Solar Future

Stephen Heckeroth
Albion CA
steve@renewables.com

Earth’s Energy Potential

Renewables in Perpetuity	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	1,000

Energy Stored in the Earth’s Crust	terawatt hours TOTAL
Coal	6,000,000
Petroleum (US 48 ½ Gone 1970)	2,000,000
Natural Gas (US 48 ½ Gone 2005)	1,500,000
Uranium 235	1,500,000
Tar Sands	200,000

Global consumption of stored energy = 50,000 terawatt hours/year

Our continued existence depends on maintaining the quality of essential resources:

1. **Air (O_2)**
2. **Fresh Water (H2O)**
3. **Soil (food)**

Humans can survive for about 3 weeks without food,
3 days without water and only 3 minutes without air (O_2)

Oxygen is arguably the most precious resource on Earth

Breathe or Burn

My son, less then an hour old

A baby needs about 400 cubic feet of oxygen to survive the first six months of life

Burning a gallon of gas uses 400 cubic feet of oxygen.

Burning a 7 lb. gallon of gas consumes 14 lbs. of O_2 and produces 21 lbs. of CO_2


40 years of oil left

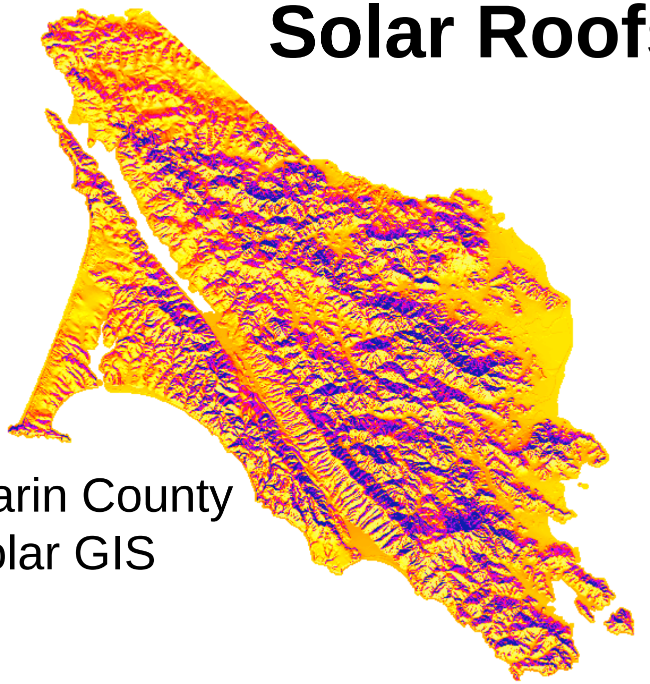

5,500,000,000 years of sunshine left
99% of motorized transportation is powered by oil

Fuel Efficiency and Climate Change

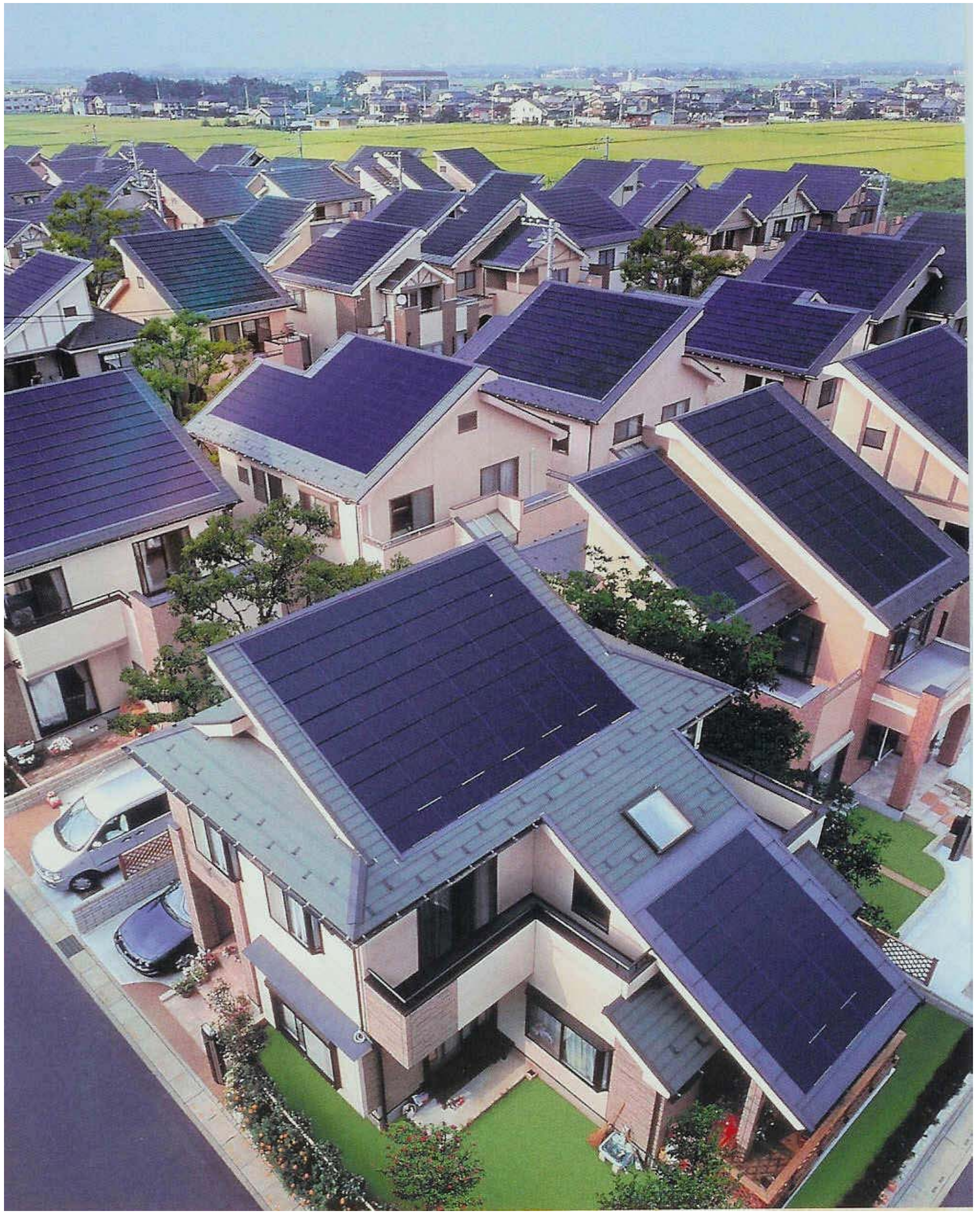
Vehicle Type	$ Gas 50 Mi. /Day	kWh 50 Mi. /Day	$/Month 50 Mi. /Day	Tons of CO_2/Year Tailpipe	+Tons of Upstream CO_2/Year*
10 MPG Gas	12.50	200	375.00	21	27.3
20 MPG Gas	6.25	100	188.00	10.5	13.6
30 MPG Gas	4.17	67	125.00	7	9.1
40 MPG HEV	3.13	50	94.00	5.2	6.8
50 MPG HEV	2.50	40	75.00	4.2	5.5
40 MPG PHEV with 25 Mile EV Range	1.56 for 25 Miles	10 for 25 Miles	62.00	2.5	3
PHEV with 50 Mile EV Range		22	33.00	ZERO	.4
EV-1, 120 Mile Range (built & crushed by GM)		12	18.00	ZERO	.2

For comparison, 20 - 30 kWh/Day are used in the average home

Solar Roofs Can Charge Electric Vehicles



Marin County
Solar GIS



PVs Charging EVs

3.5 kW EV Charging Station

10 kW EV Charging Station

30 kW EV Charging Shade Structure

100 kW EV Charging and H_2 Production

.3 kW PV on EV minivan roof ‘89

Electric Van w/ pop-top PV ‘94

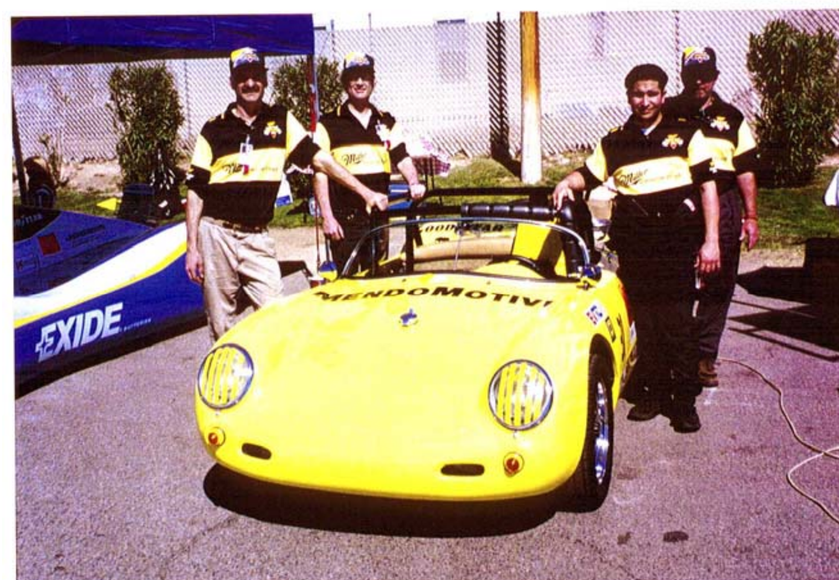
EV conversions ‘93

Electric Porsche Spyder

The crew at our shop in Ft Bragg '94

Built for GNB Battery, Australia

100 mile range

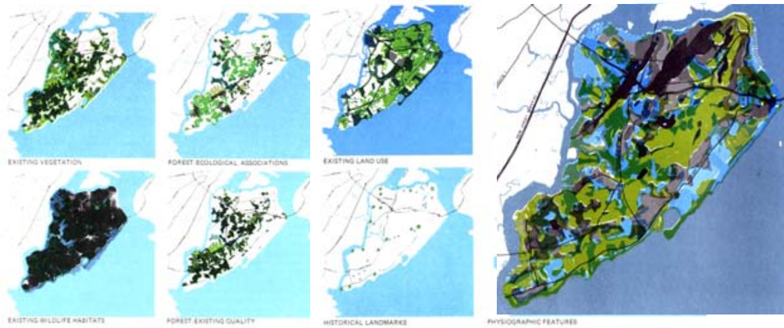


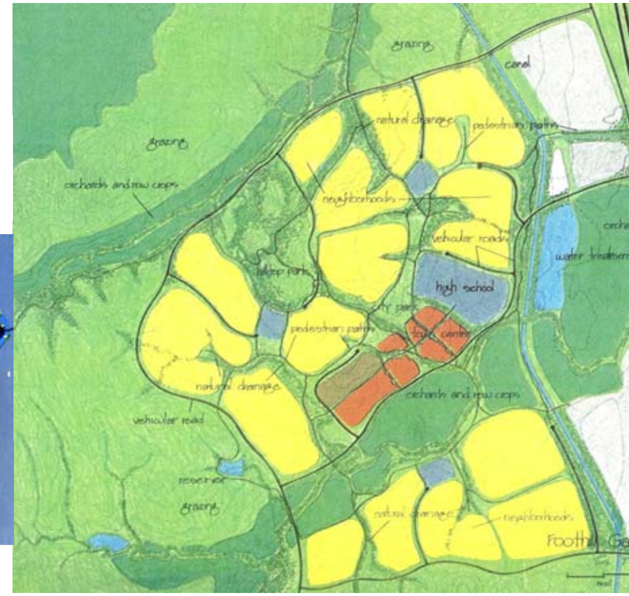
0 – 60 mph in 8 sec.

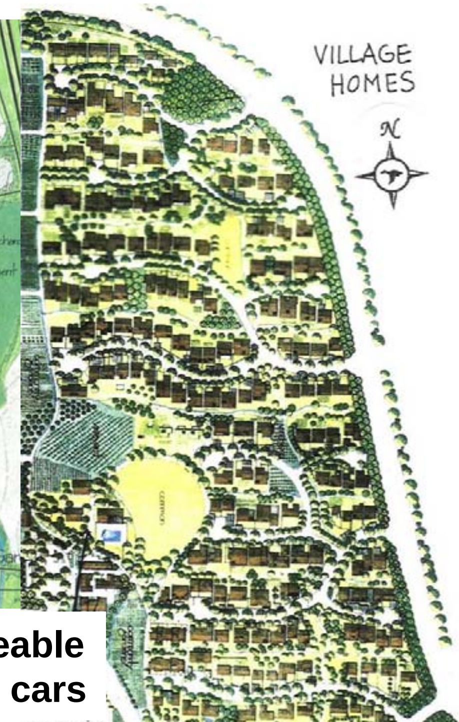
Good planning can minimize the need for cars and pavement

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

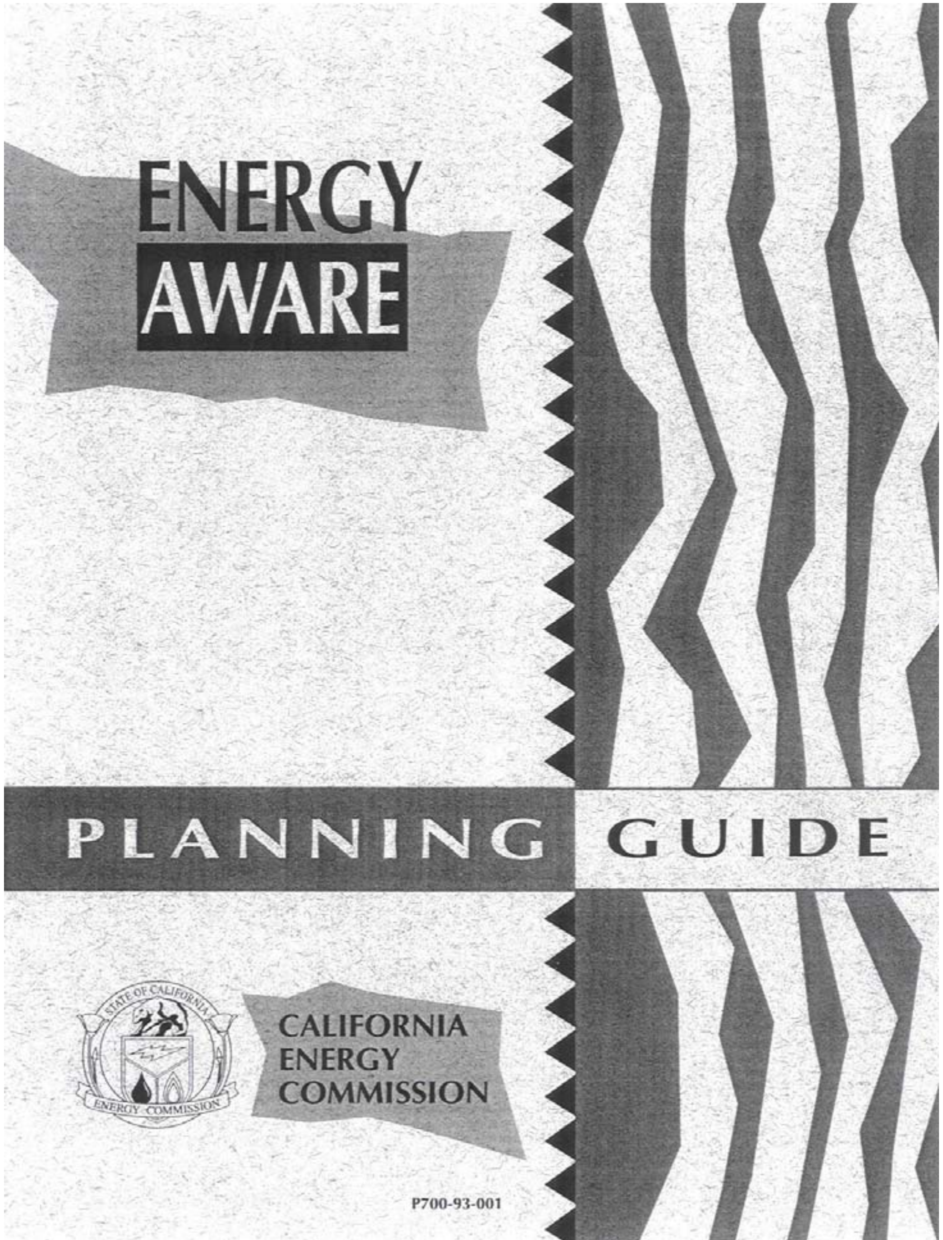
Village Homes built in the 1970s in Davis, California, is still the standard by which other sustainable neighborhood developments can be measured

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



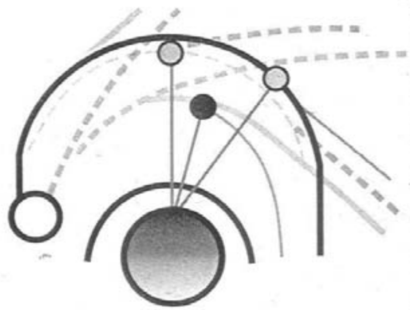
Planning strategies:

1. Mixed use development
2. Density near transit
3. Street trees
4. Pedestrian facilities
5. Bicycle facilities
6. Telecommuting
7. Fleet efficiency

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

THE ENERGY YARDSTICK:

Using PLACE^{3}S to Create More Sustainable Communities



PRODUCED FOR:

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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
OREGON DEPARTMENT OF ENERGY	WSEO Washington State Energy Office	STATE OF CALIFORNIA ENERGY COMMISSION

August 1996

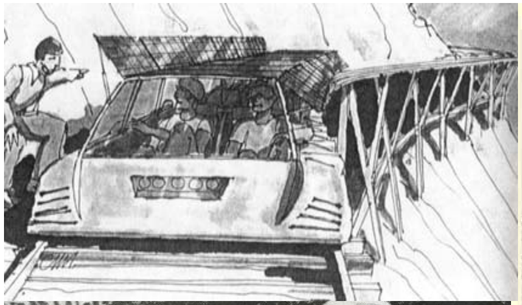
Using energy as a yardstick to measure and compare the efficiency of development options makes Informed decisions possible.

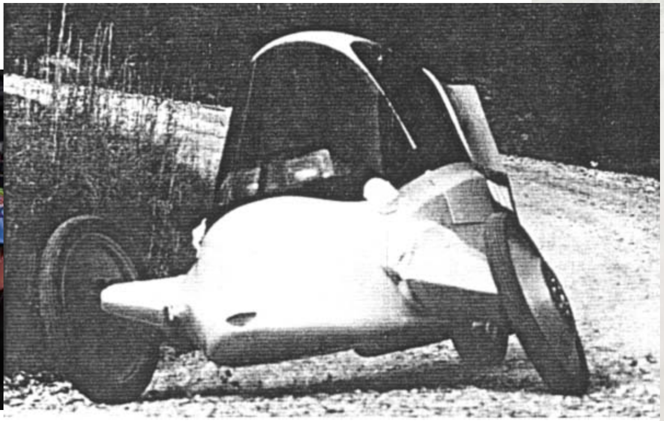
Recent developments in GPS and GIS makes this strategy an inexpensive planning tool.

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

Transportation without Pollution

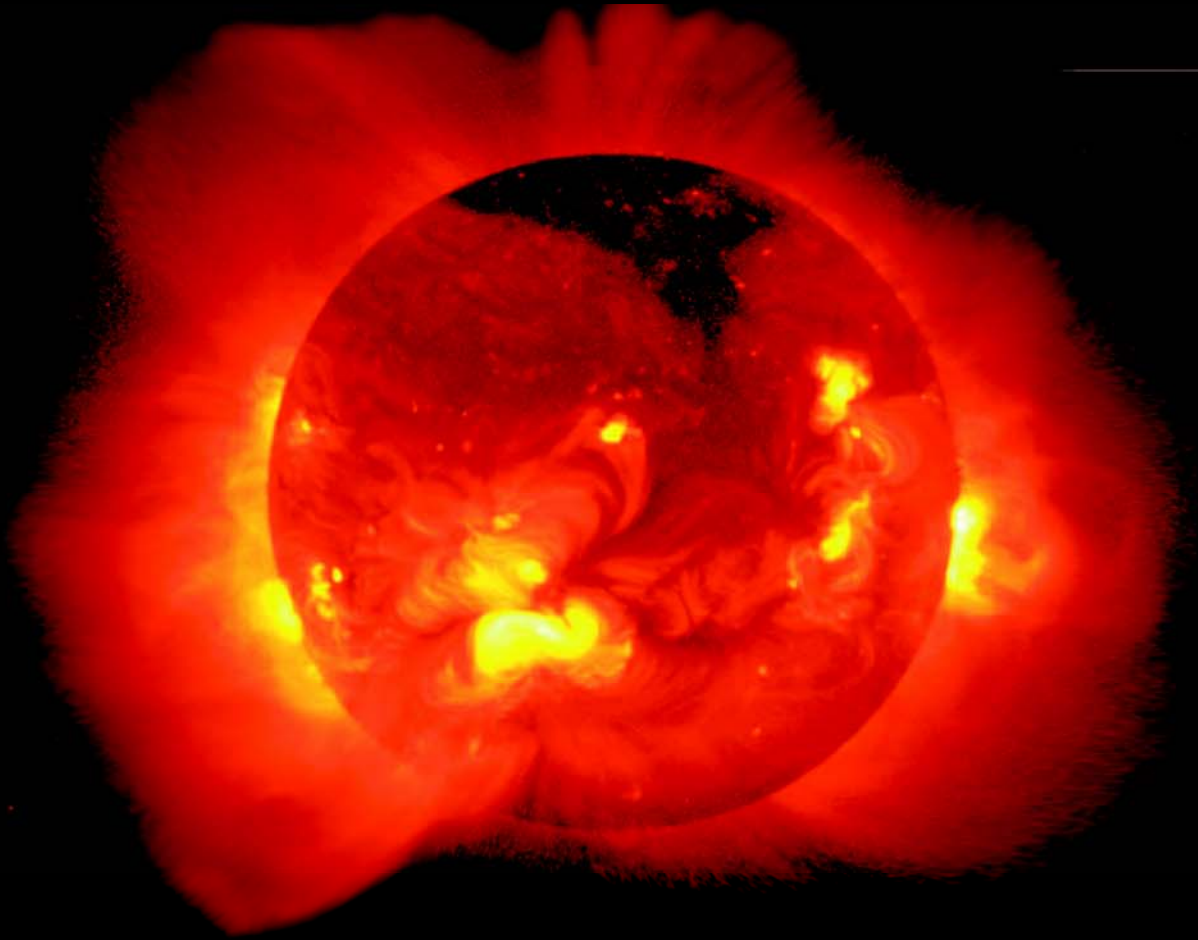
1. Consolidate Trips
2. Walk or Bike
3. Pedal Electric
4. Ultra-light EV
5. Pedal Electric Rail
6. Compact EV
7. Plug-in H_2 Hybrid
8. Biofuel





Most of our transportation $'s leave the state

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



The Suns energy only takes 8 minutes to arrive and leaves no radio active waste

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

- **Abundant solar energy**
- **Aesthetically superior**
- **Clean air / no CO2 emissions**
- **No extraction sites**
- **Healthy land**
- **No water pollution**
- **Free solar fuel**
- **National and individual security**

Advantages of Distributed Solar Generation

Conventional Power Generation

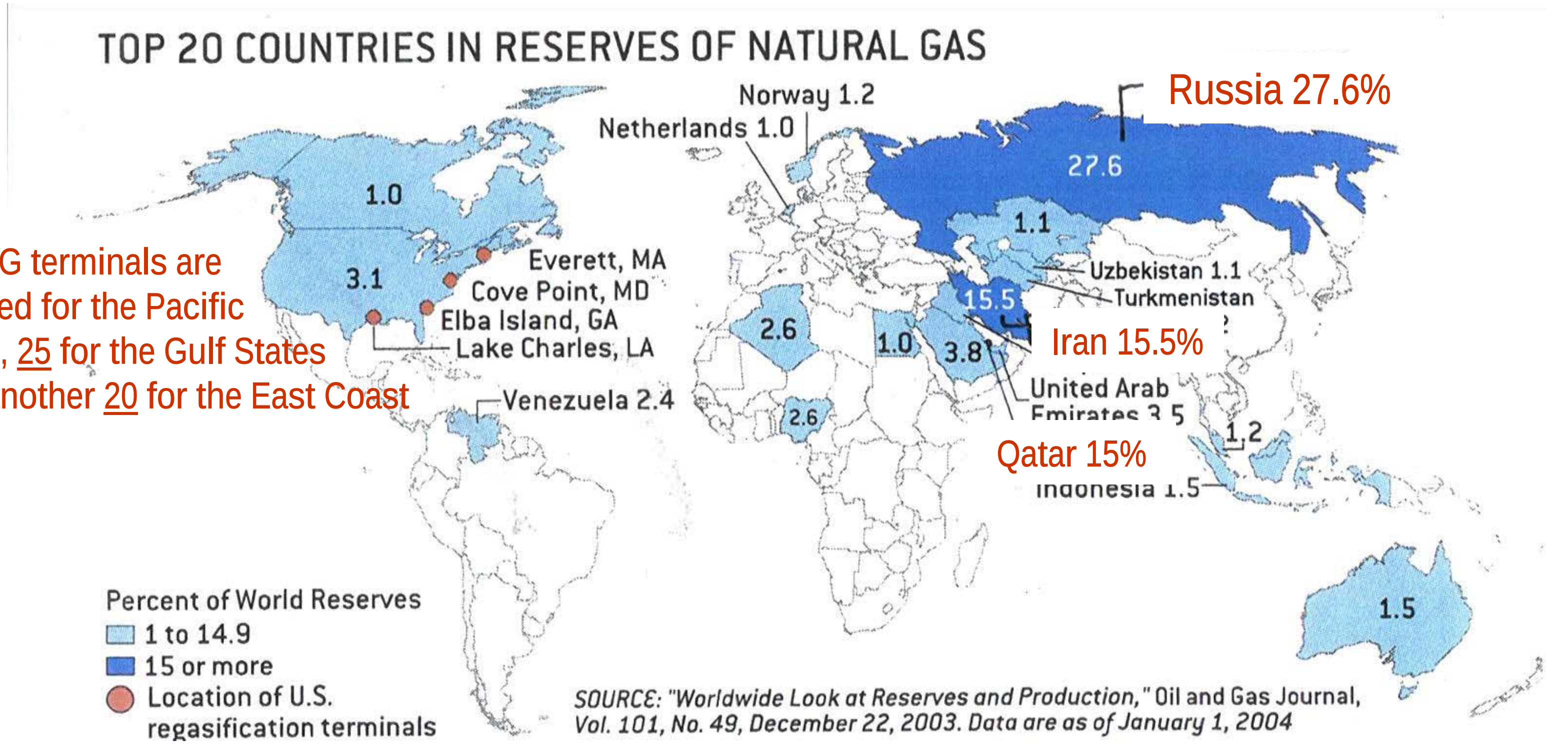
- **Explosive polluting terrorist targets**
- **Requires fuel from distant sources**
- **Price Volatility**
- **Uses land for extraction and power generation**
- **Difficult permitting process**
- **Requires security infrastructure**
- **Requires new transmission and distribution lines**
- **Power has low value ($0.03 – $0.04/kWh)**
- **Multinational corporate control**
- **Priority: Short-term profits**

Distributed Solar Generation

- **Clean and Secure**
- **Requires no fuel, only sunshine**
- **Economic stability**
- **Uses existing infrastructure**
- **Easy permitting process**
- **Cost of roofing can be offset**
- **Uses existing transmission and distribution lines**
- **Power has high value ($0.10 - $0.30/kWh)**
- **Time of Use net metering for automatic Peak Power Shaving**
- **Local control for public good**

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 85% 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

Advantages of Thin-Film BIPV

Building Applied PV

2 kW crystalline modules installed on racks

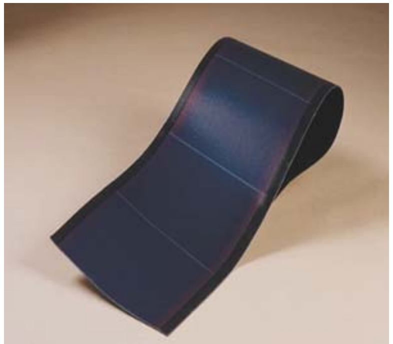
- High embodied energy
- 100 times more silicon then thin-film
- Glass modules can break
- High cost per square foot (>$100)
- Racks are expensive
- Must be removed to replace roofing
- Roof penetrations required
- Detract from building's appearance
- Modules add excess weight to roof
- Electrical cables & conduit are exposed

Building Integrated PV

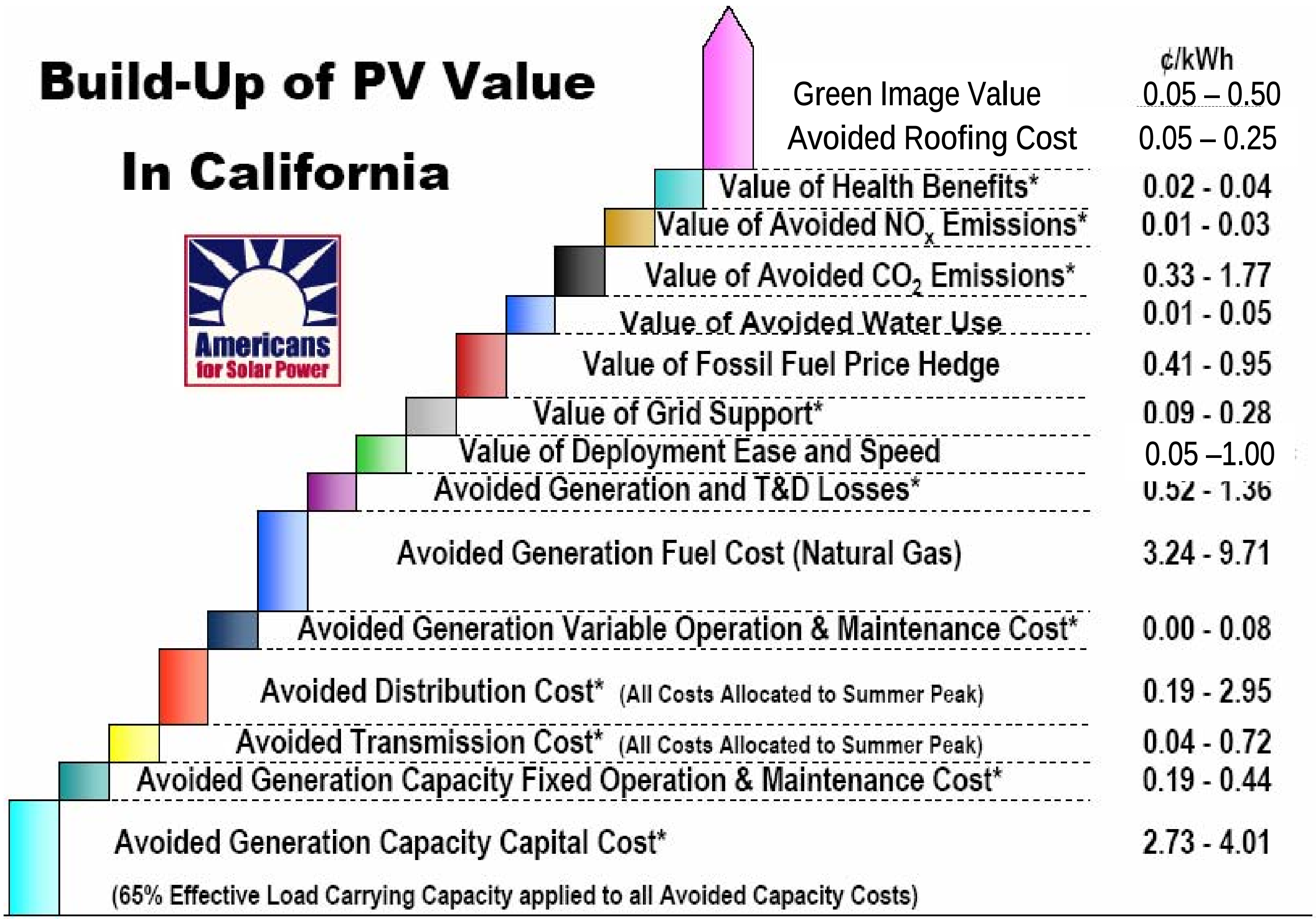
2kW flexible thin-film PV roofing

- Low embodied energy
- 100 times less silicon then crystalline
- Laminates are vandal resistant
- Lower cost per square foot (<$50)
- Avoids the expense of racks
- Synchronized roofing and PV installation
- No roof penetrations
- Laminates are aesthetically superior
- Lightweight
- Easy to install quick connects hidden and protected under ridge cap

Payback

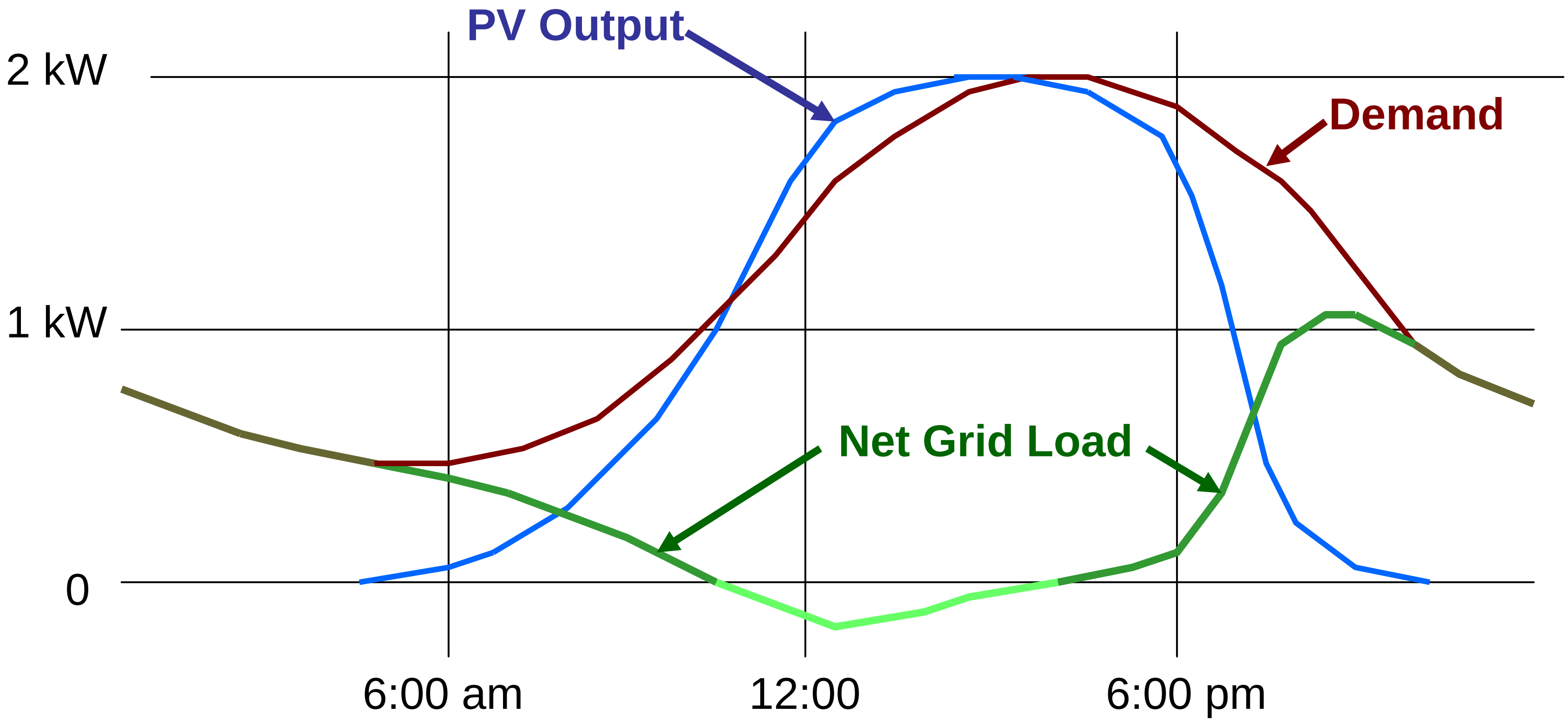
Product			
	Crystalline PV	Flexible Thin-Film PV	Gas Generator
Energy used to manufacture	**5-7 kWh/watt**	**2.5 kWh/watt**	**3-4 kWh/watt**
Power used to generate electricity	**none**	**none**	From tank: 6-7 kWh/kWh From well: 10-20 kWh/kWh From sun: >1,000 MWh/kWh
Time to payback	**4-6 years**	**18 months**	**never**
Warrantee	**20-25 years**	**20 years**	**1-2 years**
Lifecycle pollution	**trace**	**trace**	**tons**
External cost	**Cents/MWh**	**Cents/MWh**	**K$s/MWh**

The Real Economic Value of BIPV



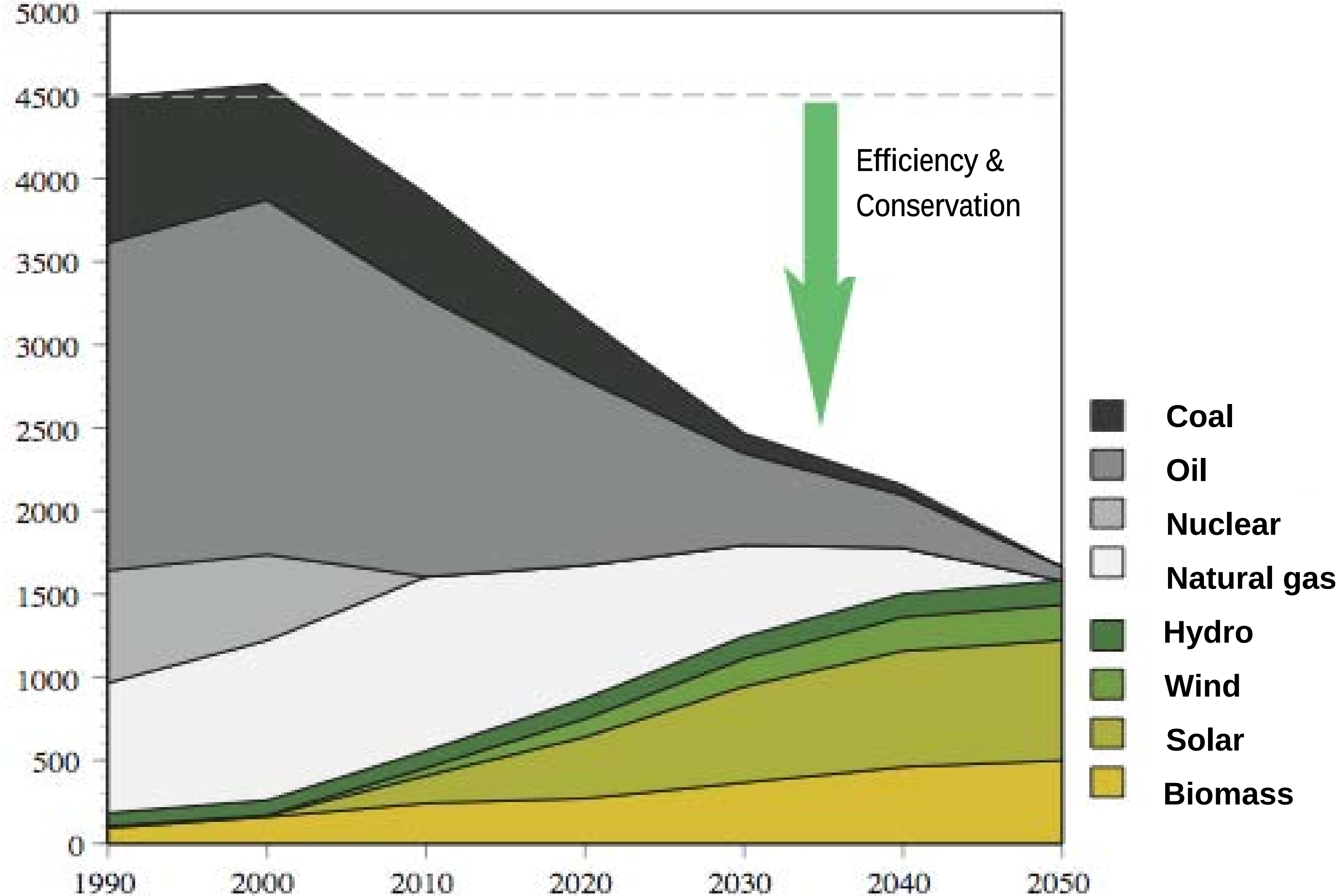
TOTAL ADDED VALUE of BIPV: $.08 – $.25 / kWh

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



Peak PV performance coincides with peak utility loads

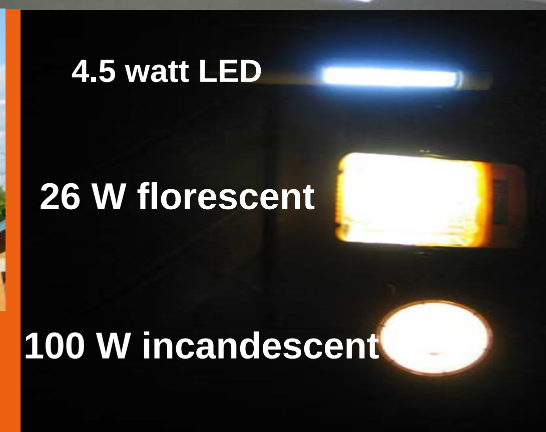
Sustainable Scenario

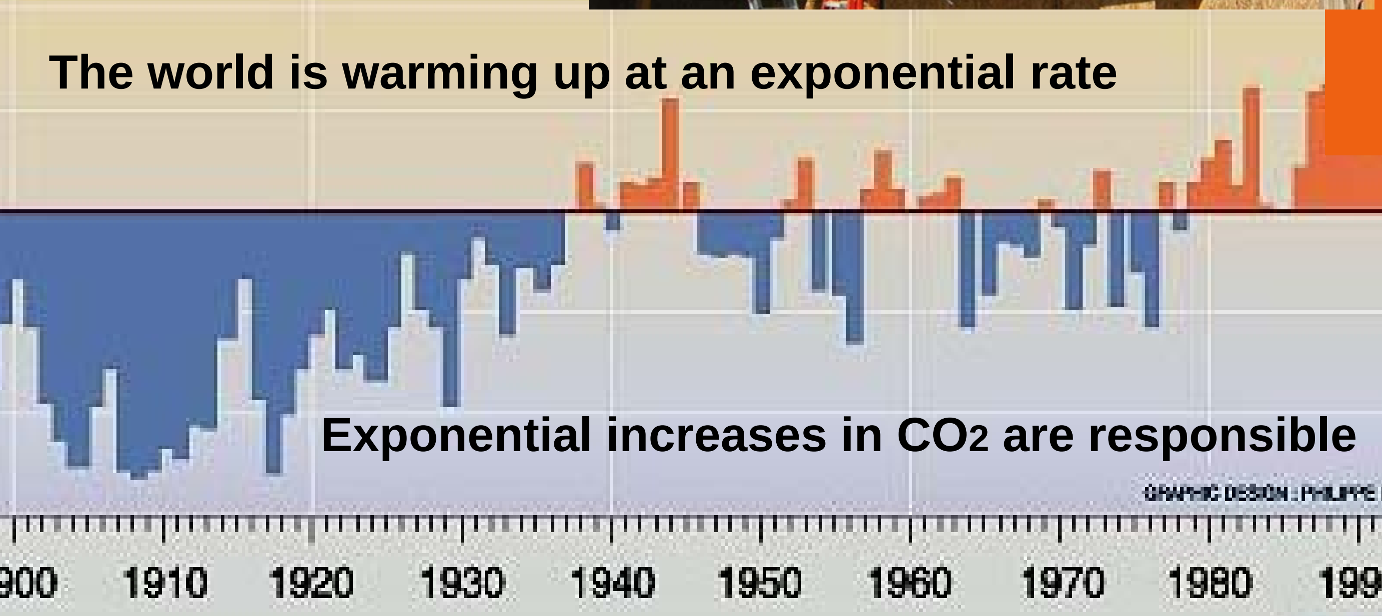


Sustainability will require the elimination of nuclear and then fossil fuels combined with extreme conservation and efficiency gains as well as ramping up renewables

Energy without Pollution

1. Conservation
2. Efficiency
3. Muscle
4. Zero Emission Renewables
5. Biofuels





Fresh Water without Pollution

1. **Gravity Fed Spring**

2. Wind or Solar Pumped Well
(must not be pumped faster than the water table is recharged on an annual bases.)

3. Rain Water Catchment
(cistern or pond)

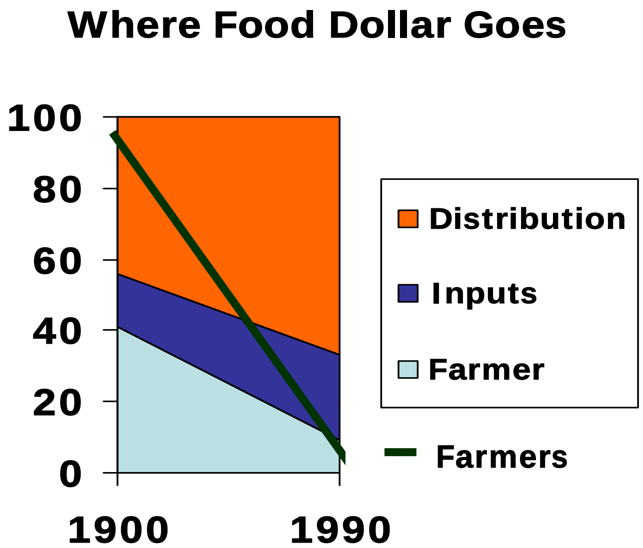
4. Wind or Solar Pumped From Stream or River
(must not be pumped at a rate that will negatively affect aquatic populations.)

Over 10% of electric generation pumps water
Over 90% of water pumping $ leave the county

Wind was the Primary Pumping Power Before Fossil Fuel

Food without Pollution

1. Organic Home Garden
And Greenhouses
1. Local Organic Farms
(farmed without fossil fuel)
3. Regional Organic Farms
(farmed without fossil fuel)
4. Fair Trade Import
(farmed without fossil fuel)



My son, the carrots worked, he's now 6' 7"

South Slope Gravity Irrigation



Solar Charged Electric Agricultural Tractors

E-tractors Built in my Ft. Bragg shop '94

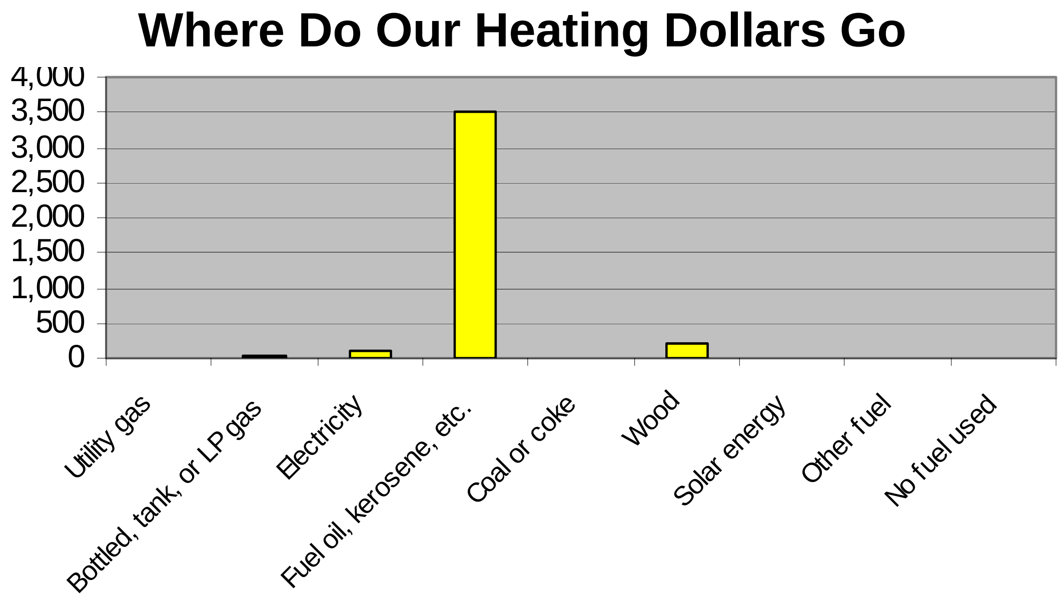
Built for Ford-New Holland '95

Scratch built with movable seat for good visibility

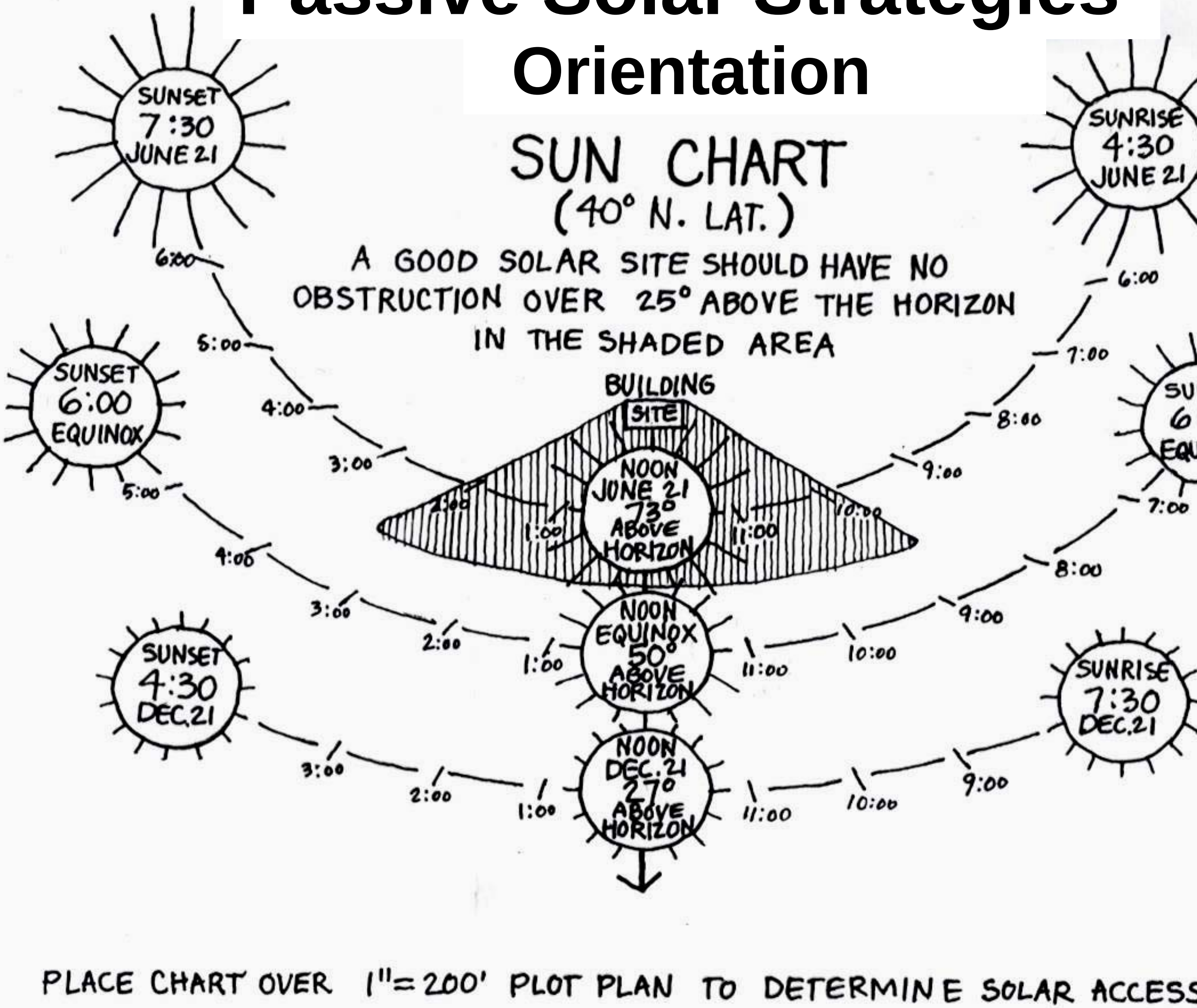
Solar powered Planter/harvester

Shelter without Pollution

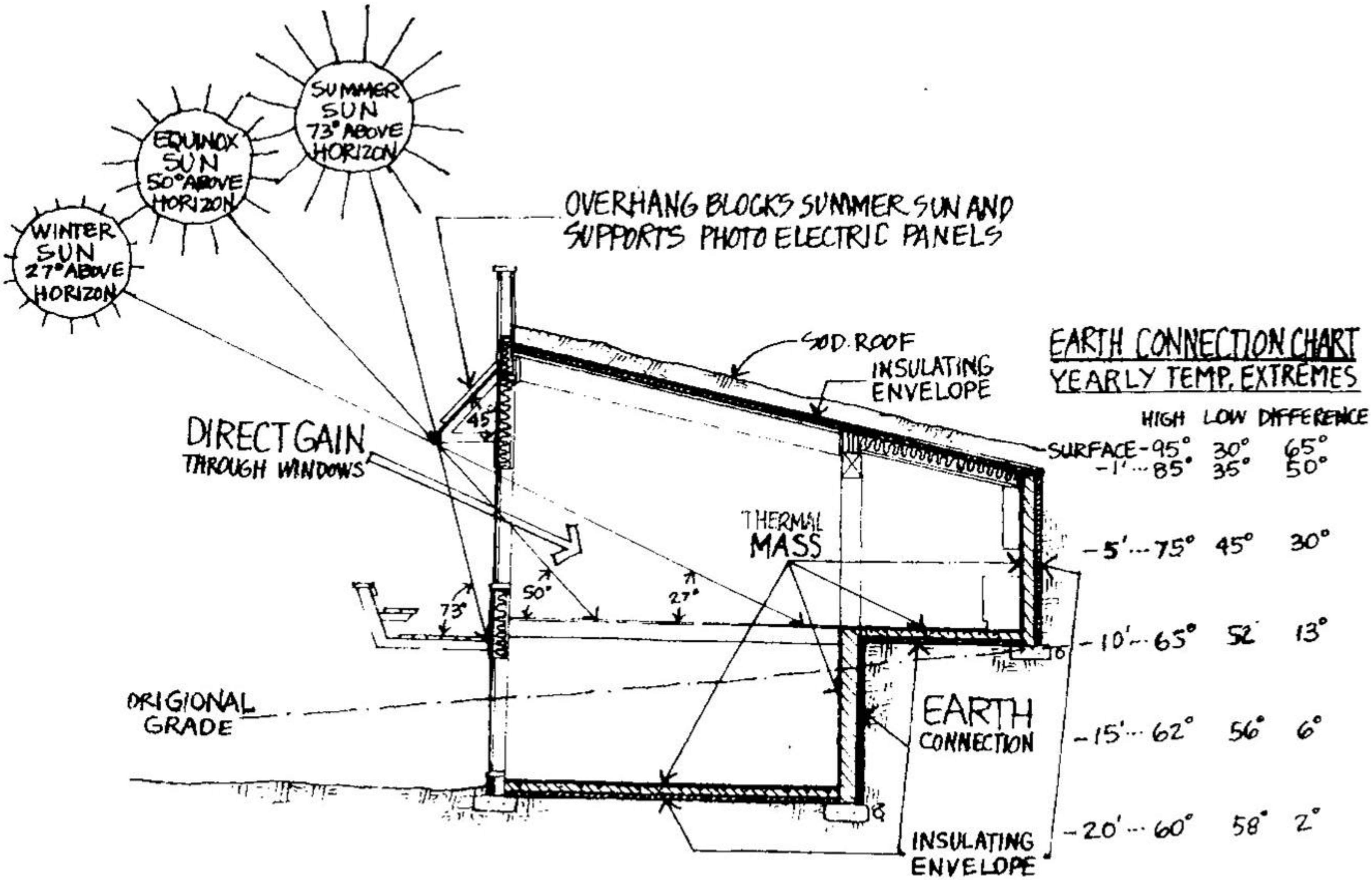
1. Passive Solar with On-Site Materials
2. Local/Recycled Materials
(produced without burning fossil fuel)
3. Regional Materials
(produced without burning fossil fuel)
4. Very Efficient/Durable



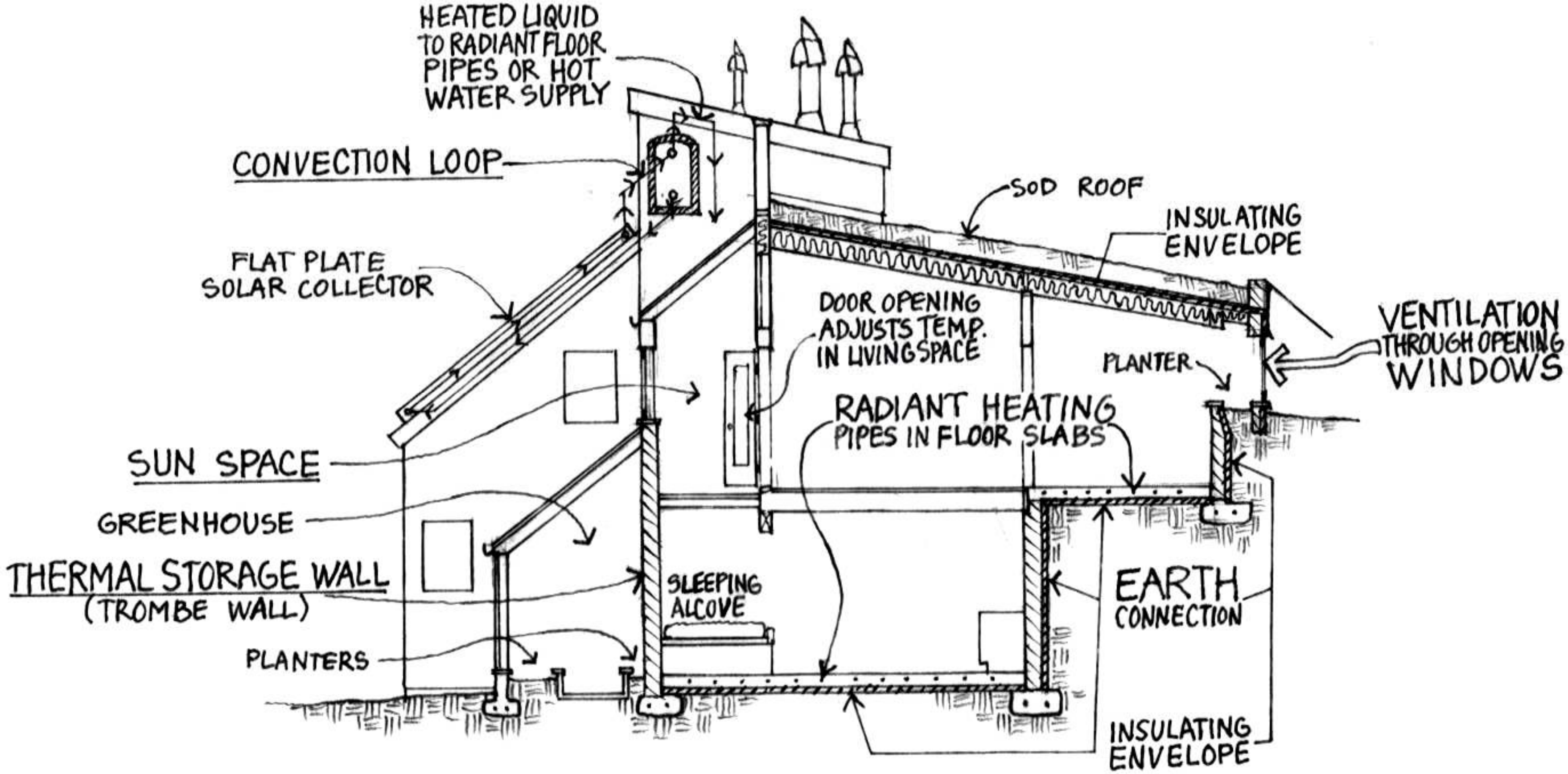
Passive Solar Strategies
Orientation

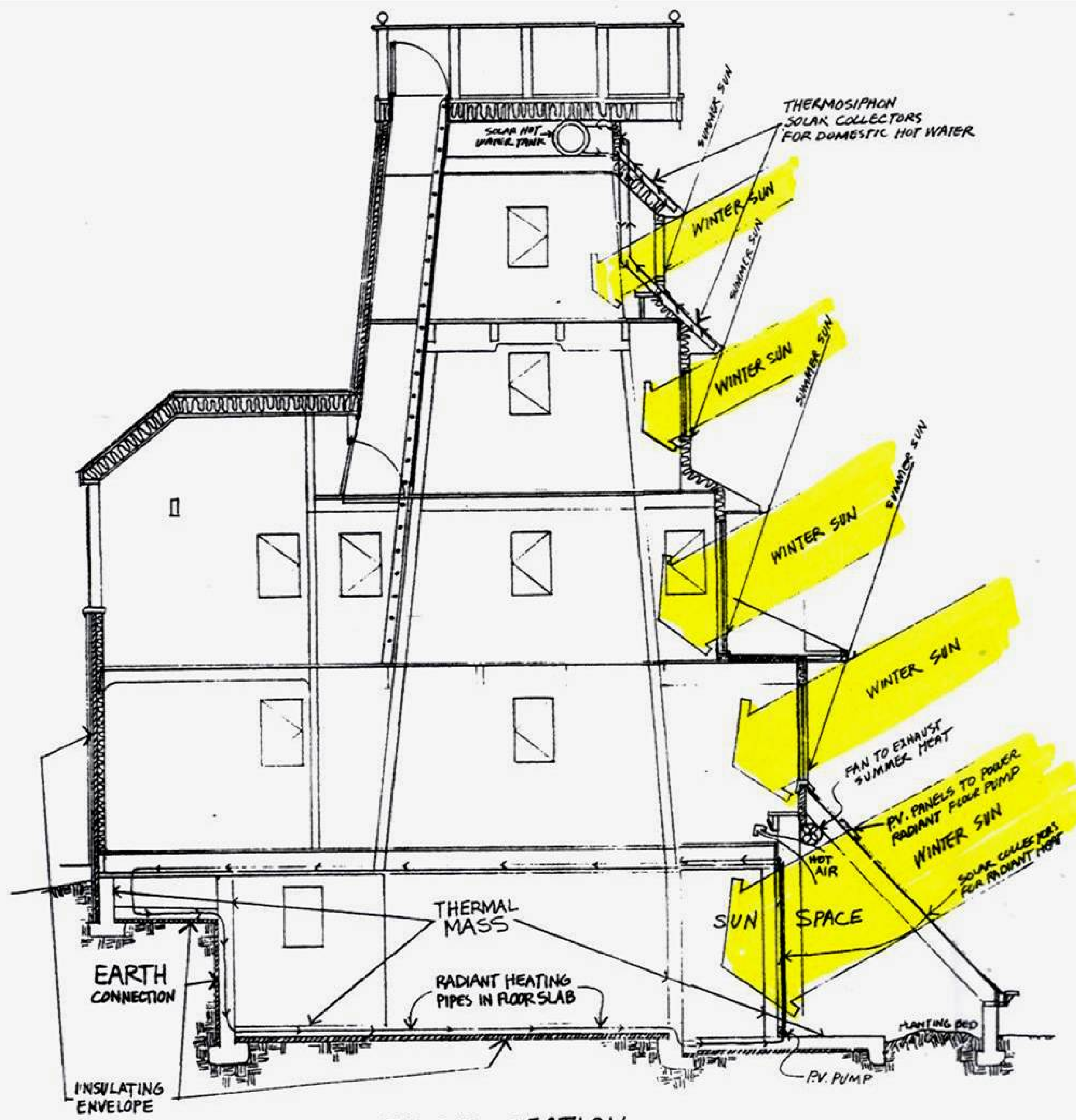


Direct Gain, Shading and Overhangs, Earth Connection, Insulating Envelope



Thermal Mass and Storage Walls, Sun Spaces, Convection or Thermal-Siphon Loops, Day-Lighting, Ventilation Openings



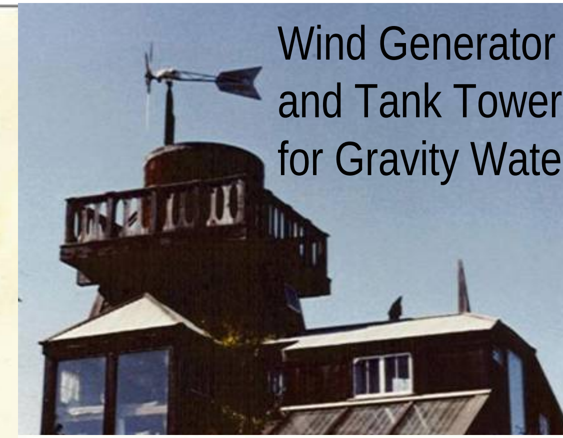

THERMOSIPHON SOLAR COLLECTORS FOR DOMESTIC HOT WATER
SOLAR HOT WATER TANK
SUMMER SUN
WINTER SUN
SUMMER SUN
WINTER SUN
SUMMER SUN
WINTER SUN
SUMMER SUN
WINTER SUN
FAN TO EXHAUST SUMMER HEAT
P.V. PANELS TO POWER RADIANT FLOOR PUMP
WINTER SUN
SOLAR COLLECTORS FOR RADIANT HEAT
HOT AIR
SUN SPACE
THERMAL MASS
EARTH CONNECTION
RADIANT HEATING PIPES IN FLOOR SLAB
PLANTING BED
P.V. PUMP
INSULATING ENVELOPE

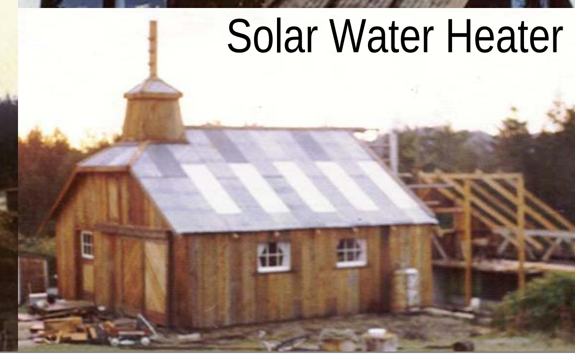
South

Passive Solar Strategies

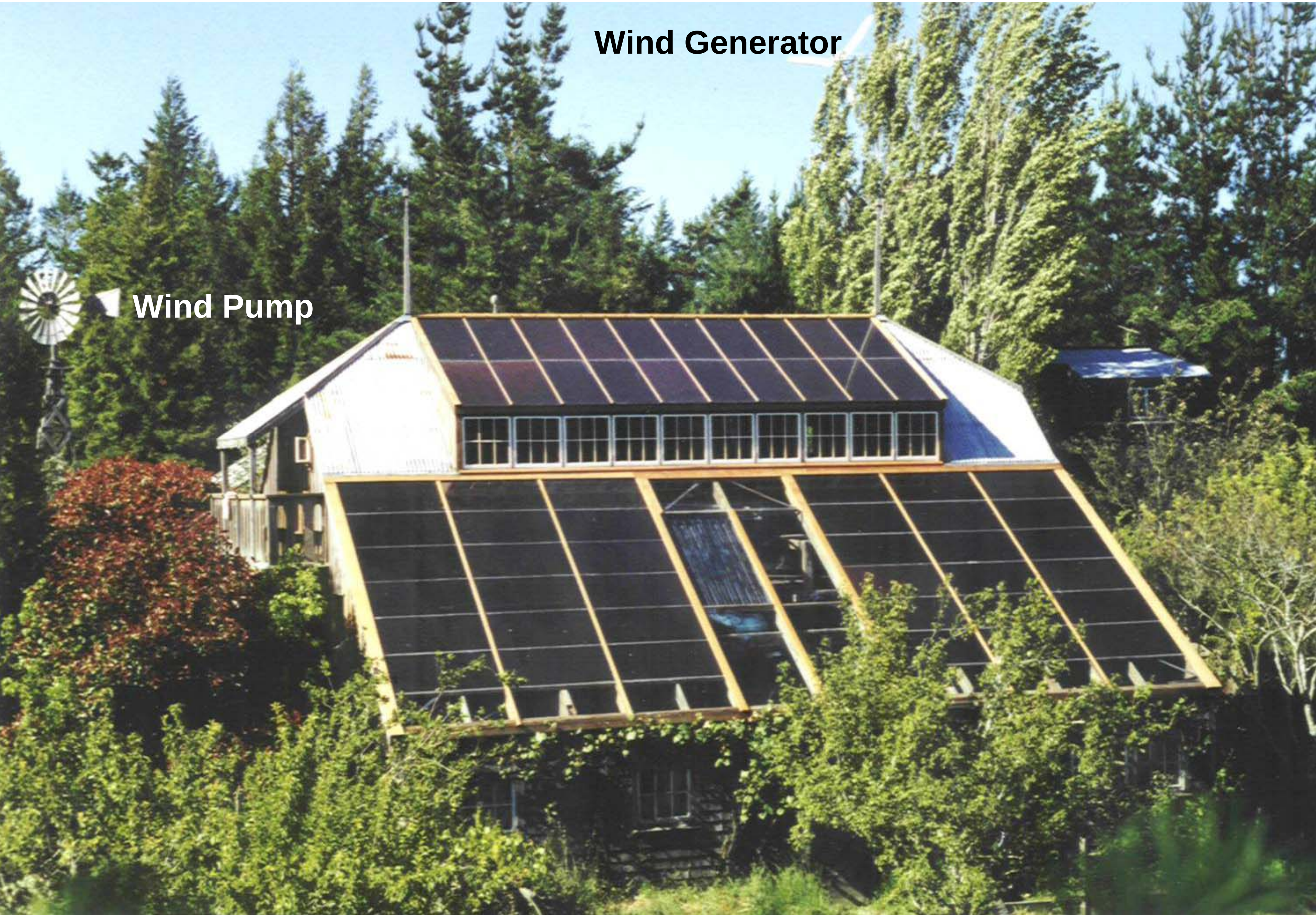
1. Orientation
2. Direct Gain
3. Thermal Mass and Storage Walls
4. Shading and Overhangs
5. Sun Spaces
6. Day-Lighting
7. Earth Connection
8. Convection or Thermal-Siphon Loops
9. Insulating Envelope
10. Convection Ventilation
11. Wind Breaks and Berms
12. Deciduous Vegetation
13. BIPV On-Site Power Generation

Homestead built with hand tools & on-site or recycled materials





3kW PV Roof with Solar Hot Water and Day Lighting



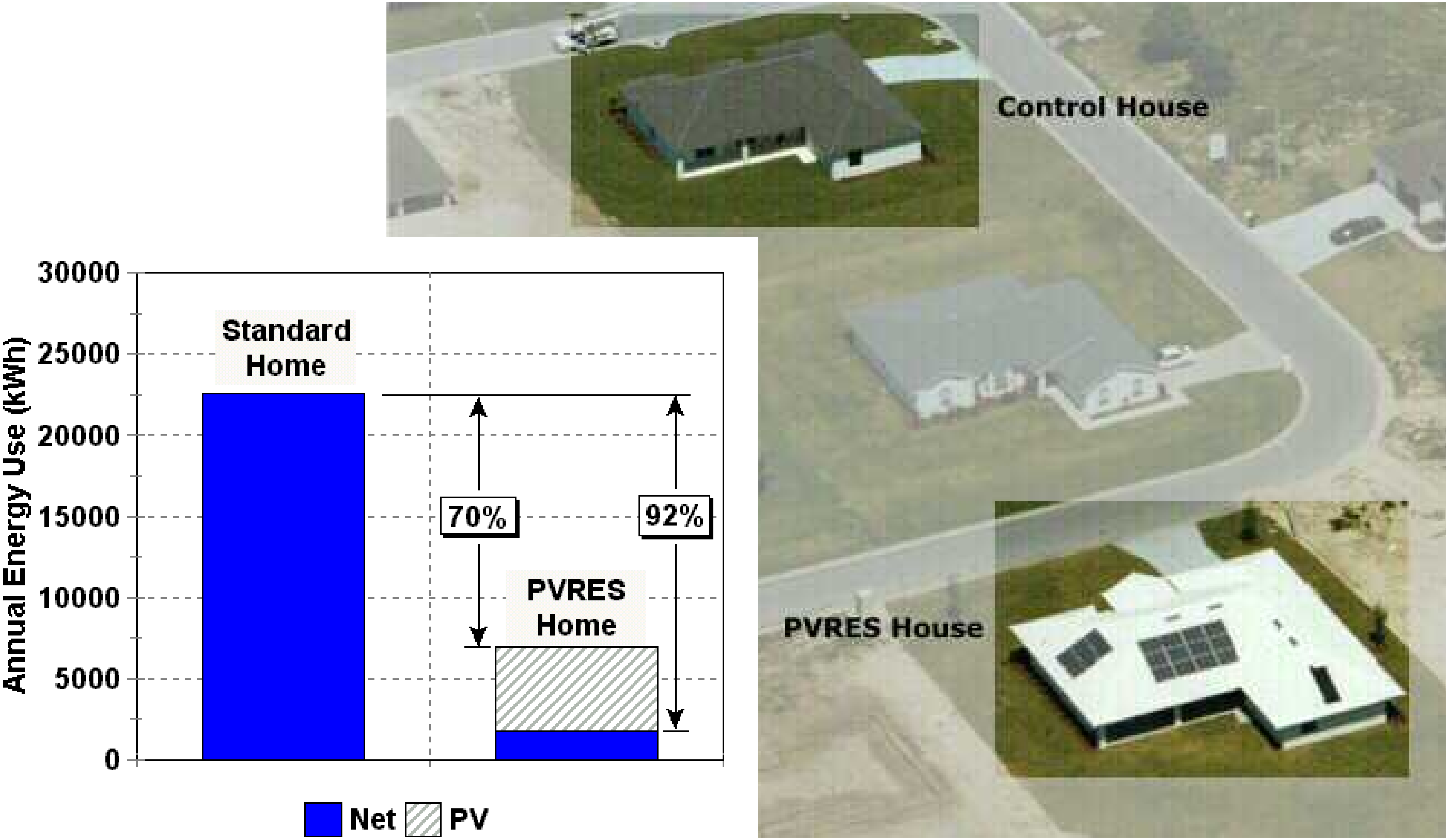
Zero Net Energy House - even in Maine!

The Lord House—Solar Design Associates

www.solarhouse.com

The Lakeland House Project

Proving the Benefits of Efficiency, BIPV and Passive Solar Design



Mendocino County General Plan

Elements included

		# of pgs
I.	Land Use	159
II.	Housing	30
III.	Circulation	109
IV.	Safety	36
V.	Seismic Safety	60
VI.	Noise	83
VII.	Recreation	25
VIII.	Open Space and Conservation	106
IX.	Scenic Highways	24
X.	Costal	› 500

What's Missing

		pgs. in plan
I.	Air Quality	3
II.	Energy	5
III.	Water	9
IV.	Agriculture	10
V.	Fisheries	7
VI.	Vegetation and Wildlife	6
VII.	Soils and Minerals	6
VIII.	Green Building	0
IX.	Recycling	0
X.	Localization	0

✓ Inventory, in county, renewable energy resources

✓ Prepare Energy Element for County General Plan that sets Goals and implement Policies that gives a time line for the transition to local clean renewables

The time for action is NOW!

Ways communities can increase the supply and reduce the cost of clean renewable energy

- **Take inventory of, in county, renewable energy resources and prepare Energy Element for County General Plan that sets Goals and Policies to make the transition to local clean renewables.**
- **Prepare implementation plan for Community Choice for submittal to California Public Utilities Commission which includes > 40% Renewable Portfolio Standard by 2020.**
- **Provide incentives for local renewable (PV, solar thermal, wind, etc.) manufacturing capacity and distributed generation by qualifying for government programs or issuing municipal revenue bonds.**
- **Execute purchasing agreement for XX MW of renewable energy capacity**
- **"Piggy Back" purchasing agreements with other California Cities and Counties i.e. $500 million available from GE capital for financing PV on schools.**
- **Create renewable energy design curriculum and installation training programs in conjunction with schools and trade organizations.**
- **Support performance based installation incentives and contracts.**
- **Enact public policy to enforce solar access laws and "Green" construction standards (LEED).**

Summary

Energy costs are at an all-time high and a new energy crisis is unfolding.

Pollution is compromising the quality of our lives and making the Earth less habitable.

A clean reliable energy source is essential to maintain our standard of living.

The external and future cost of conventional energy supplies necessitates immediate action to make the transition to clean renewables.