Testimony before:
California Air Resources Board on Early Action Measures to Reduce Greenhouse Gas Emissions

Los Angeles Airport Marriott

6 - 21-22 - '07

Steve Heckeroth
Mendocino County Energy Working Group
Chair Renewable Fuels and Sustainable Transportation Division
of the American Solar Energy Society

Global Energy Potential

Renewables Forever (5.5 billion years)	terawatt hours/YEAR
Direct Solar Radiation	**350,000,000**
Wind	200,000
Ocean Thermal	100,000
Biofuel	50,000
Hydroelectric	30,000
Geothermal	10,000
Tidal/Wave	5,000

Energy Stored in the Earth (Use it once and it's gone)	terawatt hours TOTAL
Coal	6,000,000
Natural Gas **(US Peak 2005)**	1,500,000
Uranium 235 **(US Peak 2008)**	1,500,000
Petroleum **(US Peak 1970, World Peak <2010)**	1,000,000
Tar Sands	800,000

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

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Advantages of Solar Energy

Fossil Fuel Dependence

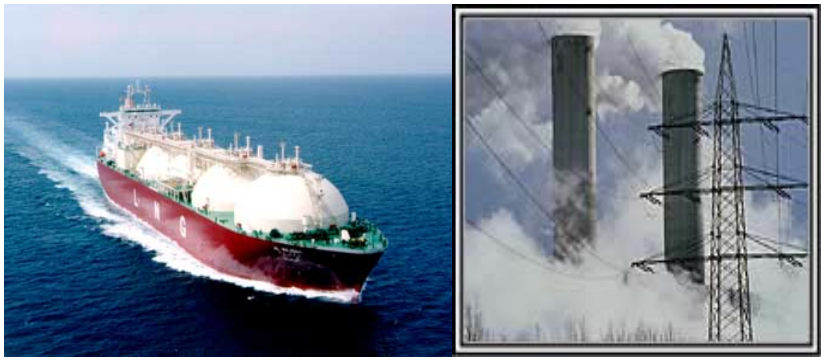
- **Finite fuel supply**
- **Ugly infrastructure**
- **Polluted air / Climate change**
- **Extraction site devastation**
- **Polluted land**
- **Spills and polluted water**
- **Energy resource wars**
- **Susceptible to terrorism**

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**

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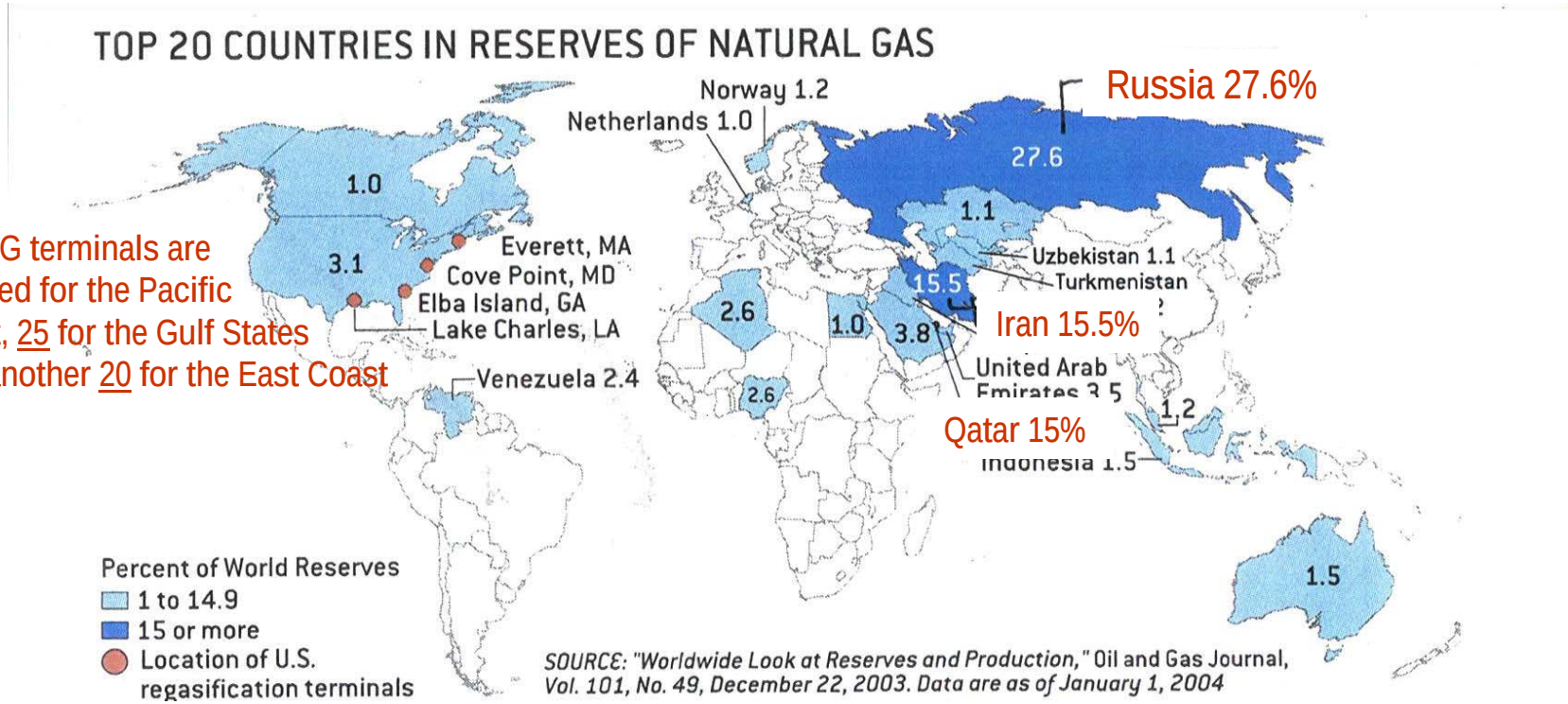
Who Has Natural Gas



15 LNG terminals are planned for the Pacific Coast, 25 for the Gulf States And another 20 for the East Coast

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

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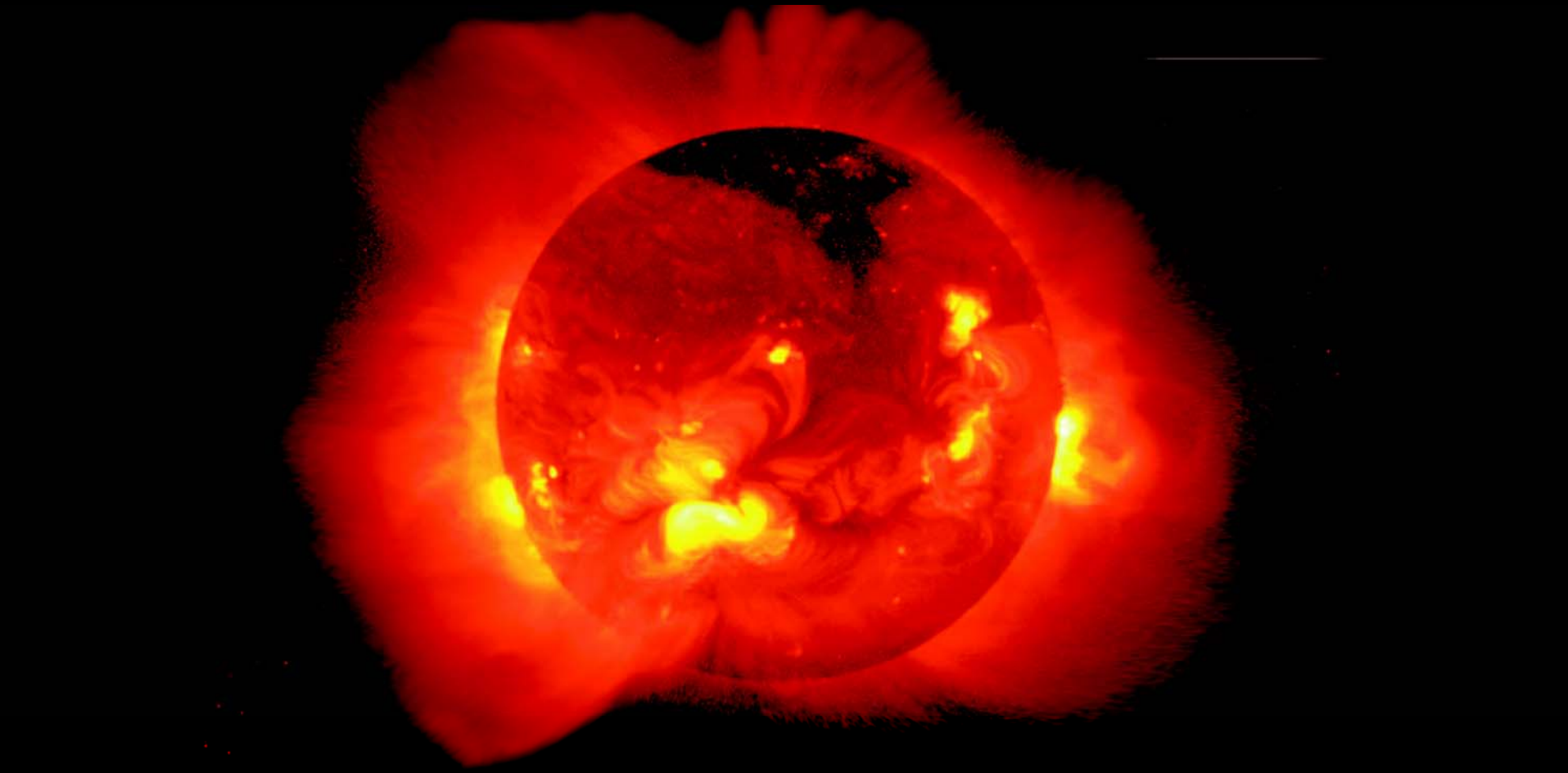
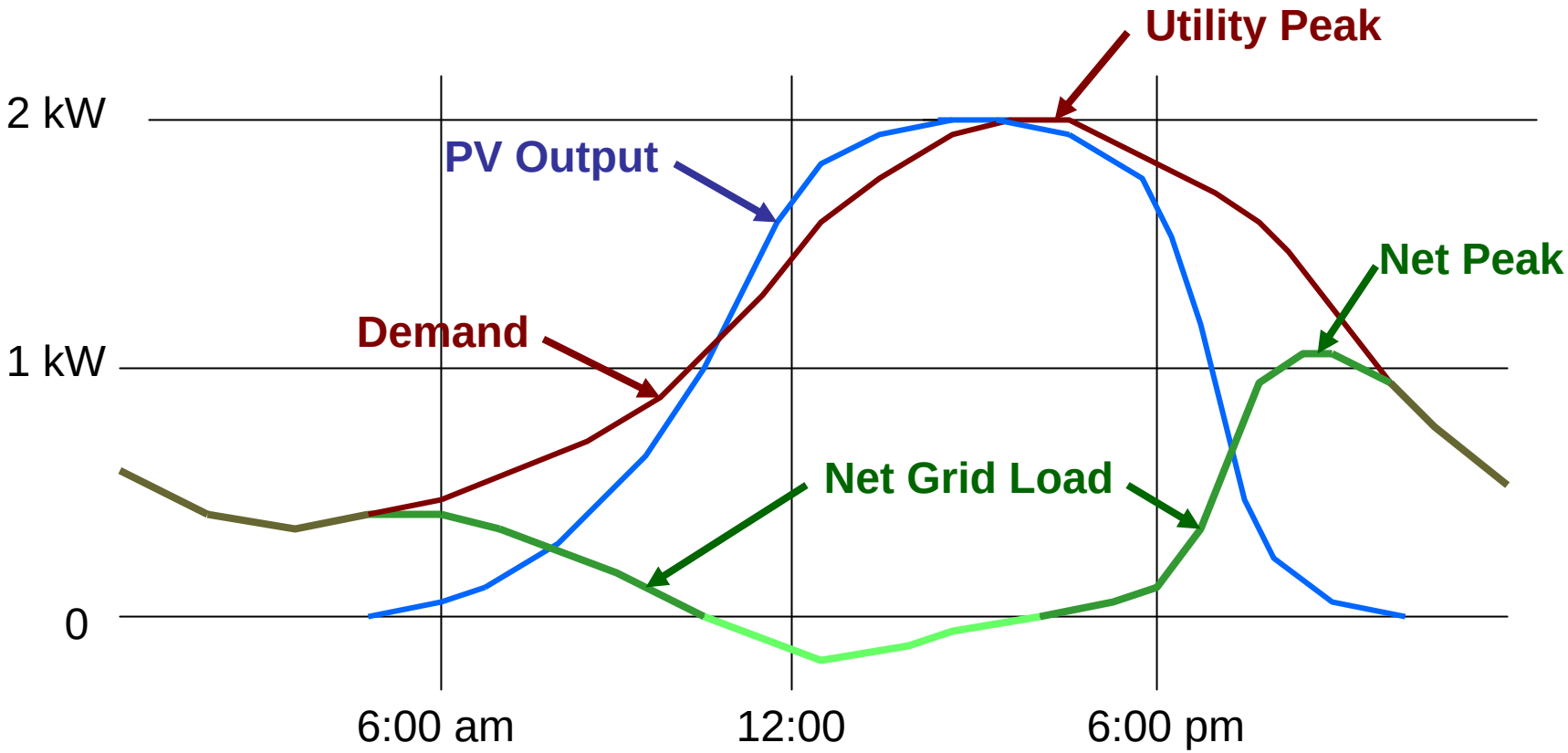
The Best Place for a Nuclear Reactor is 93,000,000 Miles Away



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.

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Advantages of True BIPV

Building Applied PV

Modules installed on racks

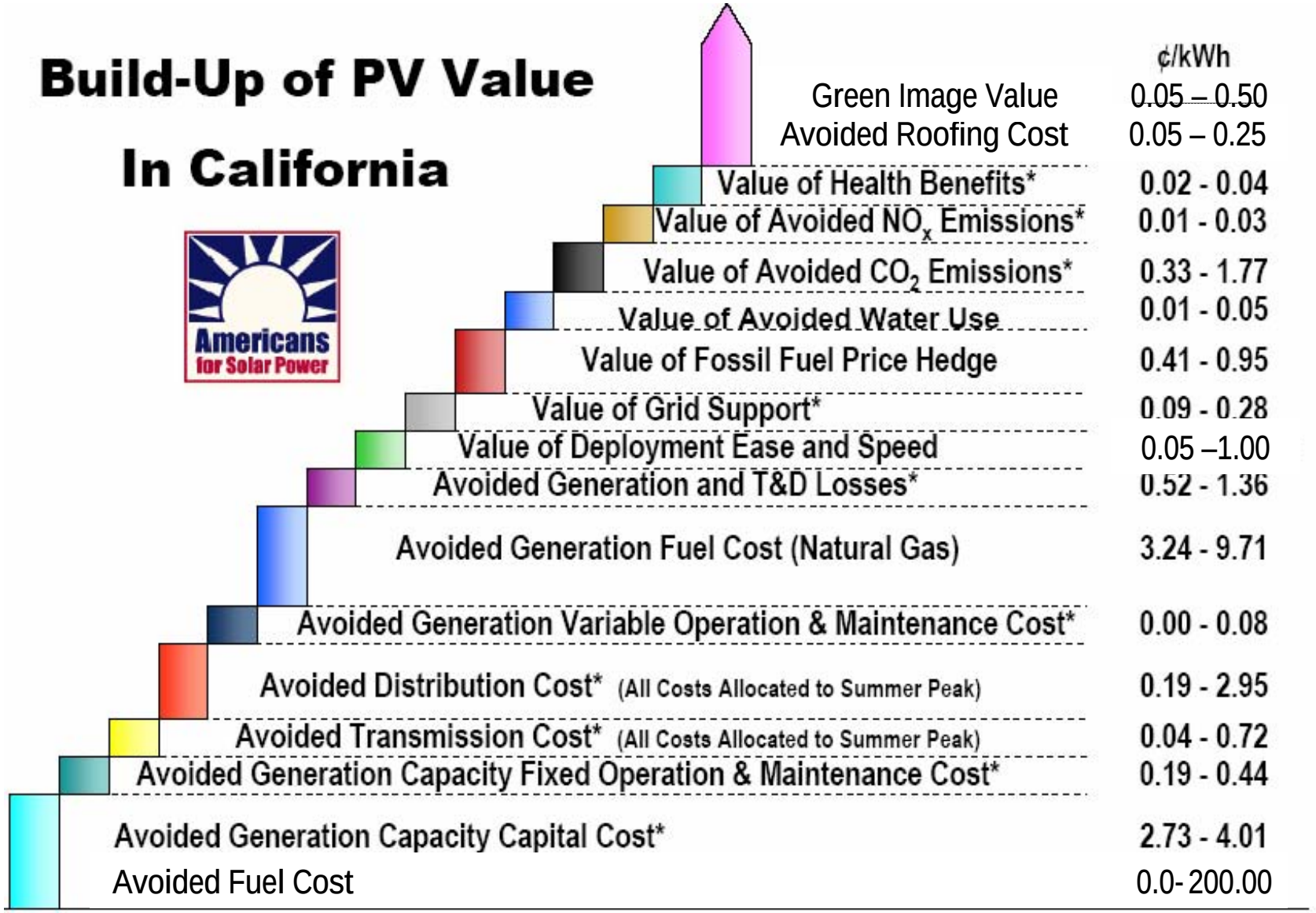
- Theft or breakage
- Racks are expensive
- Must be removed to replace roofing
- Roof penetrations required
- Detract from building's appearance
- Modules add excess weight to roof
- Electrical cables & conduit are exposed

Building Integrated PV

BIPV roofing

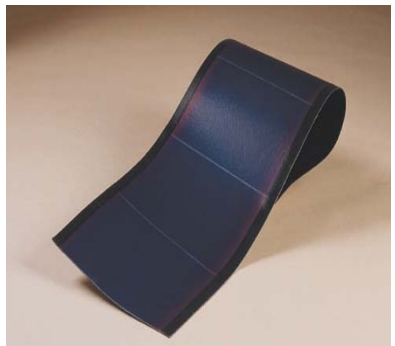
- Vandal resistant
- Avoids the expense of racks
- Synchronized roof and PV installation
- No roof penetrations
- Aesthetically superior
- Lightweight
- Electrical cables are hidden and protected

Added Value from BIPV



TOTAL ADDED VALUE of BIPV: $.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$s/MWh**

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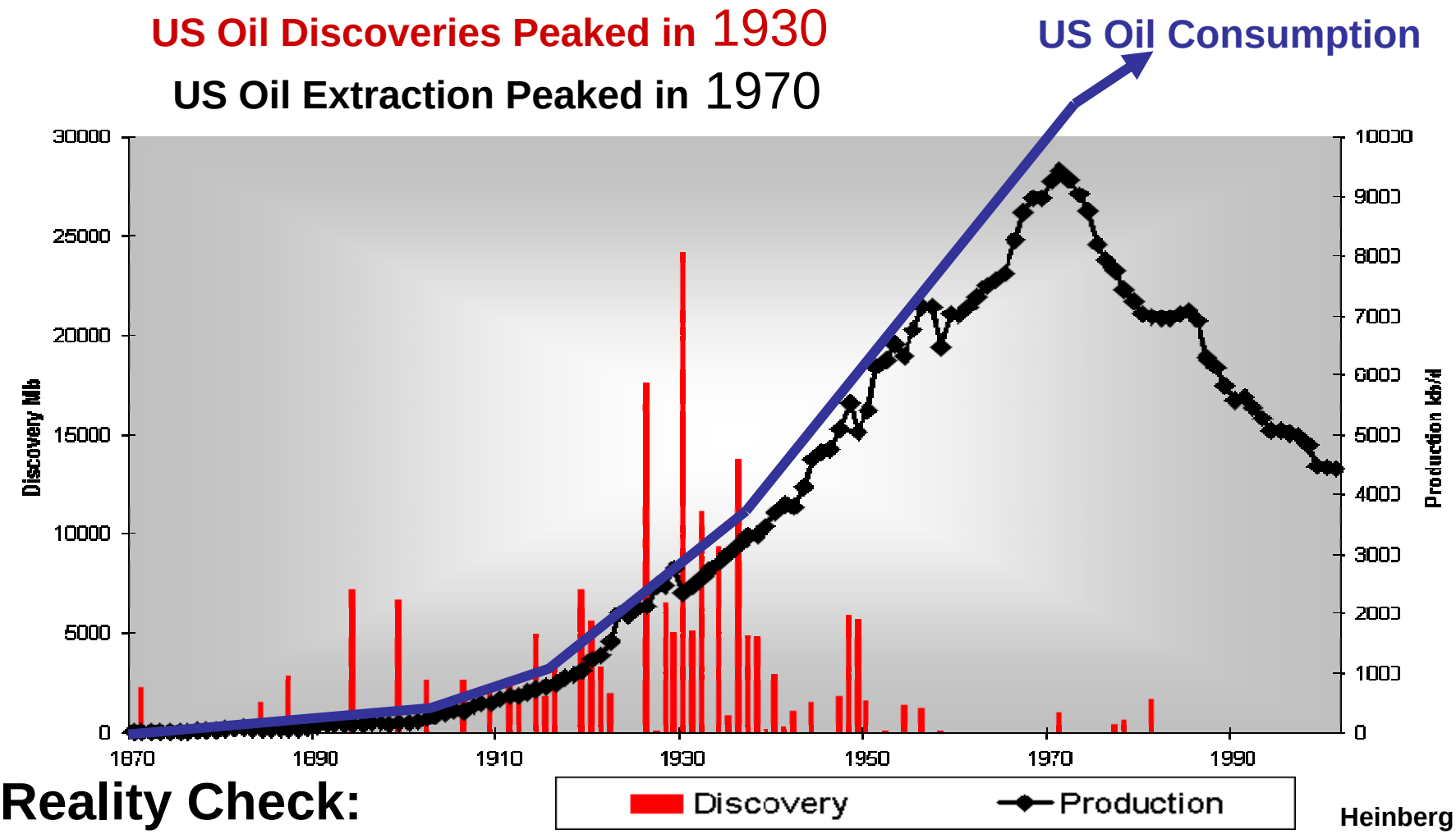
“ America is Addicted to Oil”



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.**

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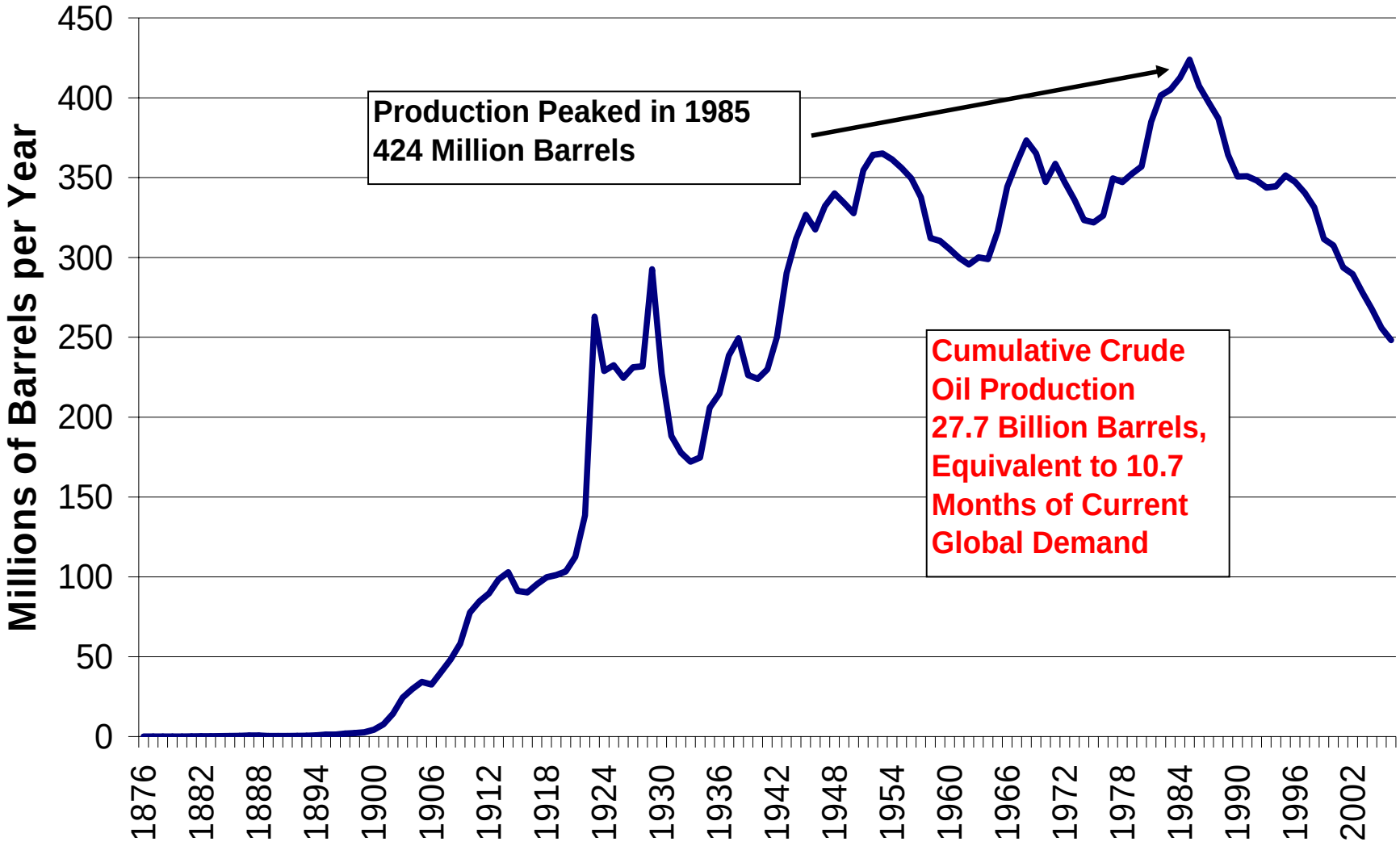
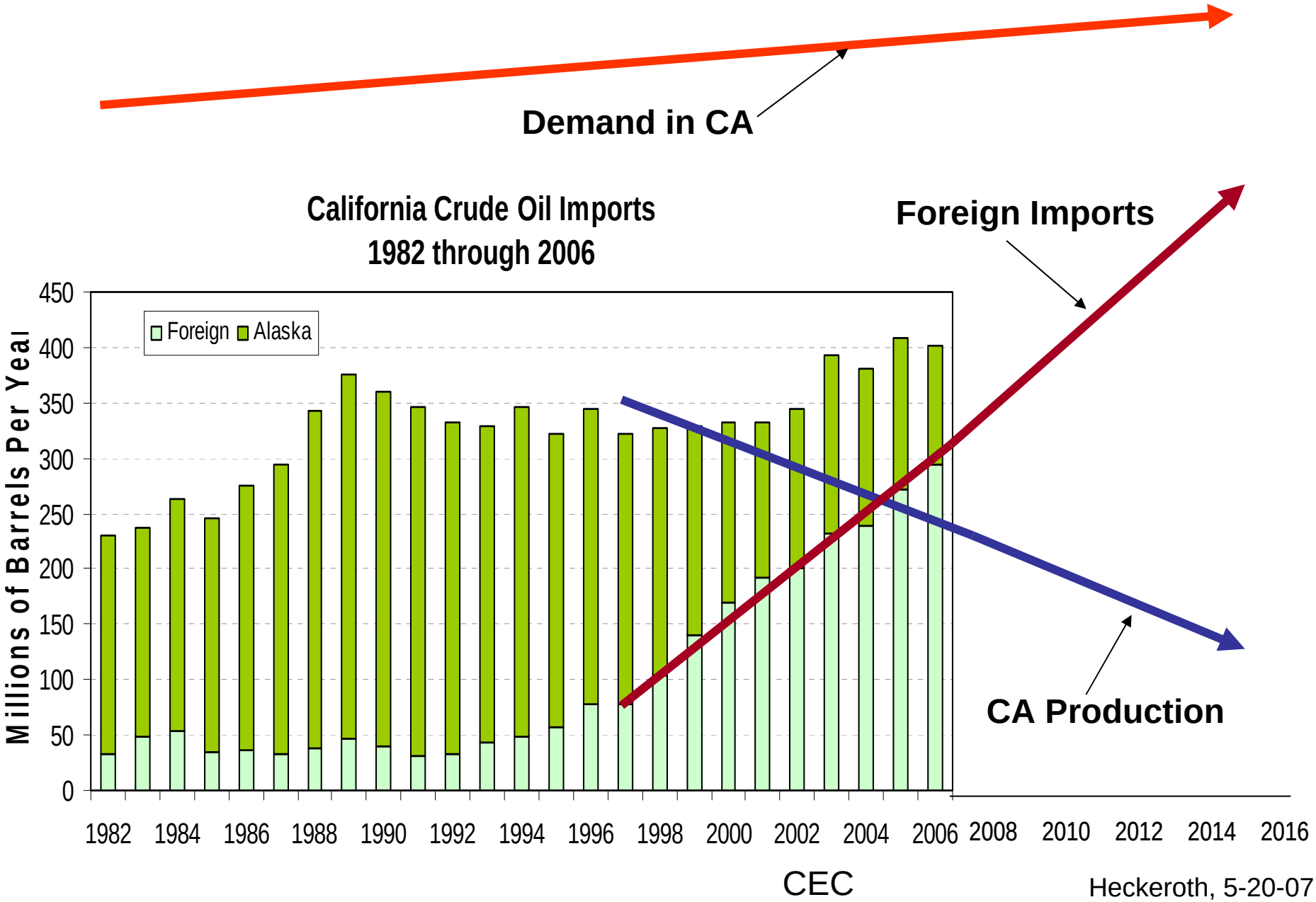
California Oil Production
1876 to 2006



CEC

80% Imported Oil in California by 2015



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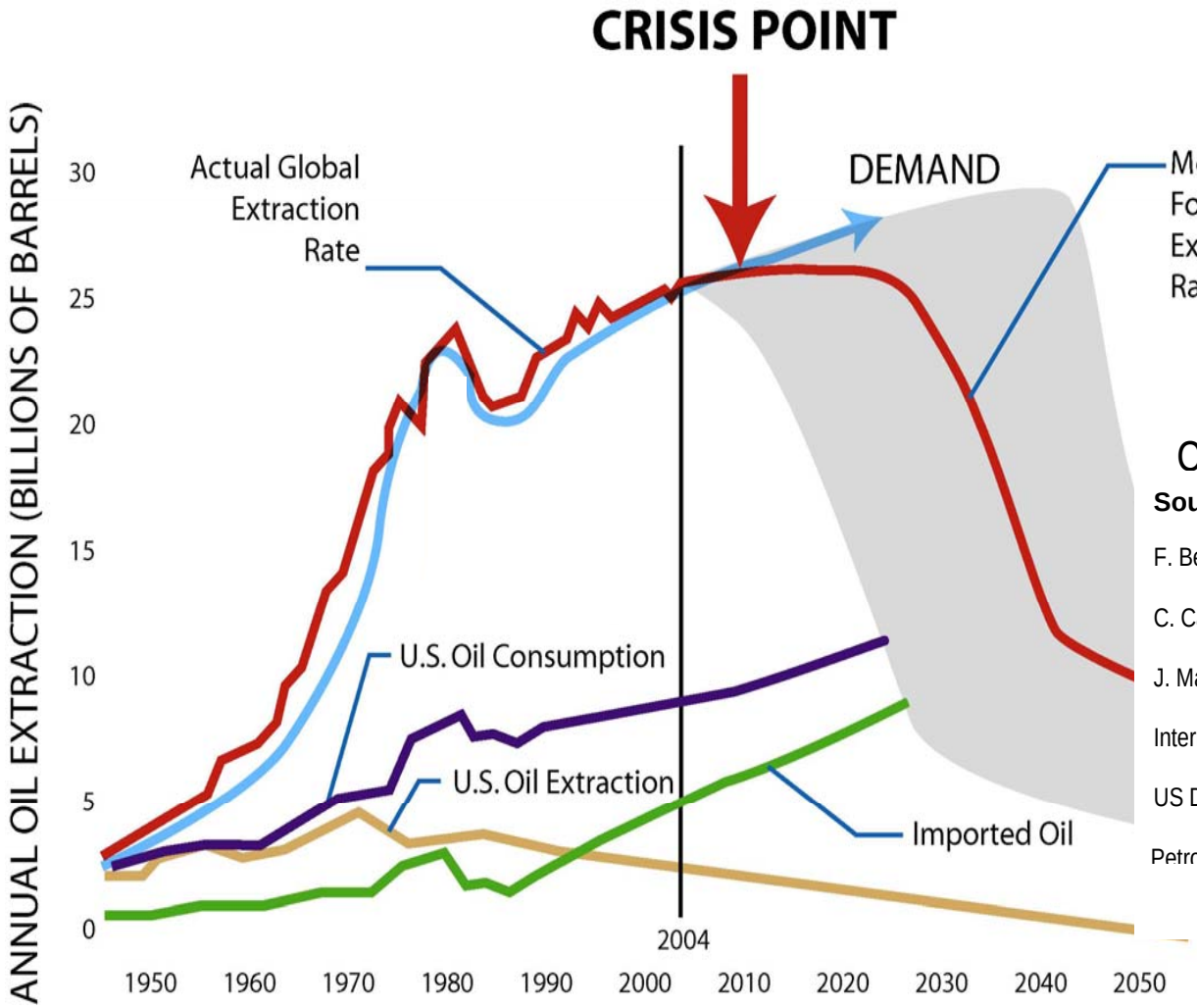
World Peak Oil



Gray Area Shows the Range of Forecast Peak Conventional Oil Reserves

Source	Peak Date
F. Bernabe, ENI SpA	2005
C. Campbell, Petroconsultants	2005-2010
J. Mackenzie, WRI	2007-2014
International Energy Agency	2010-2020
US DOE	< 2020
Petroleum Industry	2020-2040

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.

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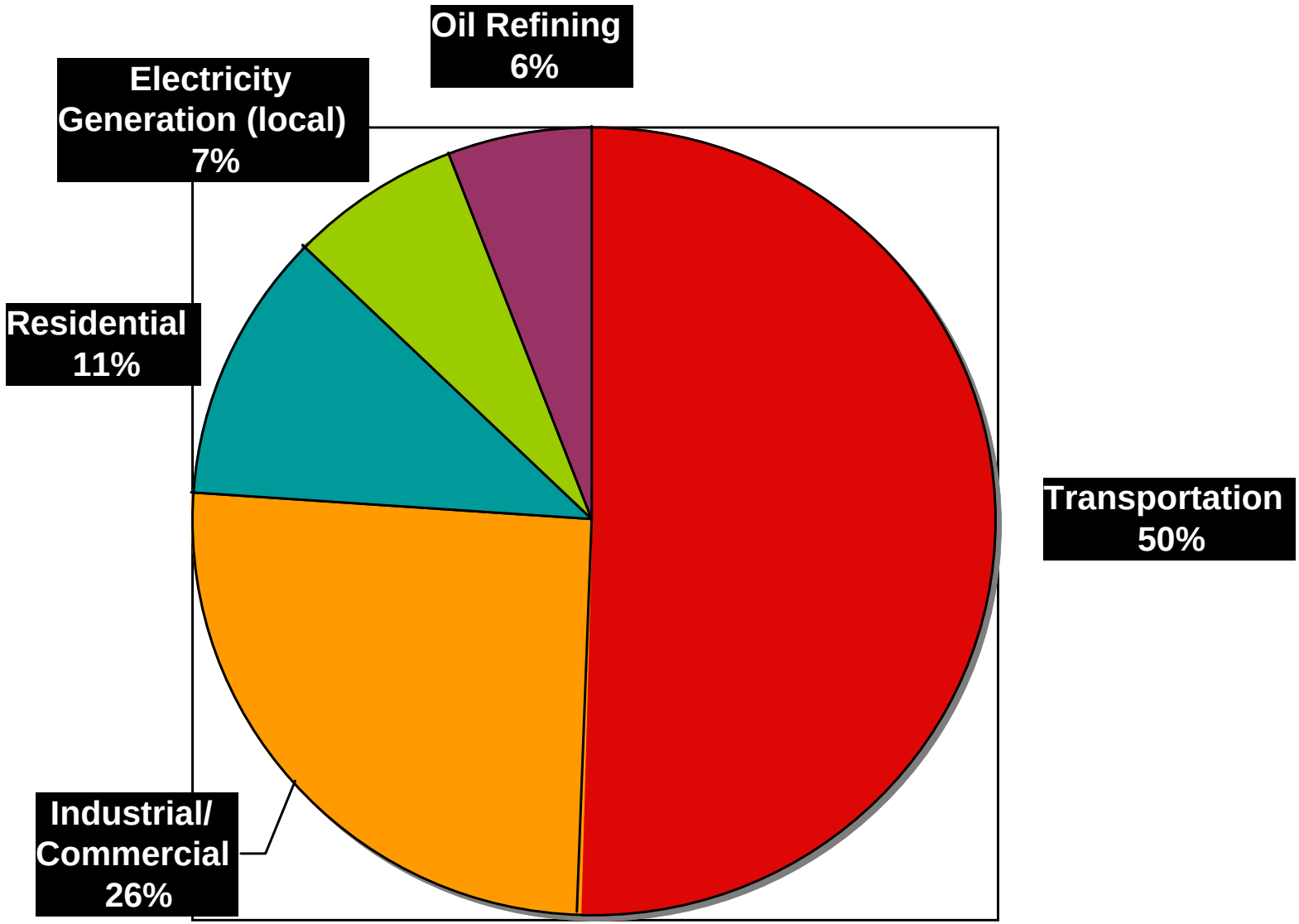
Bay Area CO2 Emissions



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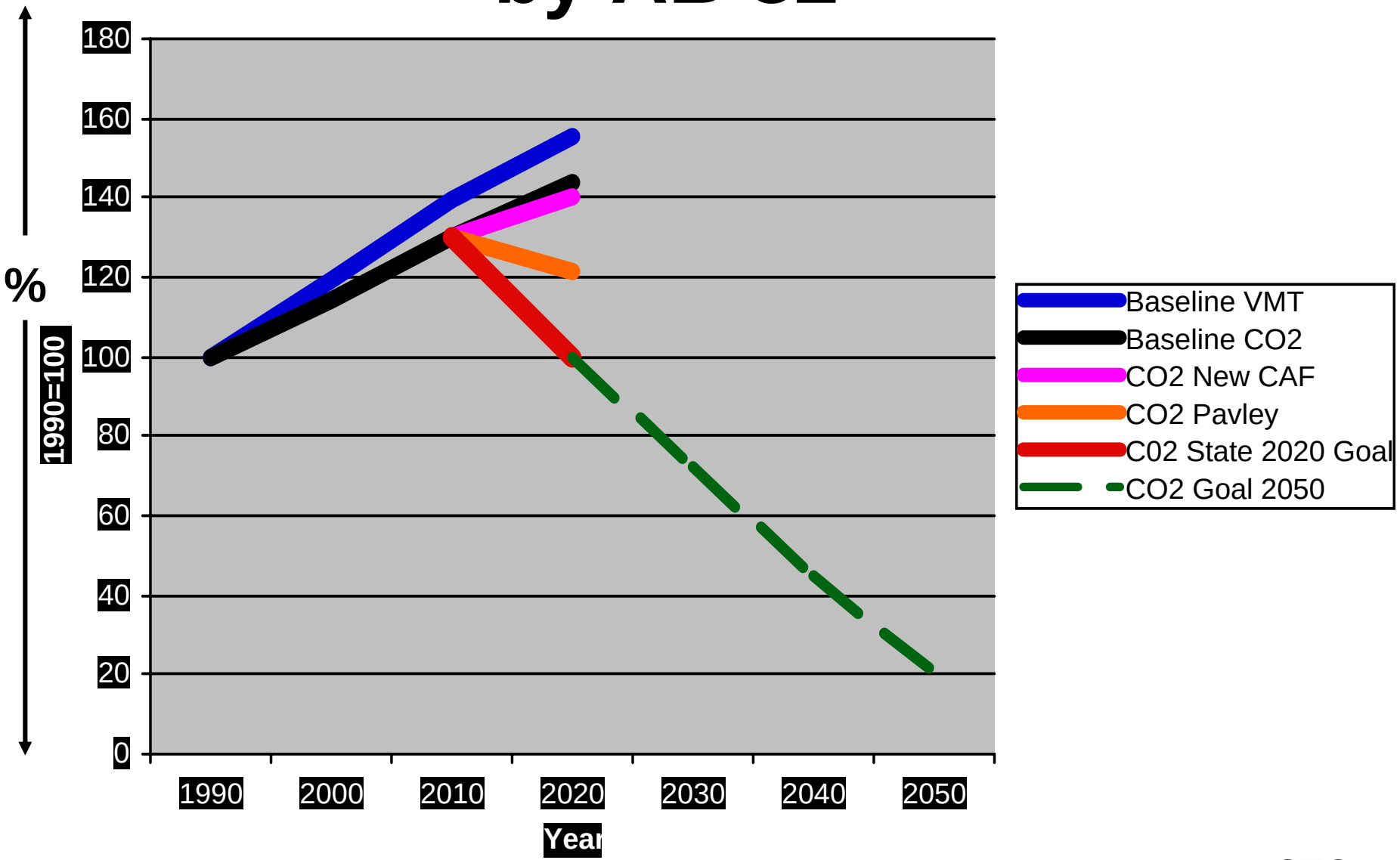
Emissions Reductions Mandated by AB 32



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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

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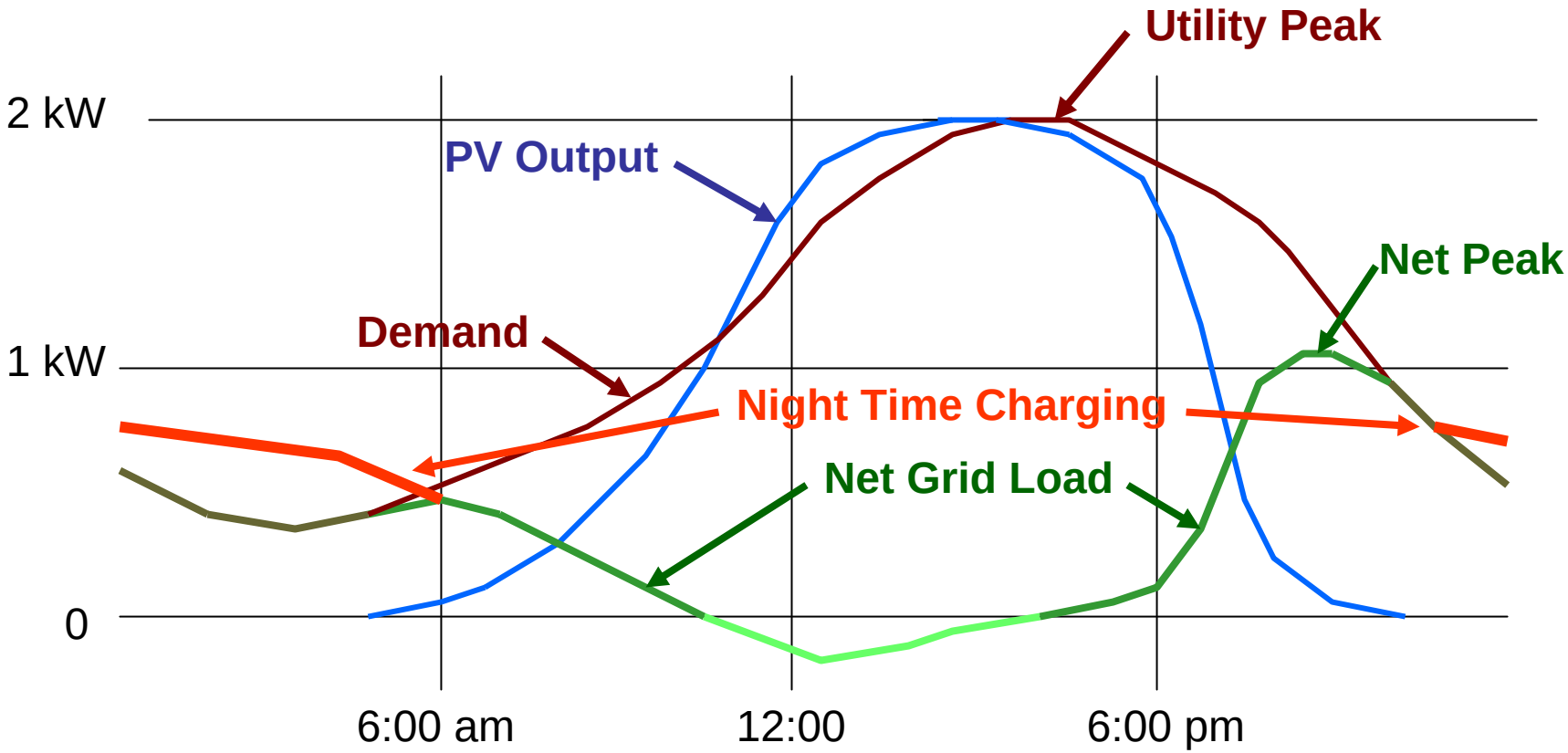
Graph of Net Grid Load on Home with a 2 kW West Facing BIPV System, a 2 kW Peak Summer Load and an EV Charged at Night



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

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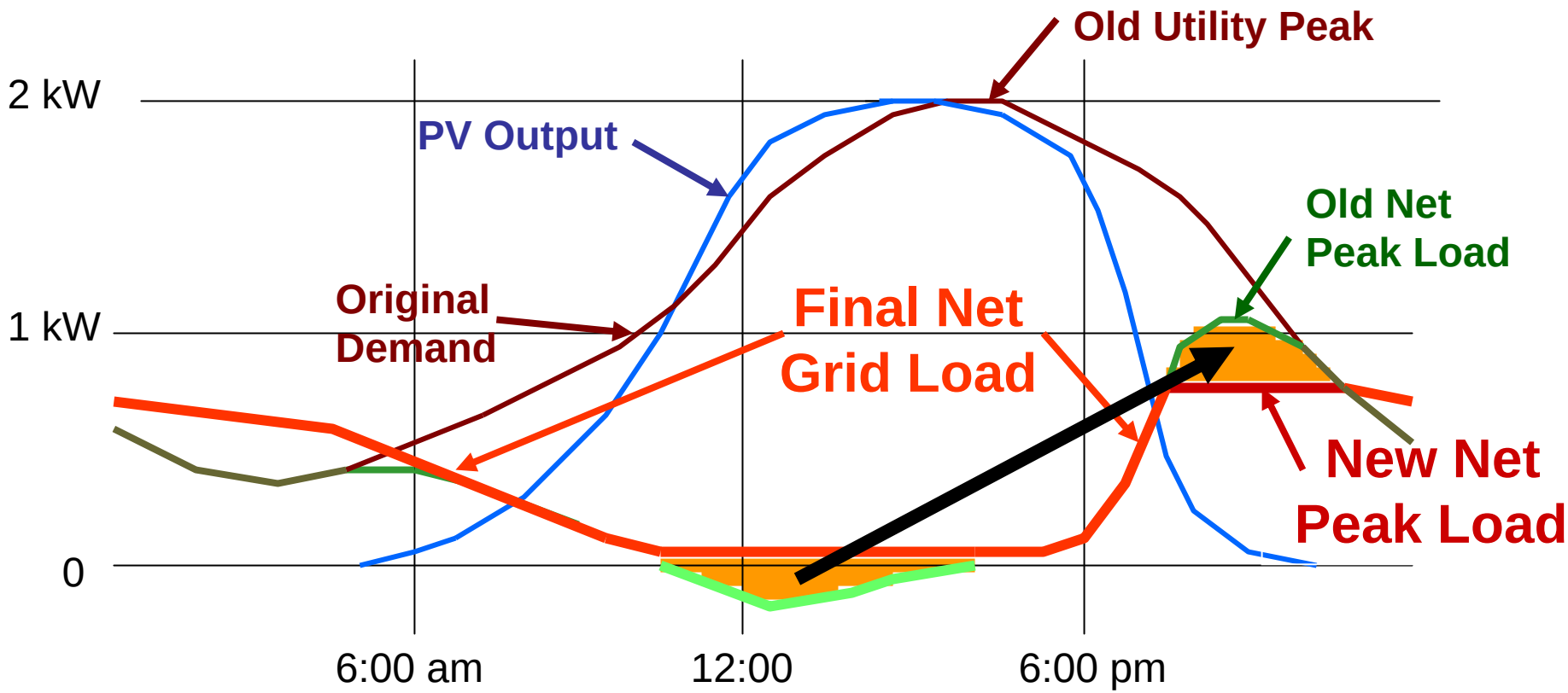
Time for an Alliance Between Utilities, PV and Transportation

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

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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.

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 CO_2 emissions for exploration, extraction, transport, refining and distribution of gasoline, as well as CO_2 emissions from the California mix of power plants that produce electricity to charge electric vehicles.

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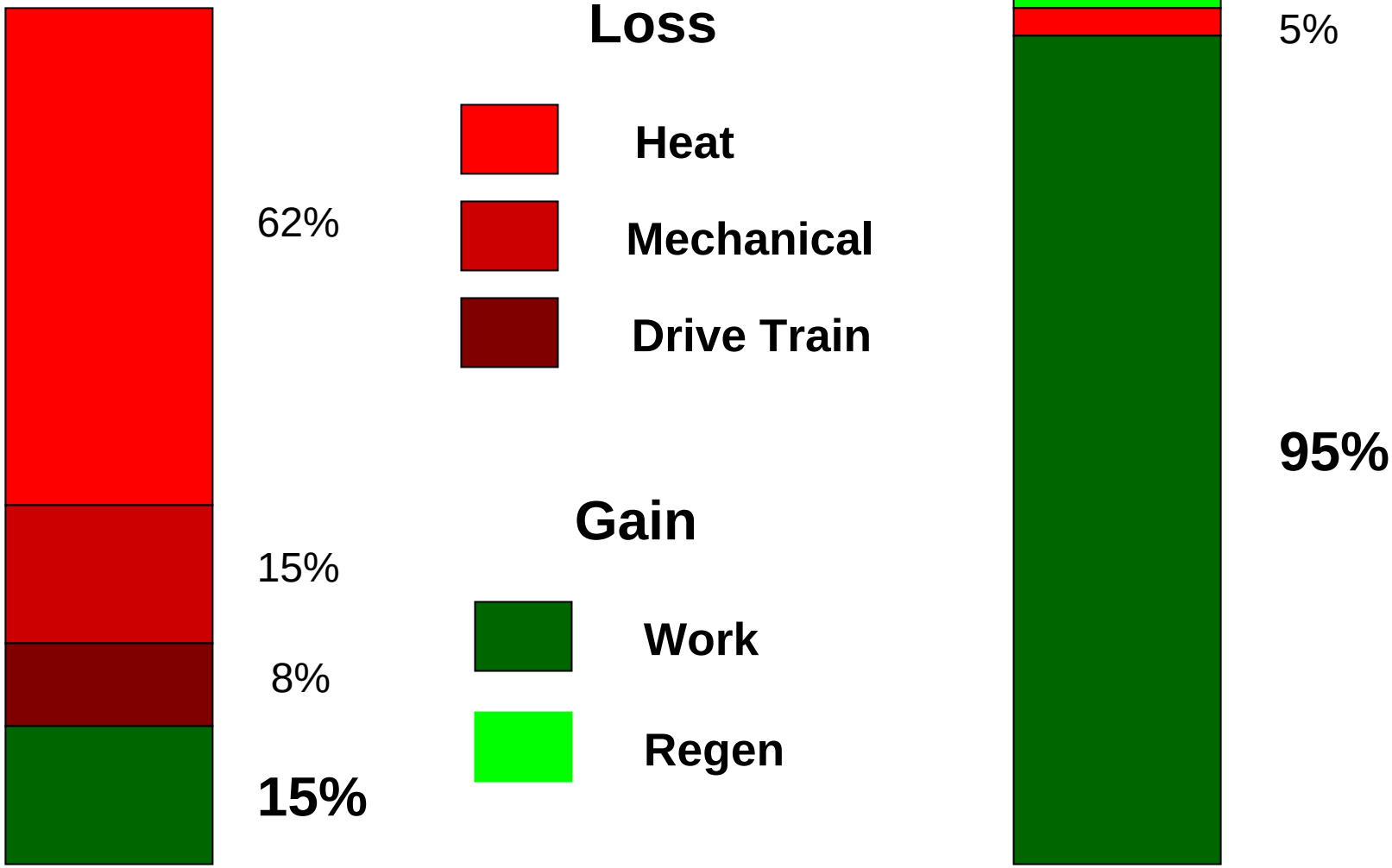
Drive Train Efficiency



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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.

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The Cost of Combustion

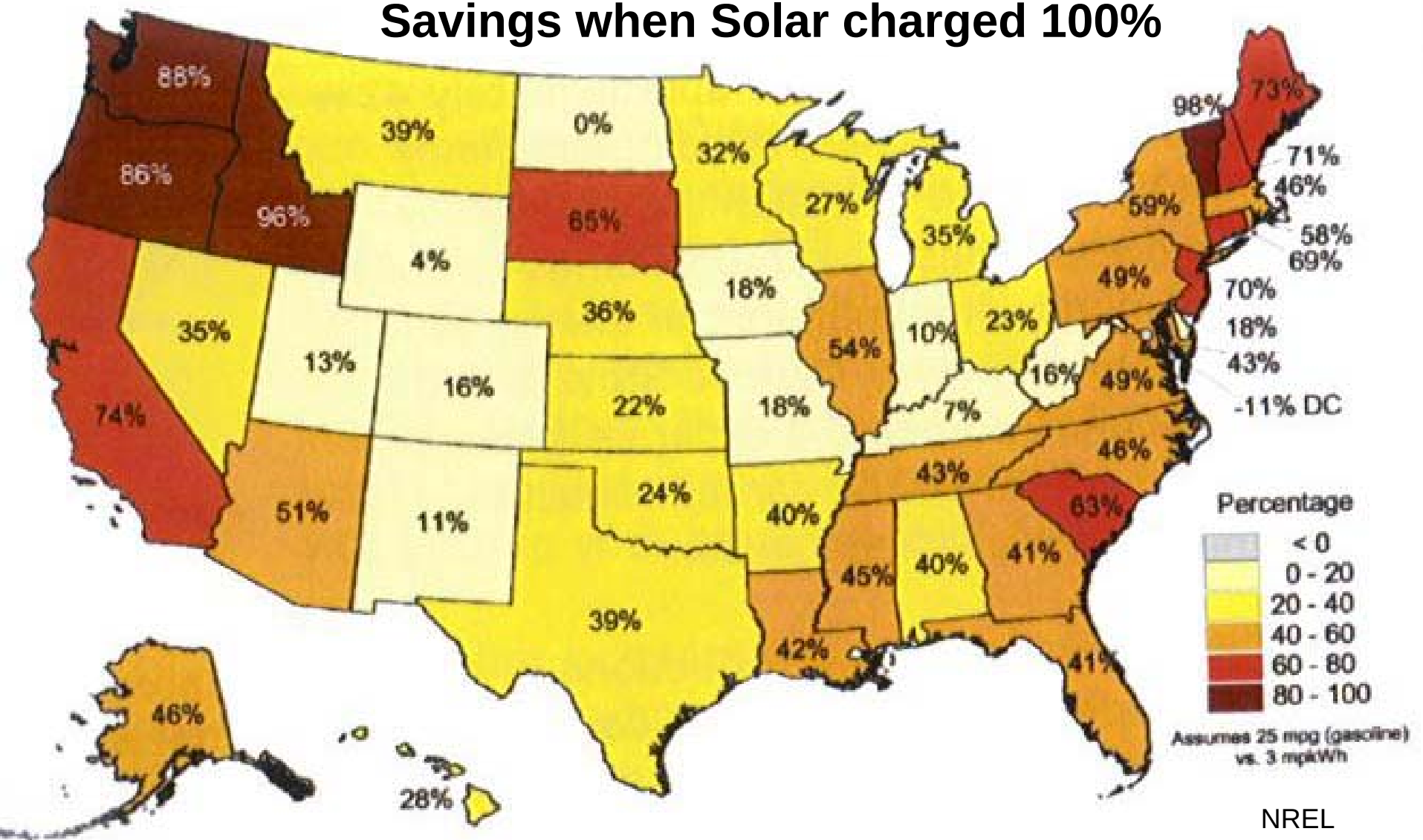
Vehicle Type	 20 MPG Gas	 PHEV/25/grid	 EV/1kW PV *
Liquid fuel used 25 mi/day / 25 yrs	**11,500 gals**	**ZERO**	**ZERO**
Energy used 25 yrs	**460 MWh**	**70 MWh**	**45 MWh**
Fuel cost now / 25 yrs $3.50/gal, $0.07/kWh	**$40,000**	**$5,000**	**$5,000**
Fuel cost over 25 yrs $10.00/gal, $0.20/kWh	**$115,000**	**$14,000**	**$5,000**
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 CO_2/gal, .5#s CO_2/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%



NREL

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	$7,000	Return, 25 yrs @$.15/kWh
Fuel cost over 25 yrs $10.00/gal, $0.20/kWh	$5,000	$115,000	$14,000	Return, 25 yrs @$.30/kWh
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 CO_2/gal, .5#s CO_2/kWh

***Current installed cost and performance in CA for PV**

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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 CO_2

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 CO_2

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**

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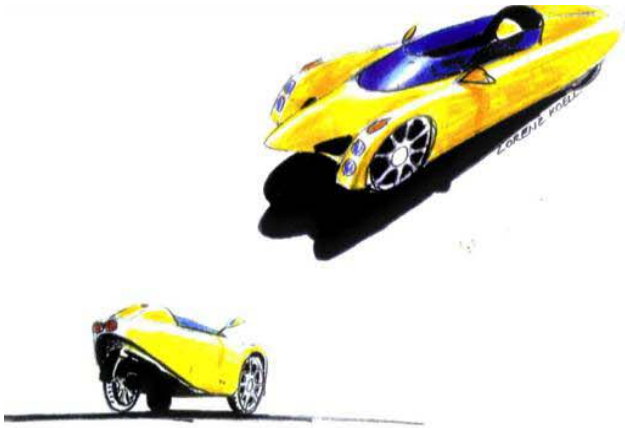
Efficient Vehicle Solutions Exist

280 mpg tandem by VW 2000

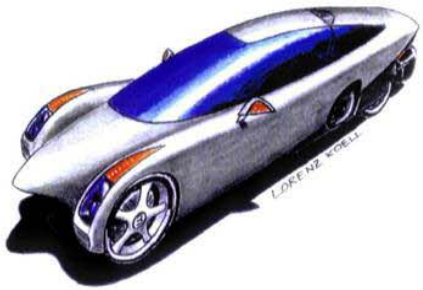
120 miles in one hour on one charge ‘93

9000 miles per gallon, built by students ‘05

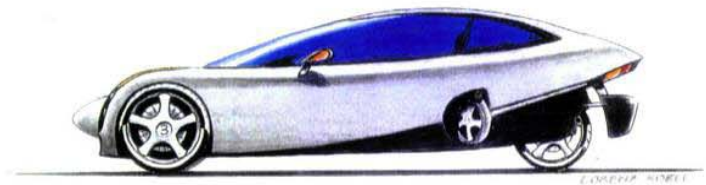
Commuter Vehicles Designed for Efficiency

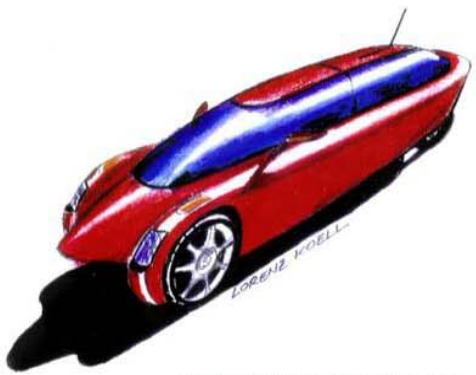


SPORT PEDAL ELECTRIC

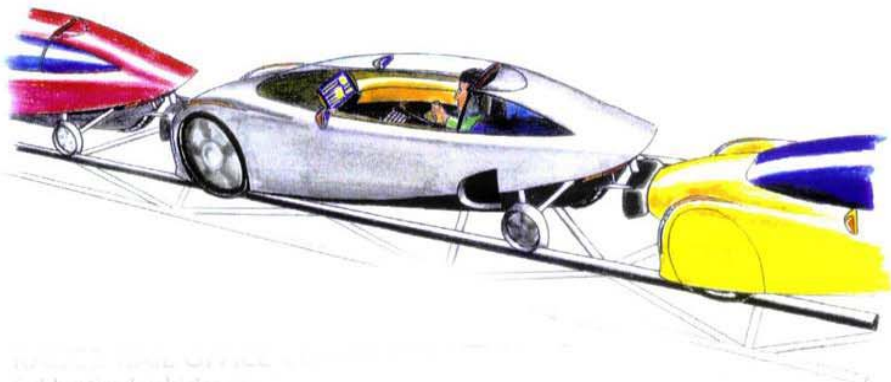


RAIL/ROAD PEDAL ELECTRIC





TANDEM 3-WHEELER



OPTIONS

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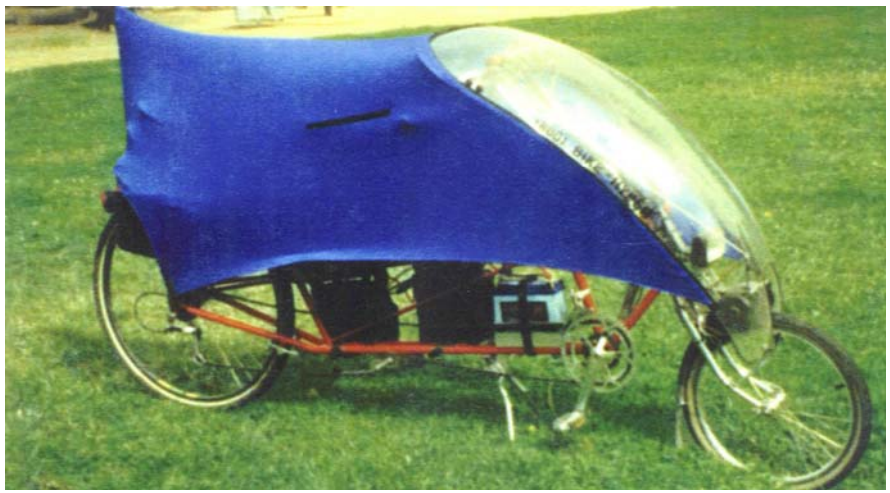
Imagine efficient electric vehicles that could be charge from renewable sources and drive onto a raised rail and safely travel at 180 mph with fuel efficiency equivalent to 280 mpg

Electric bikes with 20 mile range at 25 mph

Solar powered charging trailer

16 bike solar powered charging trailer

Trailer with surfboard rack



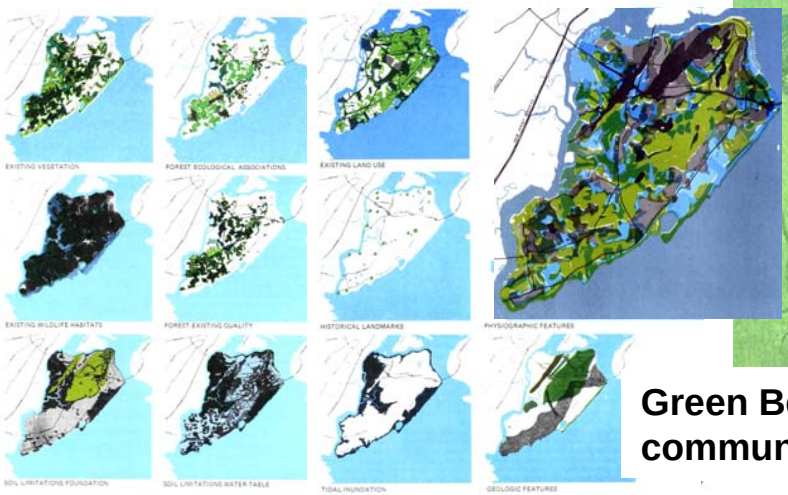
Recumbent with 35 mile range

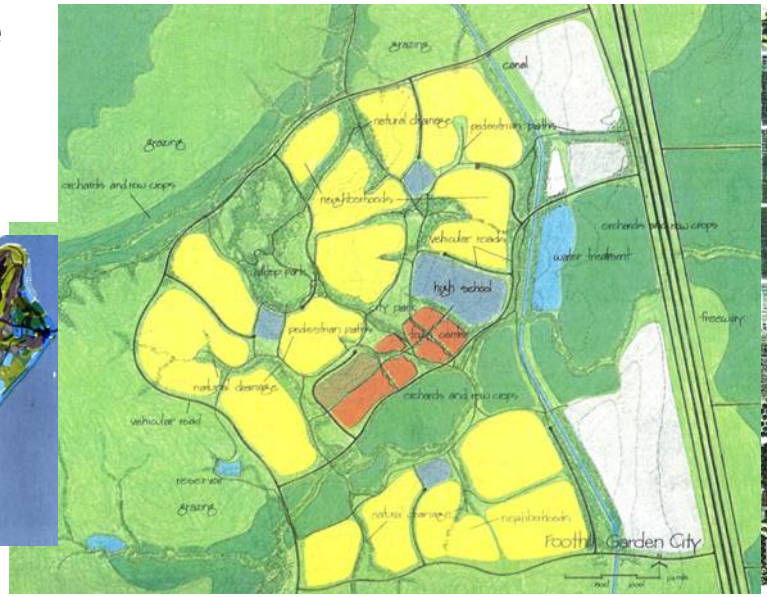
Muscle Power for Health and Mobility

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

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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.

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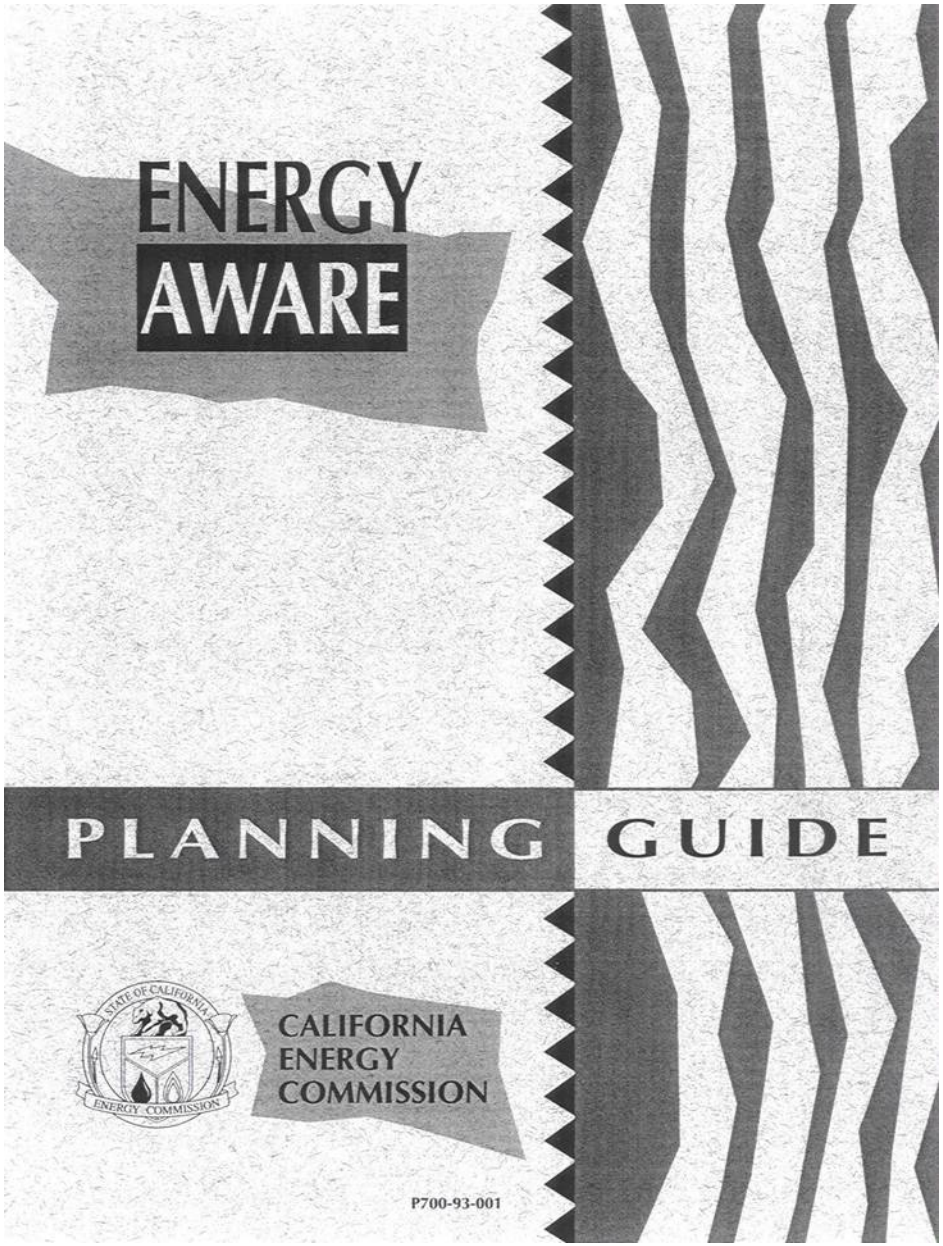
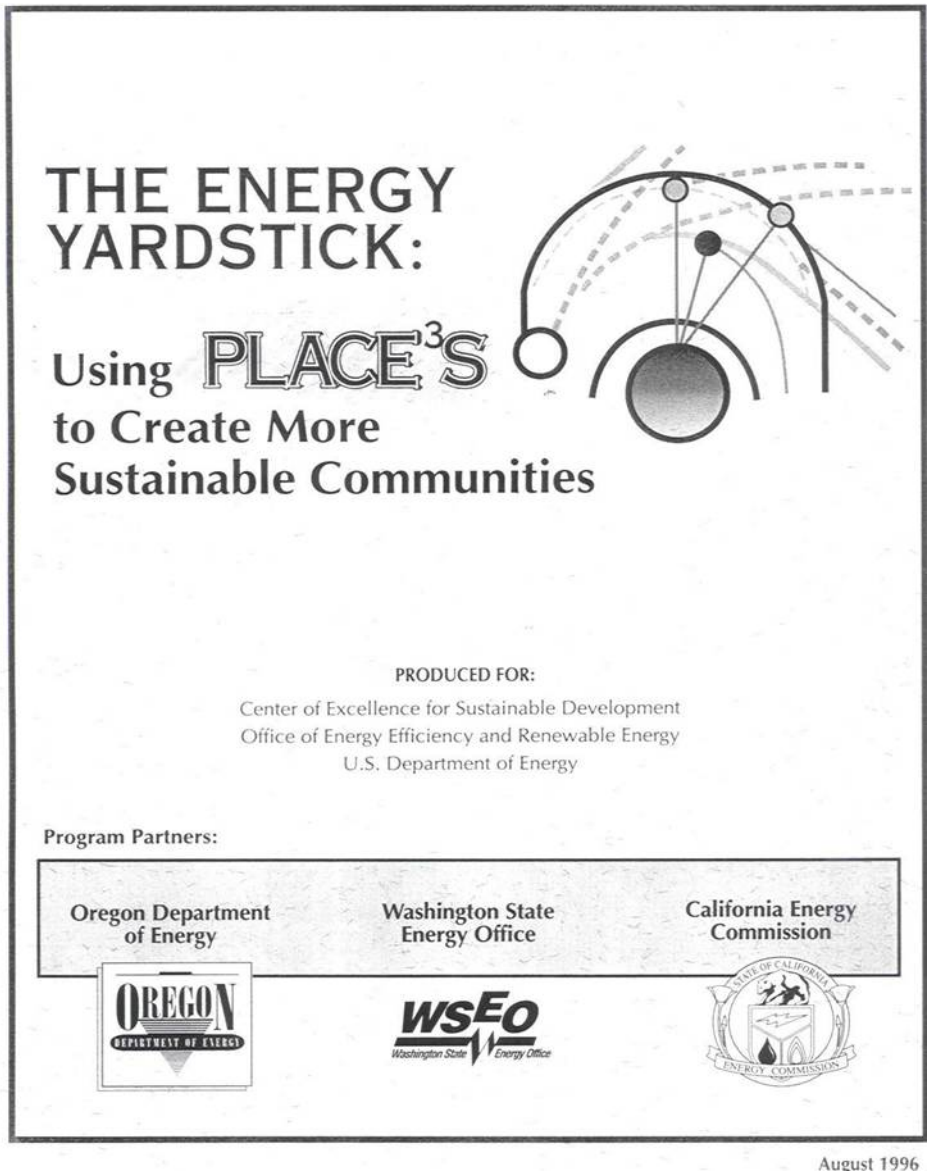
Energy Aware Published by the CEC in 1994



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 for **C**ommunity **E**nergy, **E**conomic and **E**nvironmental **S**ustainability, 1996



- Using energy as a yardstick to measure and compare the efficiency of development options makes Informed decisions possible.
- Recent developments in GPS and GIS make 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

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Emission Reduction Strategies

Increase EV and PHEV Availability

- Only allow the sale of equipment and vehicles in California that have emissions within 10% of the best in class.
- Support zero emission vehicle and equipment manufacturing with economic development funds.
- Mandatory conversion of all municipal fleets and equipment to zero emission
- Streamline registration of ZEVs
- Reduce sales tax on ZEVs
- Reduce registration fees on ZEVs
- Allow low speed (25 mph) vehicles on all city and county roads

Emission Reduction Strategies

Increase EV and PHEV Charging Capacity

- Increase EV and plug-in hybrid availability
- Free charging stations
- Solar charging parking shelters
- Support the manufacturing solar equipment with economic development funds.
- Lower off-peak charging rates
- Support 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 non-controlled access roads

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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
- Car-free town centers with electric shuttles
- Community shuttles
- Clean fuel school and transit bus 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

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

Emission Reduction Strategies

Make the polluters pay long term costs

- Raise car insurance rates based on emissions that cause climate change i.e. make polluters pay for the cost of more sever weather events, decreasing water supplies, respiratory diseases, northward migration of disease causing pests, etc.
- Tie vehicle registration fees to emissions
- Add a fee to the selling price of a vehicle based on emissions.
- Tie taxes on the sale of fossil fuels to emissions
- Tie sales taxes on Internal combustion vehicles and equipment to emissions

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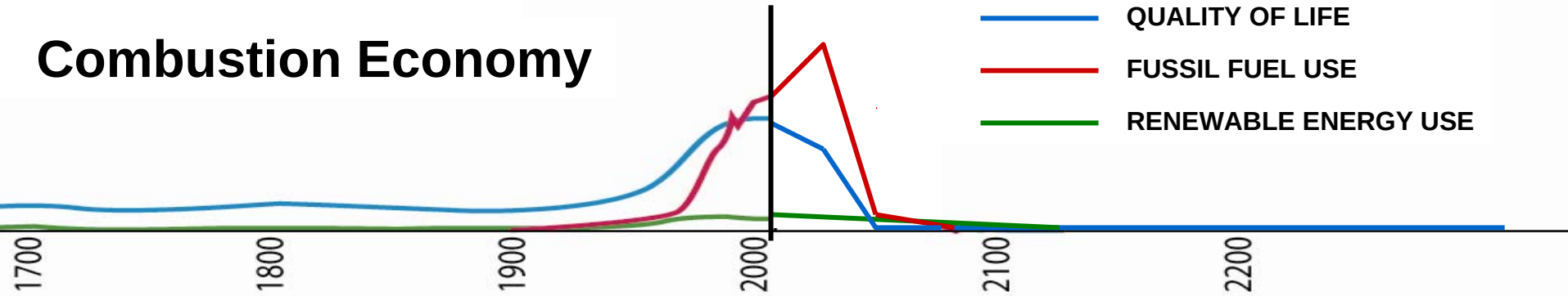
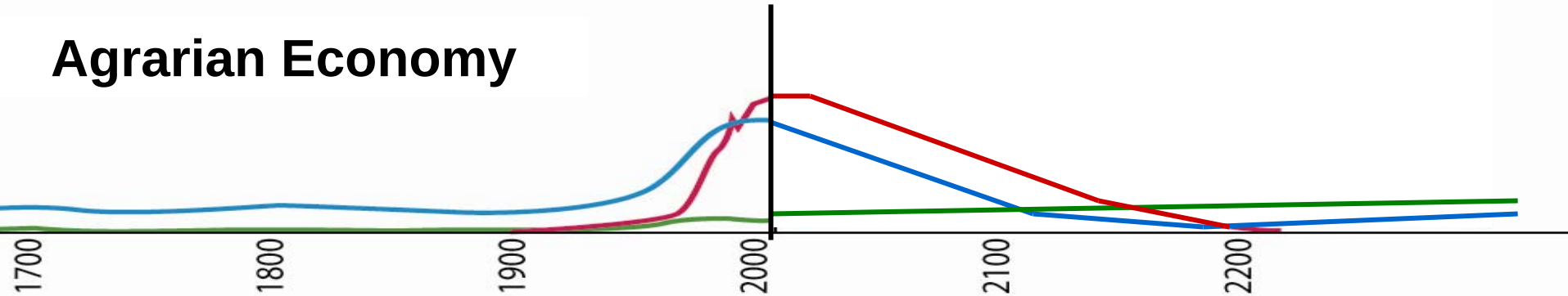
Combustion Economy



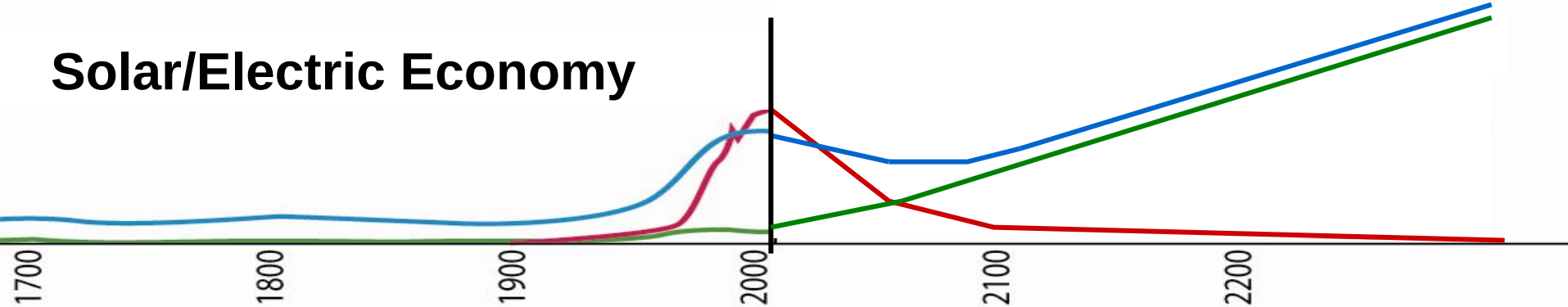
combustion depletes stored energy resources, reduces the quality of essential resources and will cause conflict and economic collapse

Agrarian Economy



Reliance on fossil energy has allowed population growth that can not be sustained by manual labor or beasts of burden

Solar/Electric Economy



Moving toward reliance on clean energy from the sun will stabilize the quality of essential resources and allow positive evolution

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5,500,000,000 years of sunshine left

Choose Wisely