

Solar and Emergency Power



This talk will cover: Home Solar
Electric Vehicles
Backup / emergency power

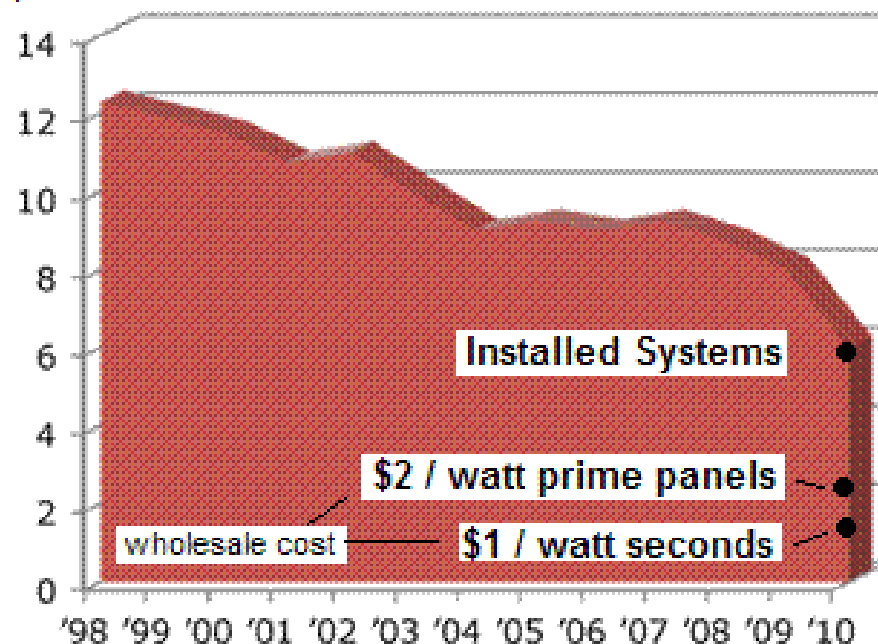
It's a whole new world of Power!

The Falling Cost of Solar

(Mar 2010)

Price per watt (DC) for a typical 5-kw system:

\$ / Watt



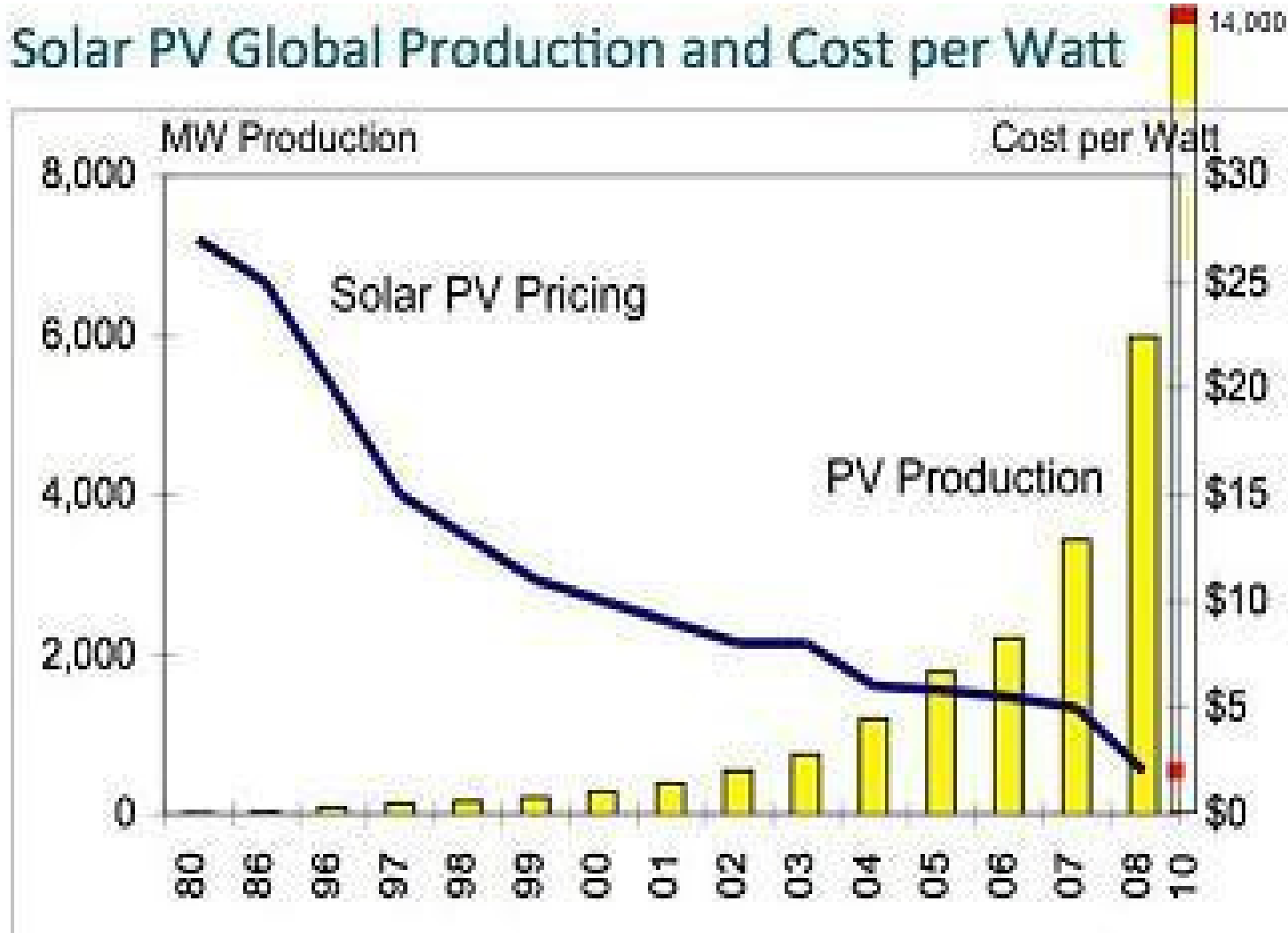
Sources: For 1998-2008 figures, Lawrence Berkeley National Laboratory. For 2009 and 2010, lowest reported or advertised installer prices in California, Arizona, Minnesota and Texas for routine 5-kilowatt residential installations.

GRAPHIC CREDIT: SUNPLUGGERS.COM

A year ago, a typical solar panel cost about twice or more what it does today at retail. Modules generally make up 50 to 60 percent of the average cost of a solar PV installation. In the United States, retail prices for most small-scale buyers did not start dropping sharply until the fall of 2009, and then only in the most active solar markets in California.

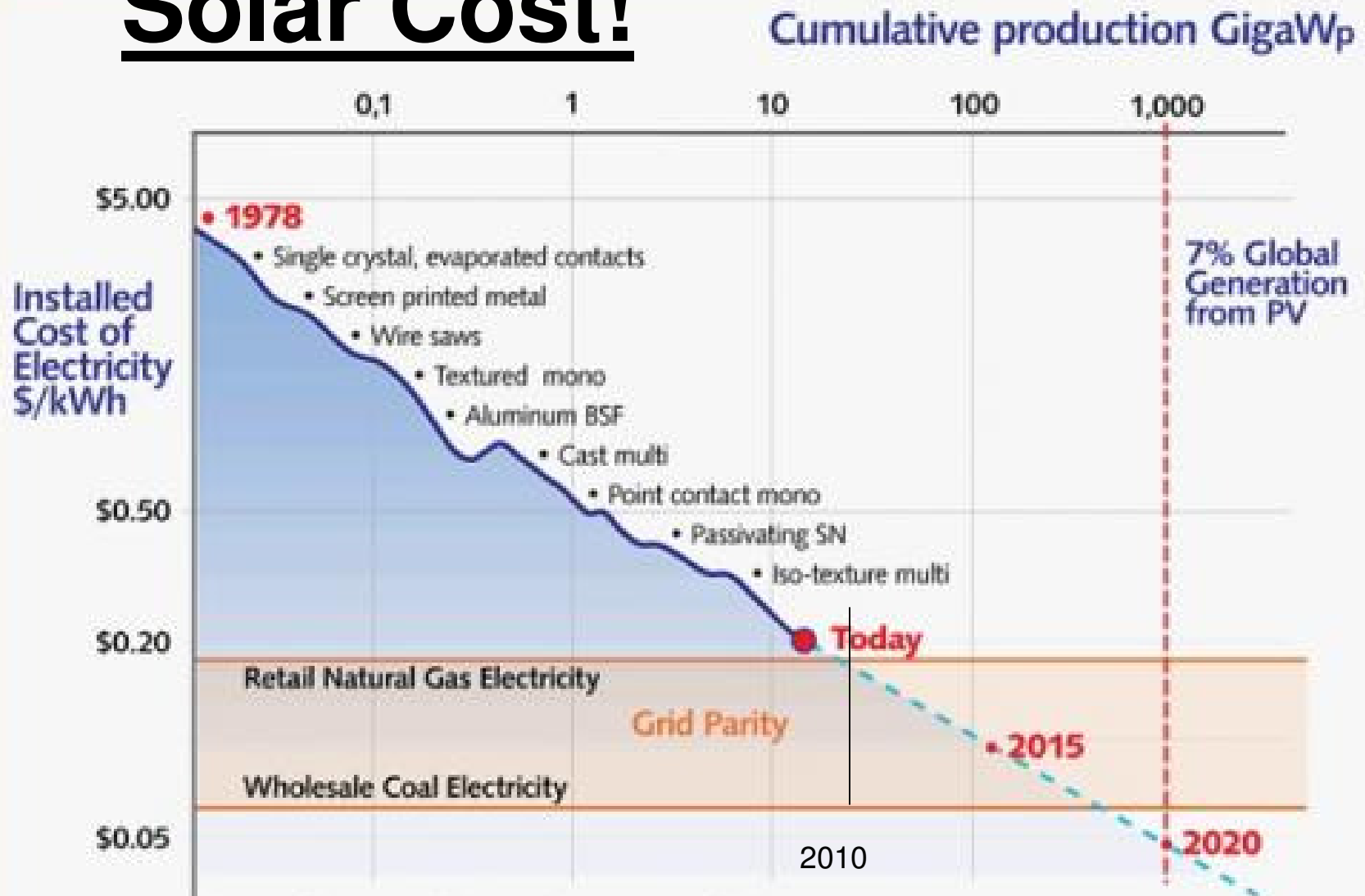
The price declines are still working their way through the system. Some suppliers and installers may still possess inventory that cost

Solar PV Global Production and Cost per Watt



Solar Buzz. Company reports.. Green Econometrics research
<http://greenecon.net/wp-content/uploads/2009/10/price.jpg>

Solar Cost!

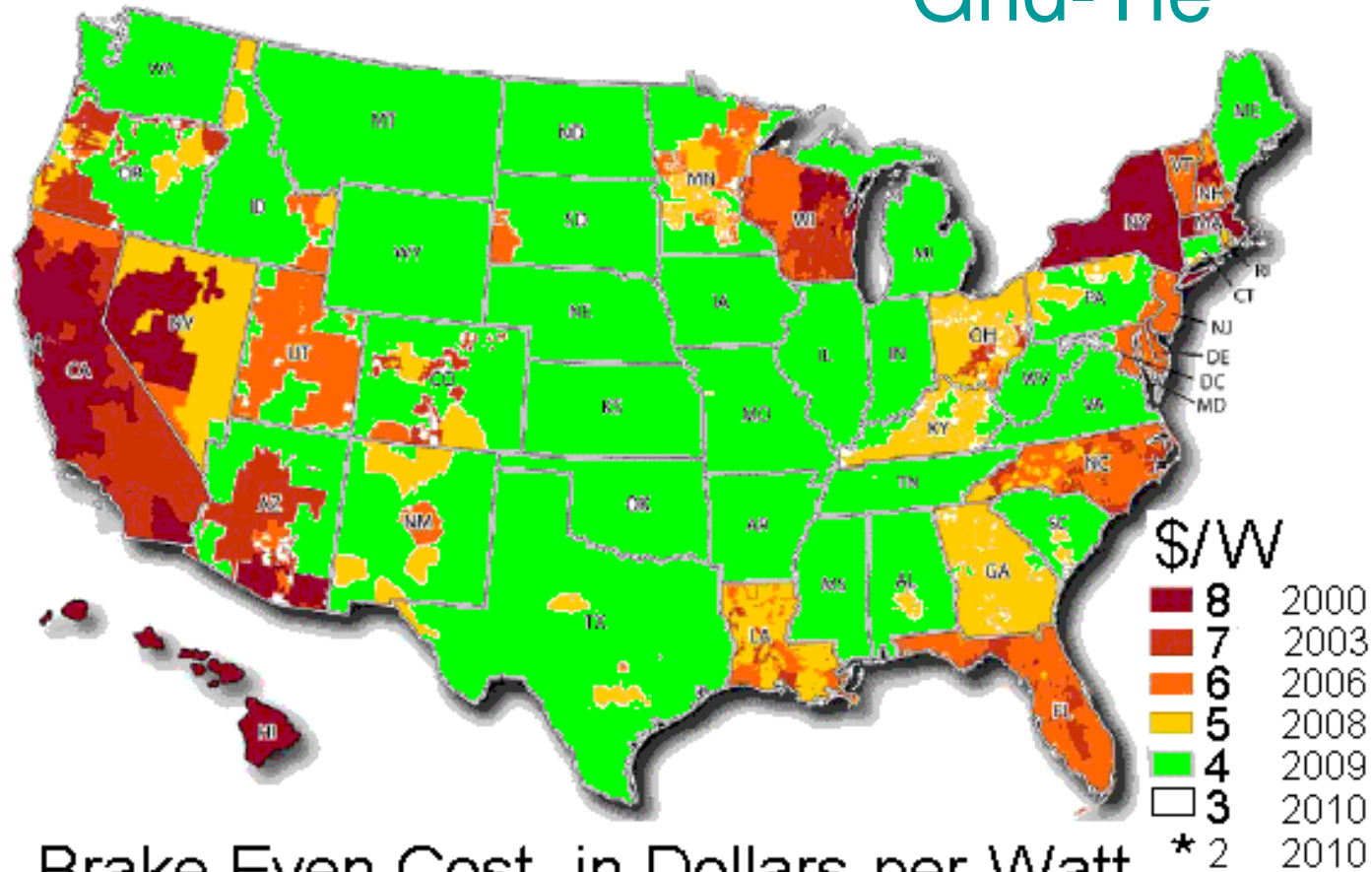


Source: Professor Emanuel Sachs, Massachusetts Institute of Technology.

* Assumes annual production growth of 35% and an 18% learning curve. PV costs based on 18% capacity factor and 7% discount rate.

It's a Whole New World!

Grid-Tie



- Cost effective in EVERY state now!

But first, my Journey to Full Solar!



Bob Bruninga
WB4APR
April 2011



www.aprs.org/alternative-energy.html



My 1st Solar Project

2004 Prius (salvage) with
\$4000 of door/frame damage
200 W added Solar Panels
100 LBs of added Batteries

On display at the IEEE PHEV Symposium in Wash DC 2007.



Gas Mileage ?



1970's view...



Detroit's view!

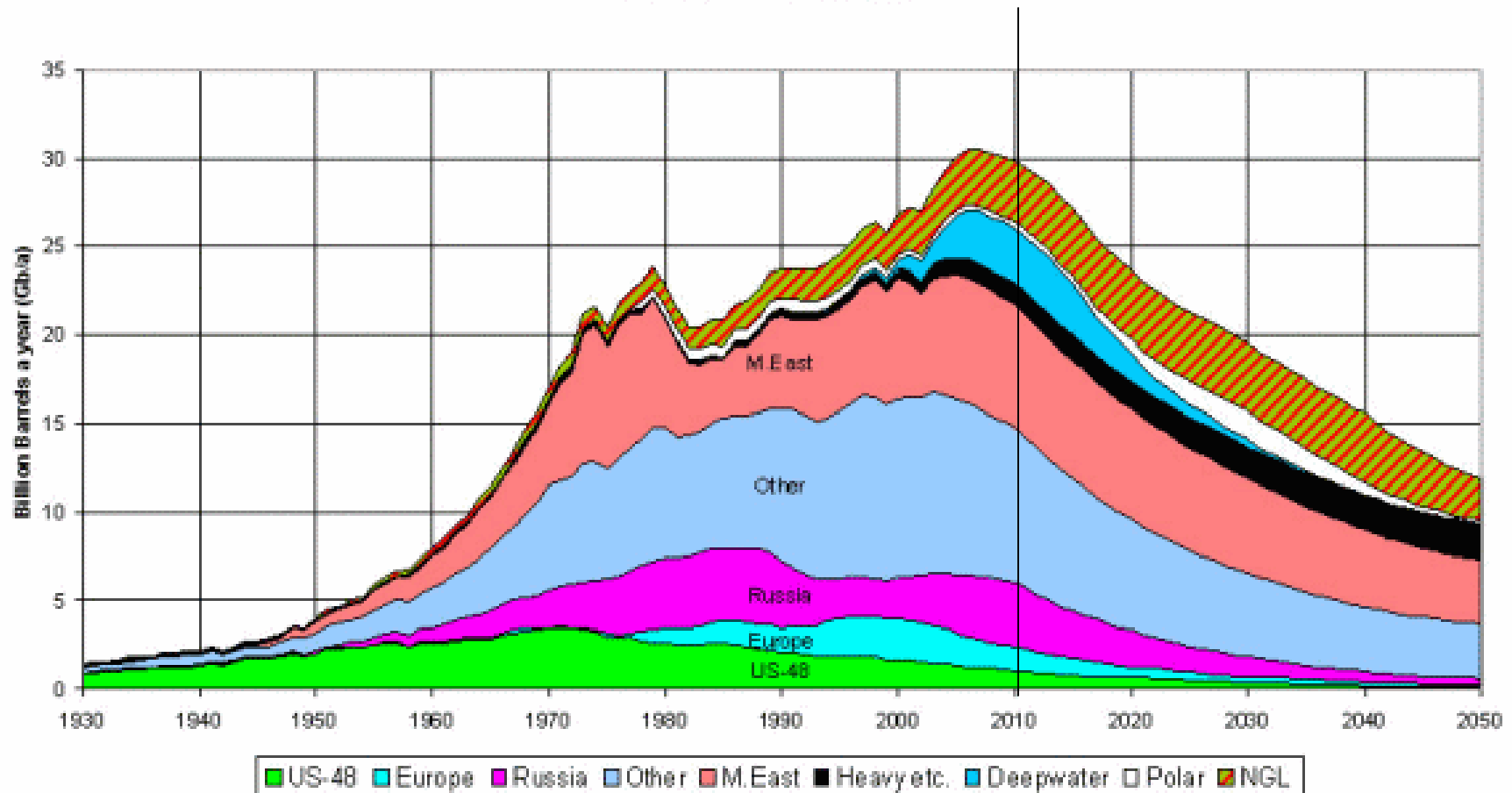
Why Fuel Efficiency?

- Who was key-note speaker to Electric Vehicle Association?
 - Ex-head of CIA
- Why is government interested in Fuel Economy?
 - \$200,000,000 per day for Middle East Oil
 - How many Terrorists does that support?
 - Gas costs us \$400/gallon in Afghanistan!
- We *must* cut our dependence on Foreign Oil!
 - Iraq, Iran, etc
 - Venezuela, Russia

Why Getting off Gas?

OIL AND GAS LIQUIDS 2004 Scenario

“Peak Oil”



What can we do about it?

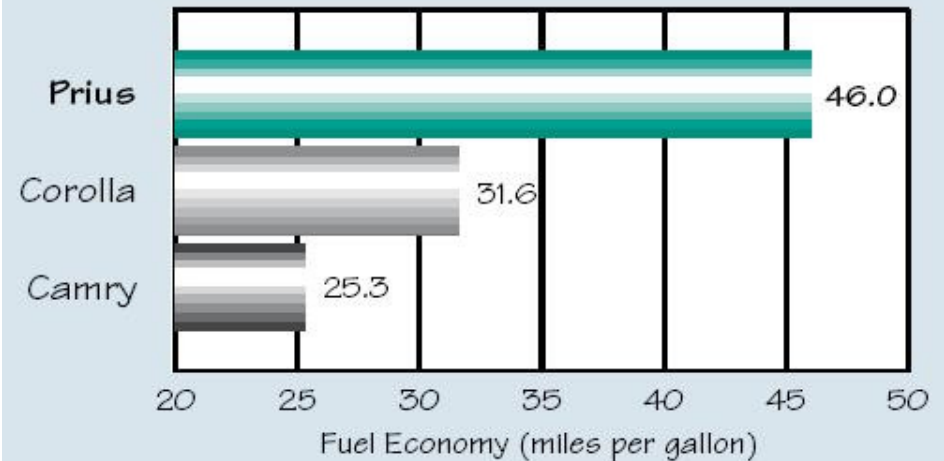
- Last century millions were killed for Salt
 - Salt was a global commodity
 - War-Lords controlled Salt Empires
- What ended their reign?
 - Refrigerators!
- Simple Technology can change Global Empires
- Eliminating our addiction to Foreign Oil is how.
- Electric Vehicles/ Solar can do it!

Electric Vs Oil

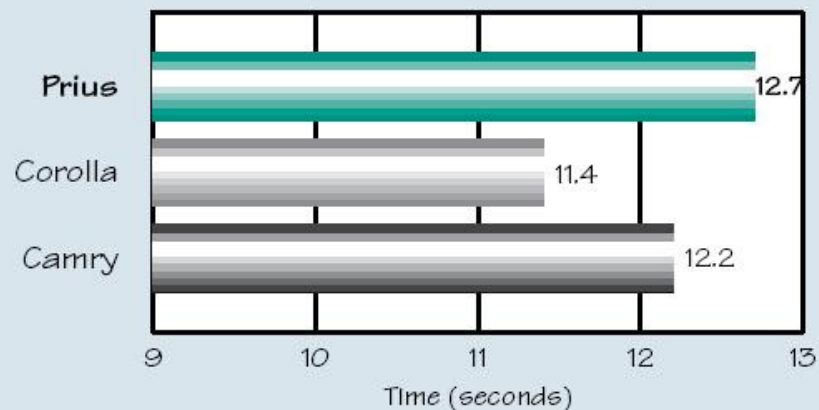
- 70% of our Oil comes from overseas (bad!)
- 99% of our electricity comes from USA! (good!)
- At night we can charge 150,000,000 electric cars for only 7% of the total USA energy grid.
- At night, electricity is cheaper (50% or less) and more plentiful
- During Day Peak demand, electricity costs 10 times more
- But those same 150,000,000 car batteries contain more peak power than FIVE TIMES the entire USA power generating capacity!
- V2G (Vehicle-to-Grid) could offset \$2000 per car in energy savings by letting the power companies buy some back during brief peak demands but still charge your car!

Prius (Hybrid) Comparisons

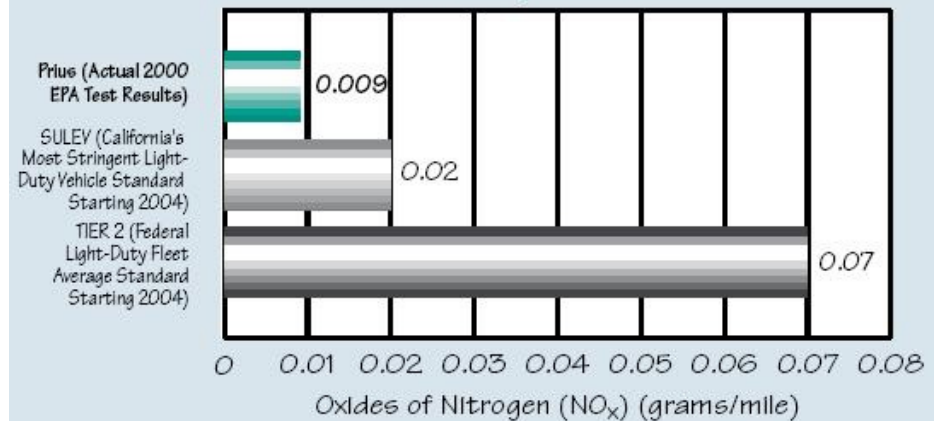
Fuel Economy



Acceleration (0–60 mph)



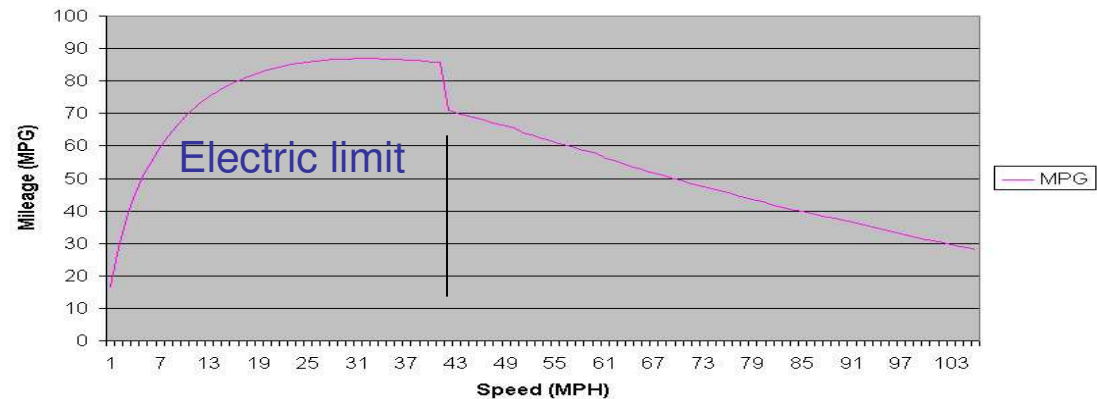
Emissions Comparison *New Car Requirements*



Impact of Speed on Air Drag

- Gas Engine Cars: (it's the brakes dummy!)
 - The main energy waste in town driving is **stopping**.
 - Low power load is where gas engine is most inefficient
 - Hence poor MPG in town, better MPG on the open road.

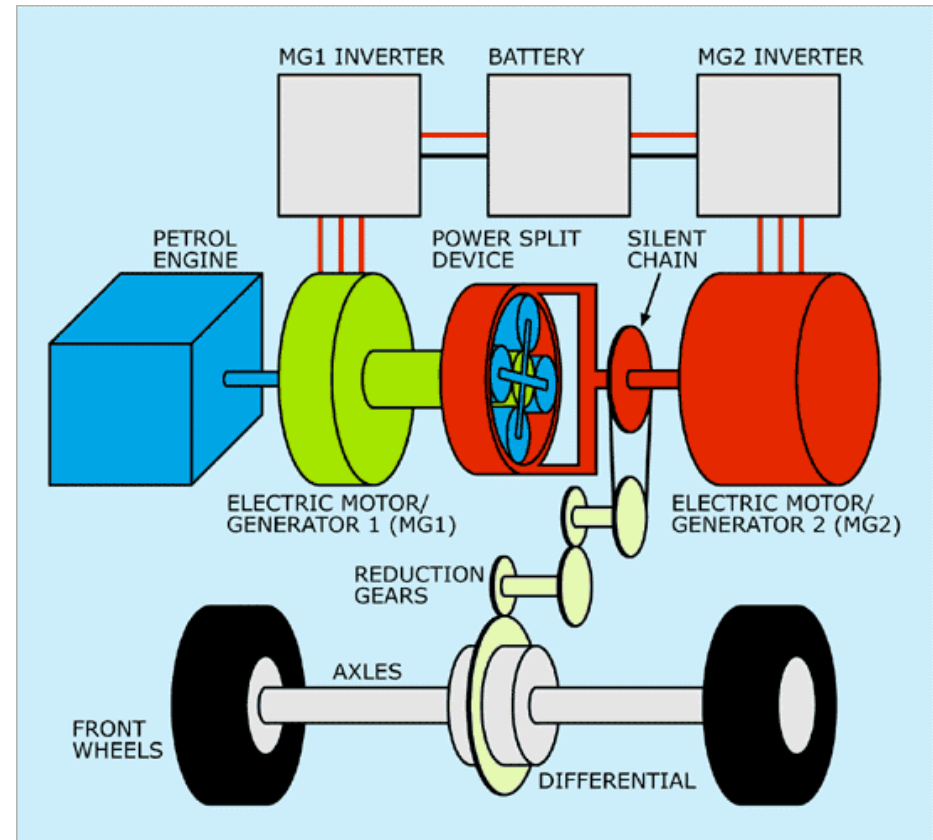
Prius Speed vs MPG



- Hybrid:
 - Regenerative Braking saves most stopping energy for re-use.
 - Electric motors are efficient at low speeds and power
 - Better mileage in town where AIR resistance is lowest.

Prius Motors and Generators

- 76 Hp Engine
- 50 kW Motor/Gen 1
- 50 kW Motor/Gen 2
- Planetary Gear System
- 50 kW Battery (1.6 KWh)



The 50 kW Inverter



Fig. 2.9. 2004 Prius inverter and converter unit.

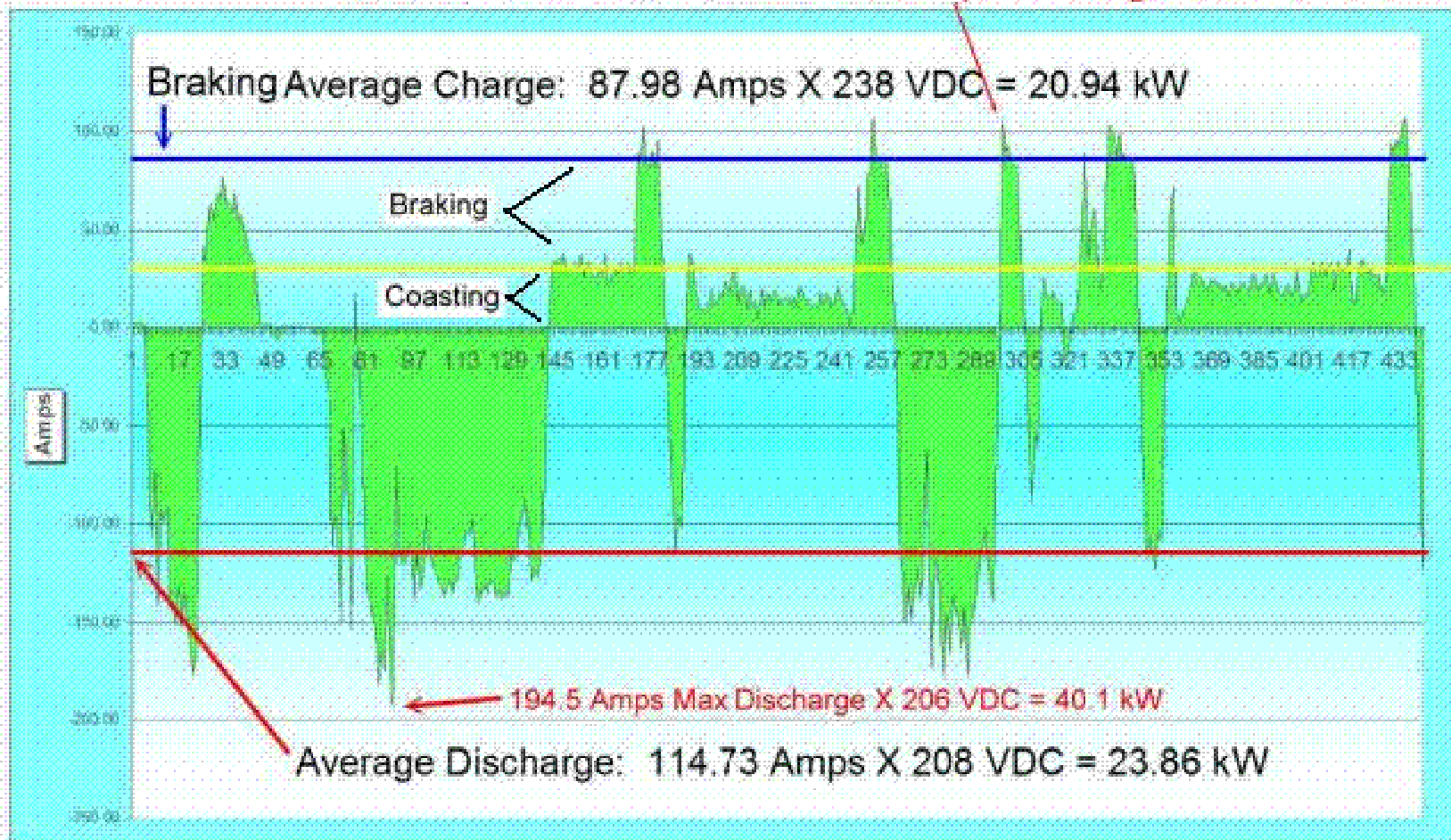
- 220 VDC to 500 VDC
 - 220 VDC to 12 VDC at 100 amps
 - 220 VDC to any motor voltage as needed
- Water cooled

Regenerative Braking

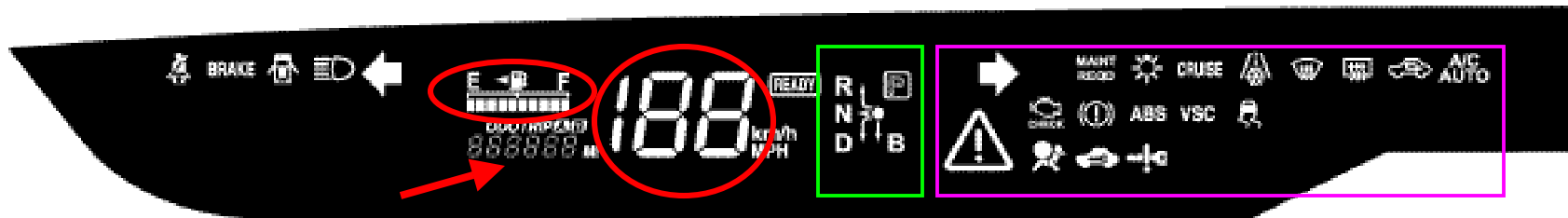
Wayne Brown's Hybrid Simulator

<http://privatenrg.com/>

107.5 Amps Max Charge X 245 VDC = 26.3 kW



Instrument Panel (my complaint)!



'05 Model

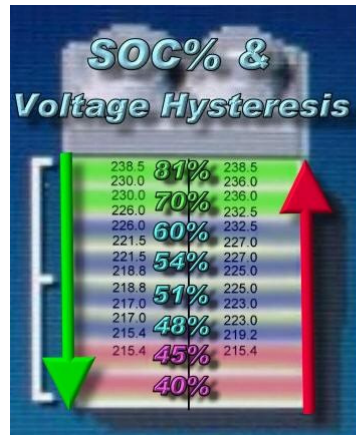
255BE2

- No Tach
- No Vacuum
- No temperature
- No volts
- No current
- No power

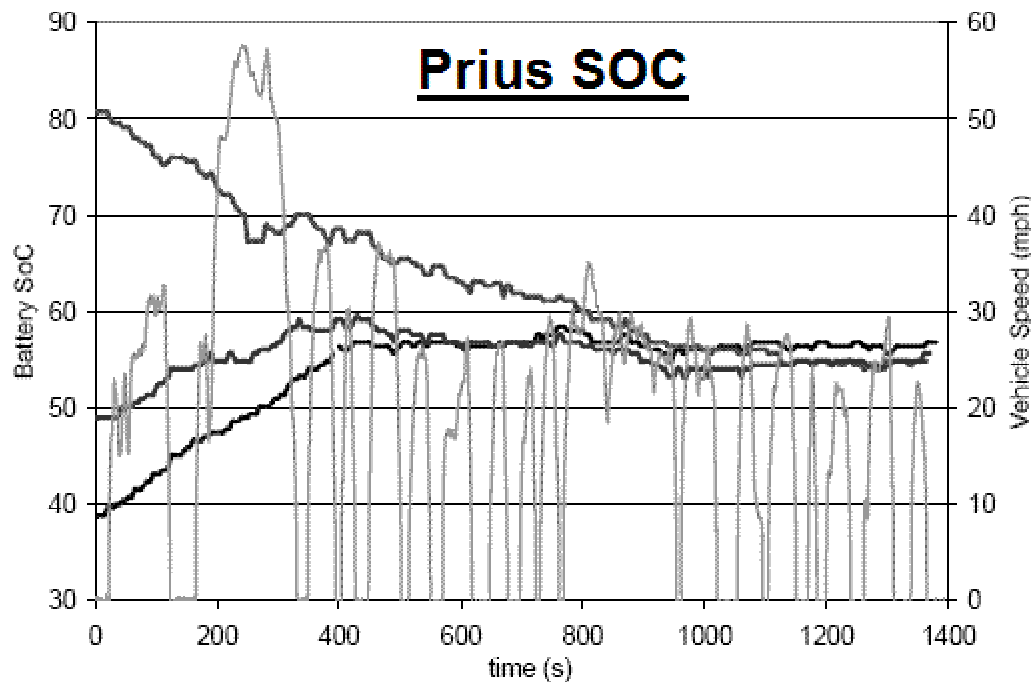
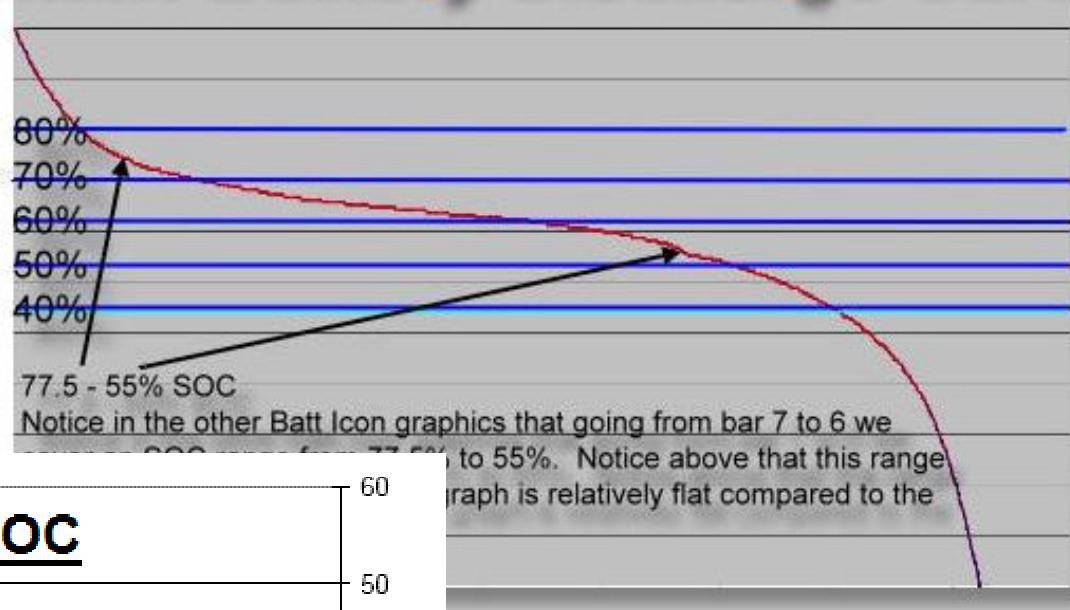
My add-on solution –
an Analog panel



NiMH Battery Discharge Curve



← Target PHEV SOC



Protecting the Battery

Prius likes to keep the battery at 58% charge

My Solar Plug-In Conversion

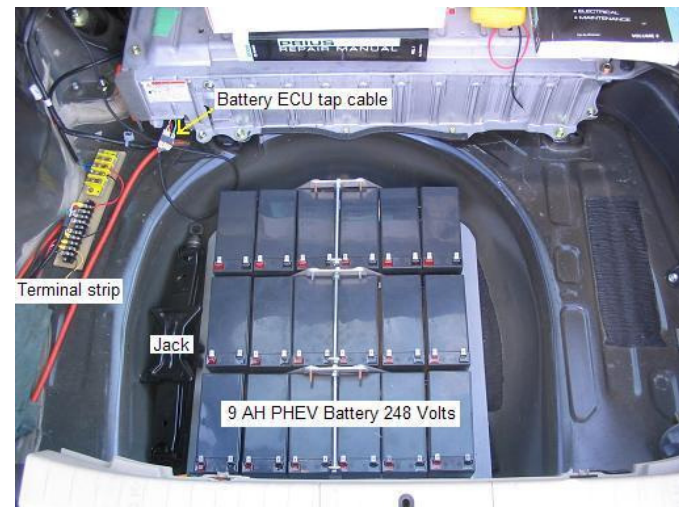


200 Watts of Solar Panels
200 W-hrs per hour in Sun
\$2400 cost.
200 W-hrs per mile needed

Solar power while
parked all day,
gives half my
electric need.

My PHEV battery
only needs to be
half as big for the
same EV range.

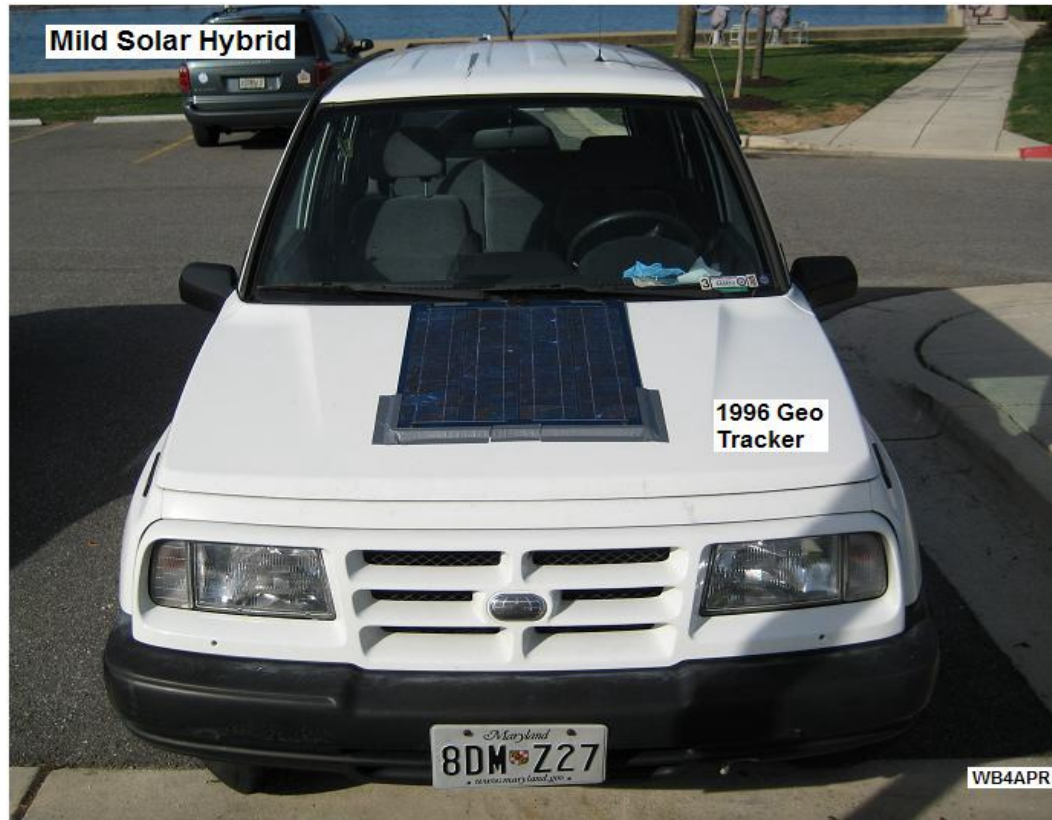
Eighteen 12V batteries
9 Amp-Hours each
225 Volts
2025 Watt-Hours



Solar - 4 Hrs per day. 4 Miles EV per trip. 40 mile commute = 10% improvement

PHEV - 8 Hrs at night. 4 Miles EV per trip. 40 mile commute = 10% improvement

Any Car can Benefit from Electric



- Geo Tracker
- Gains 15% from 26
- to 33 MPG

Disconnect Fan belt (fan, alternator and water pump)

Home Power Generation

Home Solar 4 kW



Gas 4 kW



Wind 5 Kw



Prius 50 kW peak (10 kW average)

Home Solar - I was so wrong!

I've been interested in **solar power** all my life

But never had a real need other than **just-for-fun**

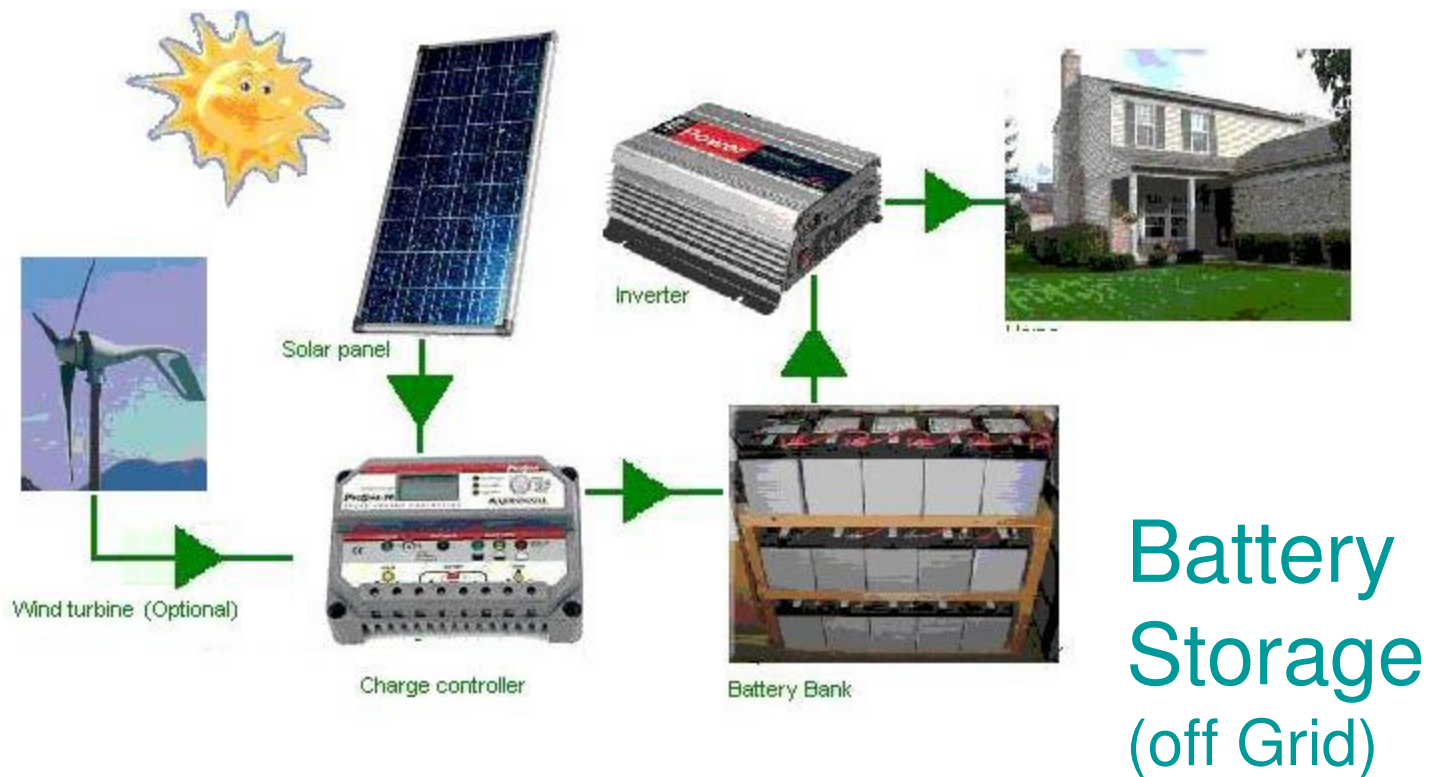
No way was it cost effective

I hate maintaining batteries, especially a house full

Unless you had no other access to power...

I was so wrong!

- My concept of solar power was this:



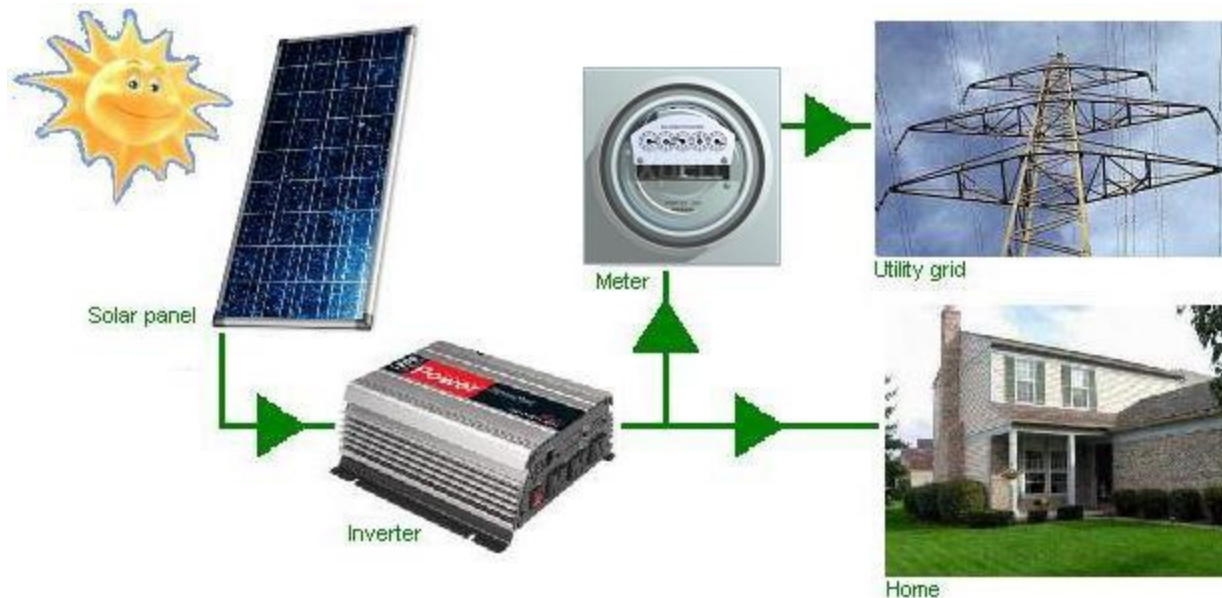
I was so wrong!

- The **problem is the Batteries!**
- My first energy system (1990) was Time-of-Use Metering
 - 2 cent electricity at night
 - 10 cent electricity during the day!
 - Why not charge batteries at night
 - Run from batteries during the day
 - **Result: Breakeven – due to battery replacement every 5 yrs**
- Compared to 2 CENTS at night, **solar never breakeven!**
 - (if batteries lasted 5 years.. Not likely)
- Conclusion...
 - Since solar power is NOT free,
 - seemed impossible to ever break even
 - (due to battery replacement cost)

It's a Whole New World!

- Get rid of the Batteries!

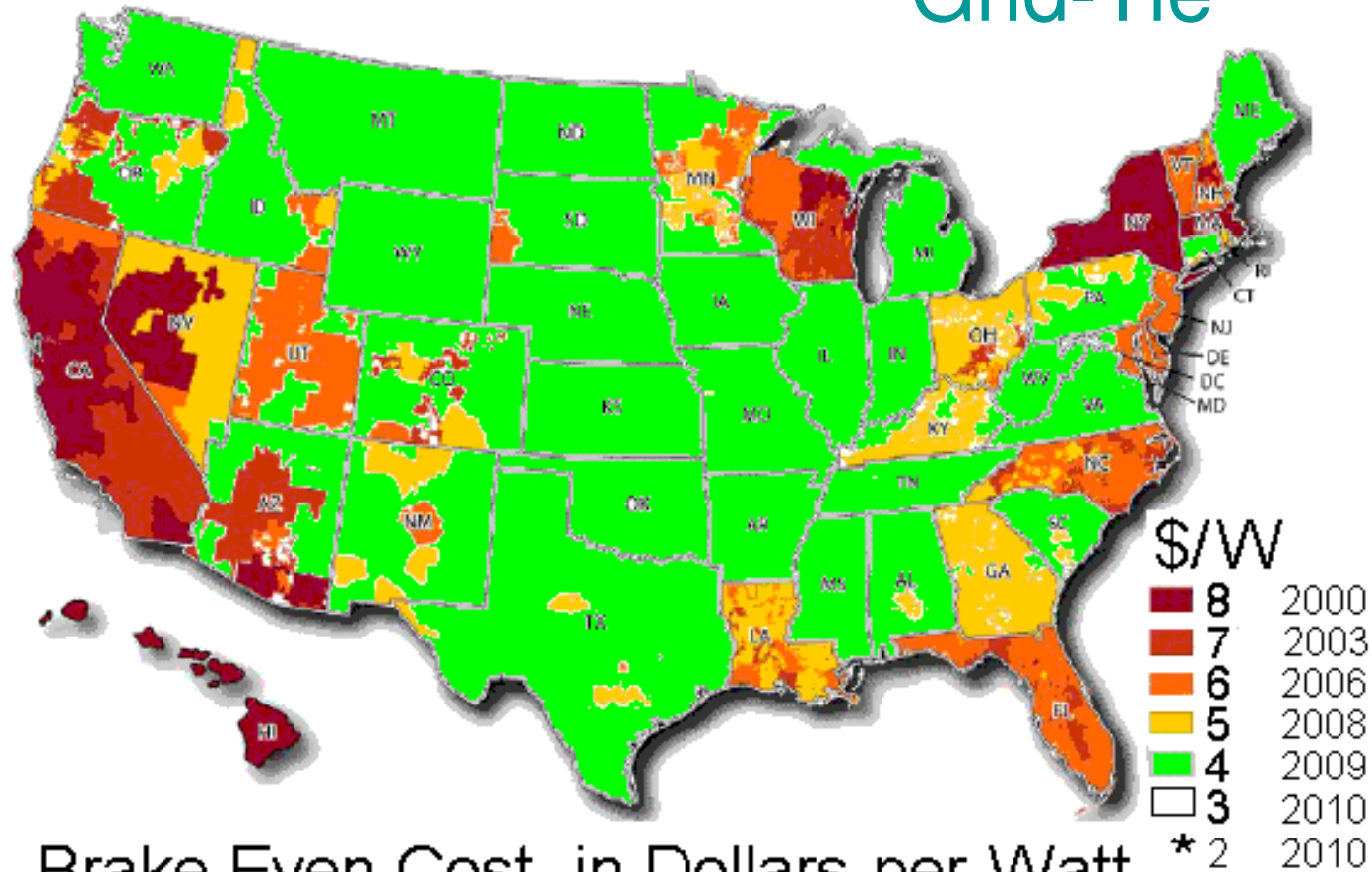
Grid-Tie



- Look AGAIN at the new economics!

It's a Whole New World!

Grid-Tie



- Cost effective in EVERY state now!

Grid-Tie Economics!

- The problem is the Batteries
 - (Only 70% EFFICIENT)!
 - Grid-tie IS 95% EFFICIENT! Improvement (factor of 1.35)
 - No battery replacement costs \$1000 per year (factor of 2)
- Economics in 2010 compared to 2007
 - Electricity cost has doubled! Factor of 2.0
 - Solar panels cost has halved! Factor of 2.0
- Therefore It's 11 times better NOW to go Solar
- But Wait, there's more!
 - Government Incentives!



Grid-tie
inverter



Government Incentives!

- Federal gives 30% tax credit. No limit
 - As much as \$15,000 right into your pocket
 - Factor of 1.43!
- State of Maryland Grant
 - For my 8kW system that's a \$7000 check in my pocket
 - \$1.25 / W for first 2 kw, \$.075 / W for next 6 kW
 - Factor of 1.3
- AA County Real Estate Tax credit
 - up to 50% of total remaining after above (Maybe \$3000)
 - Factor of 1.13
- Total Gov't Incentive Factors = 2.0



x21633867 fotosearch.com



Total Cost Factors!

- Grid-Tie versus no Batteries
 - Better by Factor of 2.7!



x21633867 fotosearch.com

- Economics of Electricity and Solar
 - X 2 (for higher rates) X 2 (for lower costs) = Factor of 4

- Tax credits and incentives
 - Factor of 2



- CONCLUSION: It makes 22 times more sense to go solar now than it did 3 years ago (if you think in terms of Battery Storage systems (typical for hams) like I did).

But there's more!

(Return on Investment)

- **Solar Energy Credits (sell your Green energy credits)**
 - About \$250 /year /KW 10% return/yr
- **Electric Bill**
 - Free Electricity for life 10% return /yr
 - Cost of 0-net-grid-tie - 5% cost /yr
 - (you still have to pay about \$10 fixed costs even if you use no electricity)
- **Maintenance**
 - Practically zero

Total Return on Investment... about 12% per year

Compare that to the banks (2% ?) or stock market (- 30% ?!)

PLUS: your 12% only goes up as energy costs go up!

But there's more!

(Do it yourself!)

- Commercial system: \$25,000 for a 4kW system?
- Cost of solar panels \$12,600 (18 at \$700 vs \$1000)
- Cost of inverter \$2100 versus \$3000
- Cost of wire, disconnects, breakers, etc \$200
- Cost of Master Electrician to certify system \$200
- TOTAL about \$15,000

Savings (DIY) \$10,000

Tax credits, Grants, SREC's etc \$ 7,500

NET COST TO YOU... \$ 7,500

Pays for itself in 4 years. Then FREE POWER for LIFE!

But I'm a ham!

I want Battery Backup...!

- Why?....
- At what cost? **\$12,000?**
- For the **2 hours** every 2 years you lose power?
- For the **2 days** you lose once every 10 years?
- Makes practically zero economic sense!
You pay about **\$240 / KWH** over 10 years (compared to **\$0.12**)
(2000 times more!)

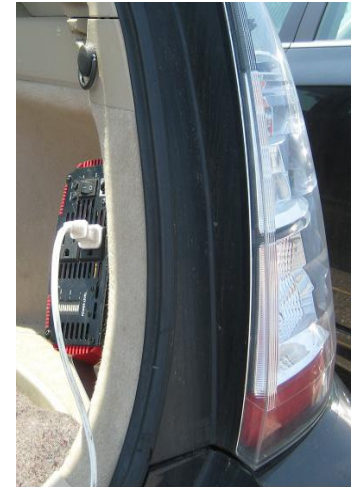


But I'm a ham!

I want Battery Backup...!

You can have it!
EASY AND CHEAP!

\$ 120



- Spend **\$120** for a 1200 Watt Inverter
- Hook to your car battery
- Power Refrigerator and lights in your house for days!
- You do use CFL bulbs, right?

But I'm a ham!

You do use CFL bulbs, right?



Down to \$1 each

25% of the power!

10 times the life

+ Air Conditioning
savings of 5%!

= 5:1 savings!

EER of 1-to-1

is 3.412 BTU/ watt. So
with EER of 10, 100W
bulb takes 30W of AC!

Use of Piers for Solar/Wind prohibited

APRIL 16, 2010

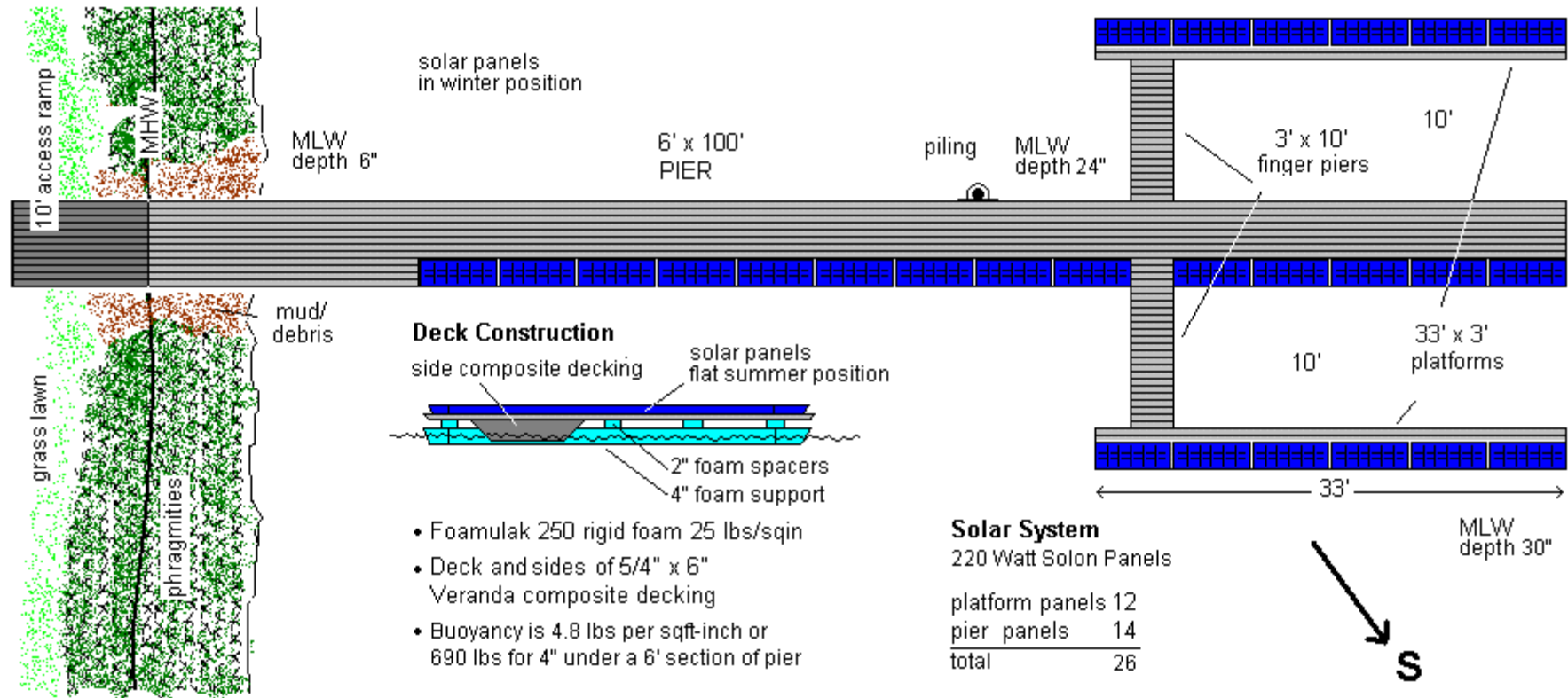
Solar pier plan hits regulatory reef



Tim Wheeler reports on the environment and Chesapeake Bay. A native of West Virginia, he has focused mainly on Maryland's environment since moving here in 1983.



Use of Piers for Solar/Wind prohibited



- Rejected by MDE due to Pier Laws

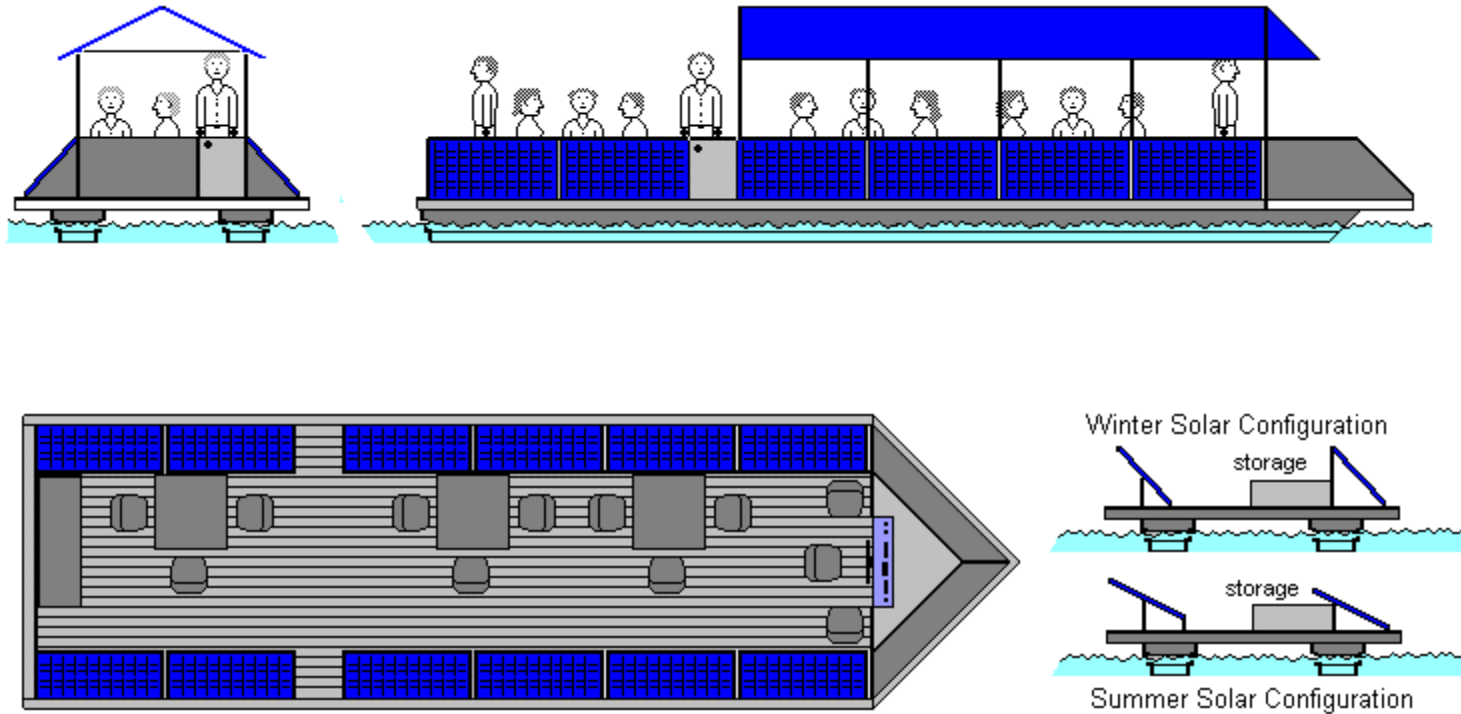
Solar Pier Argument



- My house uses
10 MWHrs / yr
- Coal Plant (for me)
produces:
 - 22,000 Lbs CO₂
 - 350 lbs sulfur dioxide
 - 1 Oz Uranium and Thorium
 - .02g of Mercury

With 10 KW Array, pollutes Zero.

2.8 kW Solar Boat Work-around



- Approved by DNR as Boat under 26'

Efficiency must $> 80\%$

To get
Gov't
Credits

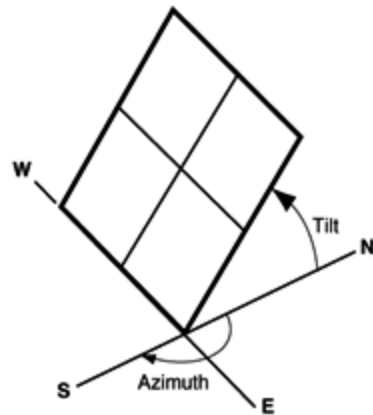


Free Home
Estimate
includes
sky
survey

No Shadows allowed for 6+ hours per day

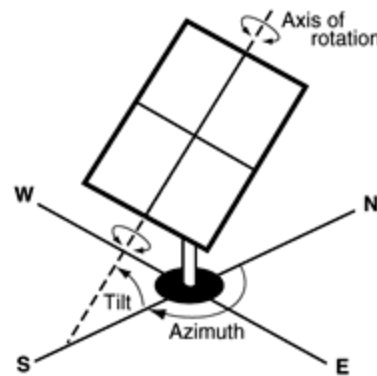
Efficiency using PVwatts

Grid-Tie implies surprising results!



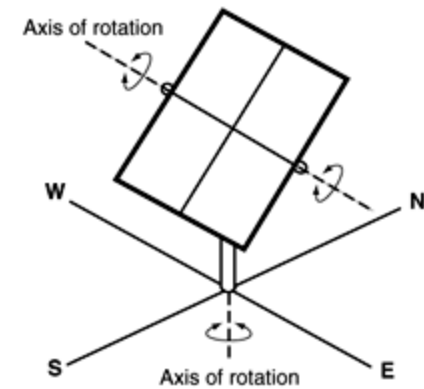
PV array facing south at fixed tilt.

100% South
94% SE
96% SW
85% FLAT!



One axis tracking PV array
with axis oriented south.

120%



Two-axis tracking PV array

125%

(battery system 65% worse and must be South)

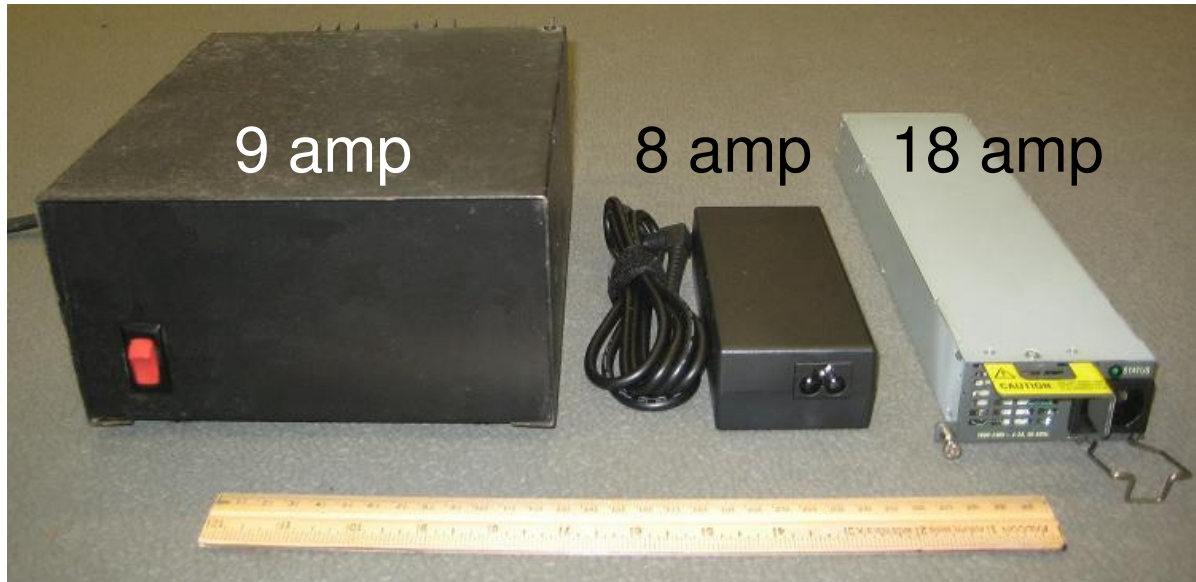
Portable Power Generation

350 W aux power
1200W AC inverter
\$120



Invert to 115 VAC
For distribution
➤ 95% efficiency
➤ Saves 100:1 in wire losses

Modern Power Distribution

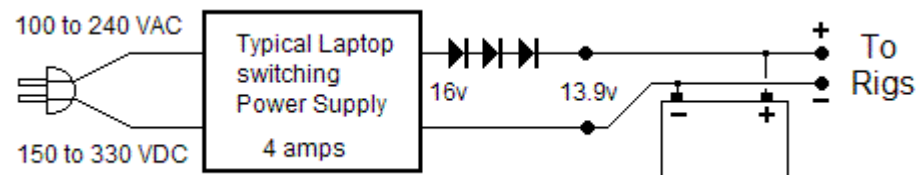


Power
Systems
have
CHANGED!

Switching supply takes up **8% of the space**

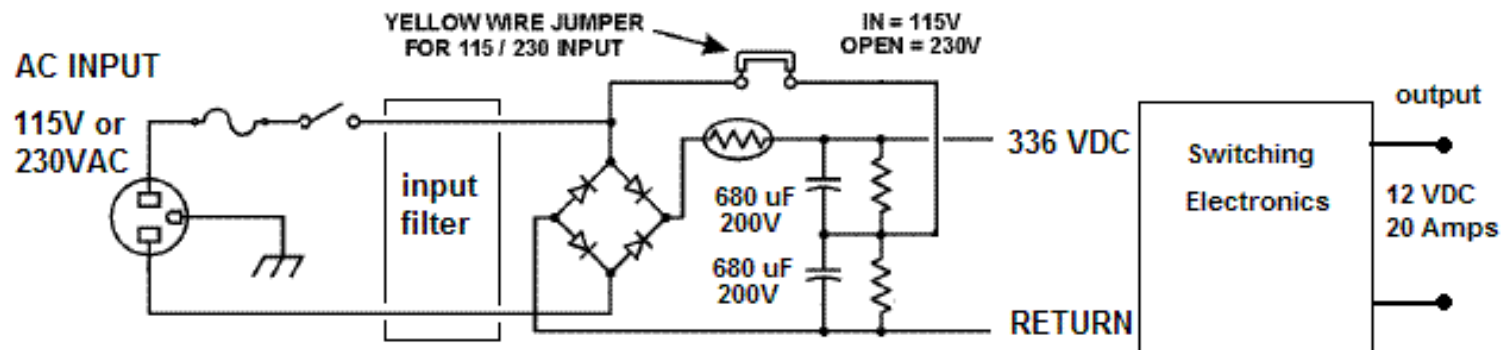
and only **10% of the mass** and works 100-240 VAC

AND 150-330 VDC



Power Distribution 330 VDC

Nearly ALL modern switching supplies will run on VDC



Almost all dual-voltage switching power supplies use this kind of input circuit. The single jumper or 115/230 volt switch converts the supply for use on 115 or 230 volts. On 115 volts AC, the capacitors and diodes act like a 60 Hz Voltage Doubler to give operating voltage of over 300 volts DC to the switching circuitry.

With the jumper removed, the 220 VAC is simply rectified to directly give the + 300 VDC.

On 220 VDC the switching circuitry will work directly, but probably with only 2/3rds of the overall output capacity.

Double to 230 VAC at source

Rectify to 330 VDC for delivery

Eliminate 75% of

Distribution losses

Power Distribution 330 VDC

Nearly ALL modern switching supplies will run on VDC



Kenwood 115 VAC only supply
Actually has internal jumper

Eliminate 75% of
Distribution losses

Power Distribution ? (the challenge)



Power Distribution - SWER



with Rorie KC2UML
later at the top



Governor Dick Hill
Equipment and

WB4APR
WA4APR
WE4APR

Double to 230 VAC at source
Rectify to 330 VDC for delivery

Single
Wire
Earth
Return

3200'
from car
to top

Not
approved
by NEC

Power 3200' from car - SWER



Single
Wire
Earth
Return

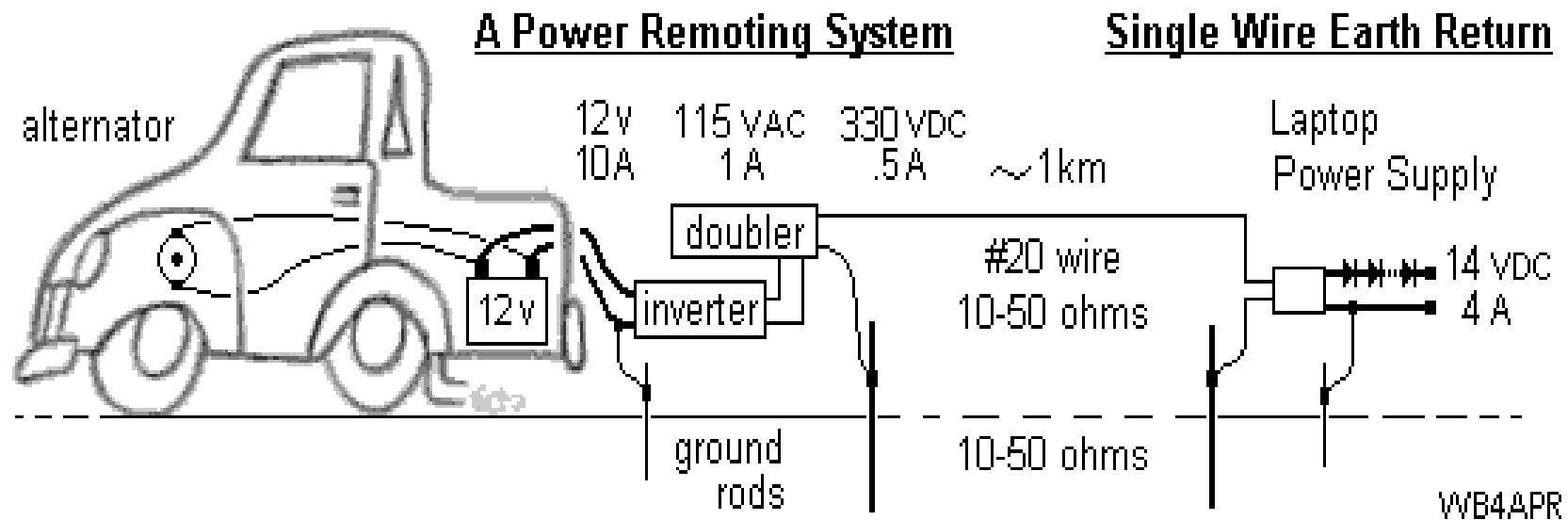
3200'
from car
to top

Not
approved
by NEC

2 Laptops, 50W dual band, 2 HT's and APRS – 6 Hours

Power Distribution SWER

Emergency Power: Use Single Wire Earth Return



Double to 230 VAC at source
Rectify to 330 VDC for delivery

Not approved by
NEC

Power Distribution SWER

Emergency Power: Use Single Wire Earth Return

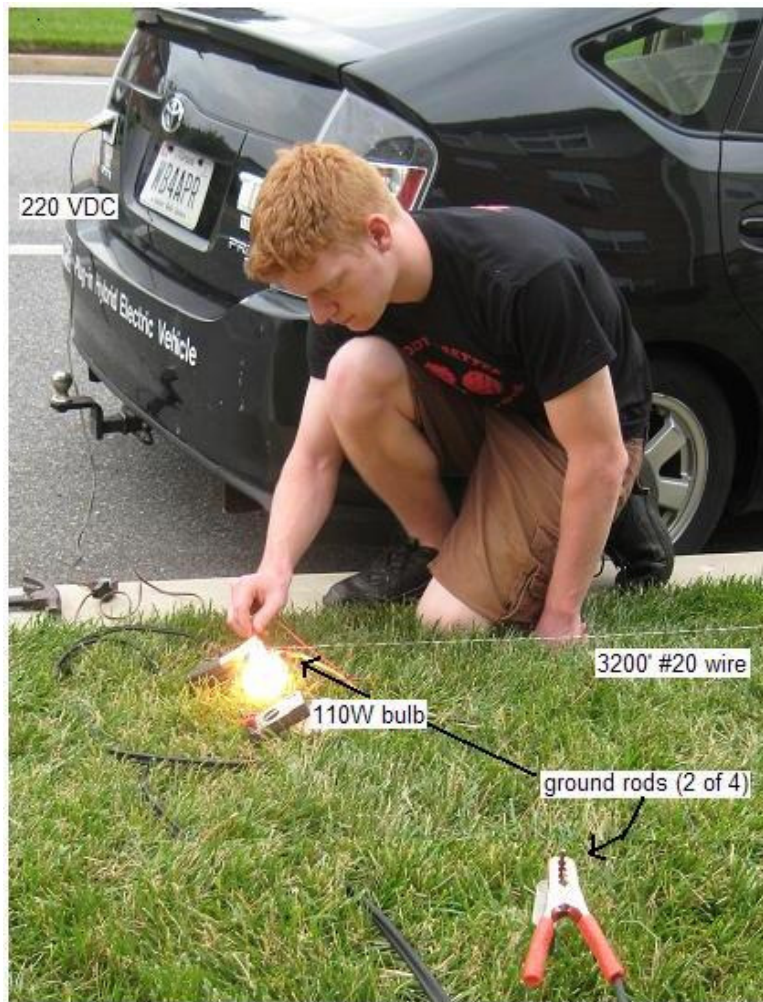


Left to right: 12v Inverter to 115 VAC, Doubler to 330 VDC, 3200' wire, Outlet box, Laptop Power Supply 18v at 4.5 amps.

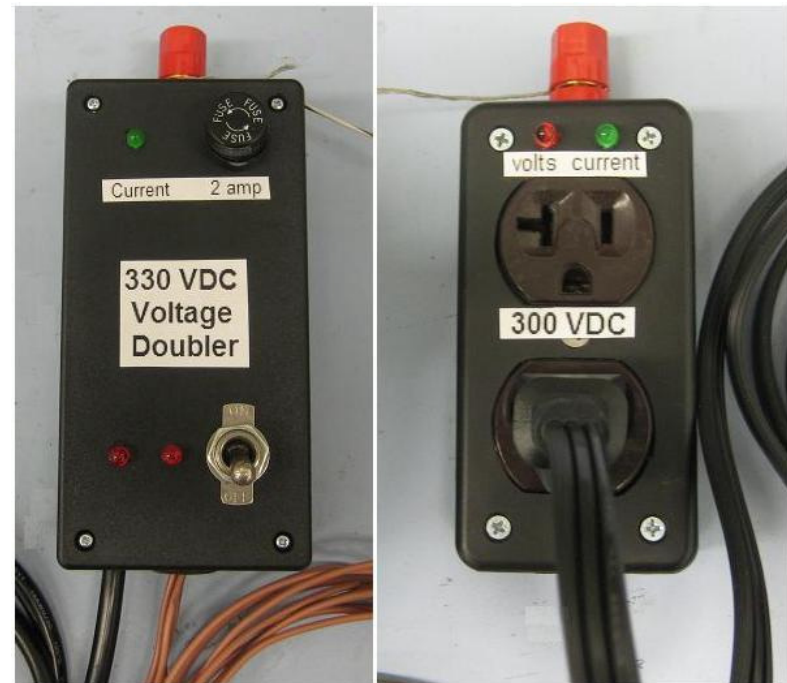
3200' system fits in laptop bag

Not approved by NEC

Power Distribution – SWER (initial test)



Emergency Power: Use
Single Wire Earth Return



Not approved by NEC

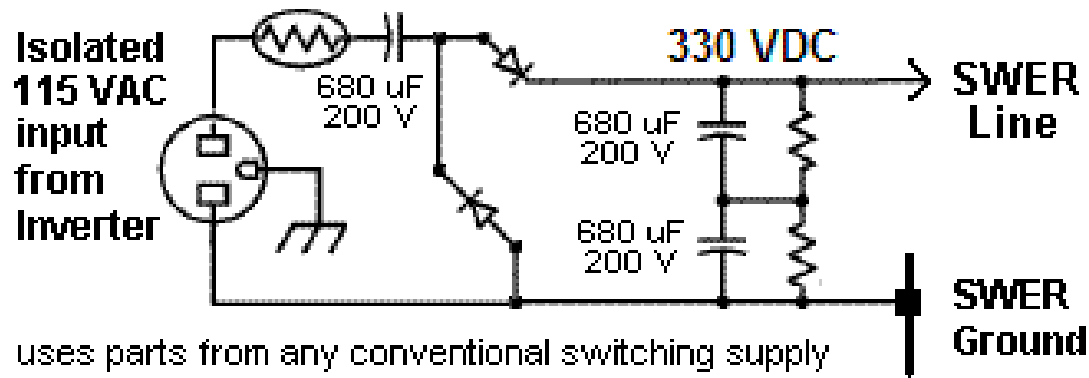
Power Distribution SWER

Emergency Power: Use
Single Wire Earth Return

Not approved by NEC

Type of soil	Earthing resistance		
	Ground electrode depth (meters)		
	3	6	10
Very moist soil, swamplike	10	5	3
Farming, loamy and clay soils	33	17	10
Sandy clay soil	50	25	15
Moist sandy soil	66	33	20
Concrete 1:5	-	-	-
Moist gravel	160	80	48
Dry sandy soil	330	165	100
Dry gravel	330	165	100
Stoney soil	1000	500	300
Rock	-	-	-

http://www.newark.inone.thinkhost.com/brands/promos/Earth_Ground_Resistance.pdf



DC Power Distribution



50 kW peak (10 kW average)



Safe, cheap connectors

(Modified to prevent incorrect use.)



Greater distances

At half the current

At twice the power

#18 zip cord can carry 1000 watts easily

Salvage Prius Toys



- 2004 in 2007
- Cost \$10k
- 29k Miles

\$2000 of solar panels



Other Salvage Prius Toys



P2

2005 in 2008
\$7k, 19k miles

2005 in 2010
\$6k, 90k miles



P2

Prius Hotel



P3

Main Photo