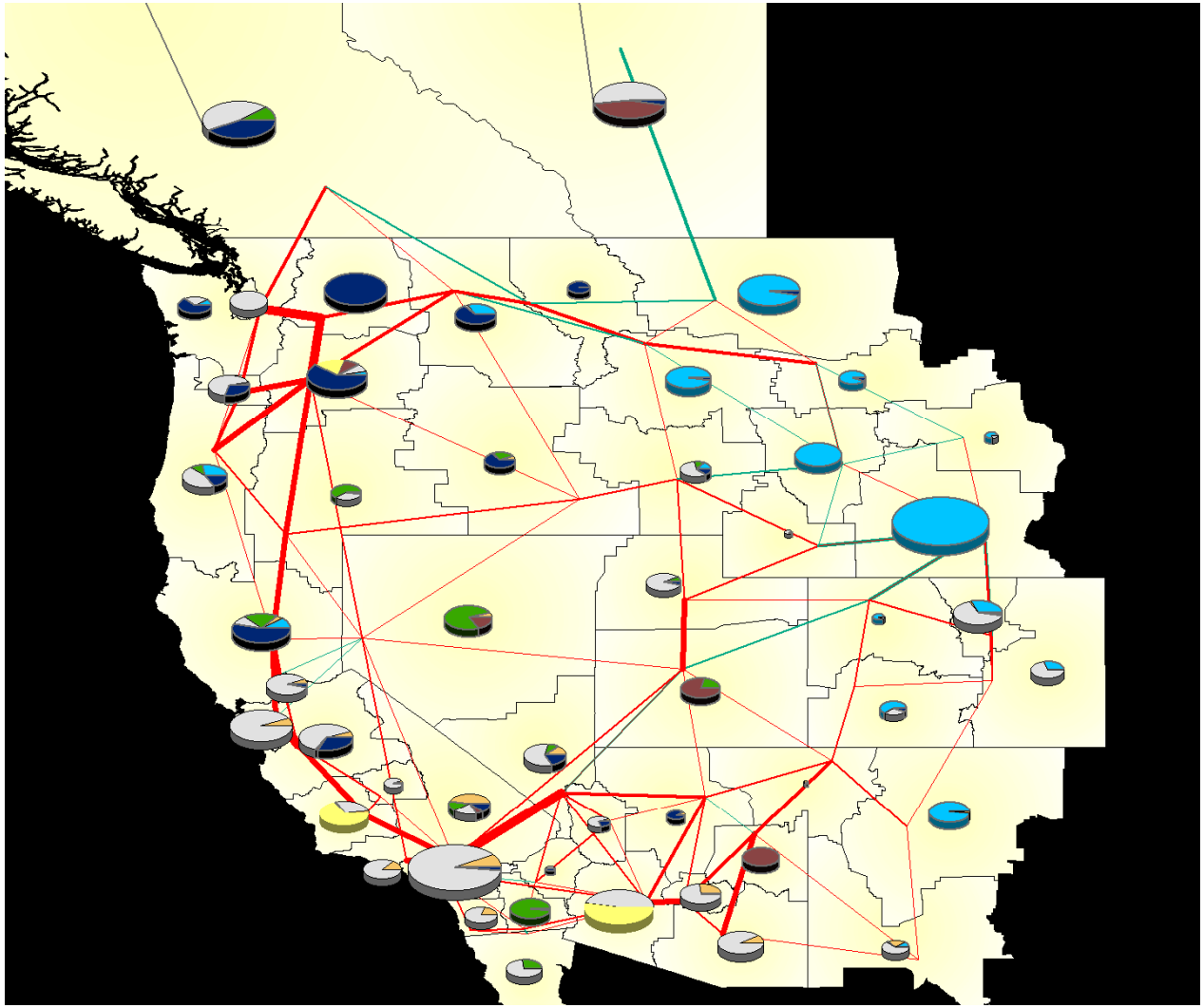
The Blueprint reduces U.S. electricity use and diversifies the energy mix



Predicted transmission $50t/CO2 in 2024

43.266455 - 1549.022003
1549.022004 - 3855.576238
3855.576239 - 6682.438322
6682.438323 - 11323.556268
11323.556269 - 20292.953970
C
43.266455 - 1549.022003
1549.022004 - 3855.576238
3855.576239 - 6682.438322
6682.438323 - 11323.556268
11323.556269 - 20292.953970

Old Transmission Lines
New Transmission Lines



Greenhouse gas and sustainability calculators:

http://coolclimate.berkeley.edu

&

http://www.coolcalifornia.org

1 Intro | 2 Transport | 3 Housing | 4 Food | 5 Goods/Services | 6 Summary

Load previous session F.A.Q.

1. Start with your home economic information

Select U.S. State

Select

Nearest major U.S. city or region

Select

How many people live in your household?

Select

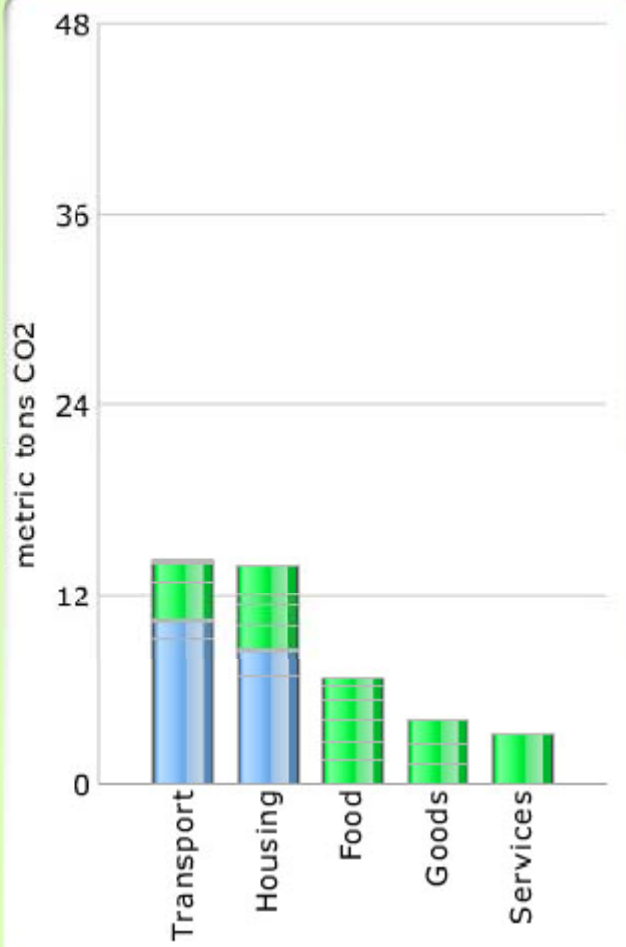
What is your gross annual household income?

Select

This info can not be viewed by others. Learn more

- Click "Transportation" or other links at top to continue
- Then, either keep the "default" values or enter your own

Your Footprint: 42 tons CO2/yr



How do you compare to the averages?