

Testimony before: The Joint Workshop on Alternative Transportation Fuels

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Global Energy Potential

Renewables Forever

(5.5 billion years)

terawatt hours/YEAR

Direct Solar Radiation

Wind

Ocean Thermal

Biofuel

Hydroelectric

Geothermal

Tidal/Wave

350,000,000

200,000

100,000

50,000

30,000

10,000

5,000

Energy Stored in the Earth

(Use it once and it's gone)

Coal

Natural Gas (US Peak 2005)

Uranium 235 (US Peak 2008)

Petroleum (US Peak 1970, World Peak <2010)

Tar Sands

terawatt hours

TOTAL

6,000,000

1,500,000

1,500,000

1,000,000

800,000

World stored energy consumption = 70,000 terawatt hours/year

Advantages of Solar Energy

Fossil Fuel Dependence



- **Finite fuel supply**
- **Ugly infrastructure**
- **Polluted air / Climate change**
- **Extraction site devastation**
- **Polluted land**
- **Spills and polluted water**
- **Energy resource wars**
- **Susceptible to terrorism**

Solar Independence



- **Unlimited energy source**
- **Aesthetically superior**
- **Clean air / Zero emissions**
- **No extraction sites**
- **Healthy land**
- **No water pollution**
- **No conflict over free sunshine**
- **National and individual security**

Advantages of Distributed Solar-Generation

Centralized Power Generation



- Uses land for extraction and power generation
- Explosive polluting terrorist targets
- Requires fuel from distant sources
- Price Volatility
- Difficult permitting process
- Requires security infrastructure
- Requires new transmission and distribution lines
- Power has low value (\$0.02 – \$0.04/kWh)
- Excess off peak power generation
- Multinational corporate control, fossil fuel dependence

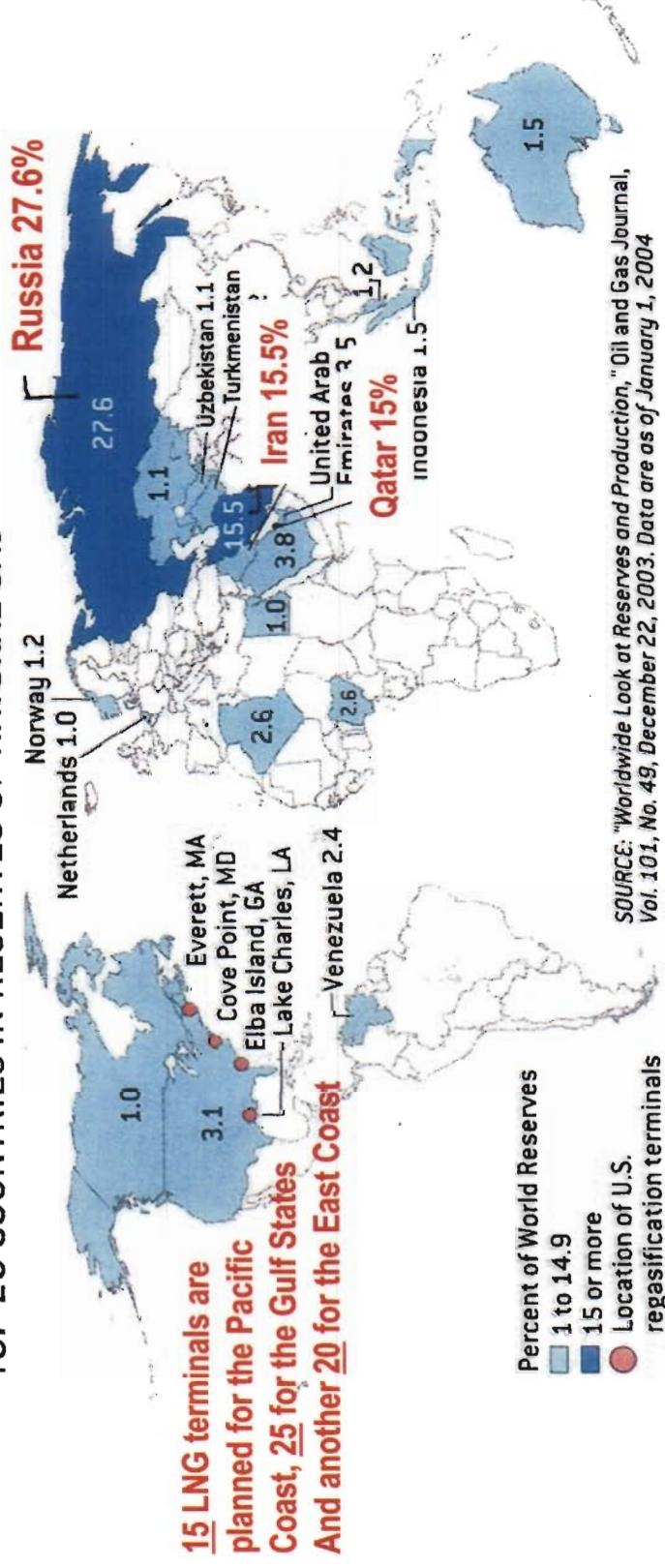
Distributed Solar Generation



- Uses existing infrastructure
- Clean and Secure
- Requires no fuel, only sunshine
- Economic stability
- Easy permitting process
- Cost of roofing can be offset
- Uses existing transmission and distribution lines
- Power has high value (\$0.10 - \$0.35/kWh)
- Time of Use (TOU) net metering for automatic peak power shaving
- Local control, energy independence

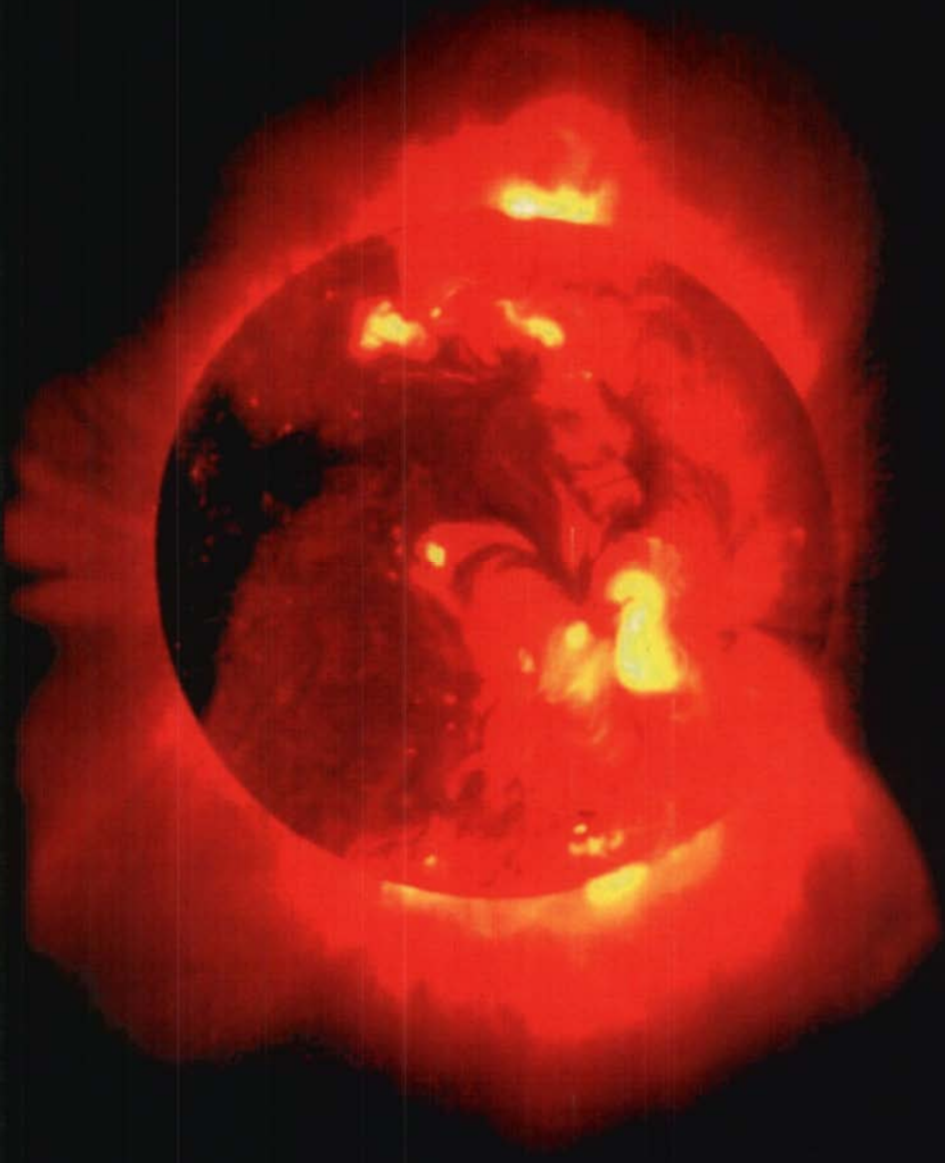
Who Has Natural Gas

TOP 20 COUNTRIES IN RESERVES OF NATURAL GAS



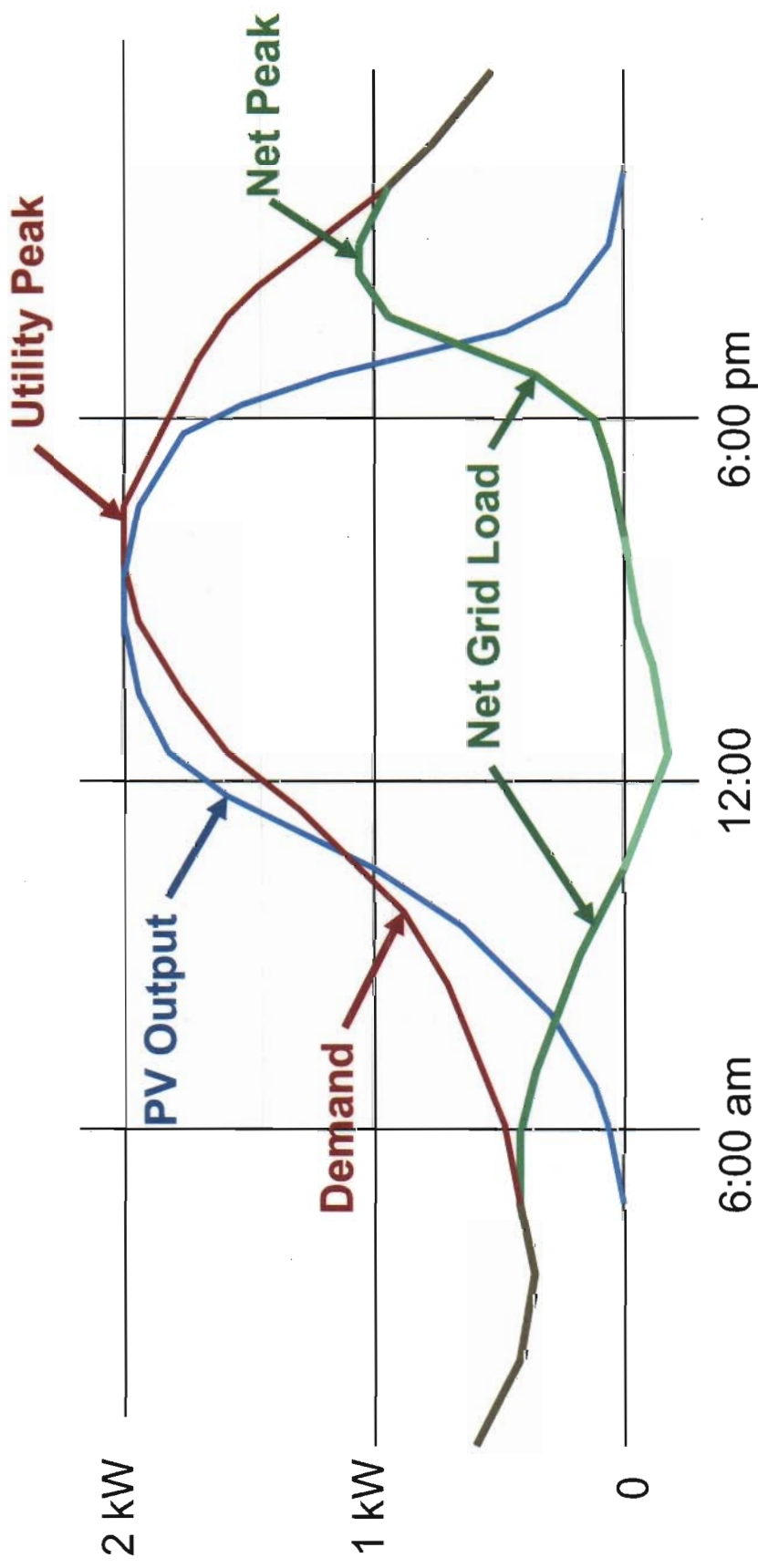
Most of the new generating capacity in California is fueled by natural gas but 87% of the fuel used is imported from outside the state. The proposed Liquefied Natural Gas (LNG) terminals will cost about \$5 billion each. If these terminals are built the cost will be passed on to the ratepayer, US trade deficits will continued to rise and dependence on distant volatile energy supplies will be institutionalized causing another round of resource wars

The Best Place for a Nuclear Reactor is 93,000,000 Miles Away



The Sun's energy only takes 8 minutes to arrive and leaves no radio active waste

Graph of Net Grid Load on Home with 2 kW West Facing BIPV System and 2 kW Peak Summer Load



High peak air-conditioning loads coincided with the peak performance from PV installations.

Advantages of True BIPV

Building Applied PV



Modules installed on racks

- **Theft or breakage**
- **Racks are expensive**
- **Must be removed to replace roofing**
- **Roof penetrations required**
- **Detract from building's appearance**
- **Modules add excess weight to roof**
- **Electrical cables & conduit are exposed**

Building Integrated PV

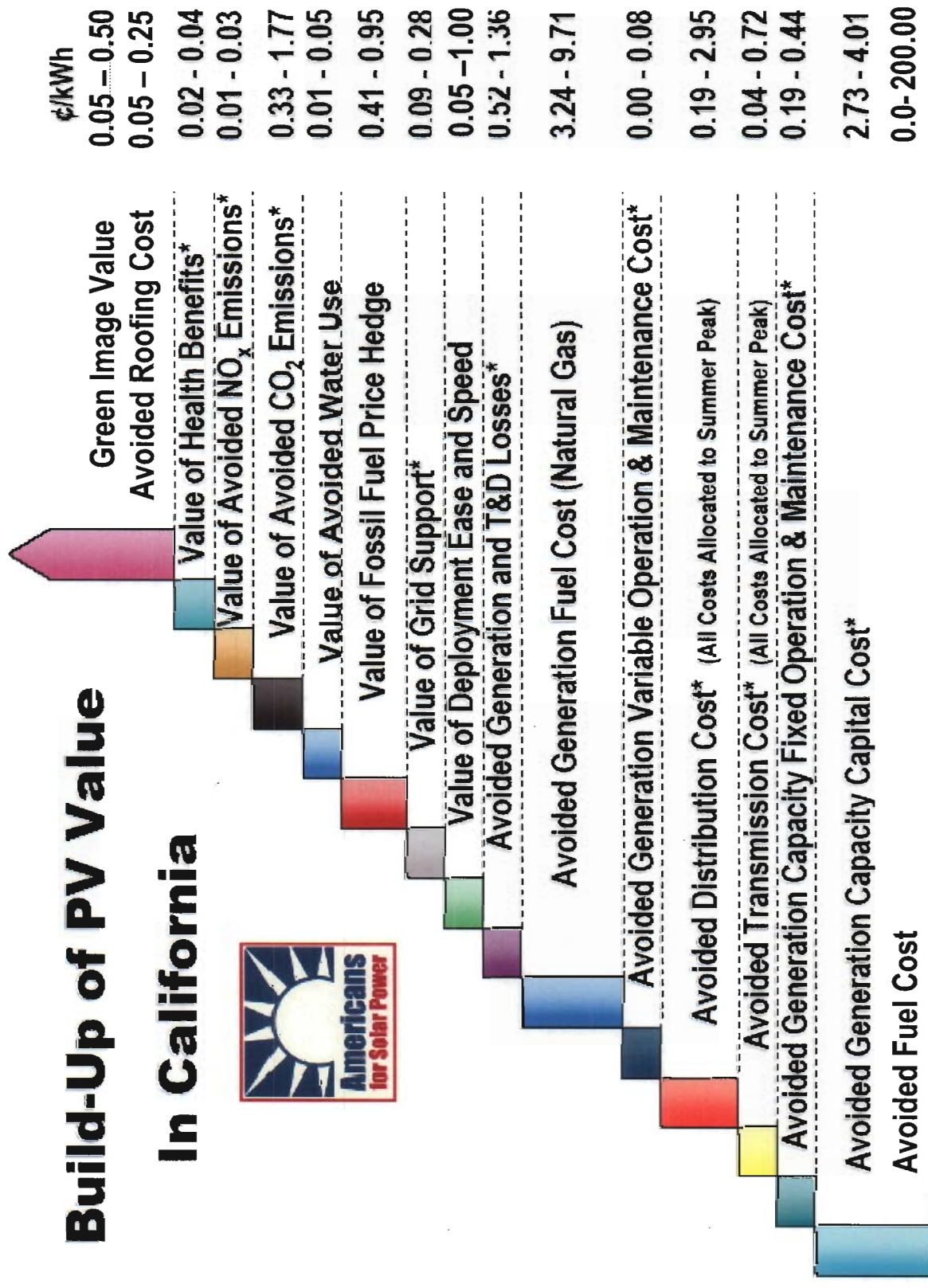


BIPV roofing

- **Vandal resistant**
- **Avoids the expense of racks**
- **Synchronized roof and PV installation**
- **No roof penetrations**
- **Aesthetically superior**
- **Lightweight**
- **Electrical cables are hidden and protected**

Added Value from BIPV

Build-Up of PV Value In California



TOTAL ADDED VALUE OF BIPV: \$0.08 - \$2.25 / kWh

Payback?

Product



Crystalline PV



Flexible Thin-Film PV



Gas Generator

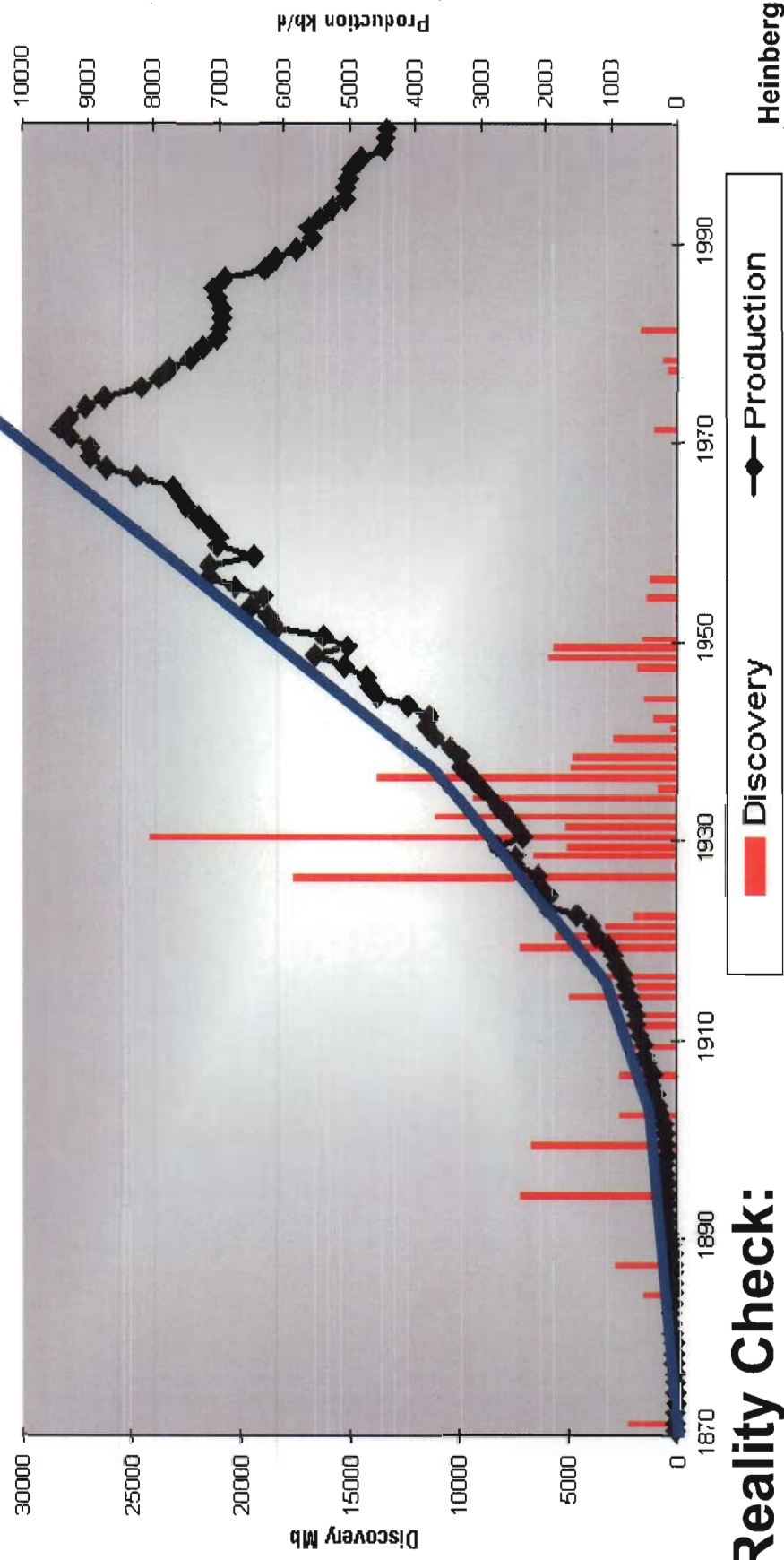
Energy used to manufacture	5-7 kWh/watt	2.5 kWh/watt	3-4 kWh/watt
Power used to generate electricity	none	none	From tank: 6-7 kWh/kWh From well: 10-20 kWh/kWh From sun: >1,000 MWh/kWh
Time to payback energy to make	4-6 years	18 months	never
Warranty	20-25 years	20 years	1-2 years
Lifecycle pollution	trace	trace	tons
External cost	Cents/MWh	Cents/MWh	K\$/MWh

“ America is Addicted to Oil”

US Oil Discoveries Peaked in 1930

US Oil Extraction Peaked in 1970

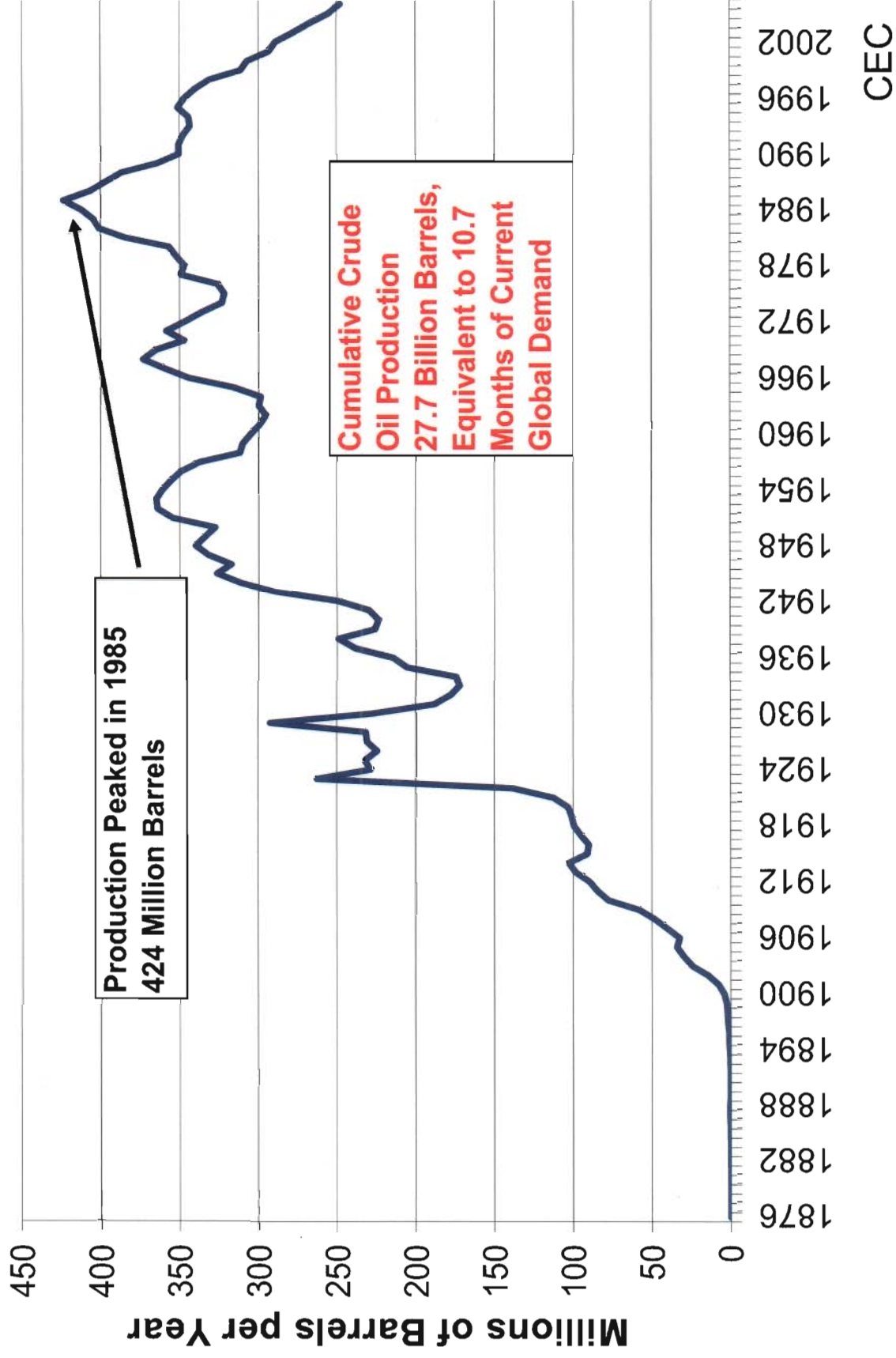
US Oil Consumption



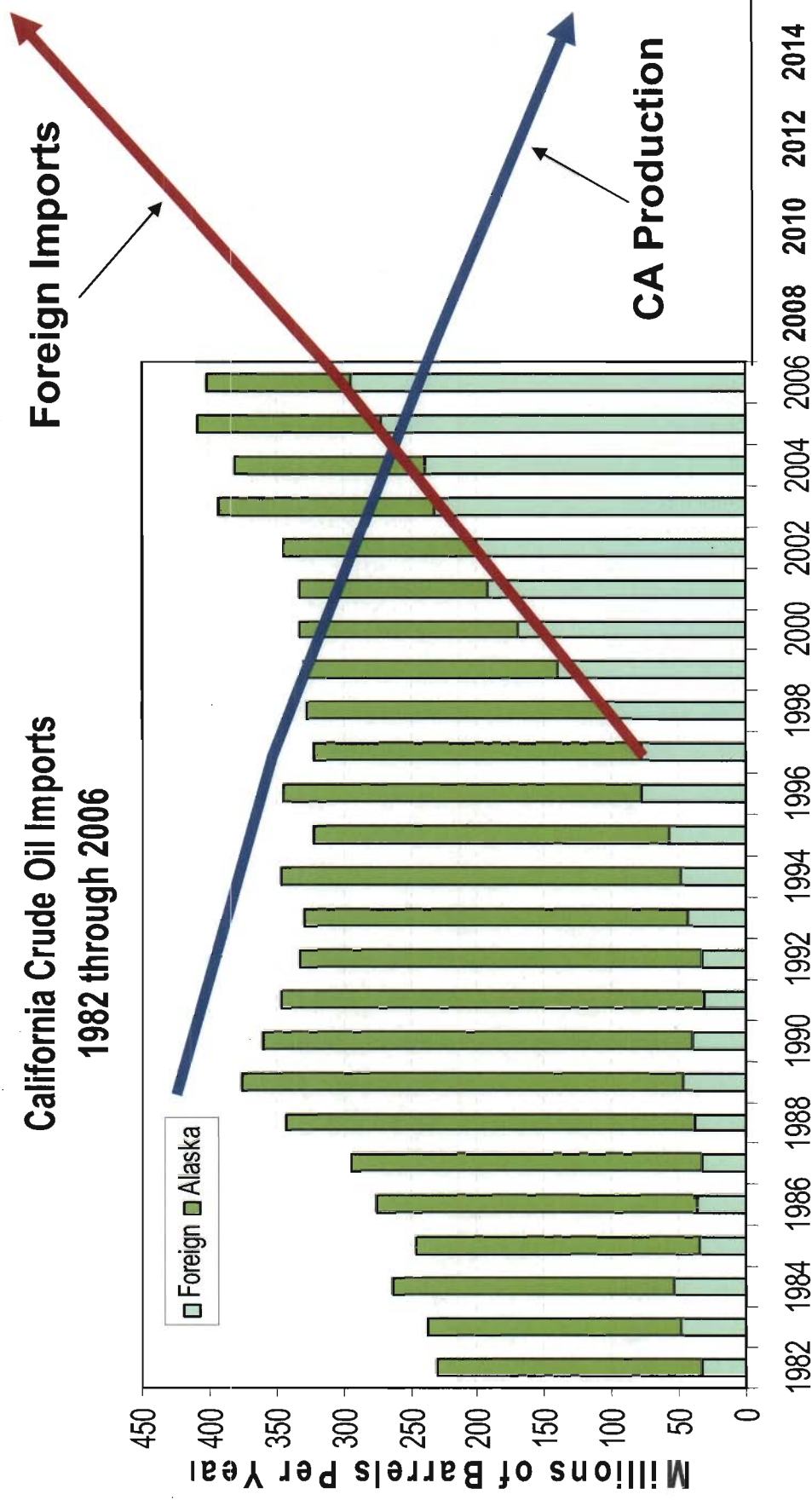
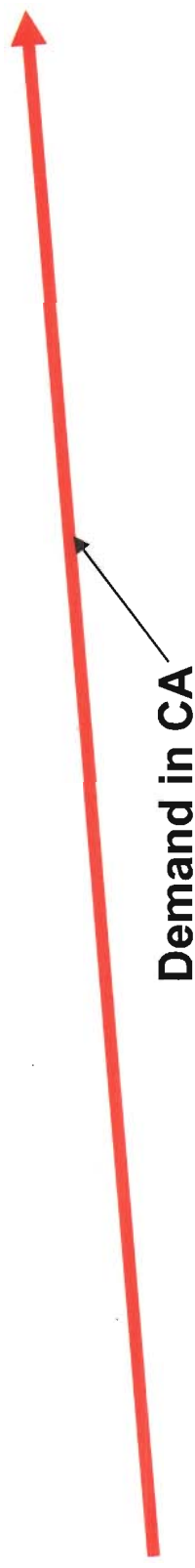
Reality Check:

- This is not a projection it is historical data from the petroleum industry.
- In a more perfect world the US might have noticed a trend after discoveries peaked in 1930.
- In a less then perfect world the US would have responded to peak extraction around 1975.
- Ignoring the realities of finite resources puts future generations at risk.
- **We are the future generation.**

California Oil Production 1876 to 2006



80% Imported Oil in California by 2015

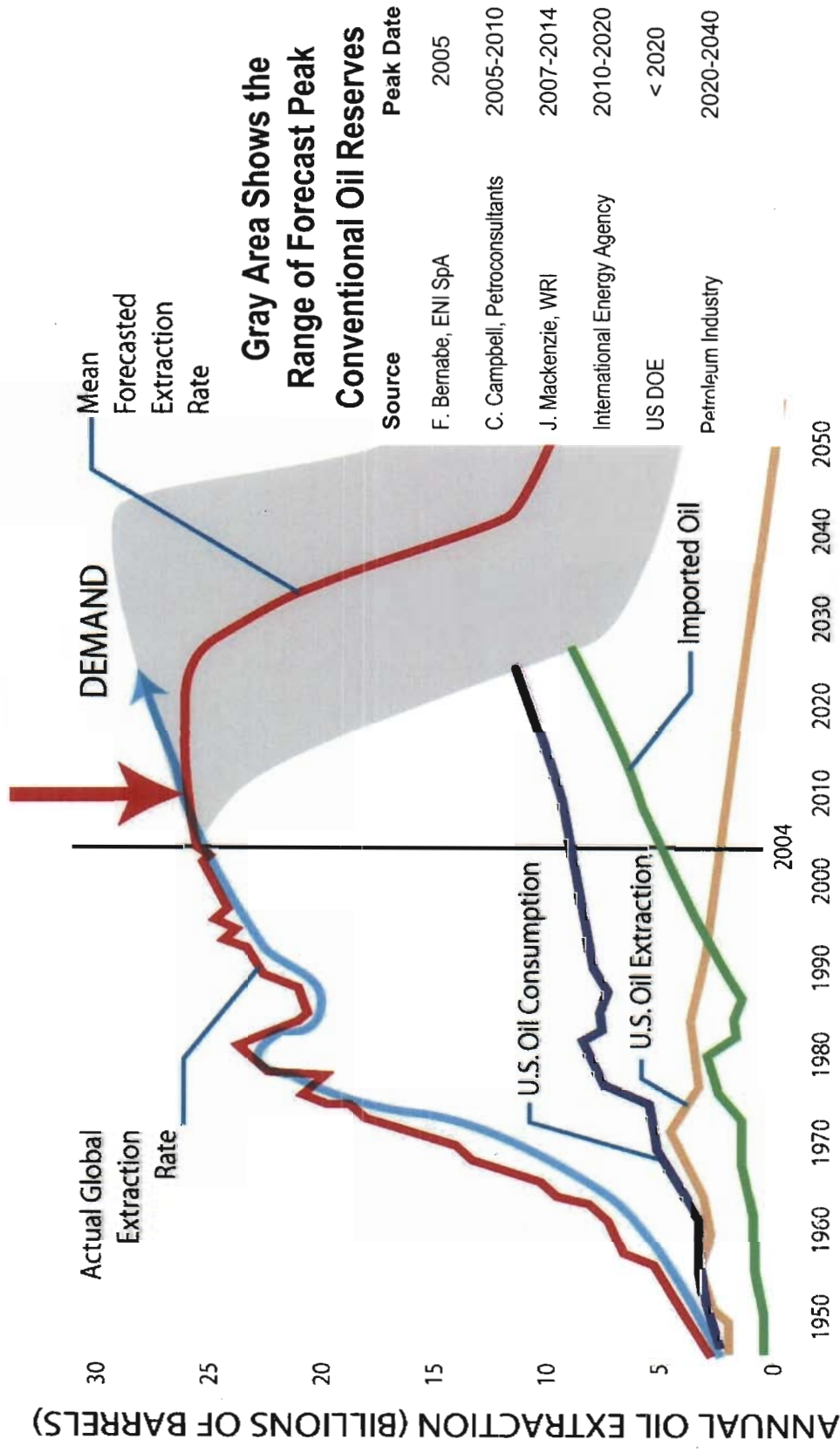


CEC

Heckerath, 5-20-07

World Peak Oil

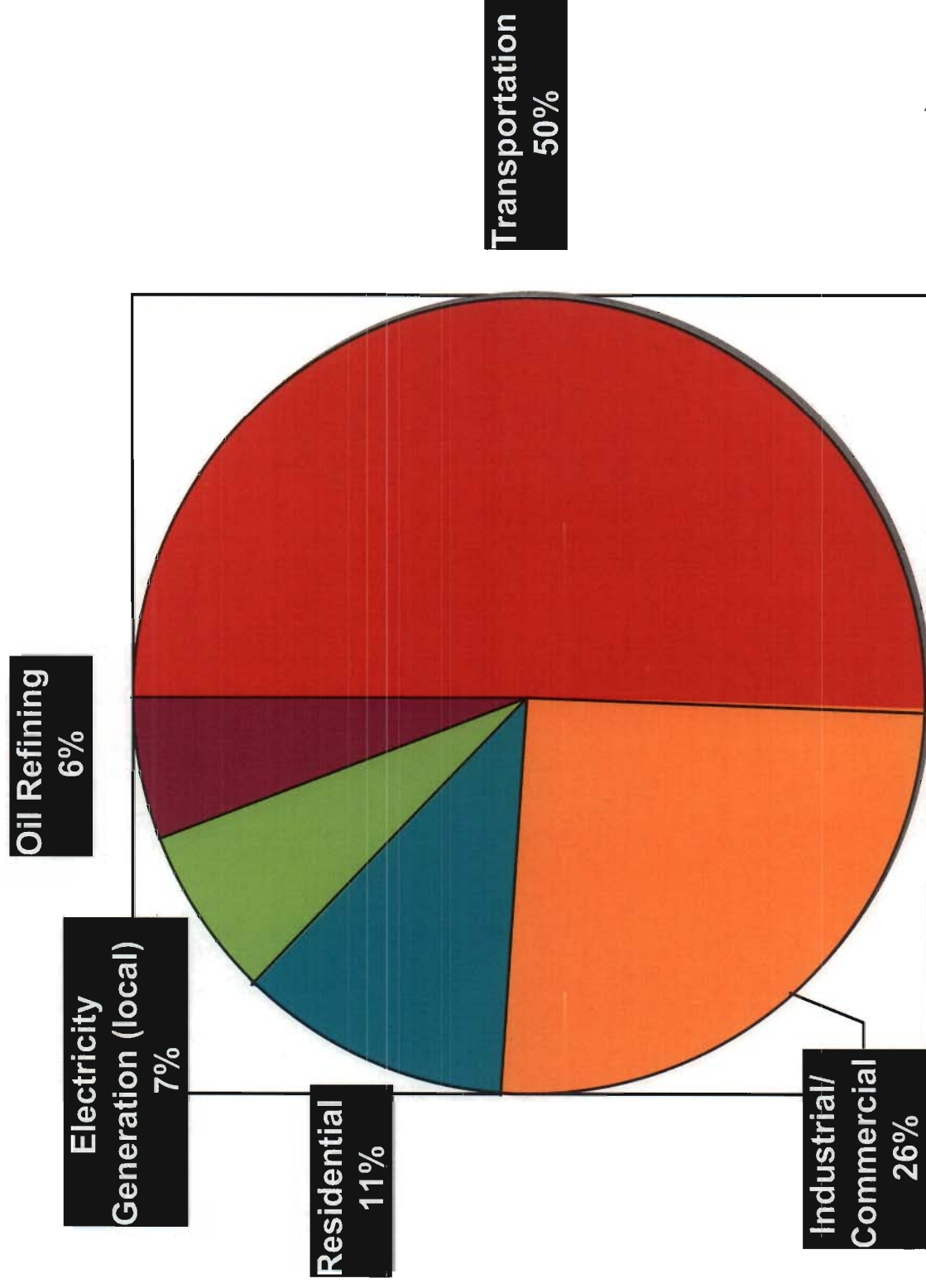
CRISIS POINT



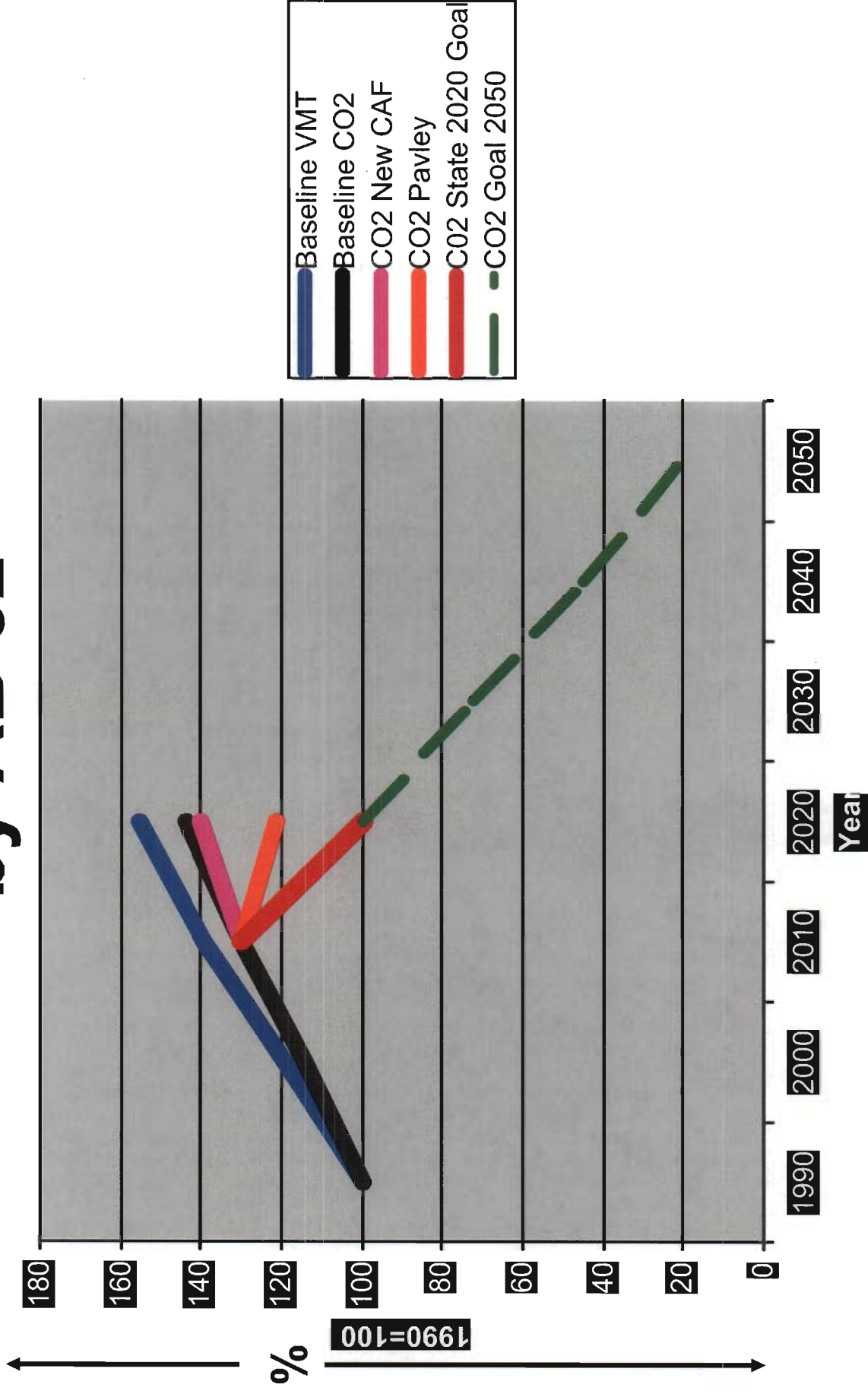
US Oil "production" has been declining at an average of 2%/year since 1985.

US Oil imports have been increasing at an average of 4%/year since 1985.

Bay Area CO2 Emissions



Emissions Reductions Mandated by AB 32



PVs Can Charge EVs to Reduce Oil Dependence



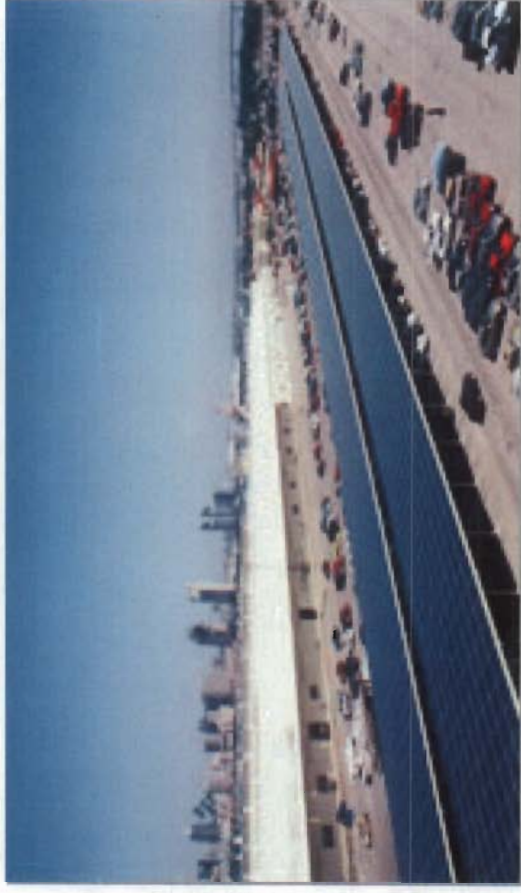
2 kW EV Charging Station



10 kW EV Charging Station



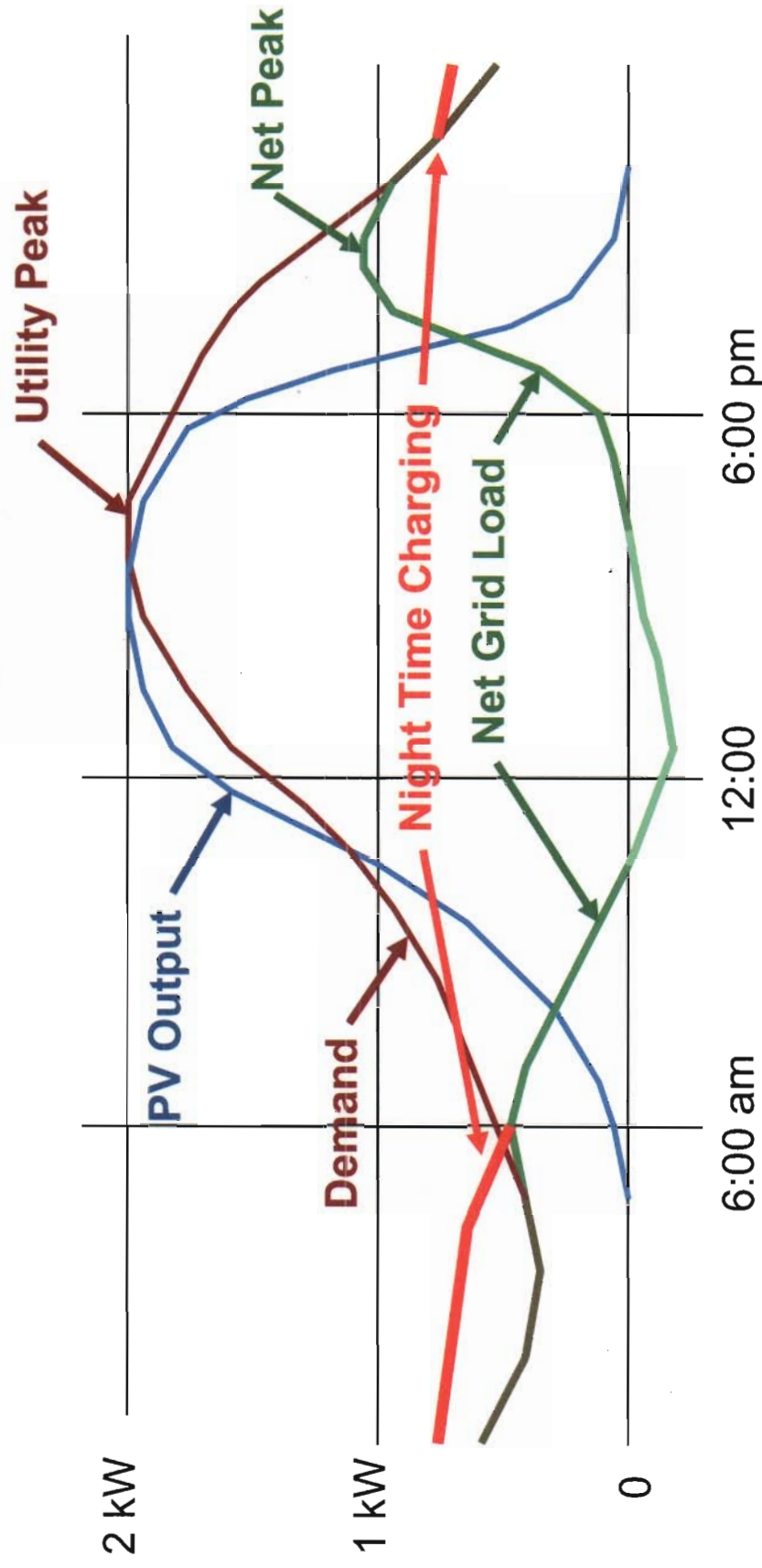
30 kW EV Charging Shade Structure



300 kW EV Charging

Heckeroth, 5-20-07

Graph of Net Grid Load on Home with a 2 kW West Facing BIPV System, a 2 kW Peak Summer Load and an EV Charged at Night



There is enough Spinning Reserve in the US to charge
>170 million PHEVs without adding new capacity

Time for an Alliance Between Utilities, PV and Transportation



26kWh/day PV
26 kWh
EV Battery

Smart Meters capable of turning off non-essential loads to avoid blackouts can also be used to buy electricity from EV batteries tied to the grid (V2G) to level utility loads. Night charging can further level utility loads and when excess renewable capacity is available EV batteries can make the sun a 24-7 energy source for your home or business.

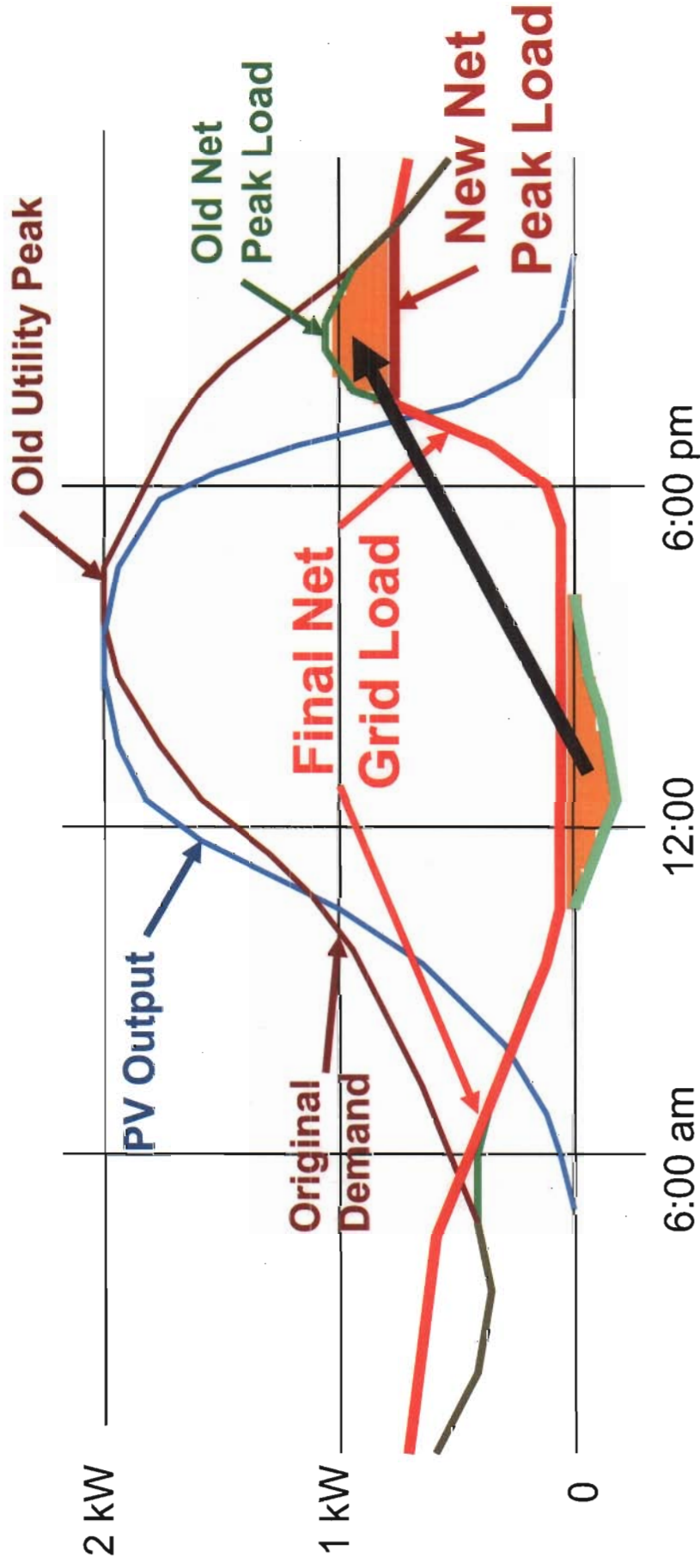


6kW BIPV provides power for
Co-Housing and shared EV



110kWh/day PV, 52 kWh of EV batteries

Using **V2G** and West Facing **PV** to further shave **Summer Peak** and **Level Utility Load**



Charging Batteries with excess **PV Capacity** and **Selling Batteries** to shave **Summer Peak**

The Clean Power/Transportation Solution



PV charging infrastructure combined with plug-in vehicles tied to the grid (V2G) will provide peak shaving, load leveling and backup power. EVs and PVs in the parking lot or garage can power a factory or home.



Photo courtesy Donald Aitkin

Fuel Efficiency and Climate Change

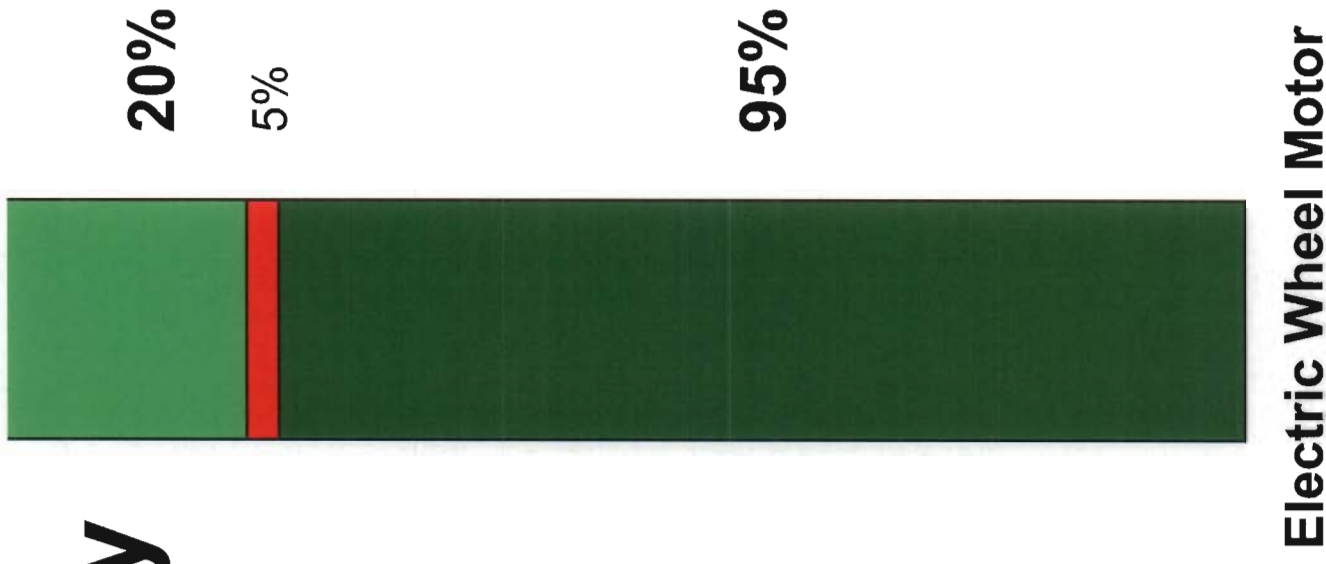
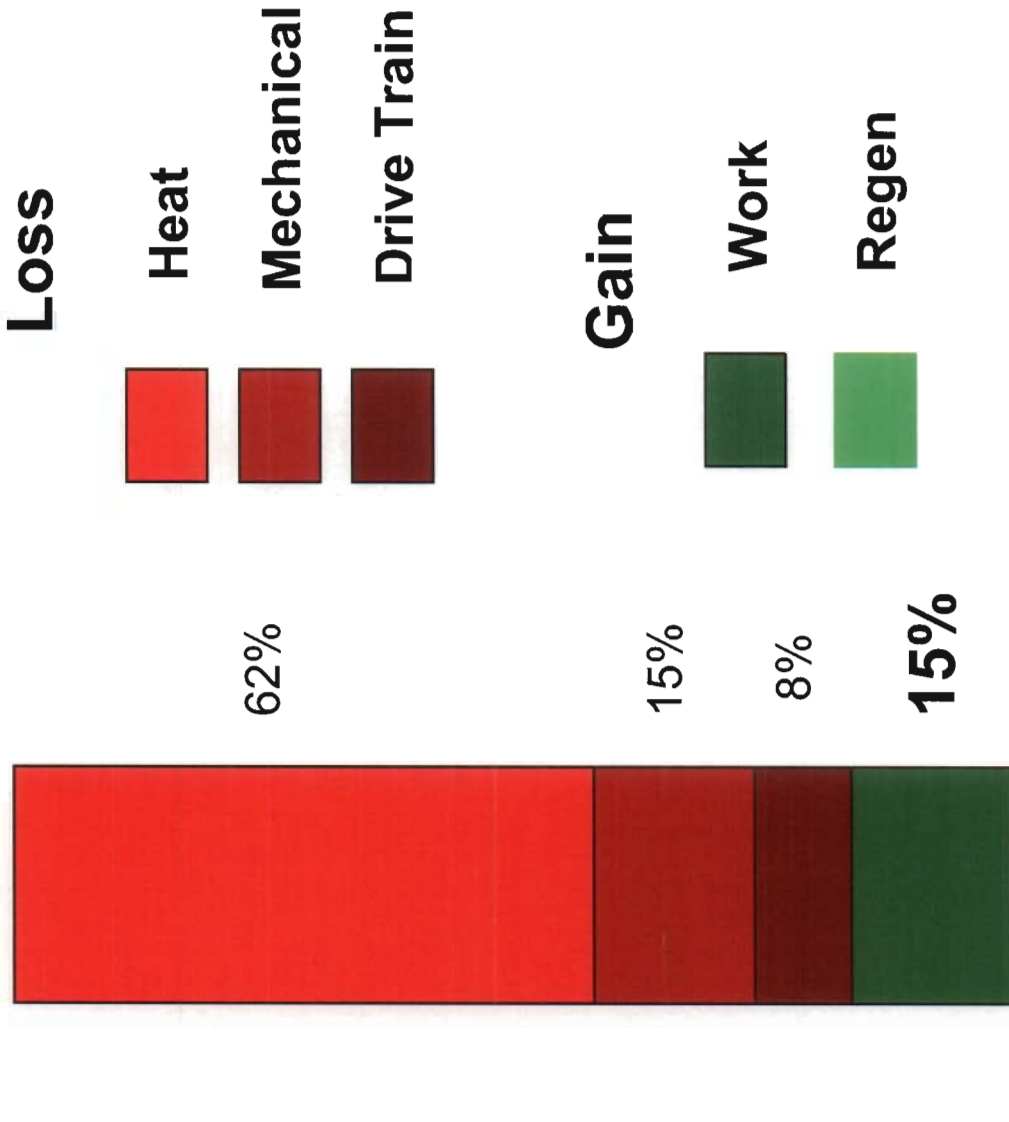


Vehicle Type	\$ Gas 25 Mi. /Day	kWh 25 Mi. /Day	\$/year 25 Mi. /Day	Gal/yr 25 Mi. /Day	Tons of CO2/Yr Tailpipe	* + Tons of Upstream CO2/Year
10 MPG Gas	8.75	100	\$3200	915	10.5	13.7
20 MPG Gas	4.37	50	\$1600	460	5.3	6.8
30 MPG Gas	2.93	34	\$1050	305	3.5	4.5
40 MPG HEV	2.20	25	\$800	230	2.6	3.4
50 MPG HEV	1.75	20	\$640	180	2.1	2.8
Plug-in HEV 25 Mile range	0	8	\$140	0	0	1.2
Battery EV	0	5	\$100	0	0	.7
Ultra light EV	0	1	\$20	0	0	.14

Assumptions: \$3.50/gal, \$.06/kWh nighttime rate, 40kWh/gal, 23#sCO2/gal

* This column includes upstream CO2 emissions for exploration, extraction, transport, refining and distribution of gasoline, as well as CO2 emissions from the California mix of power plants that produce electricity to charge electric vehicles.

Drive Train Efficiency



Biofuels?

- Using waste oil or biomass is great while it lasts but a fast food restaurant can only supply 2-3 vehicles and there are already many examples of food crop land being used to fill the tanks of SUVs. The cost of tortillas has quadrupled in Mexico in the last year because of the demand for corn to make ethanol. It takes 1000 gallons of water and more than a gallon equivalent of fossil fuel to produce one gallon of corn ethanol.
- Burning hundreds of square miles of virgin rain forest in Indonesia and Brazil to plant GMO mono-crops for biofuel production is destroying biodiversity.
- The overall efficiency of biofuels from Sun to Wheel is about 0.01–0.05 %.
- The overall efficiency of PVs charging EVs from Sun to Wheel is 3–20 %
- Solar-charged EVs are from 60 to 2,000 times more efficient than internal combustion vehicles burning biofuels - when efficiency is measured from Sun to Wheel.

The Cost of Combustion

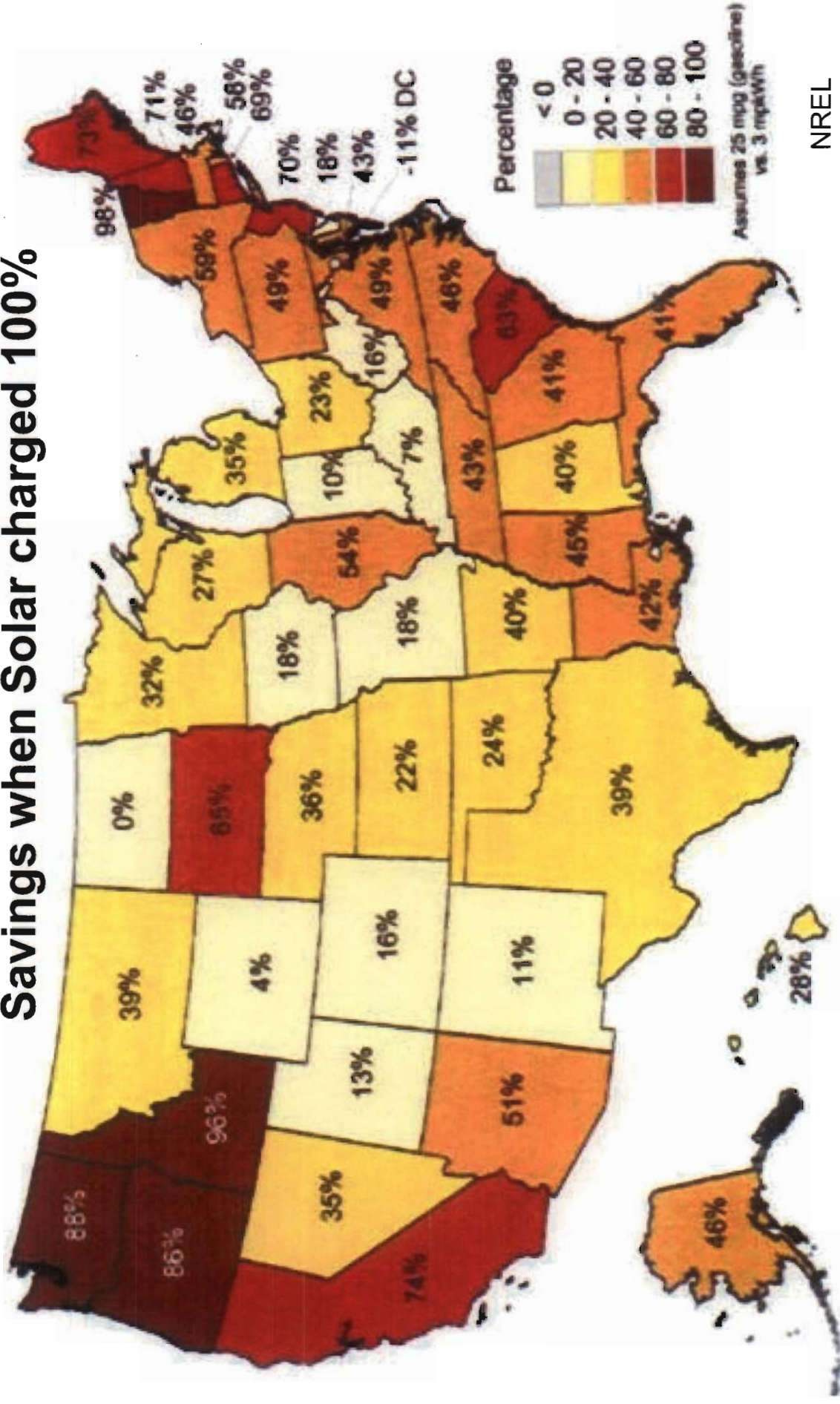
Vehicle Type			
	20 MPG Gas	PHEV/25/grid	EV/1kW PV *
Liquid fuel used 25 mi/day / 25 yrs	11,500 gals	ZERO	ZERO
Energy used 25 yrs	460 MWh	70 MWh	45 MWh
Fuel cost now / 25 yrs \$3.50/gal, \$0.07/kWh	\$40,000	\$5,000	\$5,000
Fuel cost over 25 yrs \$10.00/gal, \$0.20/kWh	<u>\$115,000</u>	<u>\$14,000</u>	<u>\$5,000</u>
Fuel cost/ month	\$385	\$45	\$15
Annual cost	\$4,600	\$420	\$180
CO ₂ / 25 years	320 tons	17 tons	trace

Assumptions average next 25yrs : 40kWh/gal, \$10.00/gal, \$0.20/kWh, 28#s CO₂/gal,

.5#s CO₂/kWh * Current installed cost and performance in CA for PV

Carbon Savings from EVs and PHEVs

National Average Savings 42%
Savings in California State 74%
Savings when Solar charged 100%



Offsetting Fuel vs. Electricity

Vehicle Type			
	EV/1kW PV *	20 MPG Gas	PV alone *
Liquid fuel used 25 mi/day / 25 yrs	ZERO	11,500 gals	ZERO
Energy used 25 yrs	45 MWh	460 MWh	45 MWh
Fuel cost now / 25 yrs \$3.50/gal, \$0.07/kWh	\$5,000	\$40,000	Return, 25 yrs @\$.15/kWh \$7,000
Fuel cost over 25 yrs \$10.00/gal, \$0.20/kWh	<u>\$5,000</u>	<u>\$115,000</u>	Return, 25 yrs @\$.30/kWh <u>\$14,000</u>
Fuel cost/ month	\$15	\$385	
Annual cost	\$180	\$4,600	
CO ₂ / 25 years	trace	320 tons	trace

Assumptions average next 25yrs : 40kWh/gal, \$10.00/gal, \$0.20/kWh, 28#s CO₂/gal, .5#s CO₂/kWh

* Current installed cost and performance in CA for PV

25 million cars in California

25 miles a day for 25 years

Oil-combustion

At \$115,000/car X 25 M cars
= \$2,875 billion for fuel
+ CA share of oil wars
\$10 B/yr = \$250 billion
Cars not included

= \$3,125 billion total

+ 8 billion tons of CO₂

Solar-electric

At \$5,000/car X 25 M cars
= \$125 billion total
+ \$100,000 for everyone in
California to spend on
electric cars or whatever

= \$3,125 billion total

+ NO CO₂

Efficient Vehicle Solutions Exist



280 mpg tandem by VW 2000



120 miles in one hour on one charge '93



9000 miles per gallon, built by students '05

Commuter Vehicles Designed for Efficiency



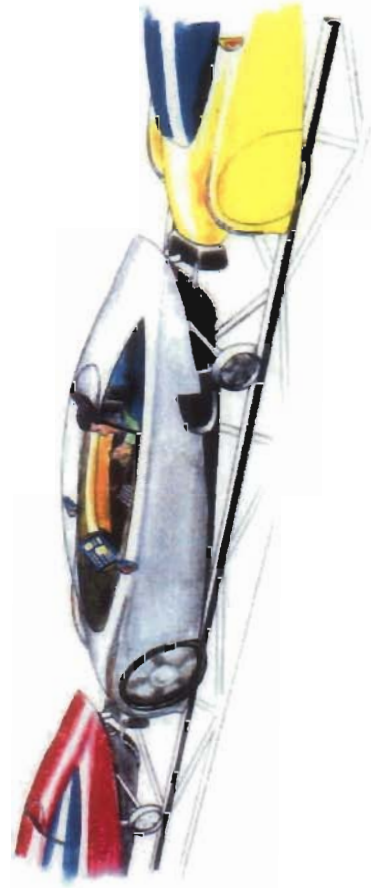
SPORT PEDAL ELECTRIC



RAIL/ROAD PEDAL ELECTRIC

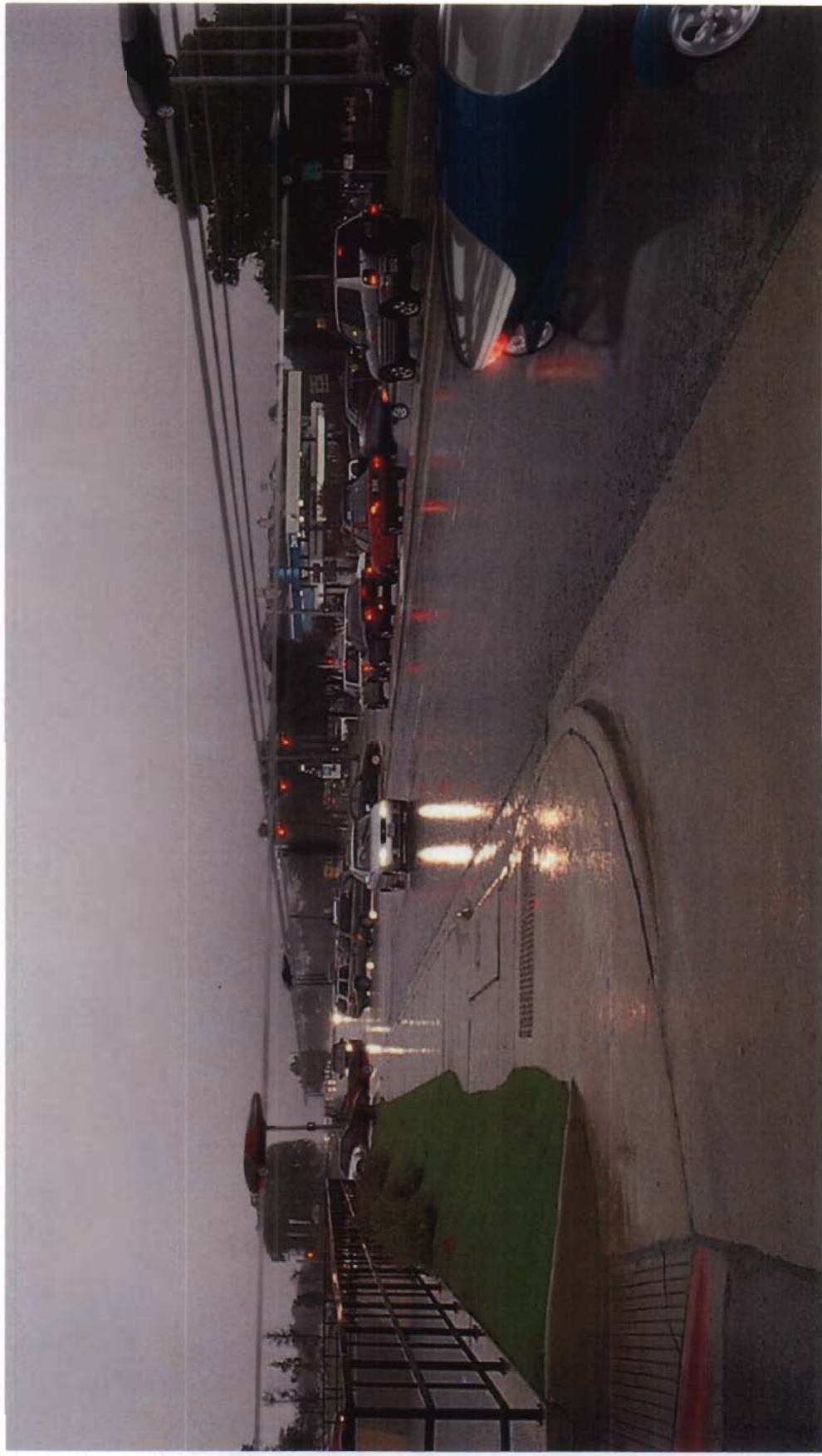


TANDEM 3-WHEELER



OPTIONS

Imagine efficient electric vehicles that could be charge from renewable sources and drive onto a raised rail and safely travel at 180 mph with fuel efficiency equivalent to 280 mpg



Electric bikes with 20 mile range at 25 mph



Solar powered charging trailer



16 bike solar powered charging trailer



Trailer with surfboard rack



Recumbent with 35 mile range

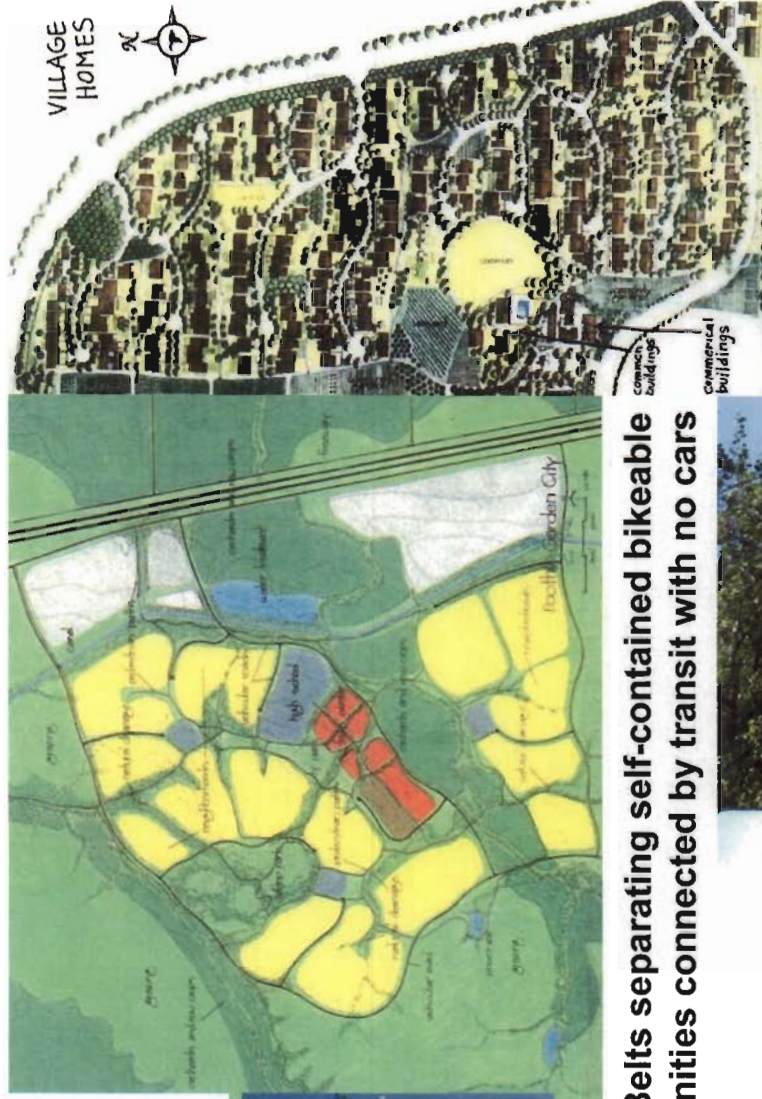
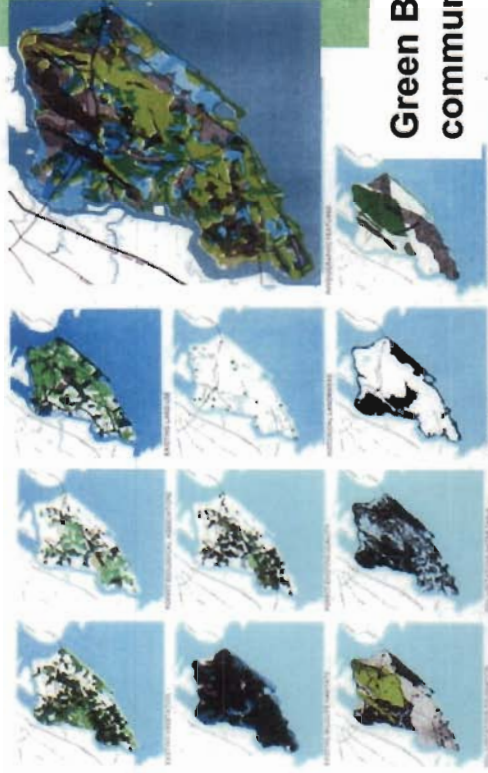
Muscle Power for Health and Mobility



Good planning can minimize the need for cars and pavement

Design with Nature

by Ian McHarg



Green Belts separating self-contained bikeable communities connected by transit with no cars



Bike trail through a greenbelt in Germany



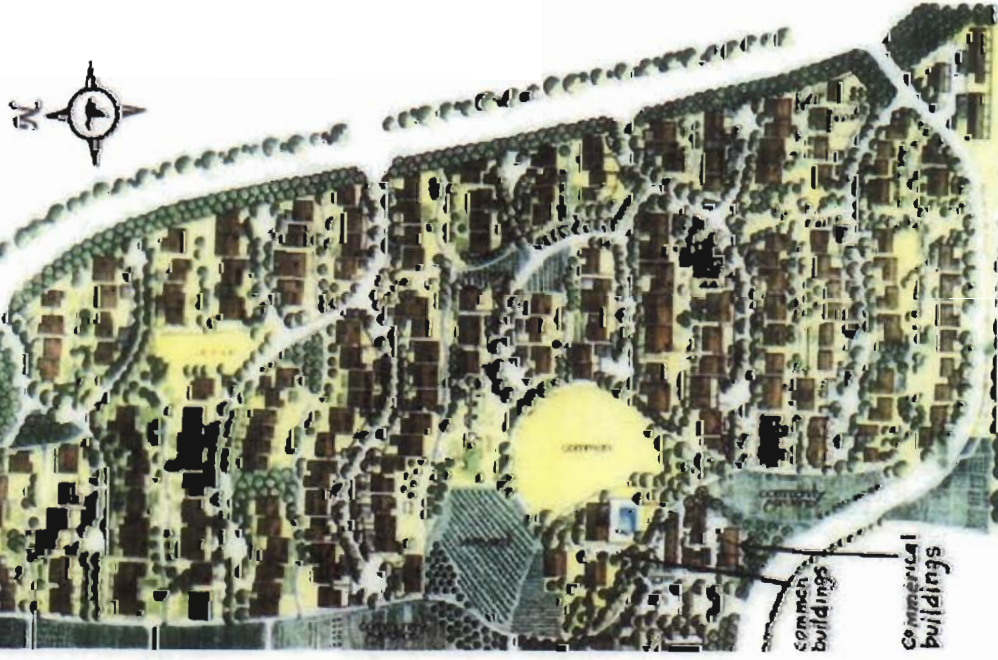
No cars in Venice



Bike trail through an orchard in Village Homes

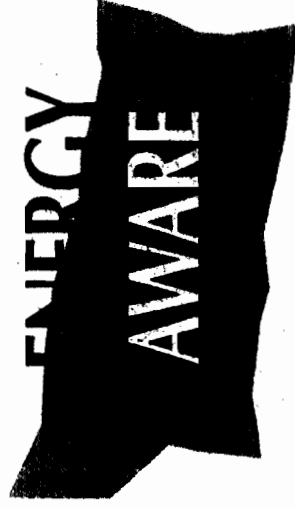
Village Homes built in the 1970s in Davis, California, is still the standard by which other sustainable neighborhood developments can be measured

What makes **Village Homes** a success



- **Density:** 200 homes and 30 rental units on about 40 acres, leaving 30 acres for Gardens, orchards and common areas, including a community center.
- **Southern Orientation:** Allows full access to solar radiation.
- **Narrow Roads:** Less pavement leaves more land available for other uses and slows down traffic.
- **Bike and Pedestrian Paths:** Makes it more convenient to use our legs and discourages the use of motor vehicles.
- **Natural Drainage:** Allows groundwater recharge
- **Common Areas:** Allows space for gardens, orchards, playing fields,, shops, offices and neighborhood and community gathering places.

Energy Aware Published by the CEC in 1994



Planning strategies:

1. Mixed use development
2. Density near transit
3. Rail 10 X more efficient
4. Street trees
5. Pedestrian facilities
6. Bicycle facilities
7. Telecommuting
8. Fleet efficiency

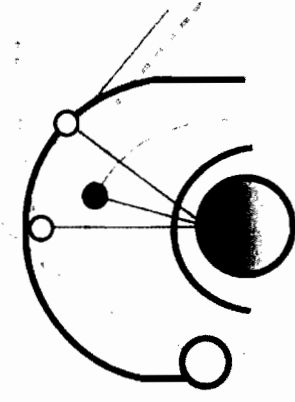
PLANNING GUIDE



P700-93-001

Planning for Community Energy, Economic and Environmental Sustainability, 1996

THE ENERGY YARDSTICK:



Using **PLACE³S**
to Create More
Sustainable Communities

PRODUCED FOR:

Center of Excellence for Sustainable Development
Office of Energy Efficiency and Renewable Energy
U.S. Department of Energy

Program Partners:

Oregon Department
of Energy

Washington State
Energy Office

California Energy
Commission



Using energy as a yardstick
to measure and compare
the efficiency of
development options
makes Informed decisions
possible.

Recent developments in
GPS and GIS makes this
strategy an inexpensive
planning tool.

We have the tools to move
beyond zero energy homes
to zero energy communities

Emission Reduction Strategies

Muscle Power

- Walk or bike incentives
- Work at home incentives
- Walk, bike and neighborhood vehicle priority community planning
- Require pedestrian and bike access to school and services as prerequisite for new development
- Require all new development to install onsite clean renewable power generation capable of achieving a net zero annual energy balance (smart growth)
- Job-school-service-home proximity database

Emission Reduction Strategies

PV, EV and PHEV

- Only allow the sale of equipment and vehicles that have emissions within 10% of the best in class.
- Increase EV and plug-in hybrid availability
- Free charging stations
- Solar charging parking shelters
- Lower off-peak charging rates
- Vehicle to Grid (V2G) smart charge/discharge meters
- Require high power (220volt, 50amp) charging ports in all new developments
- Allow low speed (25 mph) vehicles on all city and county roads

Emission Reduction Strategies

Transit and Rideshare

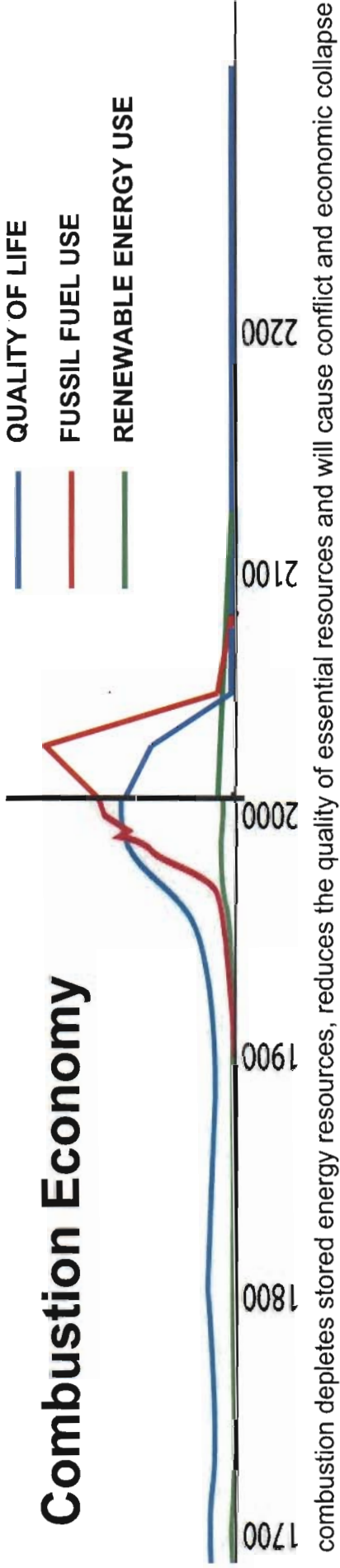
- Transit oriented development (density around light rail route)
- Increase transit ridership (grade separation high speed electric rail)
- Travel choice emissions calculator
- Combine or eliminate trips
- Car-free town centers with electric shuttles
- Clean fuel vehicle rebates
- Community shuttles
- Clean fuel school and transit bus incentives
- Reduce shopping and recreational trips
- Carpool incentives
- Clean vehicle and equipment-share programs
- Bike and zero emission city car rentals or free use.
- E-mail or dial-a-ride (community rideshare switchboard).

Emission Reduction Strategies

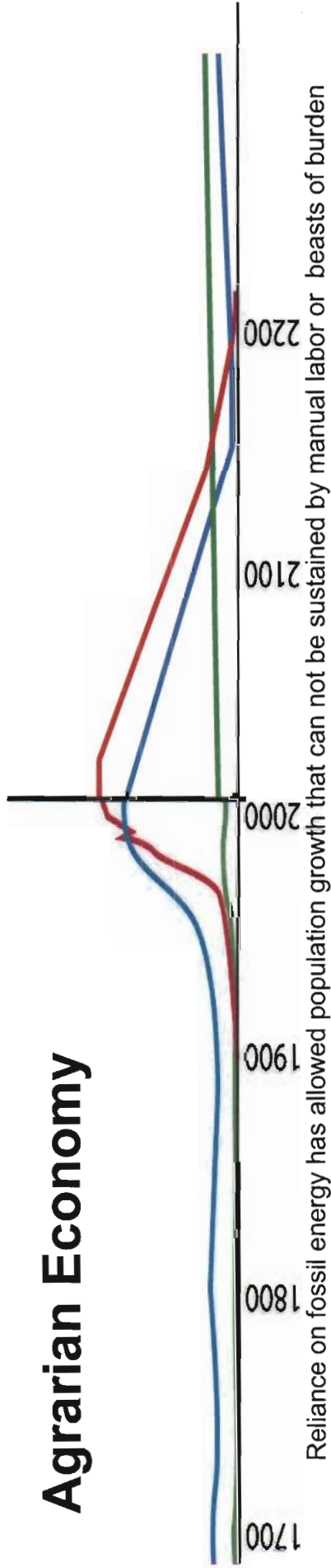
Cost and Standards and Enforcement

- Stop inter-regional (long distance) commuting
- Pay-as-you-drive insurance
- Stronger vehicle standards (increase fuel efficiency standard to within 10% of best in class)
- Accelerate fleet turnover (all cars that don't meet 15 year old emissions standards- off the road)
- Enforce speed limits (no combustion car drives over 55 mph except in car pool lane)
- Increase price of gas (higher fuel tax)
- Carbon quotas (fuel allotment)
- Road tolls

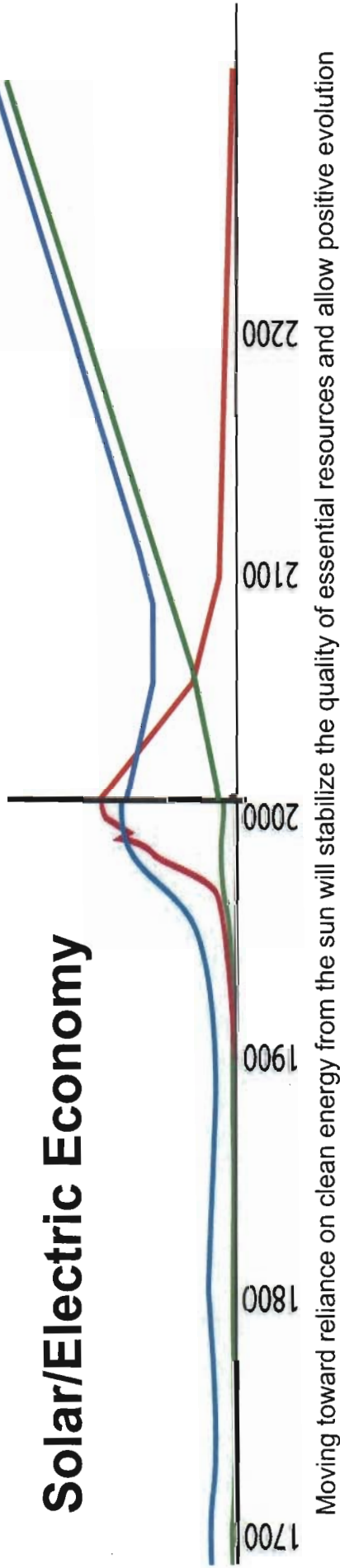
Combustion Economy

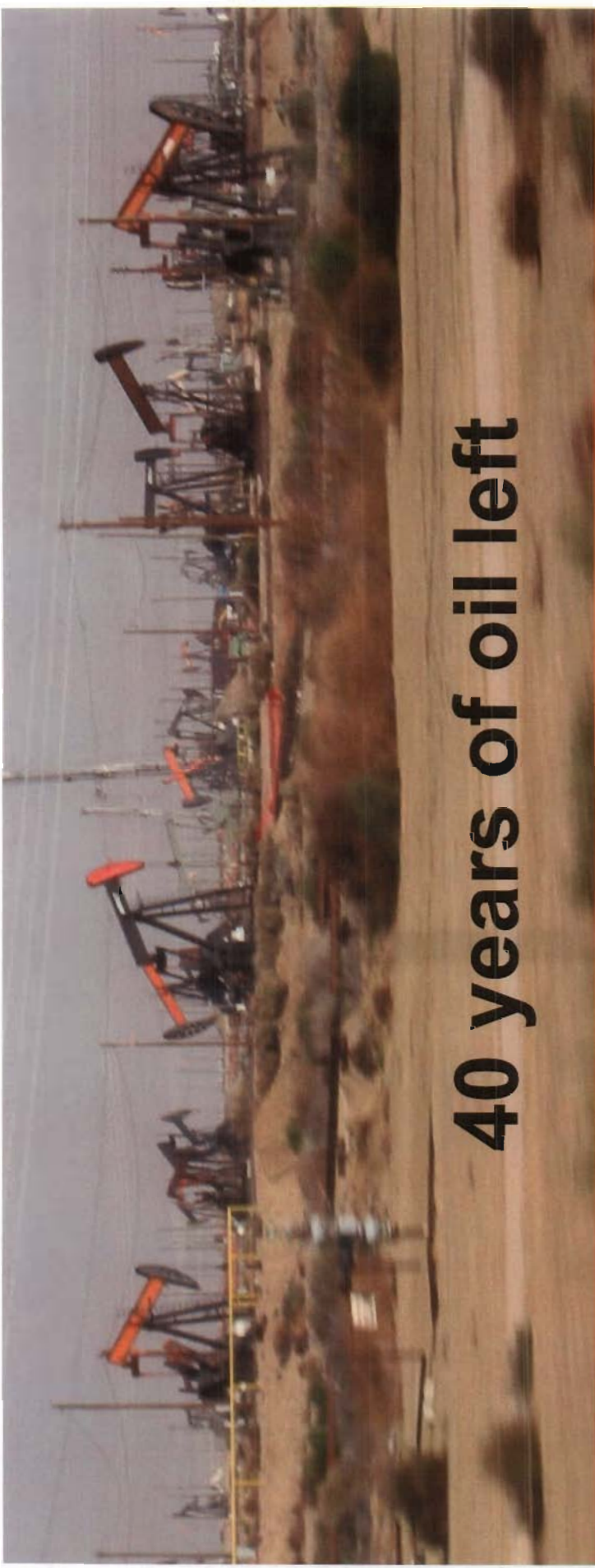


Agrarian Economy



Solar/Electric Economy





40 years of oil left

5,500,000,000 years of sunshine left

Choose Wisely