

# Energy Choices and Emergency power for the Ham

RATPAC  
12 Nov 2020



# ARRL Book - Power and Energy!

## Take advantage of a new world of power and energy.

Revolutionary changes are taking place in the way we produce and consume power for our homes, transportation, and the technology that we use every day. This book explores the ongoing changes in the world of power and energy, and takes a careful look at the choices we can make. Home solar or utility power? Oil/gas heat or electric heat pump? Gas car or hybrid/EV?

*Energy Choices for the Radio Amateur* details the author's experiences with new sources of energy. It is intended to help other radio amateurs and DIY hobbyists prepare for the inevitable major energy decisions they will face—choices that can contribute to a reduction in fossil fuel use and save money in the long run. The concepts presented in this book not only satisfy everyday power requirements, but also can help prepare for emergency and backup power at home and in the field.

### Chapters include:

- The New World of Everyday Power (DC)
- The Solar Power Revolution
- Choosing Your Home Solar System
- Solar DIY at Home and in the Field
- New Energy Sources of Radio Frequency Interference (RFI)
- Electrification of Transportation
- Electric Vehicle DIY Projects
- Conventional Backup and Emergency Power
- High Voltage DC Emergency and Backup Power
- The Powerwall and Grid Battery Storage for Home
- Life's Major Energy Milestones
- Making the Switch to Clean Renewable Energy
- Amateur Satellites and Thermal Energy Balance
- How Our Energy Use Shapes Our World Today

ARRL Life Member **Bob Bruninga, WB4APR**, has had a lifelong interest in energy, as well as Amateur Radio. In addition to developing the Automatic Packet Reporting System (APRS), his interest in energy technology has led him to embrace home solar, electric vehicles, heat pumps, and other advances that have greatly reduced his family's dependence on fossil fuels.

### About ARRL and the Amateur Radio Service

Amateur (Ham) Radio provides the broadest and most powerful wireless communications capability available to the private citizen anywhere in the world. The principles of this federally licensed radio service include public service, radio experimentation, training, and international goodwill. ARRL is the national membership association for Amateur Radio operators in the US. ARRL has books, software, online content, and other resources for licensing, operating, and lifelong learning.



The national association for  
**ARRL AMATEUR RADIO**<sup>®</sup>  
225 Main Street, Newington, CT 06111-1400 USA  
[www.arrl.org](http://www.arrl.org)



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Energy Choices for the Radio Amateur



Bruninga

# Energy Choices for the Radio Amateur

## Your Power Sources in the 21<sup>ST</sup> Century

Bob Bruninga, WB4APR



# May QST- Power and Energy!

Bob Bruninga, WB4APR, wb4apr@arrl.net

www.arrl.org QST May 2019 1

## Eclectic Technology

### Your Own Microgrid

The popularity and economy of residential solar power has been increasing in large part thanks to *grid-tie* (GT) *inverters* that deliver solar-generated power directly to the home without the need for storage batteries. They do this by maintaining a constant balance between the electricity available from the solar panels and the electricity available from the commercial power grid, switching back and forth as needed.

#### Three GT Inverter Types

A *string inverter* accommodates up to 14 solar panels in series to a maximum of about 400 V, where lower currents allow common #12 wiring.

Fortunately, SMA Sunny Boy GT string inverters, and possibly others, offer 15 A, 120 V ac *secure power outlets*, as shown in Figure 1. A *grid-down switch* allows power to be redirected to this outlet from an alternative source.

#### Making a Microgrid for Emergency Power

Solar panels are the obvious alternative if the sun is shining, but at night or on cloudy days, the inverters could still provide ac power to this outlet from a hybrid car or electric vehicle (EV) battery. Hybrids, with their 50 kW generators, can automatically run their engines as needed to meet any long-term power draw. Although EVs don't have generators, their orders-of-magnitude-larger batteries can provide emergency power for days or even a week. Plus, an EV can be recharged from the solar panels during the day and provide both transportation and nighttime electricity almost indefinitely.

This combination of GT-inverter-based solar power and battery storage, provided by a hybrid vehicle or an EV, can be an economical solution for the amateur who wants the benefits of solar power with a secure



Figure 1 — A grid-tie string inverter with a grid-down secure power outlet on the right.

backup in case commercial power fails — in other words, an independent micro power grid. Of course, this *microgrid* idea only works with string inverters that have secure power outlets and cannot be done with microinverters or optimizers.

See the author's new book, *Energy Choices for the Radio Amateur*, available from your dealer or from the ARRL Store at [www.arrl.org/shop](http://www.arrl.org/shop).

# Six Disruptive Technologies in Energy/Power

1. Universal P.S. 100-240 VAC = 100-330VDC
2. LED Lighting Everywhere
3. Solar Power now cheaper than Coal and gas
4. Hybrids – 50 kW generator in your driveway
5. EV's now Better, Faster, Cleaner, Quieter, Safer, Cheaper to buy, Cheaper to Operate, Cheaper to maintain than average gas car
6. Whole house Battery Backup – Power Wall
  - What's in Common? HVDC!

# Energy – More than a Hobby!



It can save  
**MONEY!**

[www.aprs.org/alternative-energy.html](http://www.aprs.org/alternative-energy.html)

# The Saga of The Elect-Reck



1970

# My Background

Energy!

←1965



1983



2010



1990



2012



2007



2013



2017



2009

# Emergency Power and Energy!



Emergency Response depends on Power & Energy!

It's a whole new world of Power

# WB4APR (APRS)



Field Day\* \* \*

Satellites

If you want some **SERIOUS**  
portable power,

**Think EV!**

Every hybrid has **50 kW** generator



A plug-in EV has from **16 to 85 kWh** of Battery Storage!  
And can power a house for a week or a month



SERIOUS  
Battery power

Leaf  
40 kWh



3 year old off-  
lease used is  
only  
\$9,000

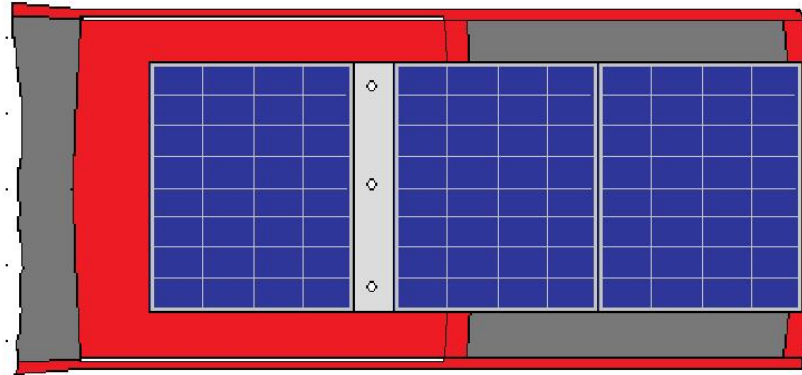
Bolt = 60 batts

Same as 3 Tesla Power walls costing \$21,000

# Emergency Power – CQ, October

## Back to the Future FrankenVolt

240 Watts and +5 cuft capacity



240 Watts for portable operations

Gains 30 mi per  
week



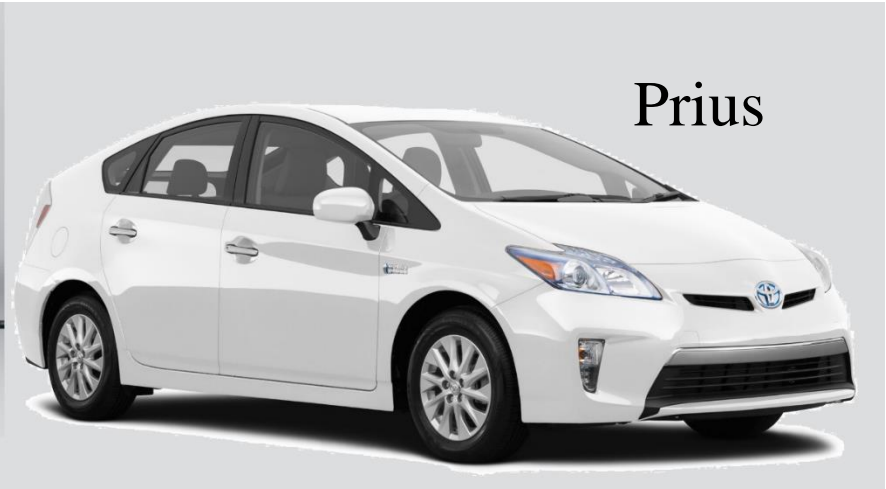
Trunk still opens normally



Total impact on car is 3 pieces of plywood

# SERIOUS Generator Power

Plugin Hybrids = 50 kW generator



Plug-in Hybrids have at least 50 kW generators.

Can power a house for a week or a month

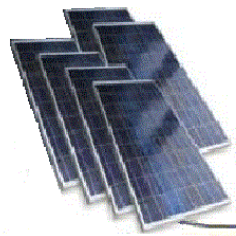


Chrysler Pacifica Minivan

Same as 1 Tesla Power wall costing \$7,000 + Generator!

# Solar and EVs – The Perfect Marriage

## 12 Panels (\$1200)



Prius



Pacifica Minivan

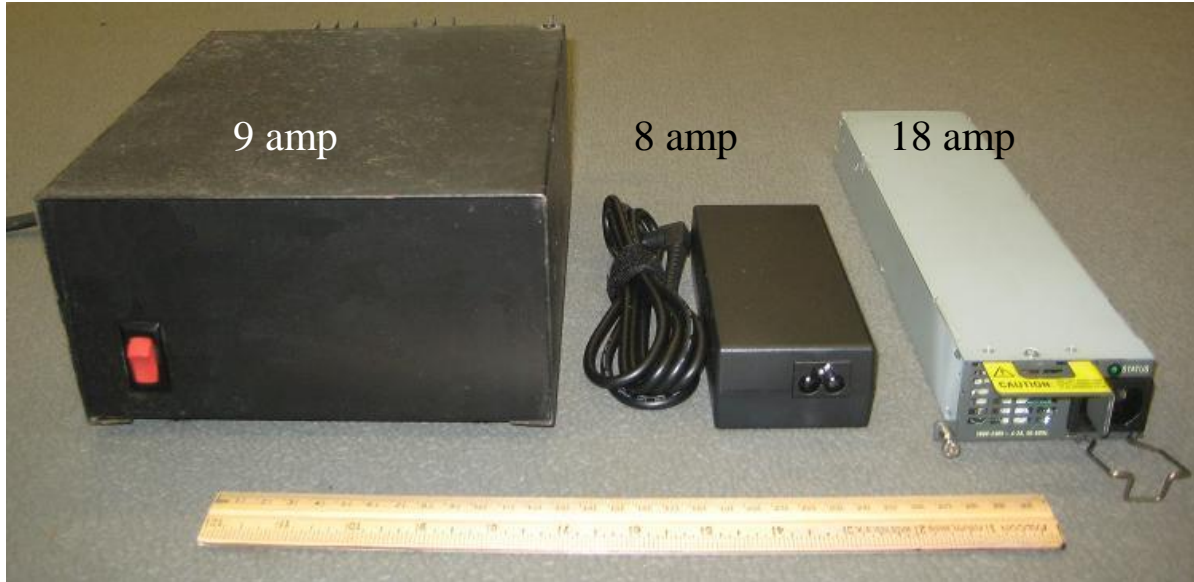
Can fully charge a **plugin**  
everyday... **FOREVER!**

No more \$2,000,000,000 per day for overseas oil

No more foreign **dependence**, no more **price fluctuation**

No more **oil**, no more **insecurity**, no more **oil wars**

# It's a new world of Power

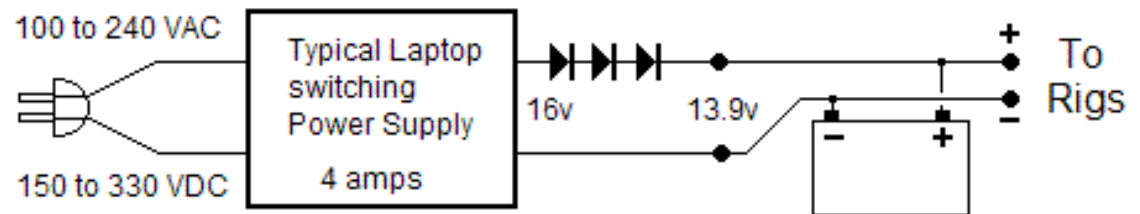


Power  
Systems  
have  
**CHANGED!**

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

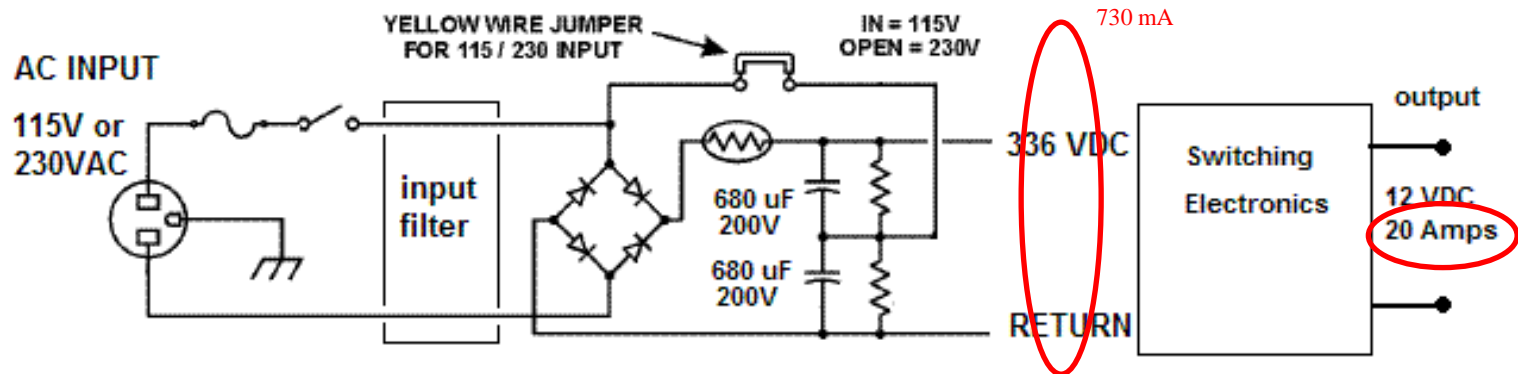
and only **10% of the mass** and works **100-240 VAC**

**AND 70-330 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.

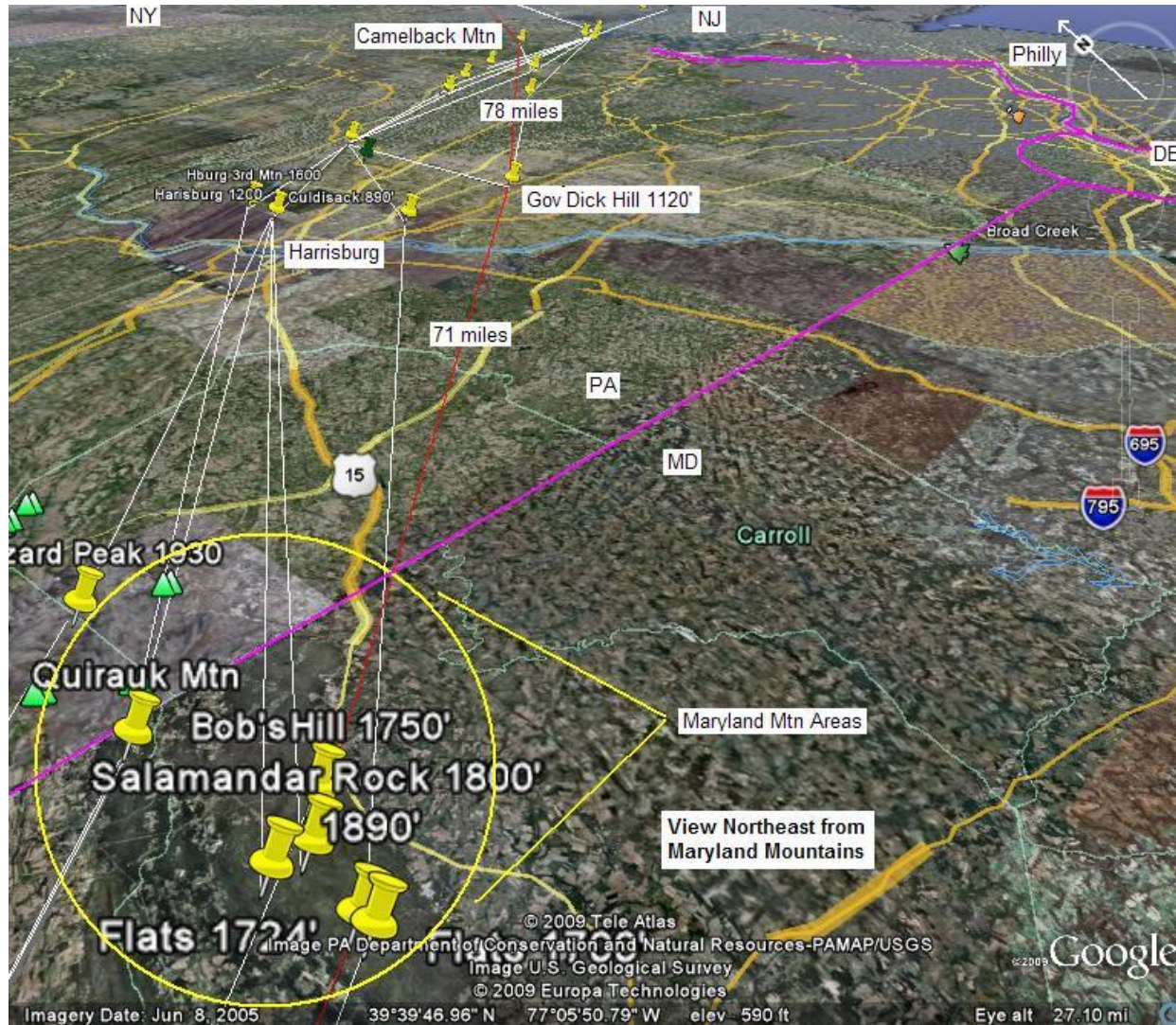
Doubles 120 to 230 VAC

Rectify to 330 VDC for delivery

Eliminate 75% of

Distribution losses

# Field Example - Golden Packet Event



**21 July  
2018**

**14 Hops  
Maine to  
Georgia!**

**SUCCESS!  
26 July  
2014**

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

# Example: Power Distribution



**Problem:** 6 Hr event from Hill top 3200' from car

# Power Distribution SWER

Emergency Power: Single Wire Earth Return



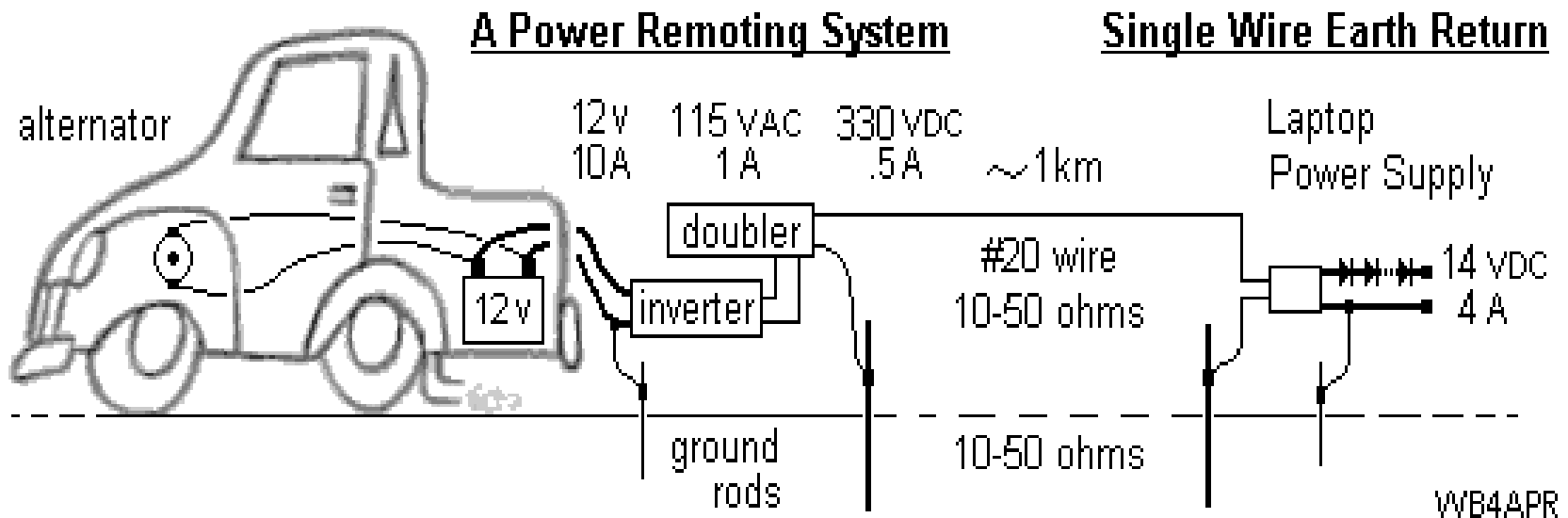
Left to right: 12v Inverter to 115 VAC, Doubler to 330 VDC, 3200' wire, Outlet box, Laptop Power Supply 18v at 4.5 amps.

3200' system fits in laptop bag

Not approved by NEC

# Power Distribution SWER

Emergency Power: **Single Wire Earth Return**



Double to 230 VAC at source

Not approved by NEC

Rectify to 330 VDC for delivery

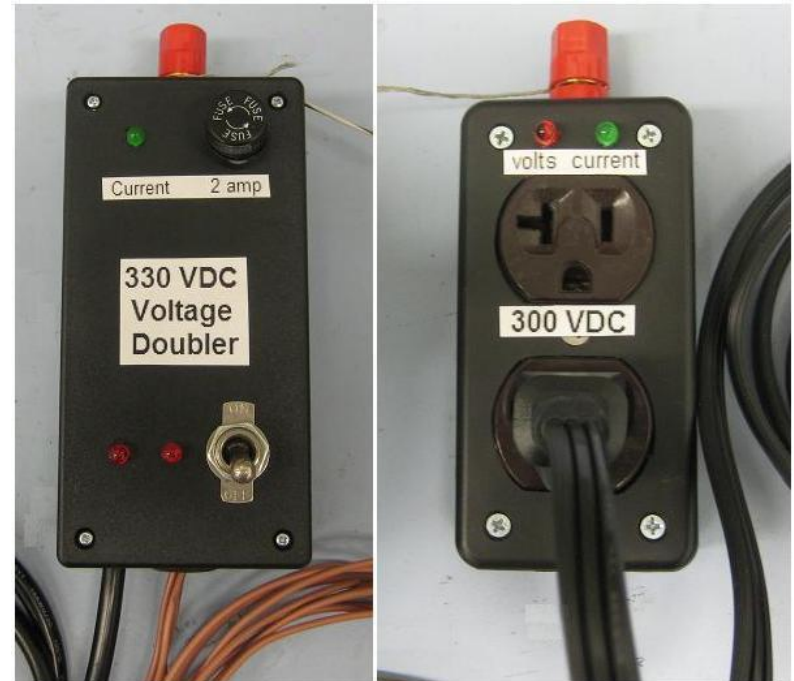
# Power Distribution SWER

Emergency Power:  
Single Wire Earth Return

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

And 3200' of #22 = 50 ohms



Not approved by NEC

# Power Distribution SWER



Single  
Wire  
Earth  
Return

Not  
approved  
by NEC

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

# Field-Day Emergency Power

- Adding solar panels to junkyard prius(s)



About 500W of  
Field Day solar power

# Typical Backup solutions Generators & Batteries



Generac  
Qt03624anax...

\$13,734



Generac  
GUARDIAN...

\$15,414



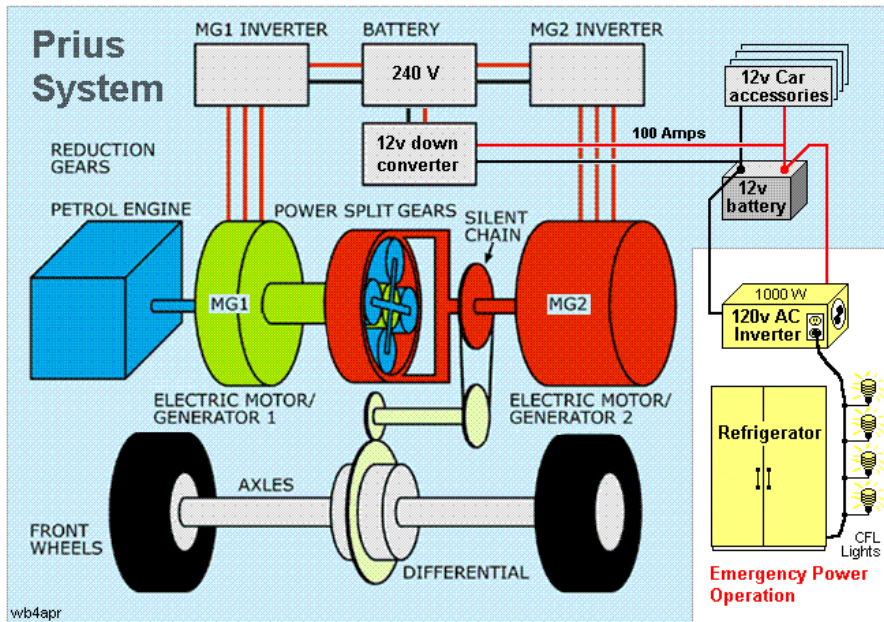
\$7,001

To provide **less than \$1** of electricity  
8 hours of 1.2kW house load  
Once a year!

[www.aprs.org/alternative-energy.html](http://www.aprs.org/alternative-energy.html)

# Every Hybrid has at least a 50 kW generator!

Suitable for about 10kW of continuous field power



Same 5kWh/gal as a good Honda generator  
(because it only runs when needed)

**Over 60 Hybrids in 2014!**

10 kW outlet for 220vDC  
And 1 kW outlet for AC

# Needs HV or 12v DC inverter

Whole House Prius Backup – 3 kW of 240 VAC



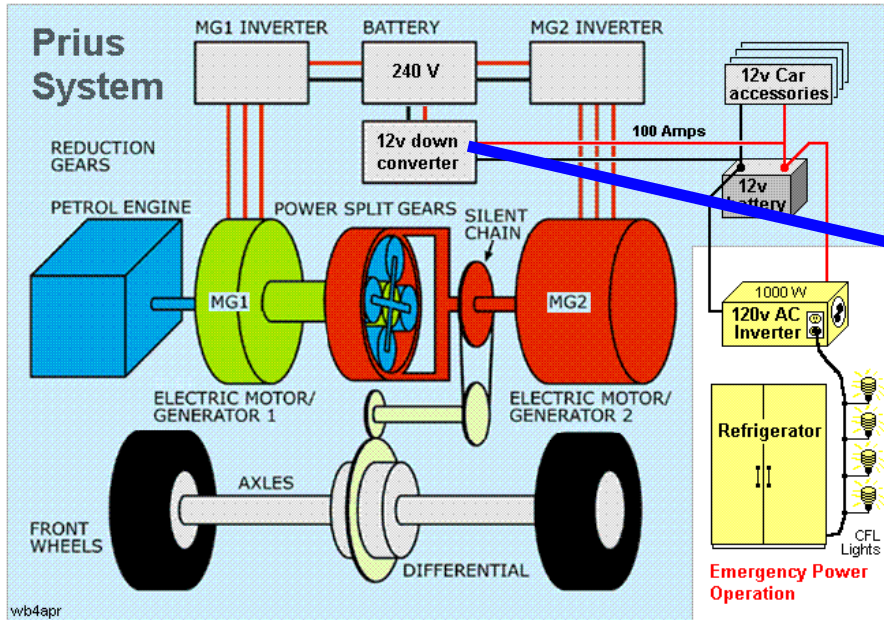
Same 5kWh/gal as a good Honda generator  
(because it only runs when needed)



Or 2 kW peak and  
800W continuous

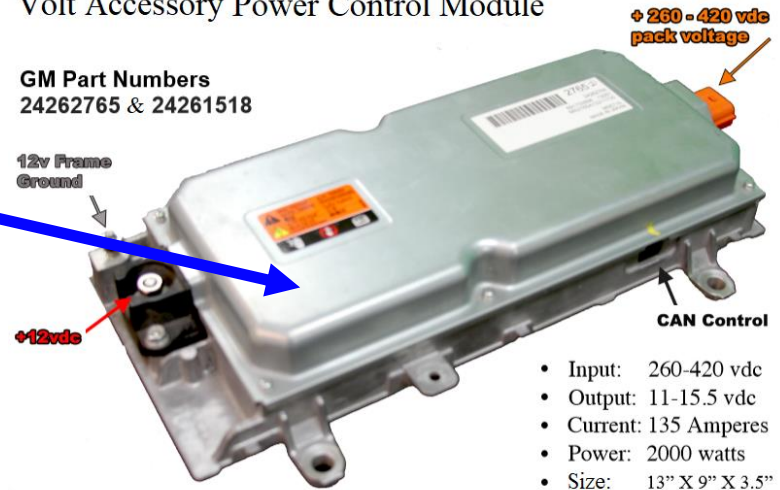
# Every Hybrid and EV has a KW+ at 12 volts

Suitable for about 10kW of continuous field power



Volt Accessory Power Control Module

GM Part Numbers  
24262765 & 24261518



**VOLT has 2 kW!**

260-420 VDC input  
12v @ 135 Amps out  
2000w from 12v system

# 220/330 VDC distribution



50 kW peak (10 kW average)



Safe, cheap connectors

(Modified to prevent incorrect use.)



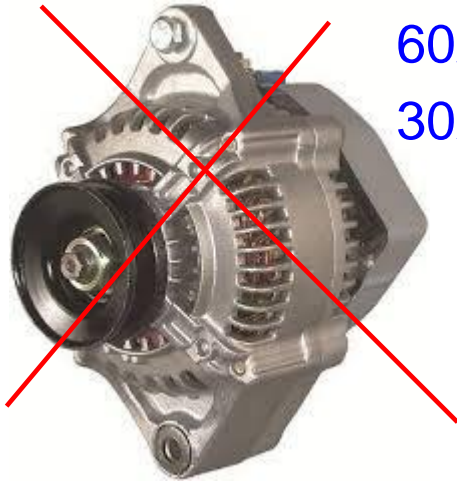
Greater distances

At half the current

At twice the power

#18 zip cord (5A) = 1100 watts easily

# Gas Cars cannot provide long term House Power



60A alternators only provide 30A at idle (400W average)..."



Can't do Whole House

Any 12v car can do this

**But only with the motor ALWAYS running.**

Only Hybrids with auto-motor start/stop can do it continuously.

# EVs can power homes during blackouts



Power out?  
Power your  
house  
From your  
Car!

EV's don't wait  
in gas lines



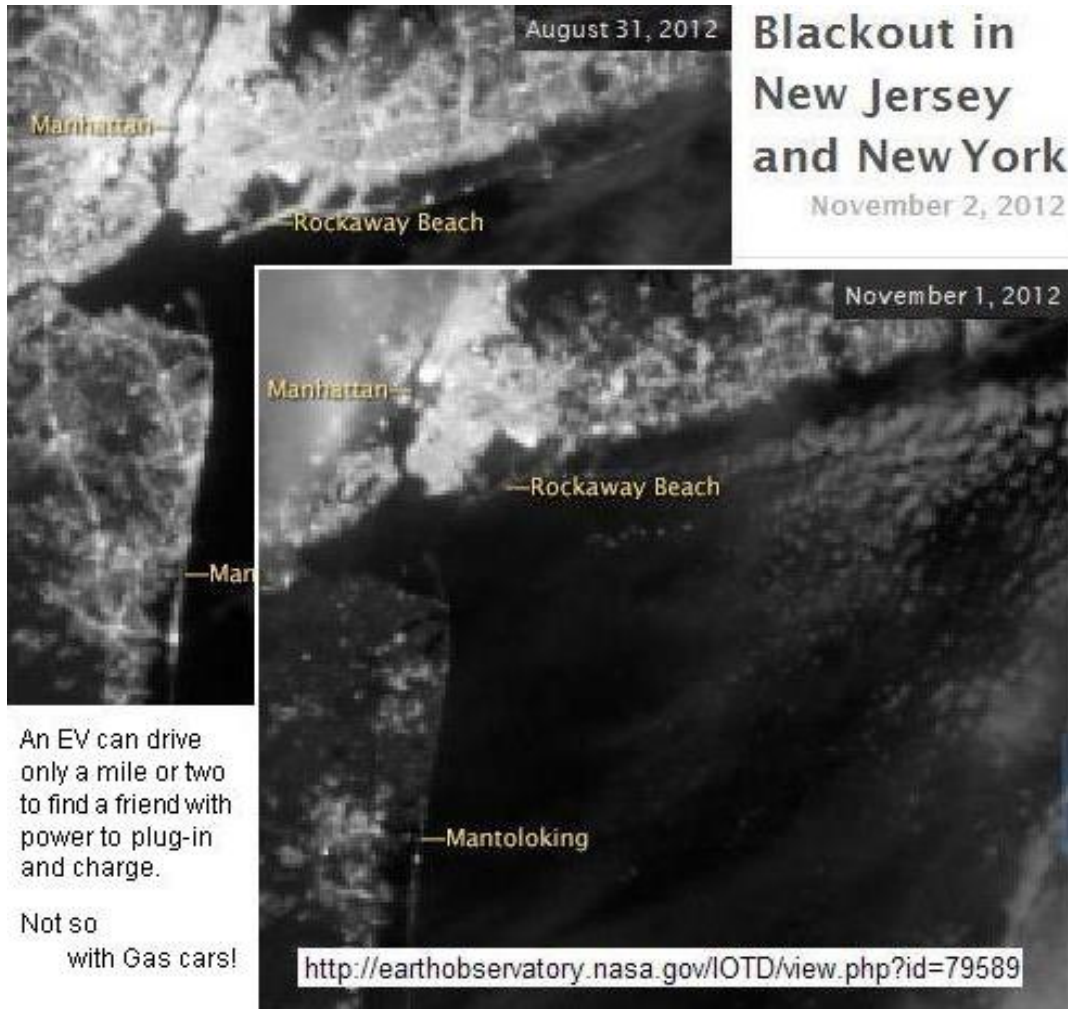
Bob Bruninga, PE

IEEE Transportation Committee

<http://aprs.org/payin-to-plugin.html>

30

# EVs can power homes during blackouts



An EV can drive only a mile or two to find a friend with power to plug-in and charge.

Not so with Gas cars!

Power out at your house?

Go across the street!

All the gas stations have no power and cannot pump gas?

EV's don't wait in gas lines

# EV's are now better, cleaner, faster, quieter, safer, cheaper to buy, cheaper to operate and cheaper to maintain than the **average** gas car

The Electric Vehicle Association of Greater Washington DC  
 Electric Vehicle Information Sheet

	Base Price	Net Price	Range	Seat.	Speed	MPG	Fuel / GC	
	(\$1000)	(\$1000)	(mi)	(seats)	(mph)	(EPA)	(Gal/Mi)	
Zeno S	\$13,345	\$13,345	76	3-4	95	462	---	Y
Brammo Empulse	\$24,995	\$26,995	80	2	10.2	110	---	\$19
Mitsubishi i (e-MiEV)	\$22,995	\$23,495	62	16	80	122	546	Y
Smart electric	\$25,000	\$27,300	88	17-6	78	207	546	Y
Chery Spark EV	\$28,885	\$28,385	82	21-8	80	138	542	Y
Nissan LEAF	\$29,050	\$29,550	84	24	95	134	546	Y
Ford Focus Electric	\$29,170	\$29,670	76	23	84	100	550	Y
Fiat 500e	\$32,800	\$34,300	87	24	85	124	546	Y
Nix Seal EV	\$33,700	\$36,200	83	27	90	105	550	Y
VW e-Golf	\$35,445	\$27,945	83	24	87	134	546	Y
Honda Fit EV	\$25,600	---	82	20	90	128	542	Y
BMW i3 (sage) (sage)	\$42,350	\$33,850	81	22	83	124	542	Y
Mercedes B-Class	\$42,400	\$33,950	87	28	101	84	558	Y
Toyota RAV4 EV	\$48,800	\$42,300	100	43-6	103	76	567	Y
Tesla Model S 85	\$79,900	\$72,400	265	85	125	89	558	Y
Tesla Model X 85	---	---	263	85	125	88	558	Y
Toyota Prius Plug In	\$29,890	\$27,890	33-gal	4-4	112	95	558	Y
Ford C-Max Energi	\$32,770	\$27,763	20-gal	7-6	102	88	572	Y
Chery Volt	\$34,170	\$28,670	38-gal	37-1	100	98	567	Y
Ford Fusion Energi	\$34,800	\$30,793	20-gal	7-6	104	88	572	Y
Honda Accord Plug In	\$39,780	\$36,354	18-gal	6-7	134	123	563	Y
Audi A3 e-tron	---	---	17-gal	8-8	140	95	---	Y
Cadillac ELR	\$75,000	\$67,500	37-gal	35-5	106	82	579	Y
Porsche Cayenne	\$76,400	\$71,065	34-gal	35-6	151	67	\$142	Y
VW VTEC (e-tron)	\$79,800	\$73,300	19-gal	23	85	---	\$76	Y
Porsche Panamera	\$96,500	\$91,348	28-gal	9-4	147	50	\$125	Y
BMW i8	\$135,700	\$131,907	25-gal	7-2	140	76	\$108	Y
Porsche 918 Spyder	\$845,000	\$841,533	12-gal	6-8	210	67	\$158	Y

- Refuel at home
- Independence from oil
- No emissions
- 0-60 in 2.3s
- Cost less to buy
- 1/3<sup>rd</sup> cost of gas
- 1/10 maintenance

# My Energy re-awakening 2007

Getting an EV by salvaging junkyard Priuses



# Most of what we think we know about EV's is likely wrong and Outdated



Most of us,  
*Greybeards* too,  
drive gas cars with  
gas-tank thinking

- ⤴ Cost too much!
- ⤴ Runs on coal from Power Plant (Carbon)
- ⤴ Range too short
- ⤴ Useless in power outage
- ⤴ Planet Impact worse than a Hummer
- ⤴ No Infrastructure
- ⤴ Not enough chargers
- ⤴ Takes too long to charge



Bob Bruninga, PE

IEEE Transportation Committee

<http://aprs.org/payin-to-plugin.html>



## 95% Energy Driving locally



With Solar or utility-wind, EV driving is 100% renewable



Bob Bruninga, PE

IEEE Transportation Committee

<http://aprs.org/EV-charging-everywhere.html>

# EV charging at ARRL HQ



# Solar at ARRL HQ

- Currently spend \$8,000 / mo on electricity
- That's \$1,000,000 in ten years.

Invest half of that now and have ARRL HQ electricity forever and an extra \$100k per year for other projects



This 576 panel array of 277W panels yields 160 kW and should equal an annual 190 MWhr total consumption

# Over 62 EV's now on Market!

(in just 8 years!)  
500 by 2025!

Half cost less than the  
average gas car! (\$35k)

Half now have ranges  
over 350 miles

Used from \$6k to \$12k

Download latest from  
EVADC.ORG

The Electric Vehicle Association of Greater Washington DC  
www.evadc.org

Electric Vehicle Information Sheet

	Base Price (\$USD) <sup>1</sup>	Net Price (\$USD) <sup>2</sup>	Range (mi) <sup>3</sup>	Batt. (kWh) <sup>4</sup>	Speed (mph) <sup>5</sup>	MPG equiv. <sup>6</sup>	Fuel / Co. <sup>7</sup>	OC <sup>8</sup>
Zero S	\$13,345	\$13,345	76	9.4	95	462	---	Y
Brammo Empulse	\$16,995	\$16,995	80	10.2	110	---	\$19	
Smart	\$22,995	\$15,495	82	16	80	112	\$48	Y
Smart electric	\$25,000	\$17,500	88	17.6	78	107	\$46	
Chevy Spark EV	\$26,885	\$18,185	82	21.8	90	119	\$42	Y
Nissan LEAF	\$29,010	\$21,510	84	24	95	114	\$48	Y
Ford Focus Electric	\$29,170	\$21,670	76	23	84	105	\$50	
Ford Focus Electric	\$31,800	\$24,300	87	24	85	116	\$48	
Kia Soul EV	\$33,700	\$26,200	93	27	90	105	\$50	Y
VW e-Golf	\$35,445	\$27,945	83	24	87	116	\$48	Y
Honda Fit EV	\$259/ma	(lease only)	82	20	90	118	\$42	
BMW i3 (plug-in)	\$41,350	\$33,850	81	22	93	124	\$42	Y
Mercedes B-Class	\$41,450	\$33,950	87	28	101	84	\$58	
Toyota RAV4 EV	\$49,800	\$42,300	100	41.8	103	76	\$67	
Tesla Model S 85	\$79,900	\$72,400	265	85	125	89	\$58	Y
Tesla Model X 85	---	---	265	85	125	89	\$58	Y
Toyota Prius Plug-in	\$29,990	\$27,490	11-gas	4.4	112	95	\$58	
Ford C-Max Energi	\$31,770	\$27,768	20-gas	7.6	102	88	\$71	
Chevy Volt	\$34,170	\$26,670	38-gas	17.1	100	98	\$67	
Ford Fusion Energi	\$34,800	\$30,793	20-gas	7.6	104	88	\$71	
Honda Accord Plug-in	\$39,780	\$36,154	13-gas	6.7	114	115	\$63	
Audi A3 e-tron	---	---	21-gas	8.8	140	95	---	
Cadillac ELR	\$75,000	\$67,500	37-gas	16.5	106	82	\$79	
Porsche Cayenne	\$76,400	\$71,065	14-gas	10.8	151	47	\$142	
VW VTRUX (plug-in)	\$79,000	\$71,500	11-gas	23	85	---	\$76	
Porsche Panamera	\$96,100	\$91,348	18-gas	9.4	167	50	\$125	
BMW i8	\$135,700	\$131,907	15-gas	7.1	160	76	\$108	
Porsche 918 Spyder	\$845,000	\$841,333	12-gas	6.8	210	67	\$138	Y

Panamera S E Hybrid    Cayenne S E Hybrid    Porsche 918 Spyder    Tesla Model S    Tesla Model X    BMW i8

# 50% have ranges > 350 miles!

Rng	EV	Cost	Plugin EV/Hybrid model
666	29	\$30k	Kia Optima Plug-In
650	27	\$30k	Hyundai Sonata PHEV
640	25	<b>\$23k</b>	Toyota Prius Prime
630	29	<b>\$20k</b>	Hyundai Ioniq PHEV
610	21	\$27k	Ford Fusion Energi
580	33	\$33k	Chrysler Pacifica hyb.
580	26	\$23k	Kia Niro PHEV
560	24	\$93k	Porsche Panamera
540	13	\$59k	BMW X5 xDrive40e
480	14	\$75k	Porsche Cayenne
460	20	\$23k	Ford C-Max Energi
460	8	\$62k	Mercedes GLE550e
450	12	\$92k	Mercedes S550e
450	18	\$48k	Volvo XC60 T8
440	30	\$68k	Cadillac CT6 Plug-In
410	8	\$44k	Mercedes C350e
410	21	\$59k	Volvo S90 T8
380	<b>53</b>	\$26k	Chevy Volt
380	16	\$35k	Audi A3 e-tron
372	16	\$48k	BMW 530e
350	22	\$42k	BMW 330e
350	19	\$60k	Volvo XC90 T8

Rng	EV	Cost	Plugin EV/Hybrid model
340	<b>47</b>	\$26k	Honda Clarity PHEV
340	14	\$86k	BMW 740e xDrive
335	EV	\$87k	Tesla 100D
330	14	\$143k	BMW i8
310	EV	\$37k	Tesla 3 extended range
310	22	\$29k	Mitsubishi Outlander
295	EV	\$89k	Tesla X 100D
259	EV	\$67k	Tesla S 75D
270	12	\$33k	MINI Cooper S E Countr
240	37	\$123k	Karma Revero
238	EV	\$72k	Tesla X 75D
<b>238</b>	EV	\$29k	Chevy Bolt
220	EV	<b>\$28k</b>	Tesla 3 std
180	97	\$41k	BMW i3 Range Extender
151	EV	<b>\$22k</b>	Nissan Leaf
125	EV	\$23k	VW e-golf
124	EV	\$22k	Hyundai Ioniq Electric
115	EV	\$22k	Ford Focus Electric
114	EV	\$27k	BMW i3
111	EV	\$26k	Kia Soul Electric
89	EV	\$26k	Honda Clarity Electric
84	EV	\$26k	Fiat 500e

# 50% cost less than the average \$35k gas car

Rng	EV Cost	Plugin EV/Hybrid model
330	14	\$143k BMW i8
240	37	\$123k Karma Revero
560	24	\$93k Porsche Panamera
450	12	\$92k Mercedes S550e
295	EV	\$89k Tesla X 100D
335	EV	\$87k Tesla 100D
340	14	\$86k BMW 740e xDrive
480	14	\$75k Porsche Cayenne
238	EV	\$72k Tesla X 75D
440	30	\$68k Cadillac CT6 Plug-In
259	EV	\$67k Tesla S 75D
460	8	\$62k Mercedes GLE550e
350	19	\$60k Volvo XC90 T8
410	21	\$59k Volvo S90 T8
540	13	\$59k BMW X5 xDrive40e
450	18	\$48k Volvo XC60 T8
372	16	\$48k BMW 530e
410	8	\$44k Mercedes C350e
350	22	\$42k BMW 330e
180	97	\$41k BMW i3 Range Extender
310	EV	\$37k Tesla 3 extended range

Less than \$35k Avg Gas Car		
380	16	\$35k Audi A3 e-tron
580	33	\$33k Chrysler Pacifica hyb.
270	12	\$33k MINI Cooper S E Countr
666	29	\$30k Kia Optima Plug-In
650	27	\$30k Hyundai Sonata PHEV
310	22	\$29k Mitsubishi Outlander
238	EV	\$29k Chevy Bolt
220	EV	\$28k Tesla 3 std
114	EV	\$27k BMW i3
610	21	\$27k Ford Fusion Energi
380	53	\$26k Chevy Volt
340	47	\$26k Honda Clarity PHEV
111	EV	\$26k Kia Soul Electric
89	EV	\$26k Honda Clarity Electric
84	EV	\$26k Fiat 500e
640	25	\$23k Toyota Prius Prime
580	26	\$23k Kia Niro PHEV
460	20	\$23k Ford C-Max Energi
125	EV	\$23k VW e-golf
151	EV	\$22k Nissan Leaf
124	EV	\$22k Hyundai Ioniq Electric
115	EV	\$22k Ford Focus Electric
630	29	\$20k Hyundai Ioniq PHEV
58	EV	\$16k Smart

# The avg new car stays on the roads for about 18 years before being scrapped.




































- A new gas car today will be belching Noxious fumes through 2035
- What will a gas car bought today be worth in 5 years for resale?



at least checkout EVs to meet your driving need

# Battery Evs (25 in 2020)

40% cost less  
than the average  
Gas car

	All Electric	Net Price (USD) <sup>1</sup>	Range (mi) <sup>2</sup>	Batt. (kWh)	0-60 (sec)	MPG equiv <sup>2</sup>	
	<b>Chevy Bolt</b>	\$34,745	259	66	6.5	118	
	<b>Fiat 500e</b>	\$25,960	84	24	8.9	112	
	<b>Honda Clarity Elec.</b> (lease only)		89	25.5	—	114	
	<b>Hyundai Ioniq Elec.</b>	\$24,500 <sup>^</sup>	170	38.3	9.5	133	
	<b>Hyundai Kona Elec.</b>	\$29,690	258	64	6.4	120	
	<b>Kia Niro EV</b>	\$31,000	239	64	7.8	112	
	<b>Kia Soul EV</b>	\$27,500 <sup>^</sup>	243	64	7.6	114	
	<b>MINI Electric</b>	\$22,400	110	32.6	6.9	—	
	<b>Nissan LEAF S</b>	\$24,100	150	40	7.4	112	
	<b>Nissan LEAF S Plus</b>	\$30,700	226	62	6.4	108	
	<b>VW e-Golf</b>	\$24,395	123	35.8	8.5	113	
<b>Average U.S. Gasoline Car Price</b>			<b>\$35,000</b>				
	<b>Audi e-tron</b>	\$67,300	204	95	5.5	74	
	<b>BMW i3</b>	\$36,950	153	42.2	7.2	113	
	<b>Ford Mustang Mach-E</b>	\$43,100	230 <sup>*</sup>	76	6.1	—	
	<b>Jaguar I-Pace</b>	\$62,350	234	90	4.5	76	
	<b>Polestar 2</b>	\$55,500	275	78	4.7	—	
	<b>Porsche Taycan 4S</b>	\$96,300	170 <sup>^</sup>	79.2	3.8	70 <sup>^</sup>	
	<b>Porsche Taycan Turbo</b>	\$143,400	201	93.4	3.0	69	
	<b>Rivian R1S 135</b>	\$75,000 <sup>^</sup>	310 <sup>*</sup>	135	3.0 <sup>*</sup>	—	
	<b>Rivian R1T 135</b>	\$71,500 <sup>^</sup>	300 <sup>*</sup>	135	3.0 <sup>*</sup>	—	
	<b>Tesla Cybertruck Dual</b>	\$49,900	300 <sup>*</sup>	120 <sup>^</sup>	4.5 <sup>*</sup>	—	
	<b>Tesla Model 3 Std.</b>	\$35,000	220	50	5.6	131	
	<b>Tesla Model 3 Std. Plus</b>	\$39,990	250	54	5.3	141	
	<b>Tesla Model 3 Long Range AWD</b>	\$48,990	322	75	4.4	121	
	<b>Tesla Model Y Long</b>	\$48,000	300 <sup>*</sup>	75 <sup>^</sup>	5.5	—	
	<b>Tesla Model S</b>	\$79,990	373	100	3.7	111	
	<b>Tesla Model X</b>	\$84,990	328	100	4.4	96	
	<b>Tesla Roadster</b>	\$200,000	620	200 <sup>^</sup>	1.9	—	
	<b>Volvo XC40 Recharge</b>	\$47,500 <sup>^</sup>	200	78	4.7	—	

1. Net price after Fed tax credit. State credits may also apply.  
2. EPA combined city/highway, except as noted

# 32 Plugin Hybrid EV's

(38% cost less than avg gas car!)

Ford, BMW, VW

Mercedes, Ford, GM

Say, all their cars will be electric in 6-8 years

**The Electric Vehicle Association of Greater Washington DC**  
evadc.org

	Net Price (USD) <sup>1</sup>	Range (mi) <sup>2</sup>	Batt. (kWh)	0-60 (sec)	MPG equiv <sup>2</sup>	
Fusion	\$32,495	32+gas	16	7.4	82	Pacifica minivan
Ioniq	\$30,391	26+gas	9	8.0	103	Honda Clarity PHEV
Sonata	\$25,900	48+gas	17	7.7	110	Kia Niro
Sonata	\$21,957	29+gas	8.9	8.9	119	Kia Optima
MINI	\$26,481	28+gas	9.8	7.6	99	Prius Prime
MINI	\$23,957	26+gas	8.9	9.0	105	RAV4 Prime
MINI	\$31,171	28+gas	9.8	9.1	101	Average U.S. Gasoline Car Price
Mitsubishi Outlander	\$32,900	17+gas	10	6.7	73	BMW 330e
Subaru Crosstek Hyb.	\$30,459	22+gas	12	9.2	74	BMW 530e
Toyota Prius Prime	\$30,645	17+gas	8.8	8.3	90	BMW 745e xDrive
Toyota RAV4 Prime	\$23,250	25+gas	8.8	10.5	133	BMW i3 Range Extender
Average U.S. Gasoline Car Price	\$29,000 <sup>a</sup>	39 <sup>+</sup> +gas	16 <sup>a</sup>	5.8 <sup>+</sup>	90 <sup>+</sup>	BMW i8
All these hybrids have a plug.	\$35,000					BMW X3 xDrive30e
PHEV — Plug-in Hybrid Electric Vehicle (Electric & Gas) —	\$39,164 <sup>a</sup>	30 <sup>+</sup> +gas	12 <sup>a</sup>	5.6	—	BMW X5 xDrive45e
RAV4	\$48,064	21+gas	12	5.9	69	Karma Revero GT
330e	\$89,714	16+gas	12	4.9	56	Land Rover Sport P400e
530e	\$40,800	126+gas	42.2	8.0	100	Mercedes C350e
745e	\$141,831	17+gas	11.6	4.2	69	Mercedes GLC350e
330e	\$42,714 <sup>a</sup>	20 <sup>+</sup> +gas	12 <sup>a</sup>	6.3	—	Mercedes GLE550e
530e	\$62,500	40 <sup>+</sup> +gas	24	5.5 <sup>a</sup>	56	Mercedes S560e
745e	\$127,500	61+gas	28	4.5	70	Porsche Cayenne
330e	\$71,913	19+gas	13	6.3	42	Porsche Panamera
530e	\$45,394	8+gas	6.2	5.8	51	Volvo S60 T8
745e	\$46,190	10+gas	8.7	6.2	56	Volvo S90 T8
PHEV — Plug-in Hybrid Electric Vehicle (Electric & Gas) —	\$62,240	8+gas	8.8	5.3	43	Volvo V60 T8
Land Rover P400e	\$103,750	20+gas	13.5 <sup>a</sup>	4.7	65 <sup>a</sup>	Volvo XC60 T8
Cavenne E-Hybrid	\$74,430	14+gas	14.1	4.7	47	Volvo XC90 T8
Panamera 4 E-Hybrid	\$97,130	14+gas	14.1	4.4	51	Mercedes C350e
Cavenne E-Hybrid	\$51,043	22+gas	10.4	4.3	69	Mercedes S560e
Panamera 4 E-Hybrid	\$58,843	21+gas	10.4	4.8	60	Mercedes GLC350e
Panamera 4 E-Hybrid	\$62,298	22+gas	10.4	4.3	69	Mercedes S560e
Panamera 4 E-Hybrid	\$49,593	19+gas	10.4	4.9	57	Mercedes GLC350e
Volvo V60	\$61,998	18+gas	10.4	5.9	55	Mercedes S560e
Volvo V60						Mercedes GLC350e
Volvo S60						Mercedes S560e
Volvo S90						Mercedes GLC350e
Volvo XC60						Mercedes S560e
Mercedes GLE550e						Mercedes GLC350e

# EV Pickups are Here! (2020)

- Rivian -2020
- WorkHorse
- Via Motors
- Ford - 2021
- Chevy- 2021
- Tesla - 2021

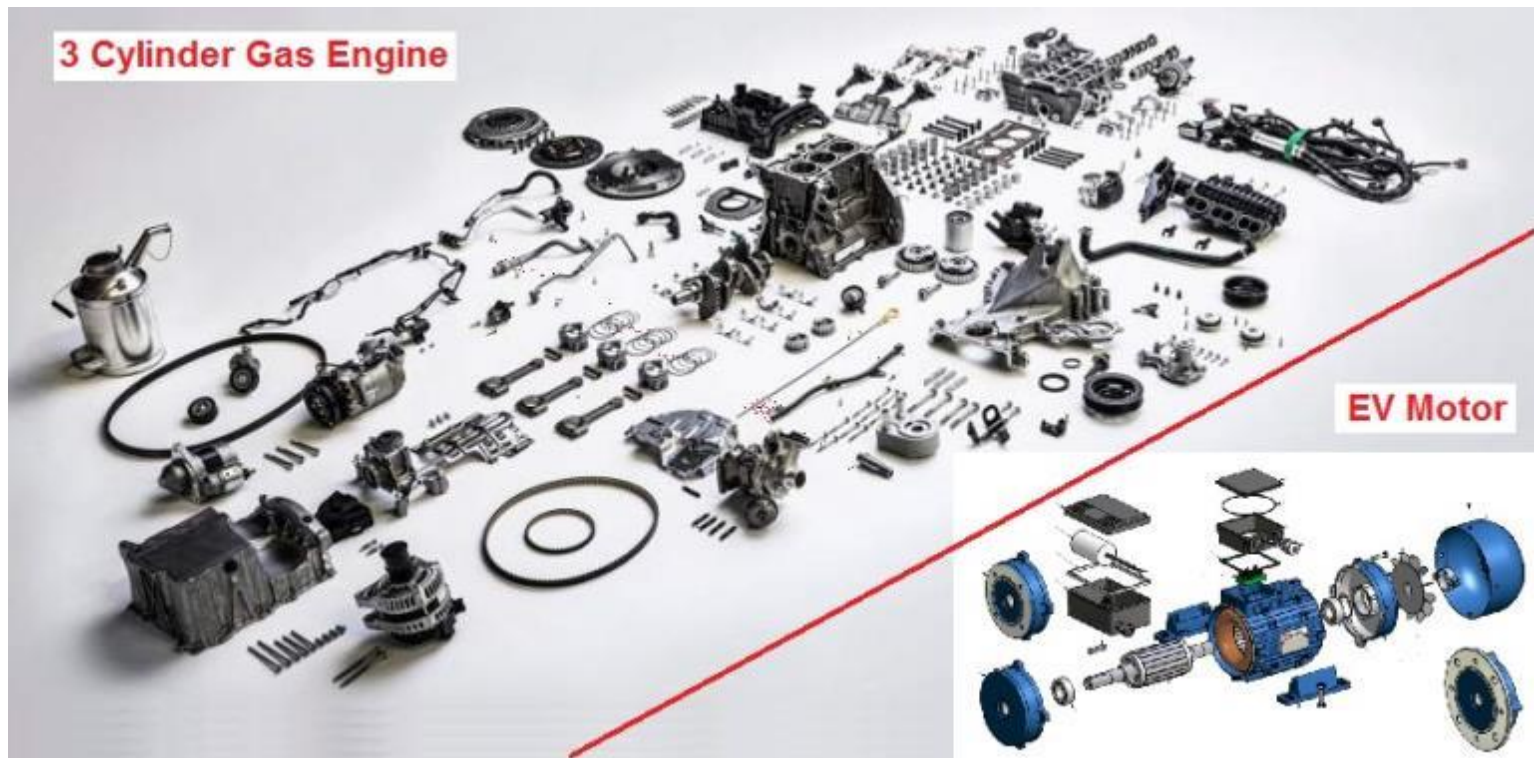


Better Torque, Field Electrical Power

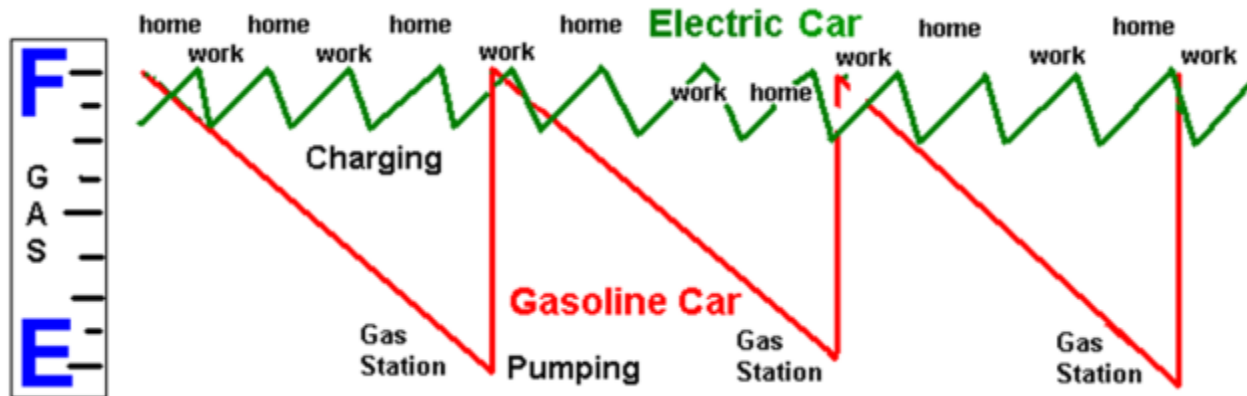


# EV engines have Only ONE moving part!

- Electricity about 1/3rd cost of gas
- Maintenance 10% of a gas car



# A Battery is not a TANK!



## The Complete Paradigm Shift:

Gas cars drive-to-empty, then fill-to-full at Public Stations

EV's charge daily at home and/or at work while parked

And are FULLL every morning



Bob Bruninga, PE

IEEE Transportation Committee

<http://aprs.org/payin-to-plugin.html>

# Our Legacy experience



# Oh the Horror!

People see this  
*And think \$40*



Reality with EV's is



**20¢/hr**

**\$1 a day**



(\$10 for Tesla 250mi)

Bob Bruninga, PE

IEEE Transportation Committee

<http://aprs.org/payin-to-plugin.html>

# Every EV can charge from any 120v outlet

Every EV comes with a 120v charge cord



Exist or \$15 each

Charging stations for every EV is not sustainable at-work:



\$8000 installed

# Charge at Home (and at work)

1% of the need

Public Charging is like looking for \$10 gas!

<u>Location</u>	<u>Charge Time</u>	<u>Price</u>	<u>Level</u>	<u>Cost</u>	<u>Driver?</u>	<u>Speed?</u>
Interstate Travel	20m Travel	\$\$\$\$	L3	\$10,000	Waiting...	20 min
Shopping/Visiting	1-2 hrs Public	\$\$\$	L2/3	\$2,000	Parked	10 Sec*
Work / Airport / Rail / Bus	4 to 8 hrs Workplace	\$\$	L1	\$25	Parked	10 Sec*
At home	8 to 10 hrs Residential	\$	L1	\$25	Sleeping	10 Sec*

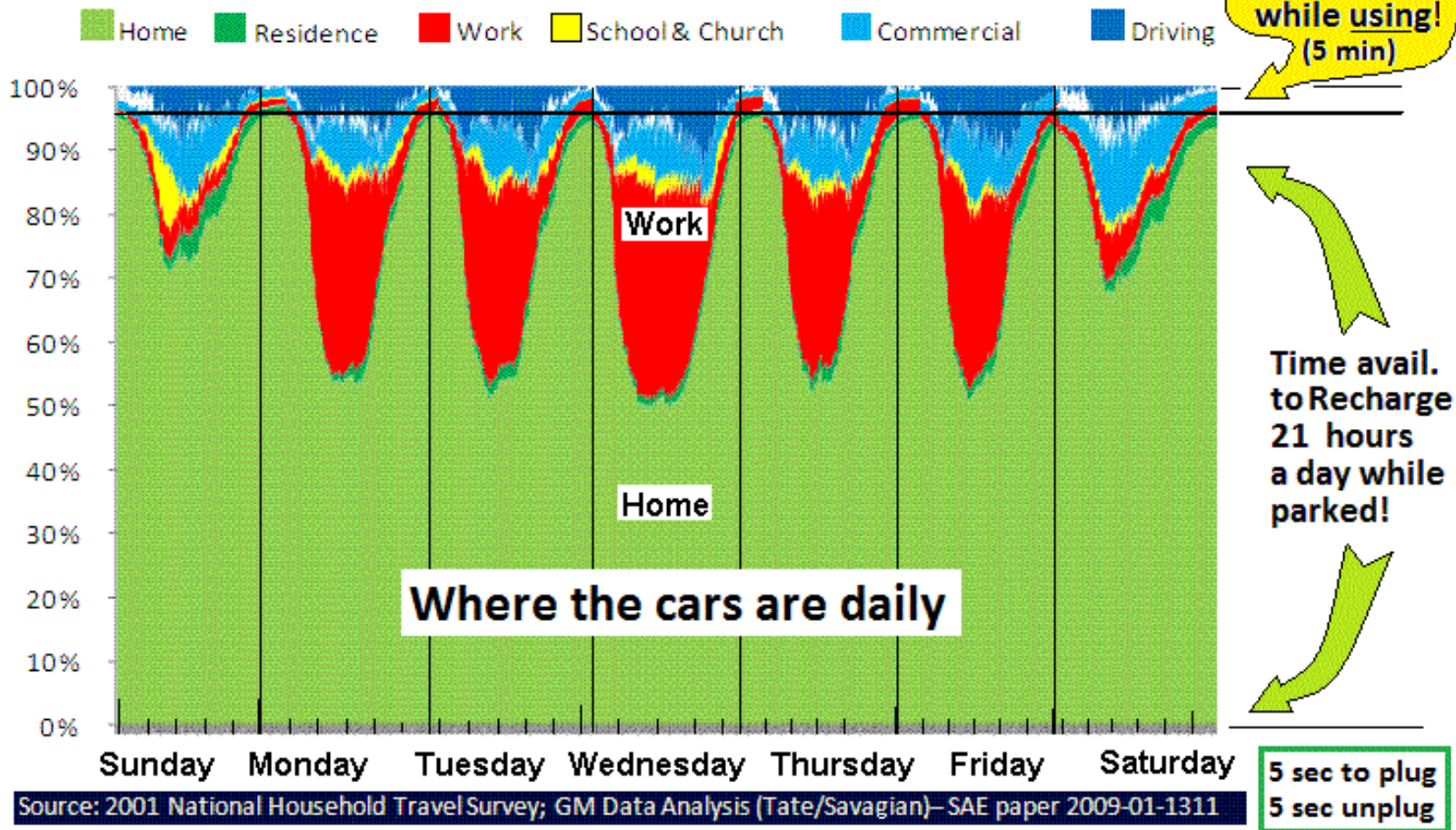
bruninga

\* connect/disconnect time

85% of all charging is at home on standard 120v outlets

# Charging While Parked (21 hrs/day)

**Gas-up while Using, Charge-up while parked!**



Bob Bruninga, PE

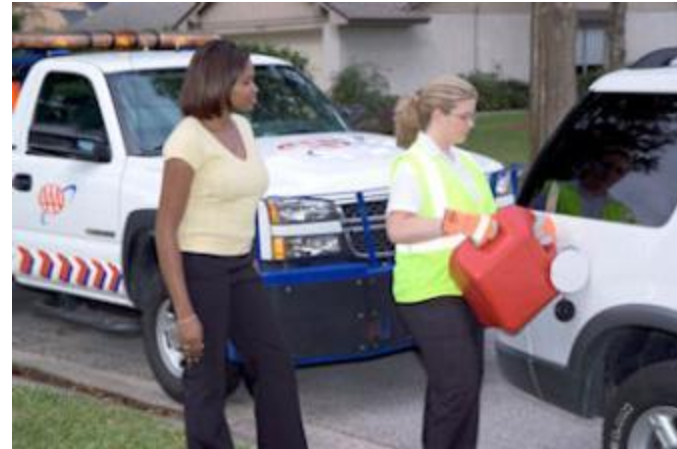
IEEE Transportation Committee

<http://aprs.org/payin-to-plugin.html>

# Public Charging – only a security blanket



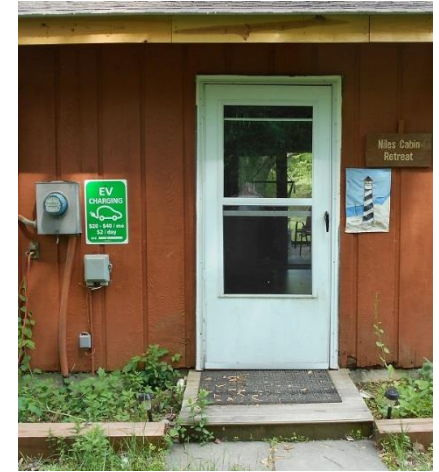
Only Provides comfort & security  
... like a spare gas can



85% of all charging is at home

Buying an EV with the idea of **public charging**, means not **understanding EV's** and maybe **buying the wrong car!**

# Every Outdoor Outlet should consider a Charging Sign



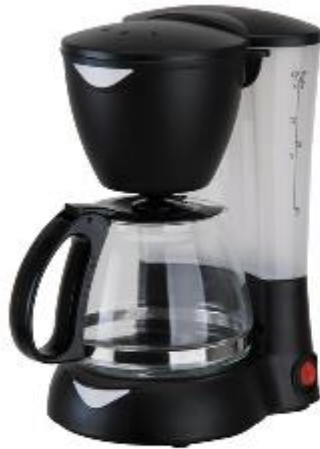
Bob Bruninga, PE

IEEE Transportation Committee

<http://aprs.org/EV-charging-signs.html>

# Charging Load at 120v:

**1 Coffee Pot = Level 1 EV charging**



**115v 12 amps**

Employee's pay for coffee mess  
and yet get free electricity

S  
A  
M  
E  
  
=  
  
L  
O  
A  
D



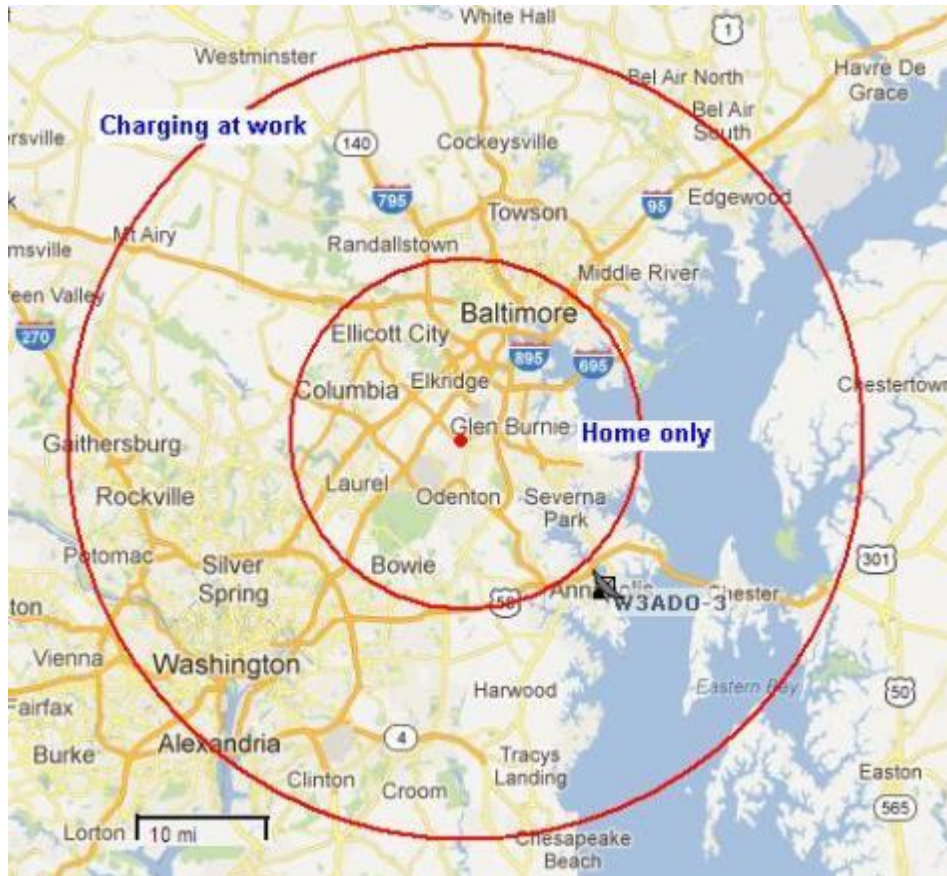
We dont want free electricity, we want to  
pay for it, and simply be allowed to plugin!

Pay \$20/mo  
For 20mi commute

# Plug-in at work (double range, quadruple area)

Charge at home only = 16 mi range (chevy Volt)

Charge L1 at work/home = 64 mi range

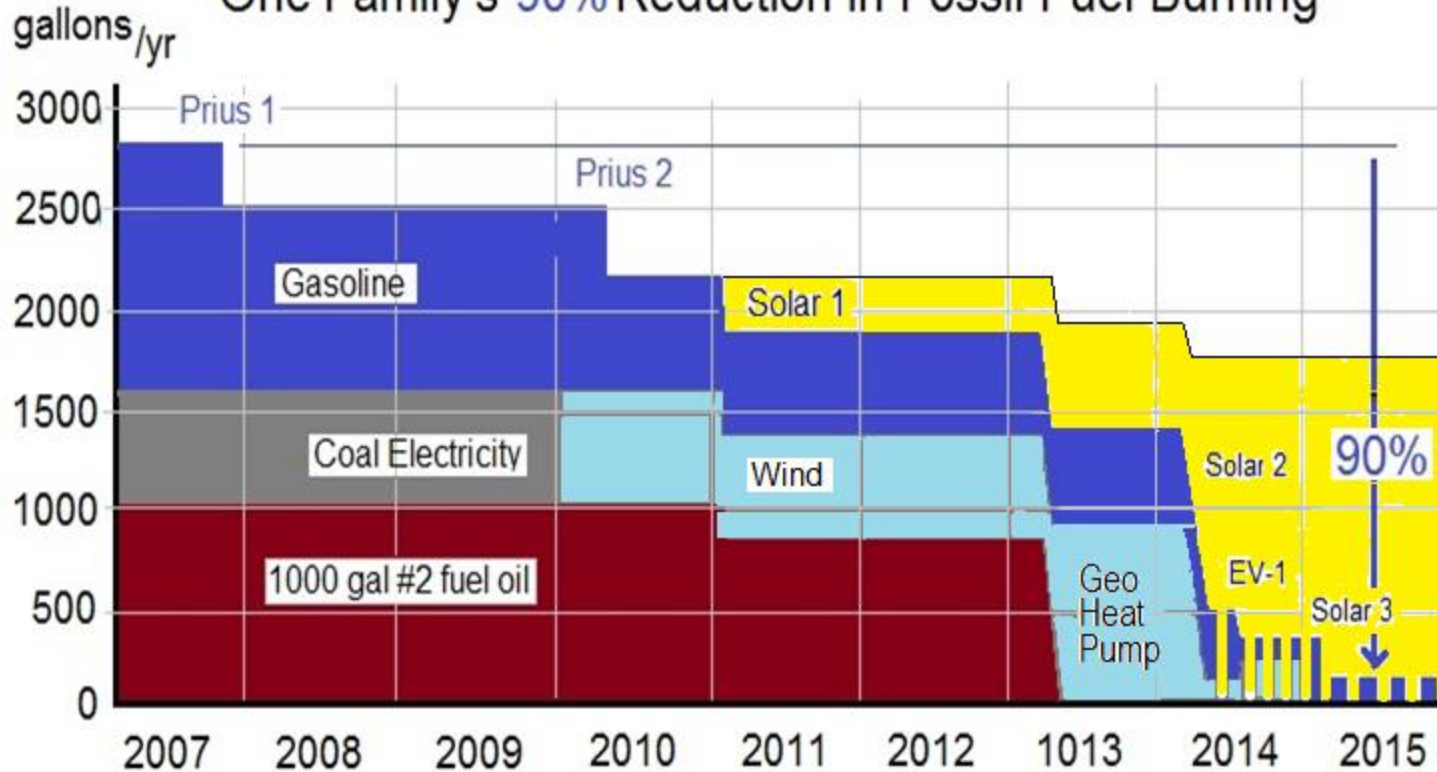


# Going Renewable Energy is Easy!

My family went from 3000 gal/year down to 300 gal/year

## One Family's 90% Reduction in Fossil Fuel Burning

\$500/  
mo



\$8/mo

Help the Environment

And save 50% money!



Go renewables!

AND Save Money too!

**Our old house Energy Costs:**

Heating Oil (1000 gal/yr)

Electricity (10,000 kWh/yr)

Incandescent Lights

Gasoline (15,000 mi/yr 30 mpg)

Total Annual Energy cost

BEFORE:

\$3000/yr

\$1000/yr

\$ 500/yr

\$1500/yr

\$6000/yr

AFTER: Heatpump, Solar, LEDs & EV

\$ 300/yr?

Help the Environment

And save money!



# My Solar re-awakening 2010

3<sup>rd</sup> Saturday in August 2010 a revelation!  
(when I looked afresh at Grid-Tie Solar)



# I was so wrong!

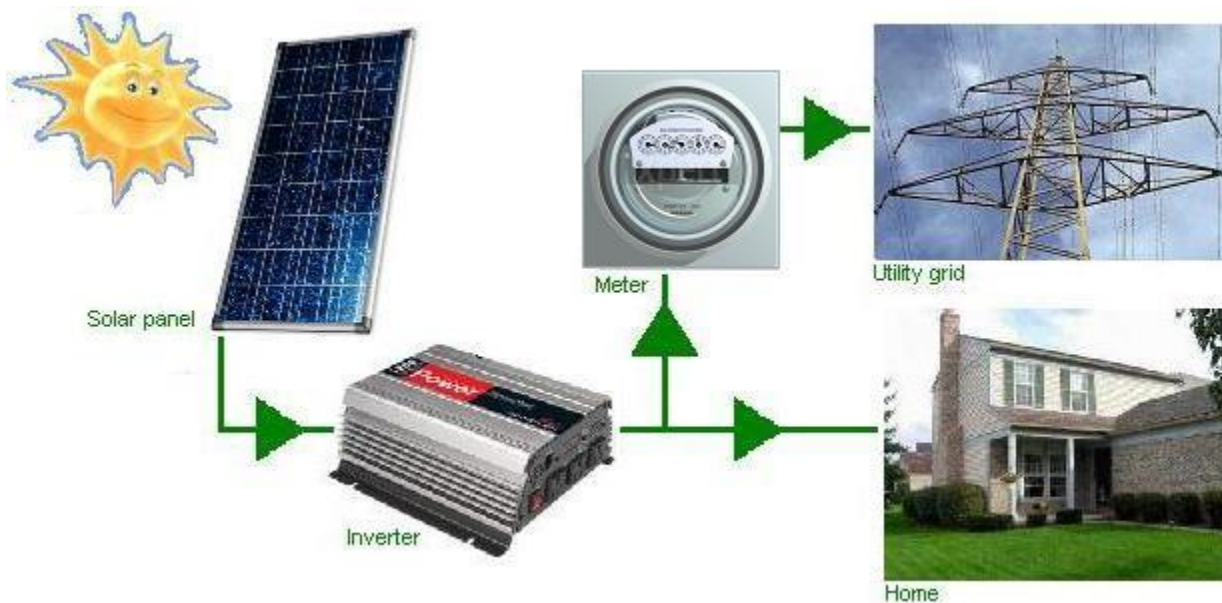
- My concept of solar always included batteries:



# Grid-tie Revolutionized Solar

- No Batteries!

## Grid-Tie

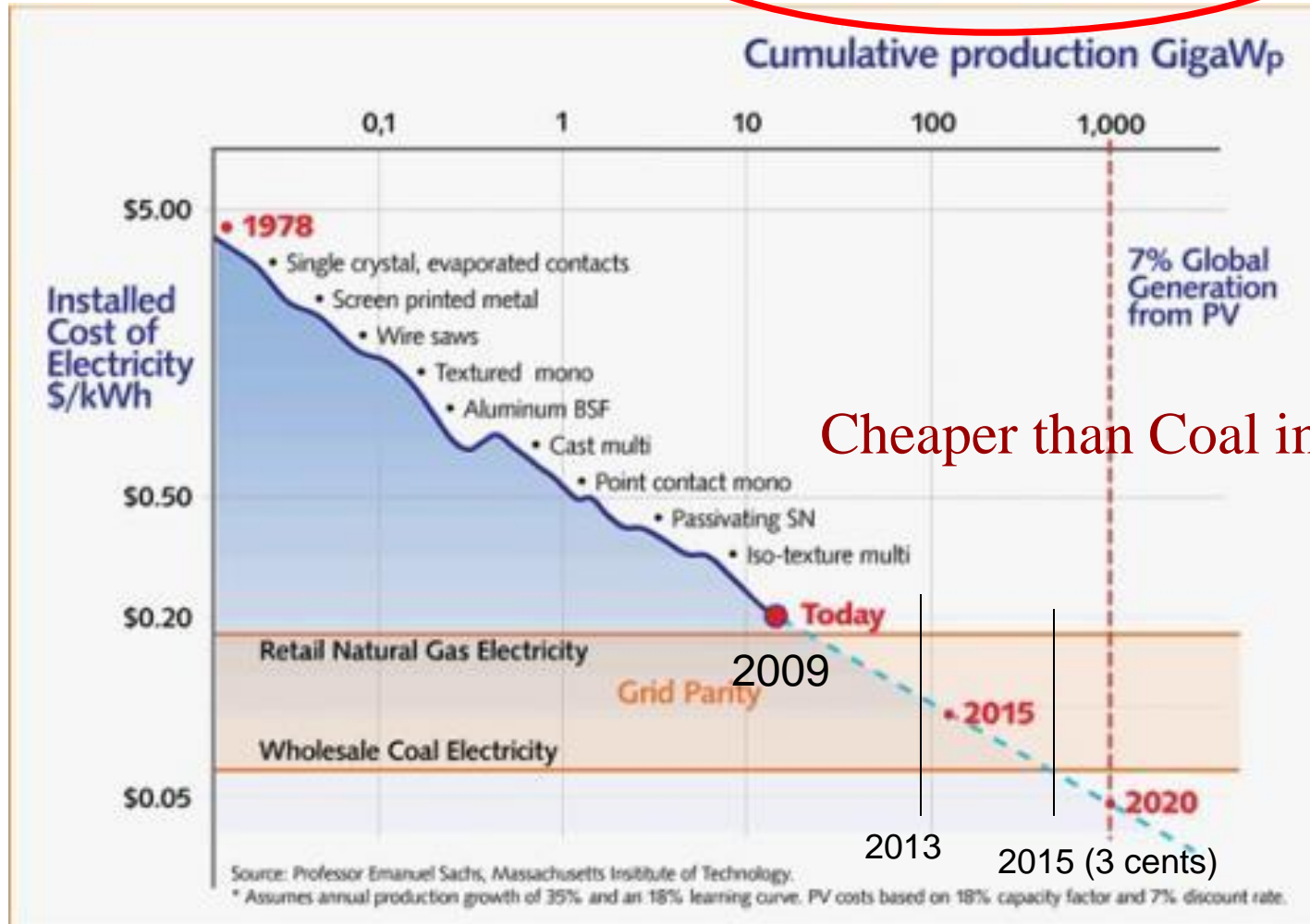


Every Watt Produced is valued at full Retail Rates!

**ZERO MAINTENANCE** and storage costs **FOR LIFE!**

# Solar Cost!

Equaled Utility in 2010  
Half the Utility in 2013



Cheaper than Coal in 2016!

Now Cheaper than wholesale coal!

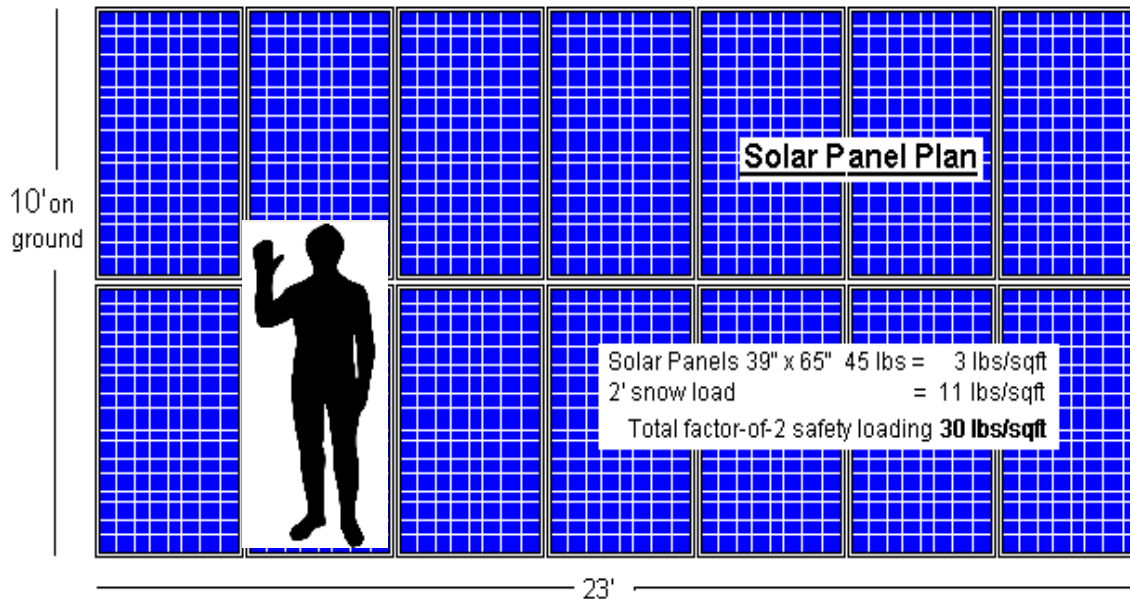
# Falling Prices 10-to-1

## Panel

## Array Cost

A 3 kW array

200 W  
220 W  
250 W  
(300W)



\$15,000 2007  
\$ 9,000 2010  
\$ 6,000 2012  
\$ 3,000 2013  
\$ 2,000 2014  
\$ 1,500 2015

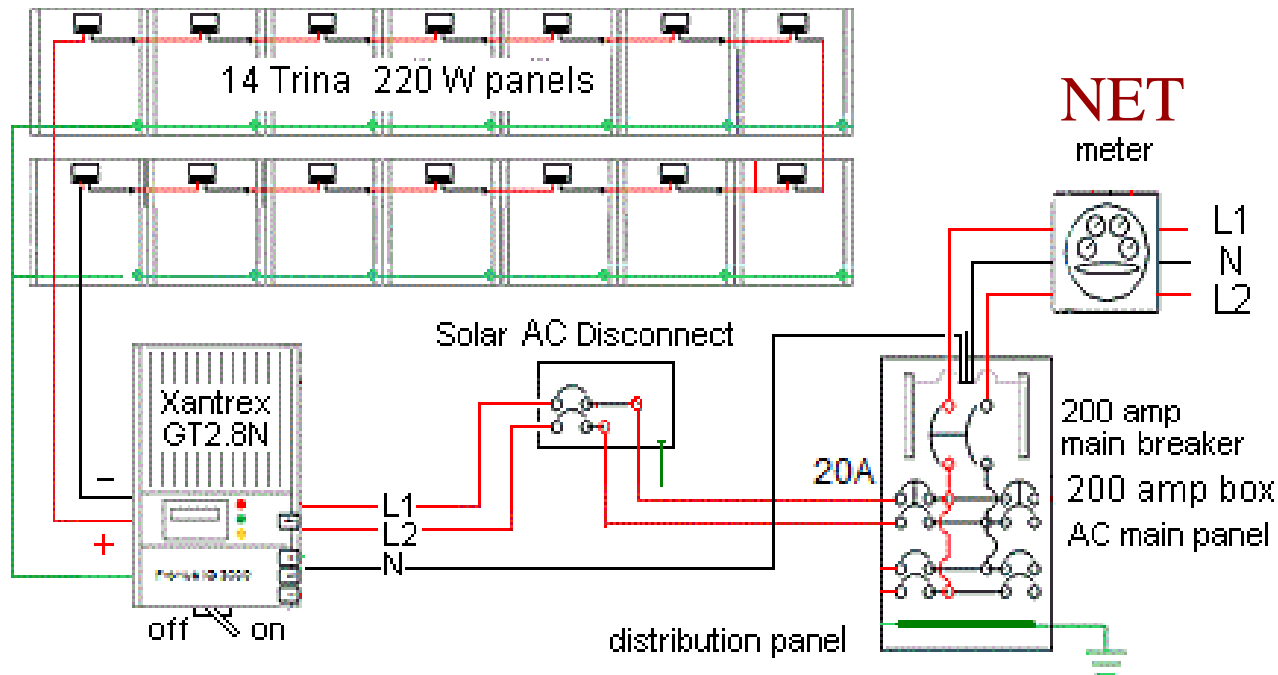
\$5/watt down to 50c/watt\* for panels in only 10 years

\*Contractor cost tho is still about \$2.75/w

# What is Grid-tie Solar?

As simple as a 20A breaker - L1, L2, N & Ground

## 3 kW Grid-Tie Solar PV system

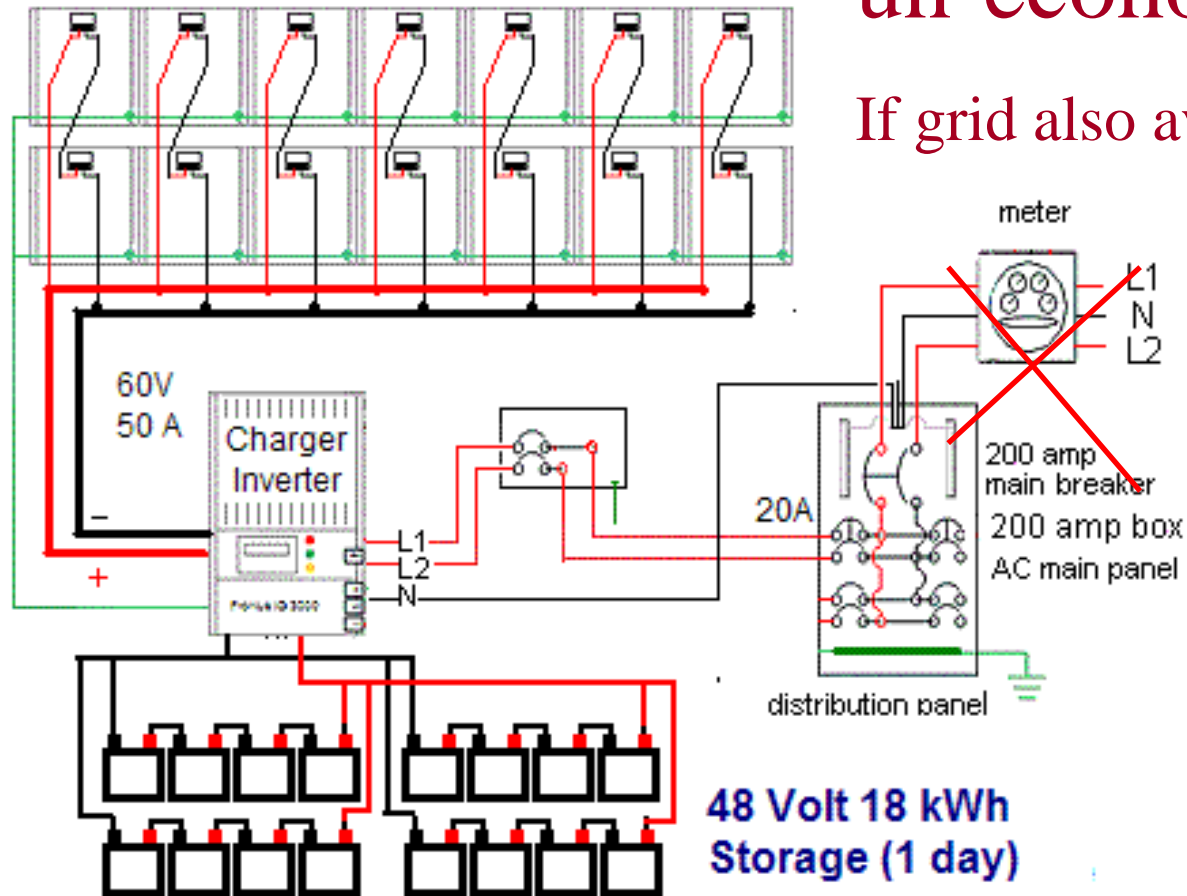


# Off-Grid costs 3 times as much

3 kW Battery Solar PV system

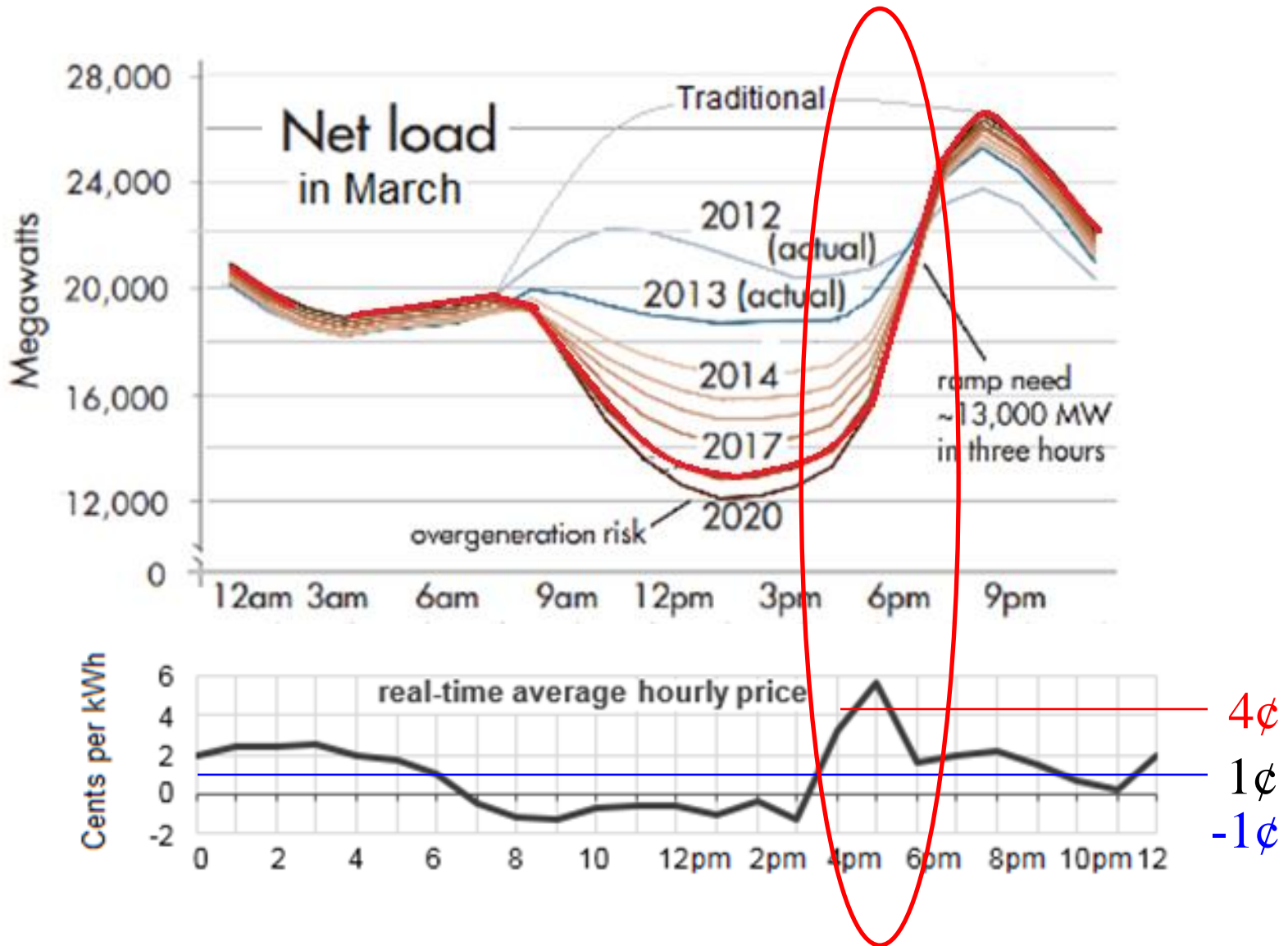
un-economical

If grid also available



#1 problem: Cannot save the DOUBLE summer power for Winter

# Future Value of Home Battery



# Grid Solar Power ~~=~~ Emergency Power

- COMPLETELY DIVORCE any thoughts of “**emergency power**” from **Economical power**.
- **Solar power (grid-tie)** is for **ECONOMICAL POWER!**
- **Emergency power** has completely different optimal solutions. (Short term and Armageddon)



\$400



\$10,000

# Grid Solar Power IS Economical Power 99.95%

- Grid Tie Solar is not “emergency power”
- For emergency power do what you do now (4 hrs/yr!)
  - Candles,
  - Generator,
  - Plug into your Hybrid car or EV
  - A few batteries and \$100 inverter, etc
- **Emergency power** has completely different optimal solutions. (Short term and Armageddon)

**Value = 60 cents**



\$400



\$10,000

# Grid Solar Power IS Economical Power

- Grid Tie Solar can now include “emergency power”
- Some Grid Inverters come with direct secure power when the grid is down (and sun is up).

SUNNY BOY GRID TIE INVERTER WITH SECURE POWER

\$1,099.00 List price \$1,925.00

1500W w/o grid

Model: SB3.0-1SP-US-40 (3000 Watt)

Select model:

3000 Watt

3800 Watt

5000 Watt

6000 Watt

7000 Watt

7700 Watt

Even when overcast,  
a 5 kW array can produce 500W



# Power your house from your EV for a week in power outage



**Leaf-to-Home:**  
6 KVA – 24 kWh battery



**Prius-to-Home (50 kW gen)**  
\* Currently in Japan only

# Power your house from any EV or Hybrid

- Your EV, or Plugin-Hybrid is now **Emergency Power!**



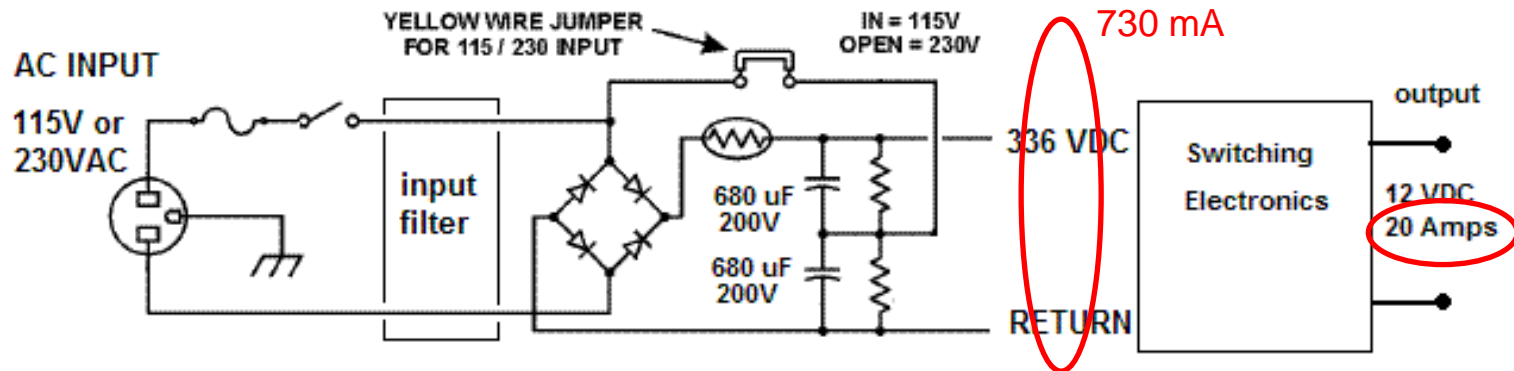
Just a cigarette lighter 120v inverter can power at least 20 LED bulbs in your house.



A larger 1000W inverter clipped to the battery can power all the lights and the refrigerator too!

# But all modern equip can run on 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.

Doubles 120 to 230 VAC

Rectify to 330 VDC for delivery

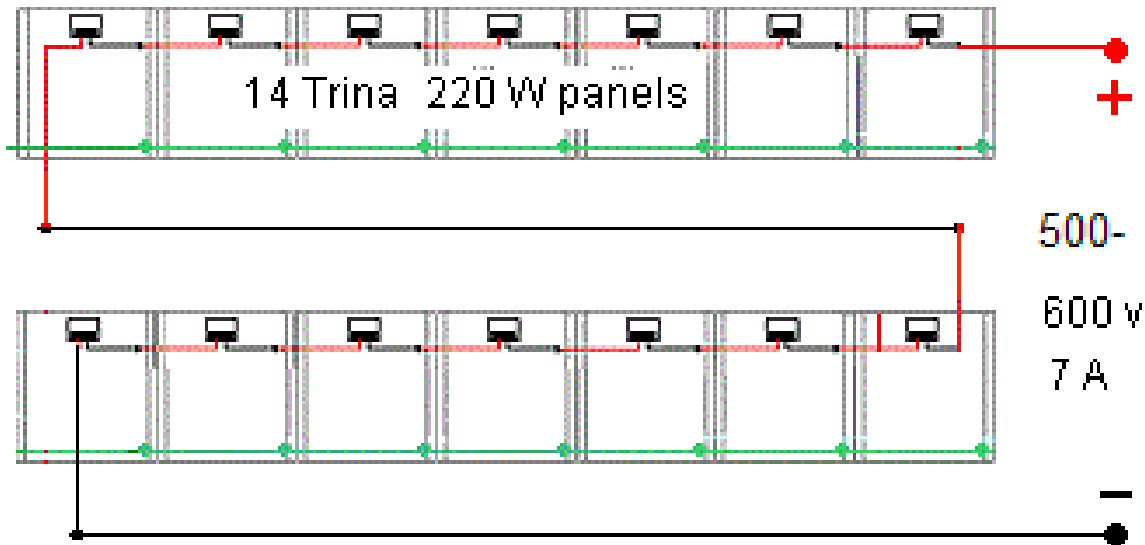
Eliminate 75% of

Distribution losses

# Standard Grid-tie Solar (Series)

500/600V Series to minimize wire loss (7A = 4 kW w #14 wire)

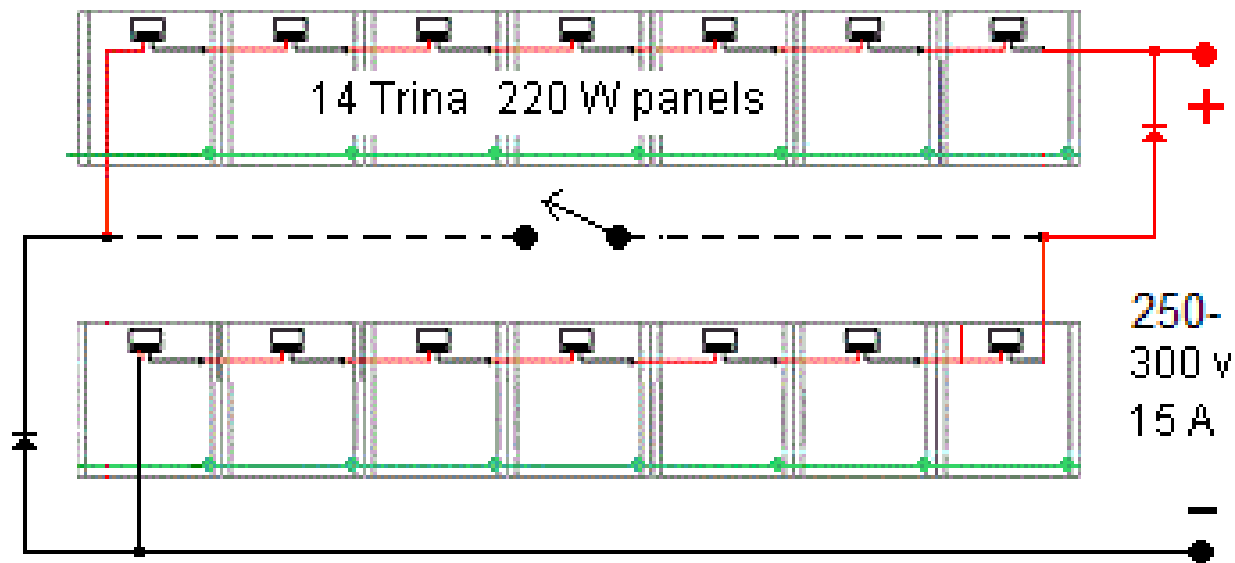
## 3 kW Grid-Tie Solar PV system



# DIY backup Solar Power

Emergency Switch to 300 v to power Universal Powered Systems

## 3 kW Grid-Tie Solar PV system



# DIY backup Solar Power

Emergency Switch to 300 v to power Universal Powered Systems



Simple A/C Disconnect

60 amps

600v

Only \$6

# DIY backup Solar Power

Emergency Switch to 300 v to power Universal Powered Systems

TV, Stereo

PC, internet, laptop

Chargers: Cell

Ham Radio (Switching  
PS)

Lights (incandescent-  
series)

Anything with SW/PS

~~Well pump~~

~~Furnace Blower~~

~~Appliances~~

~~Heaters~~

~~A/C~~

~~Everything you NEED~~

# #1 DIY backup Power Need

We NEED a 200-500 VDC input – 60 Hz Inverter!



Prius Plug-out-kit:  
2, 3 & 5 KVA

50 kW generator Hybrid!



200-300VDC Series solar

# Grid-down Solar Power

We NEED a 200-500 VDC input – 60 Hz Inverter!



Leaf-to-Home:  
6 KVA – 24 kWh battery



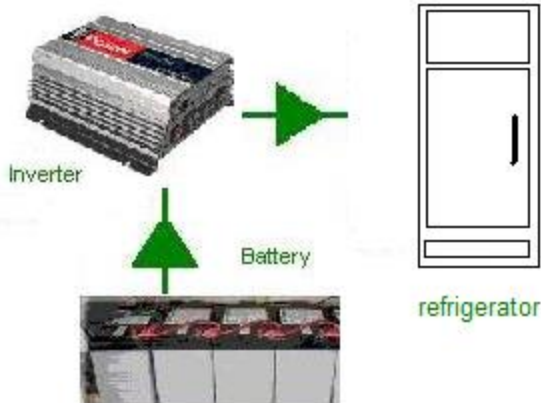
Prius-to-Home (50 kW gen)

But only in Japan!

# Solar Backup Power Ideas

- Even cloudy days = 10% of array power
- Minimum overnight power: Refrigerator & Lights
- 16 Hrs x 250W = 4 kWh
- Four Deep-cycle Car Batteries

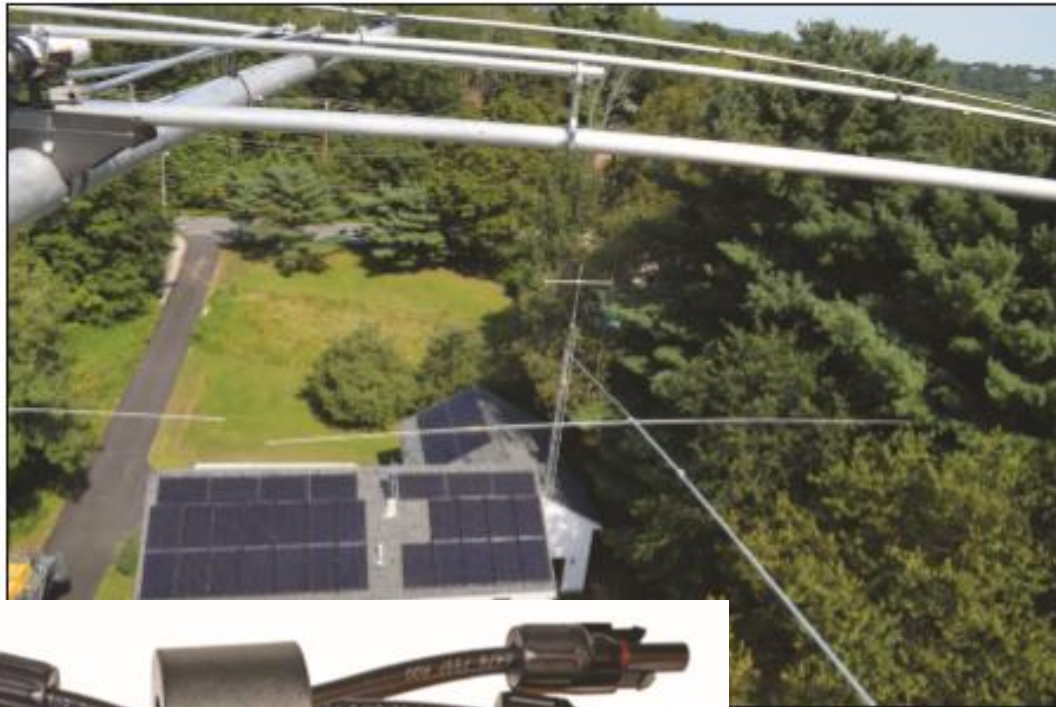
\$150



And LED bulbs

\$400

# But BEWARE of Solar RFI!



RS!  
!

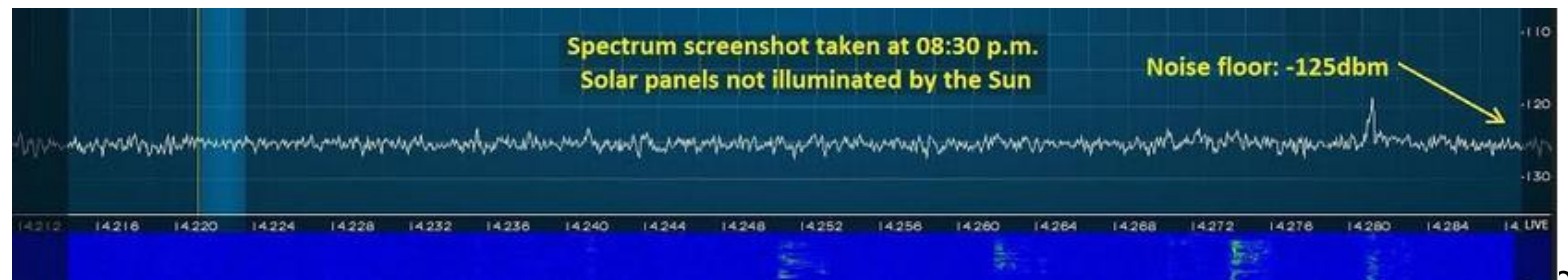
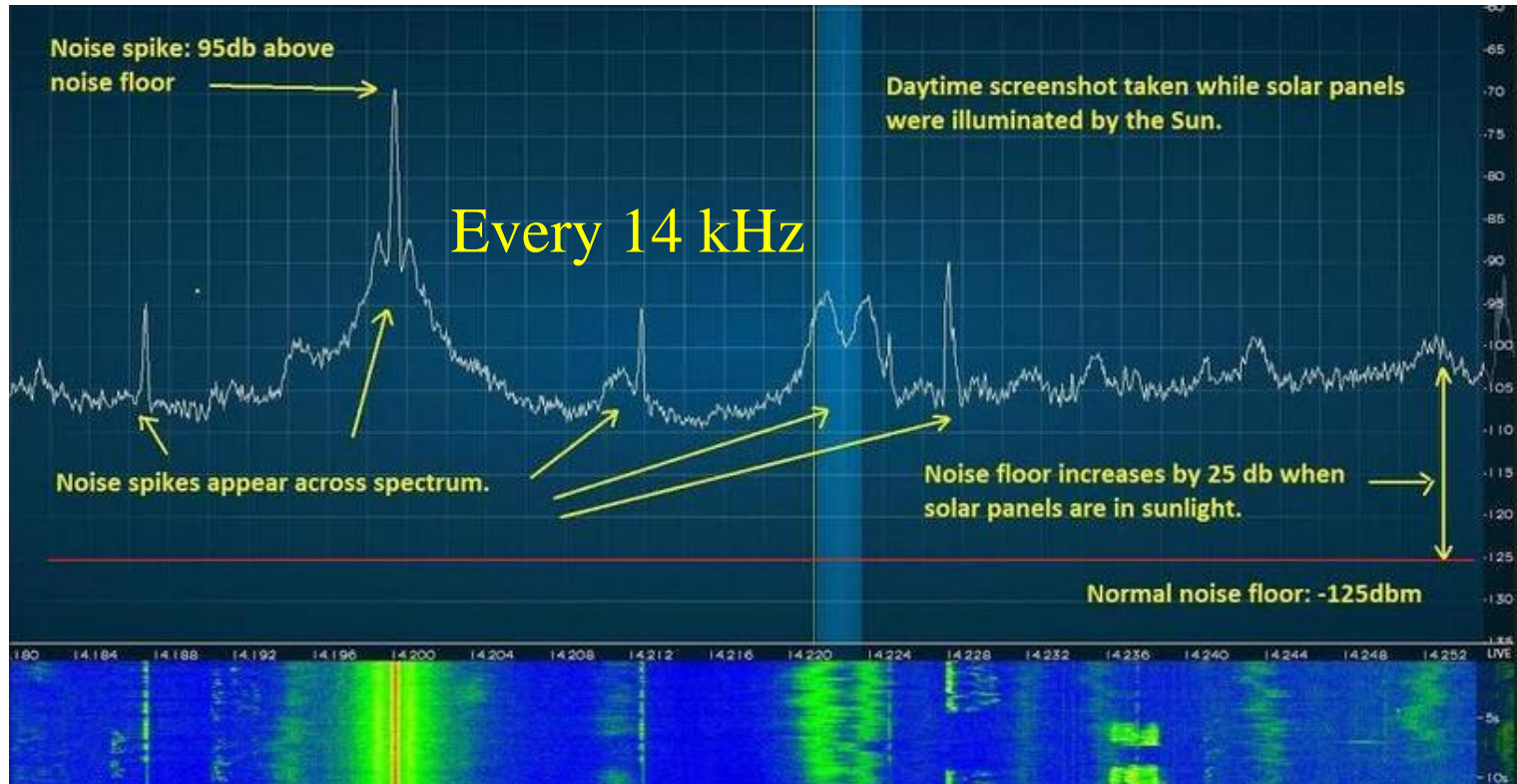
April 2016 33



Figure 5 — Three bifilar turns of #10 PV wire on Fair-Rite 2631626202 core with MC4 connectors installed.

K1KP's  
QST article

# BEWARE of Solar RFI!





# UNITED STATES COAST GUARD

U.S. Department of Homeland Security

## **MARINE SAFETY ALERT**

### **Inspections and Compliance Directorate**

August 15, 2018

***Let us enlighten you about LED lighting!***

Safety Alert 13-18

### **Potential interference of VHF-FM Radio and AIS Reception.**

Radio frequency interference caused by these LED lamps were found to create potential safety hazards.

## Test Procedures:

1. Turn off LED light(s).
2. Tune the VHF radio to a quiet channel
3. Adjust the VHF radio's squelch control until the radio outputs audio noise.
4. Re-adjust the VHF radio's squelch control until the audio noise is quiet
5. Turn on the LED light(s).
6. If the radio does not output audio noise, then the LED lights have not raised the noise floor.



**Dead WRONG! It's a Noise-Squelch Dummy**

# “Optimizers” -Very Difficult to Control!

Especially OPTIMIZERS!  
By Solar Edge! ARGH!



Figure 6 — The chokes from Figure 2, as well as the twisted wire transmission cables can be seen between two of the aluminum support rails before solar panels were installed.

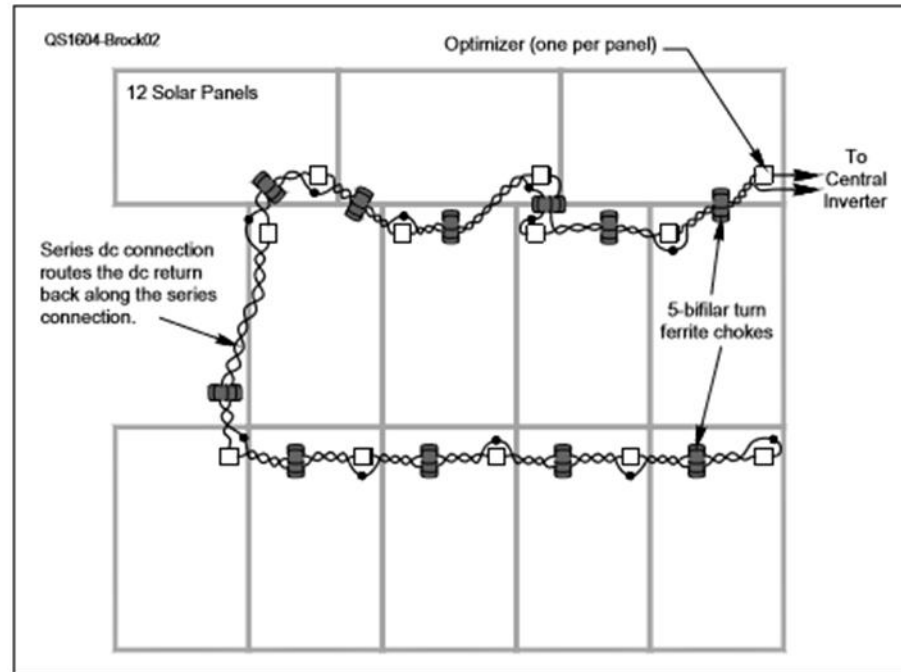
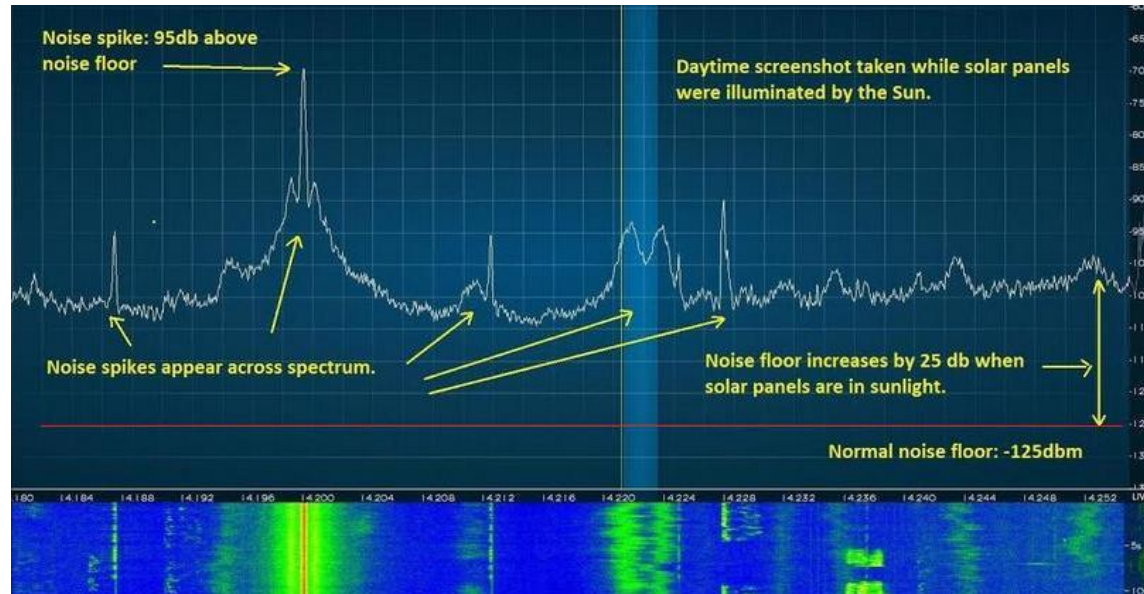


Figure 2 — New wiring configuration shows a closed loop of a twisted pair of conductors, and ferrite beads to suppress common mode currents.

# Talk to your neighbor!... NOW



If you wait till you hear it, Its too late!

You've lost HF hobby (Daytime) forever

# 7,000,000,000 people sharing the Air and Water

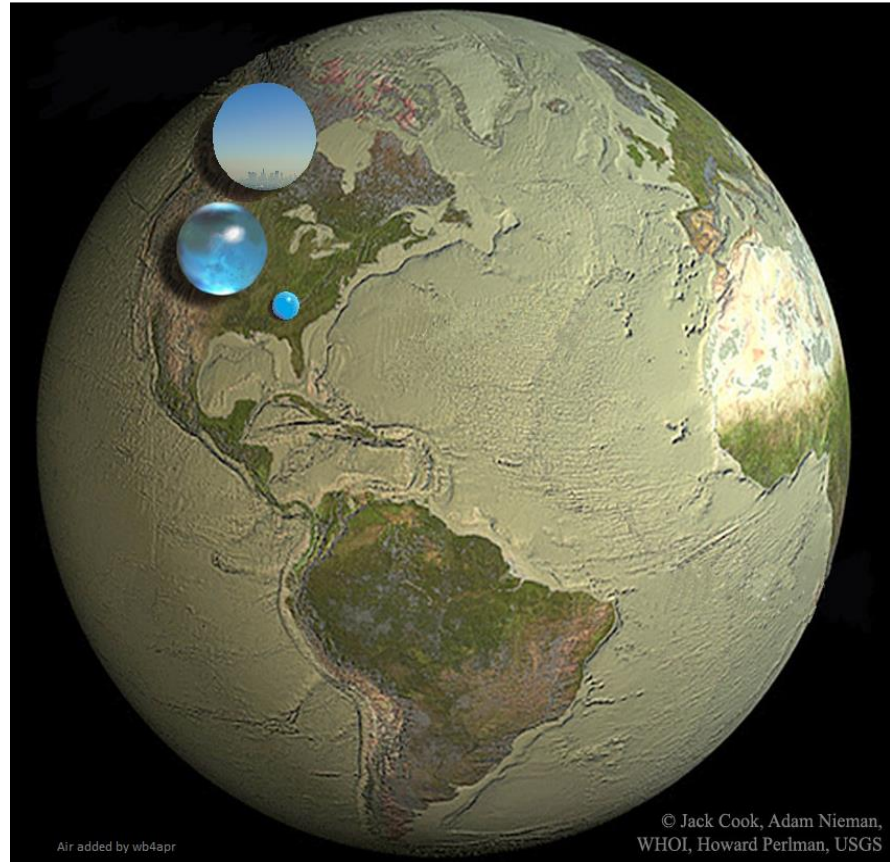
The Clock is ticking

All the Air on Earth

All the Water on Earth

All the fresh water on Earth

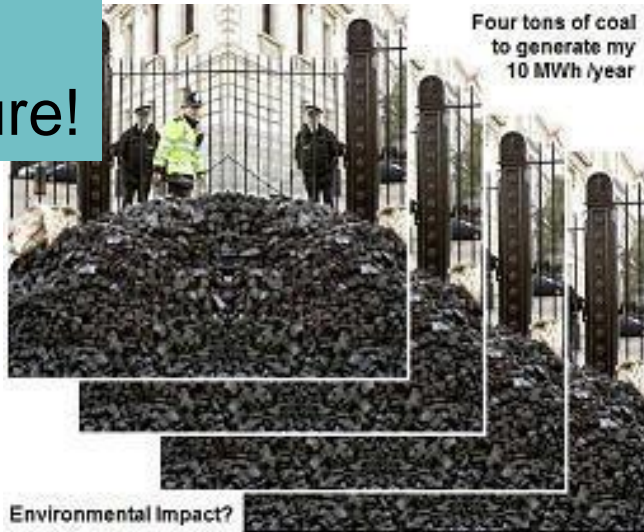
And every cubic foot of air  
has passed through a  
combustion engine at least  
once in the last 200 years



Bob Bruninga, WB4APR

<http://aprs.org/AFM-environment.html>

Big  
Picture!



**1 House,  
1 Year  
4 Tons of  
Coal**



Yes, we have 100 years of coal, but there won't be anything left of WV!  
Nor clean air to breathe!

# Mining for Energy



Lithium



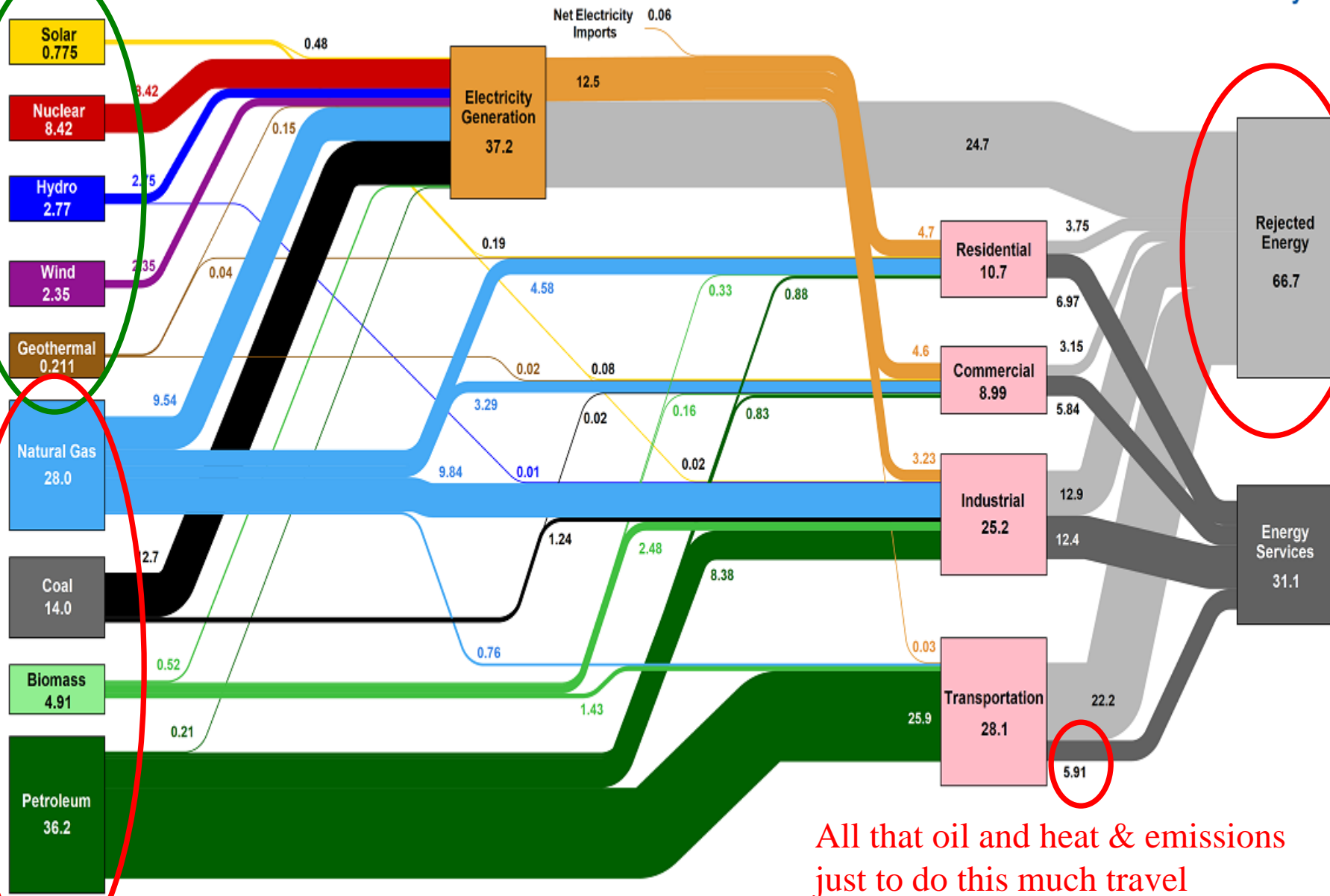
Coal



Oil

© Jiri Rezac / Greenpeace

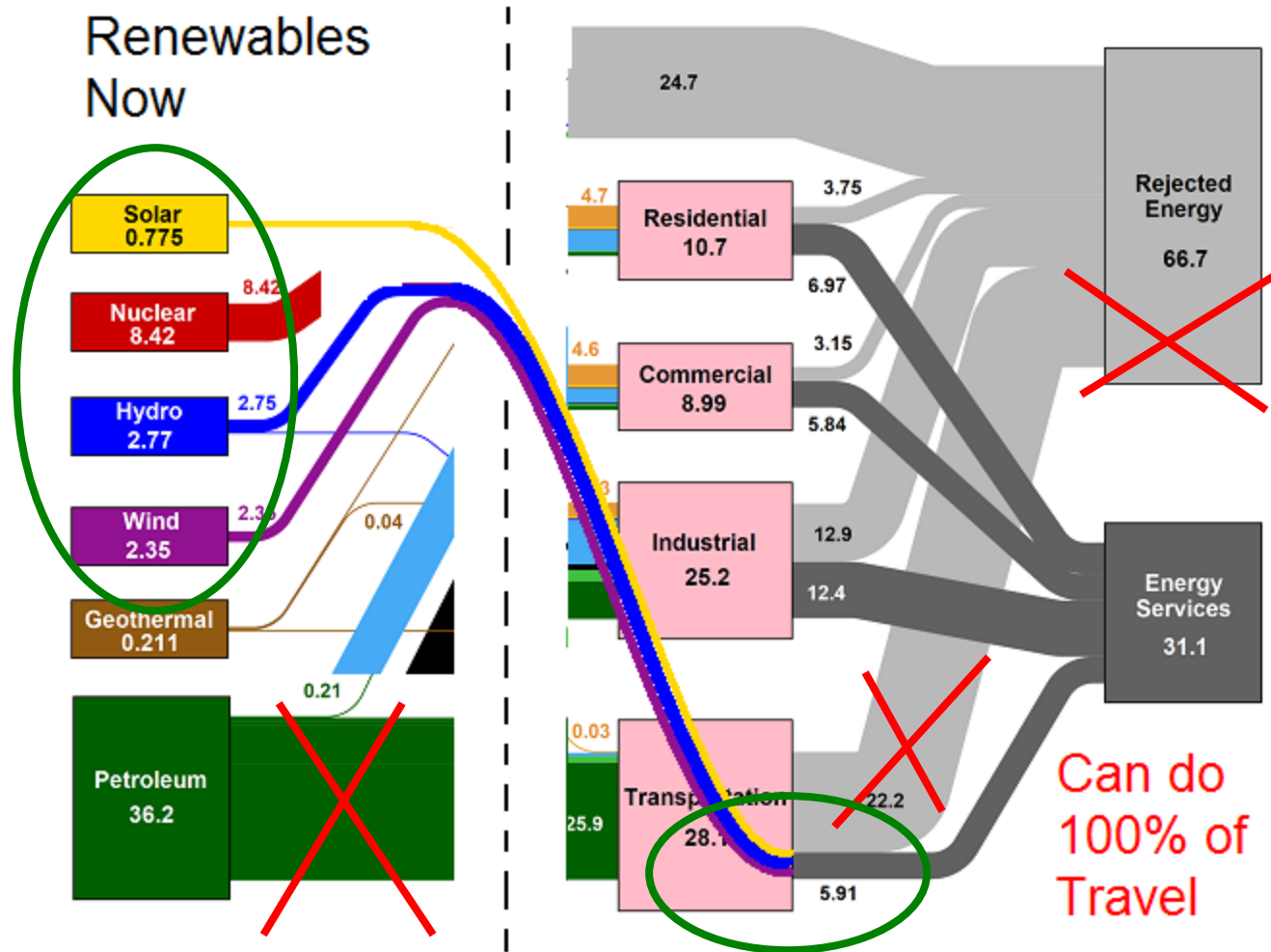
# Estimated U.S. Energy Consumption in 2017: 97.7 Quads



All that oil and heat & emissions just to do this much travel

Source: LLNL April, 2018. Data is based on DOE/EIA MER (2017). If this information or a reproduction of it is used, credit must be given to the Lawrence Livermore National Laboratory and the Department of Energy, under whose auspices the work was performed. This chart was revised in 2017 to reflect changes made in mid-2016 to the Energy Information Administration's analysis methodology and reporting. The efficiency of electricity production is calculated as the total retail electricity delivered divided by the primary energy input into electricity generation. End use efficiency is estimated as 65% for the residential sector, 65% for the commercial sector, 21% for the transportation sector, and 49% for the industrial sector which was updated in 2017 to reflect DOE's analysis of manufacturing. Totals may not equal sum of components due to independent rounding. LLNL-MI-410527

# Oil - Biggest Polluter is Easiest to Eliminate!



# Good news! We all face major Decision points in our lives.

## Every 2 years (avg) we face a major **Energy Decision....**

Every 20 years, a new roof  
Every 15 years, a new HVAC system  
Every 12 years, a new job, a move, retirement  
Every 9 years, a new water heater  
Every 6 years, a new car  
Every 5 years, a new lawnmower  
Every 1 year, Energy choice from Utility

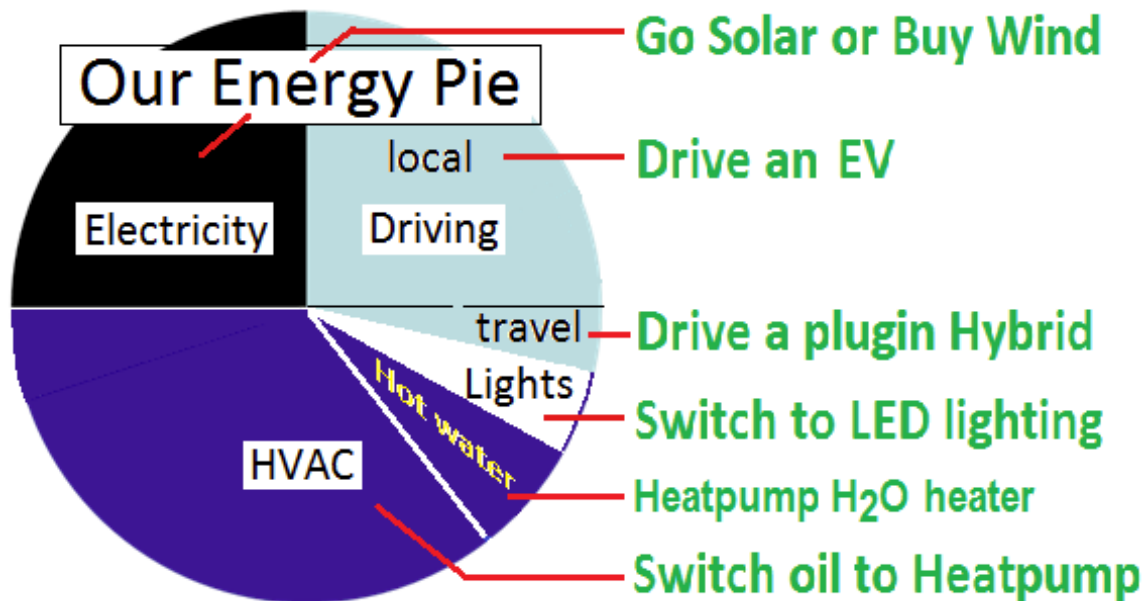


Having a prepared mind is essential

A clean energy investment is better in the long run and cheaper too!

# Every 2 years you face a major **Energy Decision....**

A prepared mind is essential



A clean energy investment is better in the long run and cheaper too!



# Electric/Solar Transportation Forever!

**12** Panels can fully charge Average American 40 miles daily Forever!



3 kW  
\$2000

Electric & Gas	Model	MPG
Ford C-Max Energi	20+gas	
Ford Fusion Energi	20+gas	
Hyundai Sonata	27+gas	
Audi A3 e-tron	17+gas	
BMW X5 xdrive40e	14+gas	
Volvo XC90 T8	13+gas	
VIA VTRUX (fleet)	40+gas	
Porsche Cayenne	14+gas	
Mercedes C350e	18+gas	
Mercedes S550e	12+gas	
Porsche Panamera	15+gas	
BMW i8	14+gas	
Porsche 918 Spyder	12+gas	

Electric & Gas	Model	MPG
Chevy Volt	53+gas	
Chrysler Pacifica hyb	30+gas	
Cadillac ELR	40+gas	
VIA VTRUX (fleet)	40+gas	

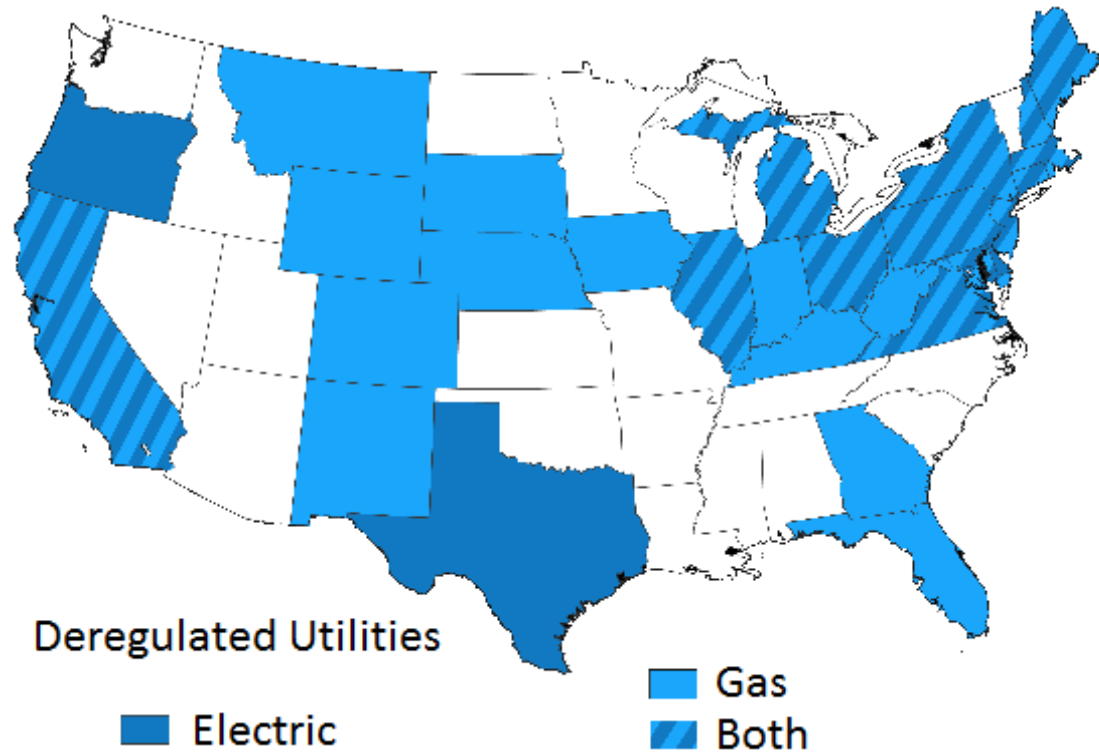
40 mi/day average commuter Forever!

**The Electric Vehicle Association of Greater Washington DC**  
www.evadc.org

**2016 Electric Vehicle Information Sheet**

Model	Base Price (USD) <sup>1</sup>	Net Price (USD) <sup>2</sup>	Range (mi)	Batt. (kWh)	Speed (mph)	MPG equiv <sup>3</sup>	Fuel / Mo. <sup>4</sup>	QC <sup>5</sup>
Smart								
Mitsubishi i (i-MiEV)	\$22,995	\$15,495	62	16	80	112	\$50	Y
Smart electric	\$25,000	\$17,500	68	17.6	78	107	\$50	
Chevy Spark EV	\$25,120	\$17,620	82	21.3	90	119	\$50	Y
VW e-Golf	\$28,995	\$21,495	83	24.2	87	116	\$46	Y
Ford Focus Electric	\$29,170	\$21,670	76	23	84	105	\$50	
Fiat 500e	\$31,800	\$24,300	84	24	85	112	\$50	
Kia Soul EV	\$31,950	\$24,450	93	27	90	105	\$50	Y
Nissan LEAF SV	\$34,200	\$26,700	107	30 <sup>7</sup>	95	112	\$50	Y
Chevy Bolt (2017)	\$37,500	\$30,000	200 <sup>7</sup>	60 <sup>7</sup>	91	---	---	---
Mercedes B250e	\$41,450	\$33,950	87	28	101	84	\$67	
BMW i3 (e-gas opt.)	\$42,400	\$34,900	81	22	93	124	\$46	Y
Tesla Model S 85	\$80,000	\$72,500	265	85 <sup>7</sup>	140	89	\$62	Y
Tesla Model X 90D	---	---	257	90 <sup>7</sup>	155	92	\$58	Y
Volvo S90								
Tesla Model S								
Tesla Model X								
Mercedes B250e								
Spark EV								
i-MiEV								
Focus Electric								
VW e-Golf								
BMW i3								

# 1<sup>st</sup> Sign up for Wind!



Sign up via your Utility that offers “choice”

# 2<sup>nd</sup> LED Lighting: Save 9 to 1 Energy!

(breakeven in 2 weeks!)



Cost under \$2

Save \$60 over the life of the bulb!

House with 50 bulbs saves \$2500

Now LEDs



## Only 3 in 4 households do it!

Yet BGE reports 20% load reduction since 2008!  
Across USA, Coal burning is down more than 20%

# 3<sup>rd</sup> Go electric on all small engines!

Gas mowers are **TEN times more polluting\*** than a CAR. Buy one Electric mower for \$200 more and reduce toxic emissions as much as spending \$10,000 more on an EV



EGO

21 in. 56-Volt Lithium-ion Cordless Battery Self Propelled Mower with 7.5Ah Battery and Charger Included

- Delivers the high torque of gas-powered mowers
- 7.5Ah 56-volt battery (shipped separately) and rapid charger
- 60 minutes cut time and 60 minutes charge time

~~\$599<sup>00</sup>~~ /each **\$550**

6 lb  
battery



I Love it!

\* Toxicity, carcinogens, etc (not carbon)

# 4<sup>th</sup> The easiest step – Buy a Plugin

The Electric Vehicle Association of Greater Washington DC  
www.evga.org

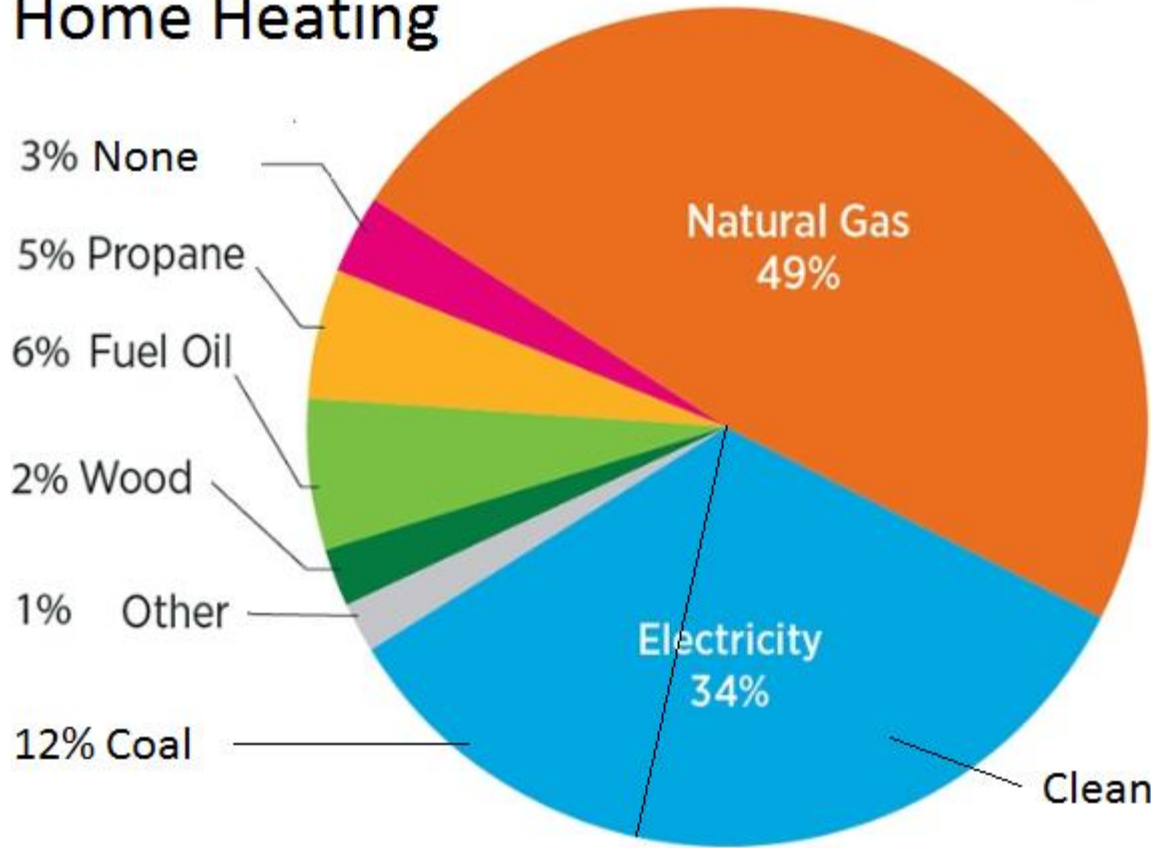
Electric Vehicle Information Sheet

Model	MSRP	EV Range (mi)	MPGe	MPG	MPG City	MPG Hwy	MPG Comb	MPG City	MPG Hwy	MPG Comb	MPG City	MPG Hwy	MPG Comb
2013 Nissan Leaf	\$28,999	75	120	120	120	120	120	120	120	120	120	120	120
2013 Chevrolet Volt	\$32,999	53	106	49	49	49	49	49	49	49	49	49	49
2013 Ford Focus Electric	\$31,999	75	119	119	119	119	119	119	119	119	119	119	119
2013 Tesla Model S	\$64,999	265	105	85	85	85	85	85	85	85	85	85	85
2013 Tesla Model X	\$74,999	207	85	65	65	65	65	65	65	65	65	65	65
2013 BMW i3	\$42,300	109	124	124	124	124	124	124	124	124	124	124	124
2013 Mitsubishi i-MiEV	\$21,999	66	128	128	128	128	128	128	128	128	128	128	128
2013 Honda FCX	\$59,999	160	130	130	130	130	130	130	130	130	130	130	130
2013 Toyota Mirai	\$49,999	401	101	80	80	80	80	80	80	80	80	80	80
2013 Hyundai Ioniq	\$32,999	124	131	131	131	131	131	131	131	131	131	131	131
2013 Kia Niro	\$28,999	239	131	131	131	131	131	131	131	131	131	131	131
2013 Chevrolet Bolt	\$36,699	238	120	120	120	120	120	120	120	120	120	120	120
2013 Ford Mustang Mach-E	\$46,999	300	116	116	116	116	116	116	116	116	116	116	116
2013 Tesla Model 3	\$35,999	220	125	125	125	125	125	125	125	125	125	125	125
2013 Nissan Ariya	\$40,999	300	111	111	111	111	111	111	111	111	111	111	111
2013 Hyundai Kona	\$24,999	261	131	131	131	131	131	131	131	131	131	131	131
2013 Kia EV6	\$41,999	330	131	131	131	131	131	131	131	131	131	131	131
2013 Volkswagen ID.4	\$38,999	276	131	131	131	131	131	131	131	131	131	131	131
2013 Ford F-150 Lightning	\$59,999	320	118	118	118	118	118	118	118	118	118	118	118
2013 Chevrolet Equinox	\$32,999	246	131	131	131	131	131	131	131	131	131	131	131
2013 Ford Explorer	\$34,999	270	131	131	131	131	131	131	131	131	131	131	131
2013 Chevrolet Blazer	\$33,999	246	131	131	131	131	131	131	131	131	131	131	131
2013 Ford Bronco	\$36,999	270	131	131	131	131	131	131	131	131	131	131	131
2013 Chevrolet Tahoe	\$48,999	246	131	131	131	131	131	131	131	131	131	131	131
2013 Ford Expedition	\$46,999	270	131	131	131	131	131	131	131	131	131	131	131
2013 Chevrolet Silverado	\$42,999	246	131	131	131	131	131	131	131	131	131	131	131
2013 Ford Super Duty	\$40,999	270	131	131	131	131	131	131	131	131	131	131	131
2013 Chevrolet Camaro	\$24,999	246	131	131	131	131	131	131	131	131	131	131	131
2013 Ford Mustang	\$22,999	270	131	131	131	131	131	131	131	131	131	131	131
2013 Chevrolet Malibu	\$21,999	246	131	131	131	131	131	131	131	131	131	131	131
2013 Ford Focus	\$20,999	270	131	131	131	131	131	131	131	131	131	131	131
2013 Chevrolet Cruze	\$19,999	246	131	131	131	131	131	131	131	131	131	131	131
2013 Ford Fiesta	\$18,999	270	131	131	131	131	131	131	131	131	131	131	131
2013 Chevrolet Spark	\$17,999	246	131	131	131	131	131	131	131	131	131	131	131
2013 Ford EcoSport	\$16,999	270	131	131	131	131	131	131	131	131	131	131	131
2013 Chevrolet Trax	\$15,999	246	131	131	131	131	131	131	131	131	131	131	131
2013 Ford Escape	\$14,999	270	131	131	131	131	131	131	131	131	131	131	131
2013 Chevrolet Equinox	\$13,999	246	131	131	131	131	131	131	131	131	131	131	131
2013 Ford Explorer	\$12,999	270	131	131	131	131	131	131	131	131	131	131	131
2013 Chevrolet Blazer	\$11,999	246	131	131	131	131	131	131	131	131	131	131	131
2013 Ford Bronco	\$10,999	270	131	131	131	131	131	131	131	131	131	131	131
2013 Chevrolet Tahoe	\$9,999	246	131	131	131	131	131	131	131	131	131	131	131
2013 Ford Expedition	\$8,999	270	131	131	131	131	131	131	131	131	131	131	131
2013 Chevrolet Silverado	\$7,999	246	131	131	131	131	131	131	131	131	131	131	131
2013 Ford Super Duty	\$6,999	270	131	131	131	131	131	131	131	131	131	131	131
2013 Chevrolet Camaro	\$5,999	246	131	131	131	131	131	131	131	131	131	131	131
2013 Ford Mustang	\$4,999	270	131	131	131	131	131	131	131	131	131	131	131
2013 Chevrolet Malibu	\$3,999	246	131	131	131	131	131	131	131	131	131	131	131
2013 Ford Focus	\$2,999	270	131	131	131	131	131	131	131	131	131	131	131
2013 Chevrolet Cruze	\$1,999	246	131	131	131	131	131	131	131	131	131	131	131
2013 Ford Fiesta	\$999	270	131	131	131	131	131	131	131	131	131	131	131
2013 Chevrolet Spark	\$899	246	131	131	131	131	131	131	131	131	131	131	131
2013 Ford EcoSport	\$799	270	131	131	131	131	131	131	131	131	131	131	131
2013 Chevrolet Trax	\$699	246	131	131	131	131	131	131	131	131	131	131	131
2013 Ford Escape	\$599	270	131	131	131	131	131	131	131	131	131	131	131
2013 Chevrolet Equinox	\$499	246	131	131	131	131	131	131	131	131	131	131	131
2013 Ford Explorer	\$399	270	131	131	131	131	131	131	131	131	131	131	131
2013 Chevrolet Blazer	\$299	246	131	131	131	131	131	131	131	131	131	131	131
2013 Ford Bronco	\$199	270	131	131	131	131	131	131	131	131	131	131	131
2013 Chevrolet Tahoe	\$99	246	131	131	131	131	131	131	131	131	131	131	131
2013 Ford Expedition	\$89	270	131	131	131	131	131	131	131	131	131	131	131
2013 Chevrolet Silverado	\$79	246	131	131	131	131	131	131	131	131	131	131	131
2013 Ford Super Duty	\$69	270	131	131	131	131	131	131	131	131	131	131	131
2013 Chevrolet Camaro	\$59	246	131	131	131	131	131	131	131	131	131	131	131
2013 Ford Mustang	\$49	270	131	131	131	131	131	131	131	131	131	131	131
2013 Chevrolet Malibu	\$39	246	131	131	131	131	131	131	131	131	131	131	131
2013 Ford Focus	\$29	270	131	131	131	131	131	131	131	131	131	131	131
2013 Chevrolet Cruze	\$19	246	131	131	131	131	131	131	131	131	131	131	131
2013 Ford Fiesta	\$9	270	131	131	131	131	131	131	131	131	131	131	131
2013 Chevrolet Spark	\$8	246	131	131	131	131	131	131	131	131	131	131	131
2013 Ford EcoSport	\$7	270	131	131	131	131	131	131	131	131	131	131	131
2013 Chevrolet Trax	\$6	246	131	131	131	131	131	131	131	131	131	131	131
2013 Ford Escape	\$5	270	131	131	131	131	131	131	131	131	131	131	131
2013 Chevrolet Equinox	\$4	246	131	131	131	131	131	131	131	131	131	131	131
2013 Ford Explorer	\$3	270	131	131	131	131	131	131	131	131	131	131	131
2013 Chevrolet Blazer	\$2	246	131	131	131	131	131	131	131	131	131	131	131
2013 Ford Bronco	\$1	270	131	131	131	131	131	131	131	131	131	131	131
2013 Chevrolet Tahoe	\$0	246	131	131	131	131	131	131	131	131	131	131	131
2013 Ford Expedition	\$0	270	131	131	131	131	131	131	131	131	131	131	131
2013 Chevrolet Silverado	\$0	246	131	131	131	131	131	131	131	131	131	131	131
2013 Ford Super Duty	\$0	270	131	131	131	131	131	131	131	131	131	131	131
2013 Chevrolet Camaro	\$0	246	131	131	131	131	131	131	131	131	131	131	131
2013 Ford Mustang	\$0	270	131	131	131	131	131	131	131	131	131	131	131
2013 Chevrolet Malibu	\$0	246	131	131	131	131	131	131	131	131	131	131	131
2013 Ford Focus	\$0	270	131	131	131	131	131	131	131	131	131	131	131
2013 Chevrolet Cruze	\$0	246	131	131	131	131	131	131	131	131	131	131	131
2013 Ford Fiesta	\$0	270	131	131	131	131	131	131	131	131	131	131	131
2013 Chevrolet Spark	\$0	246	131	131	131	131	131	131	131	131	131	131	131
2013 Ford EcoSport	\$0	270	131	131									

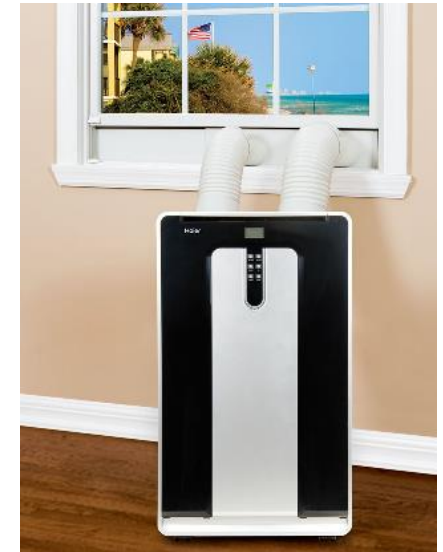
# 5<sup>th</sup> The easiest step - Heatpmp

<https://energy.gov/energysaver/home-heating-systems>

## Home Heating



\$528.00 / each



# Easy Heatpumps

- Window Units
- Portable Units
- Mini-Split units
- Hot Water Units



Easy DIY - No Ductwork!



And is best of zone heating and cooling!

# Ductless Heatpumps Anywhere!



12,000 BTU 1 Ton  
Ductless Mini Split Air Conditioner  
and Heat Pump - 208-230V/60Hz

**\$1,199<sup>00</sup>** /bundle

✓ Shipping available

[Add To Cart](#)

# Never Buy or Replace an AC unit Again!

When that time comes, **buy a bi-directional Heatpump!**  
It only costs about 10% more but..

It Cools!

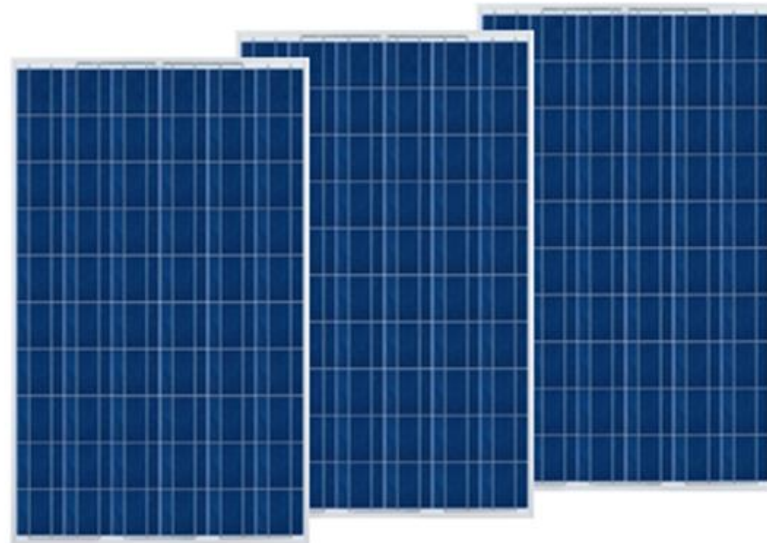
It Dehumidifies

**It Heats!** (with 1/3<sup>rd</sup> the cost of Electricity, 1/2 the cost of Oil/Propane)

# You can even buy Solar HVAC

**Solar Air  
Conditioner  
Heat Pump**

**ACDC12b SOLAR AC  
SAVE >90% ON COOLING / HEATING COSTS**



Or make your own from a new variable speed HVAC

# Finish this Sentence:

- There is nothing certain in life except

Death and ....

Taxes ...

and Utilities!

But you can do something about these!

# Finish this Sentence:

- There is nothing certain in life except

Death and .....

Taxes ...

Save  
30%

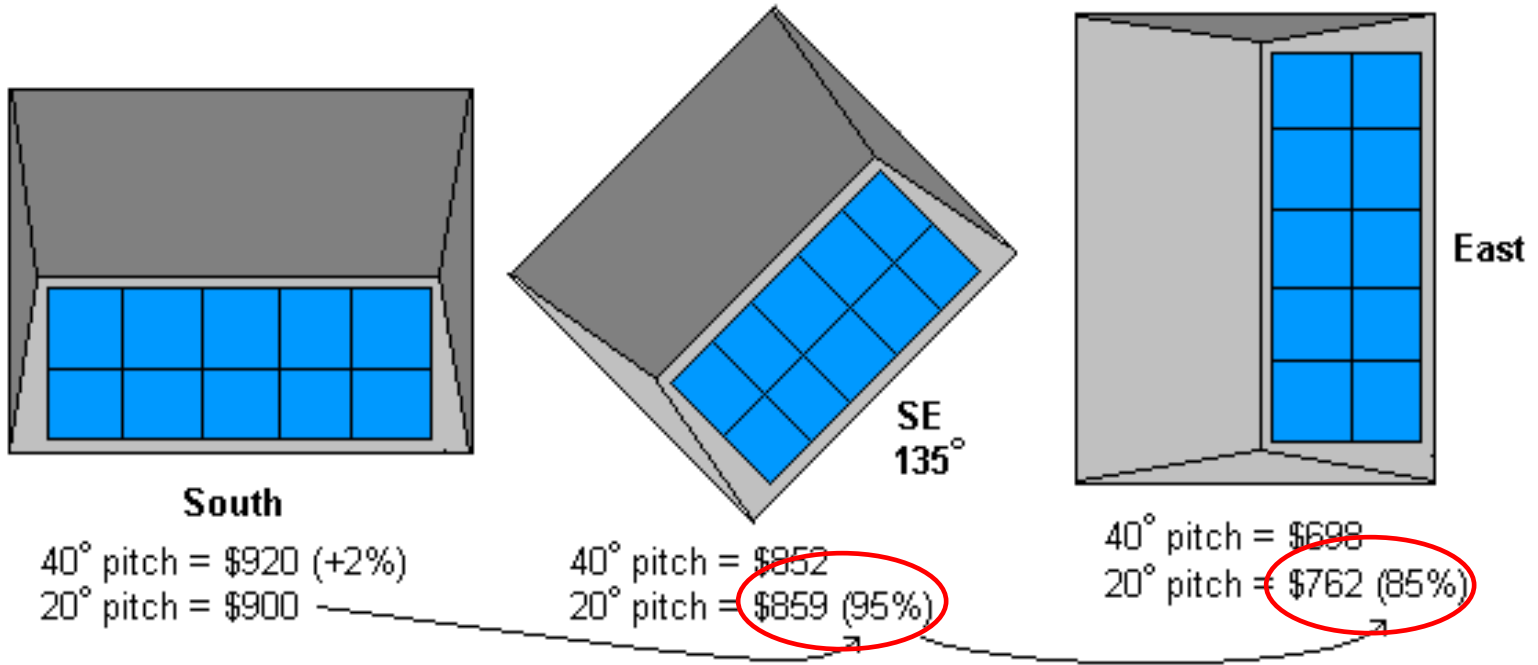
Eliminate  
100% to  
Zero!

and Utilities!

But you can do something about these!

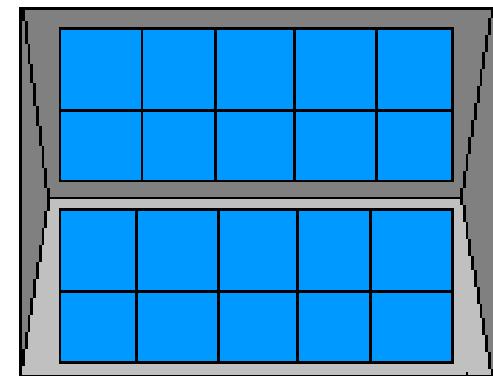
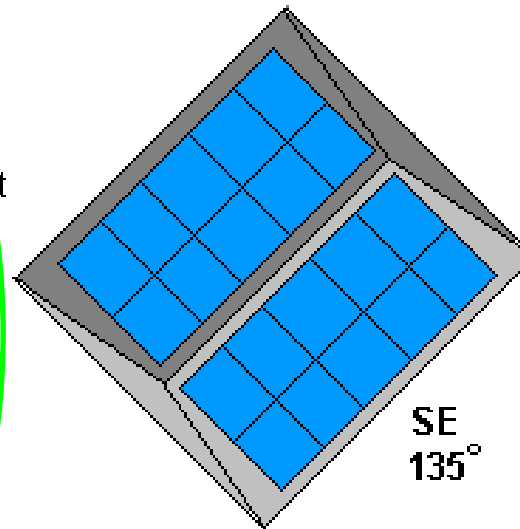
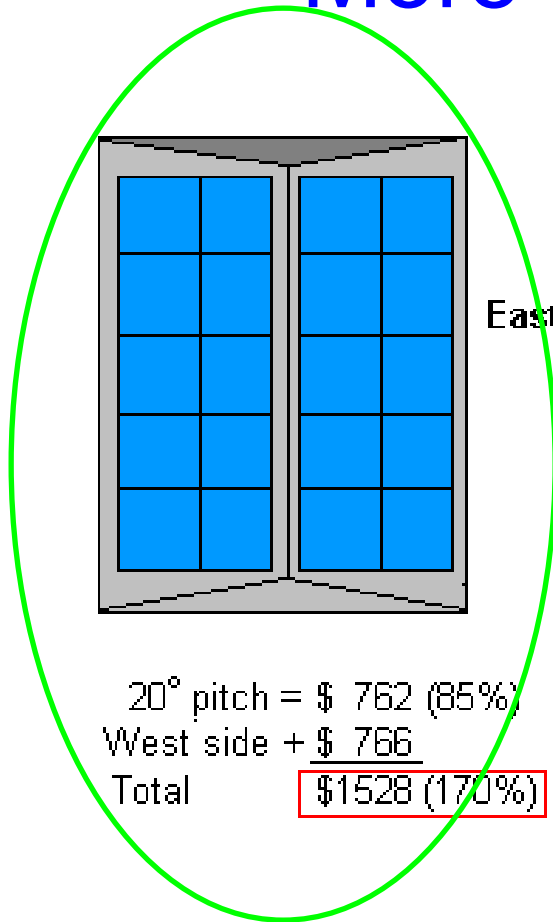
Lets talk Solar!

# Direction - not important with Grid-Tie



Amazing, even due East, you still get 85% effectiveness!

# Direction - less important, More Roof is!



Amazing! Increase power by 60% to 100% on other side!

# Tilt Angle not important\* with Grid-tie

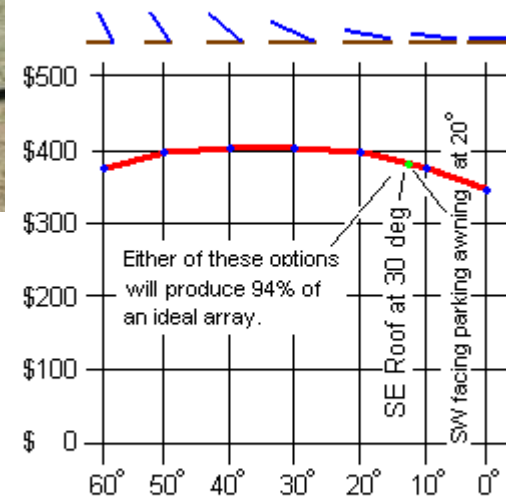


Tilt angle chosen was 25 deg instead of 35 deg to reduce visibility (<1% loss)

Any angle from 20° to 50° is within 1% of annual total

(\*Tilt is absolutely essential for *winter* with off-grid)

**Annual Power Production**  
2.2kW South Array versus Angle



For annual total power, the tilt angle is not that important. The more important parameter is shade (location)

# One of the Biggest problems for Solar is **Shade**



And **easiest to fix**

Solar panels can also provide a bit of shade to the roof

# A chain saw fixes a lot!

- A 6 kW array reduces carbon as much as 200 trees (2 acres)
- So **give up one** if you have to, and...
- **Plant a new one** just where you want it
- In 20 years it might be over 30' tall!

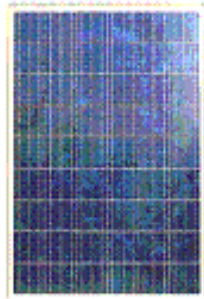


**8 Trees Eliminate these Pollutants 1yr**

- 400 lbs of carbon dioxide
- 48 lbs of particulates
- 9 lbs of nitrogen dioxide
- 6 lbs of sulfur dioxide
- 2 lb of carbon monoxide



Derived from data on: <http://www.coloradotrees.org/benefits.htm>



**One 220W solar panel Eliminates Per Year:**

- 440 lbs of Carbon Dioxide
- 57 lbs of Particulates
- 7 lbs of Sulfur Dioxide
- 1.4 lbs of Nitrous Oxide
- 0.4 lbs of Carbon Monoxide
- .0012 lbs of Uranium and Thorium
- .0000008 oz of Mercury

Derived from [http://en.wikipedia.org/wiki/Fossil\\_fuel\\_power\\_plant](http://en.wikipedia.org/wiki/Fossil_fuel_power_plant)

Bob Bruninga, WB4APR

Big Picture!

**Clean Energy, SOLAR**

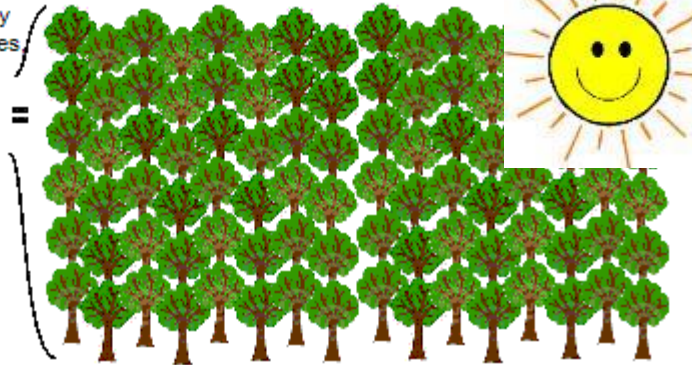
**Carbon Equivalence!**

Each Panel = 8 Trees.

Our system = 312 trees!

= (3 acres of trees)

Proposed Array  
1 set = 100 trees

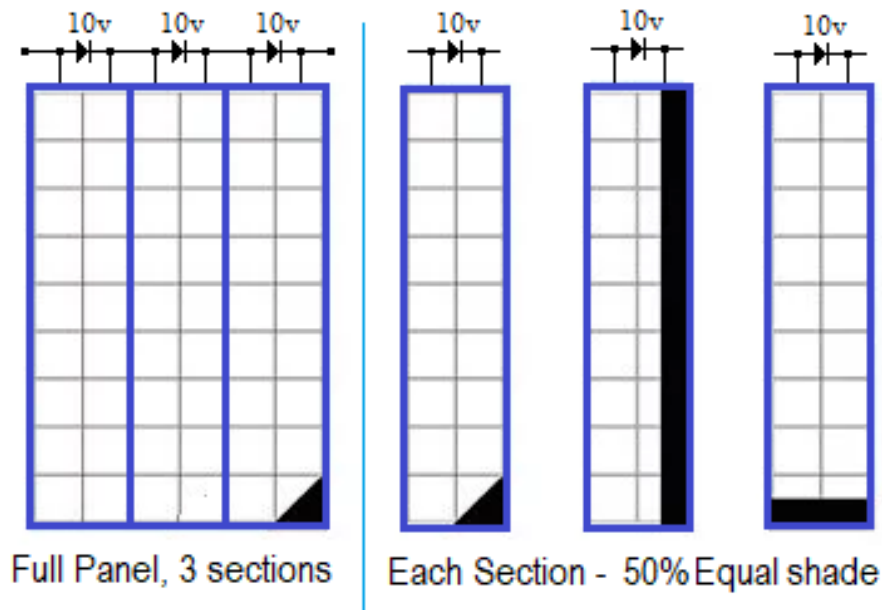


The 3 arrays = 300 trees!

100 trees!

WB4APR

# Shade on a cell takes out whole section ( $1/3^{\text{rd}}$ ) of panel



Same effect on both String arrays AND Microinverters!

# 10% or more annual Return on Investment for Life!



x21633867 fotosearch.com

- Federal gives 30% tax credit. No limit
- State Grants (was \$5000 in 2011, \$10000 now)
- County Real Estate Tax credit (was \$2500)
- Total Gov't Tax Credits were ~ 40% of investment!

Compare 1% ROI from banks

Compare zip-squat-zero ROI from utility!



# When did you hear about solar?

- In 2010, when solar city showed it was cheaper than the utility In Maryland? (9 years ago)
- What did you do about it?
- At \$100/mo electric bill, you have thrown away \$11,000 to the utility
- And missed over \$3300 in Tax credit
- And missed over \$2000 in local tax benefits
- Your cost for doing nothing? Nearly \$15,000

# The Value of \$12,000 Savings?

For Someone with a \$100/mo elec bill (\$1200/yr)



In bank @ 1%

Pay \$1200/yr for electricity forever\*



Buy 6 kW solar

\$16k equity

Get back \$4000 immediately on taxes (OPM)

Get back \$600/yr in SRECs (5 yrs) \$3,000

Get \$1200 free electricity/year

Get \$1000 from state? County? City?

\$ 0 Equity left 10 yrs

\$ 1200 Earned interest

Own nothing

Continue \$1200/yr utility for life

\$ 0 after 1 more year 11 yrs

\$12,000 System Value

\$ 5,000 Tax refund

\$ 3,000 SREC's

\$20,000 Equity

Avoided \$12,000 in electric bills

You own your own Energy system

Net value \$32,000\* 10 yrs

NO utilities for life!



\* Apples and Oranges  
your mileage may vary

# The Value of \$12,000 Savings?

For Someone with a \$100/mo elec bill (\$1200/yr)



In bank @ 1%

Pay \$1200/yr for electricity forever\*



Buy 6 kW solar

\$16k equity

Get back \$4000 immediately on taxes (OPM)

Get back \$600/yr in SRECs (5 yrs) \$3,000

Get \$1200 free electricity/year

Get \$1000 from state? County? City?

\$ 0 Equity left

11 yrs

\$12,000 System Value

\$ 5,000 Tax refund

\$ 3,000 SREC's

\$20,000 Equity

Avoided \$12,000 in electric bills

You own your own Energy system

Net value \$32,000\*

10 yrs

NO utilities for life!



Own nothing

Continue owing \$1200/yr utility for life

\* Apples and Oranges  
your mileage may vary

# Remember:

- There is nothing certain in life except

Death and ....

Save  
30%

Eliminate  
100% to  
Zero!

Taxes ...

and Utilities!

But you can do something about these!

And 10% return for life!

## Solar panels better than a pension, says minister

8% - 10%

Energy minister says those approaching retirement should consider putting some of their savings into solar panels to deliver a better financial return than a pension



Greg Barker, the energy minister, said that anyone approaching retirement should consider putting some of their savings into solar panels because they would deliver a better financial return than a pension.

Email

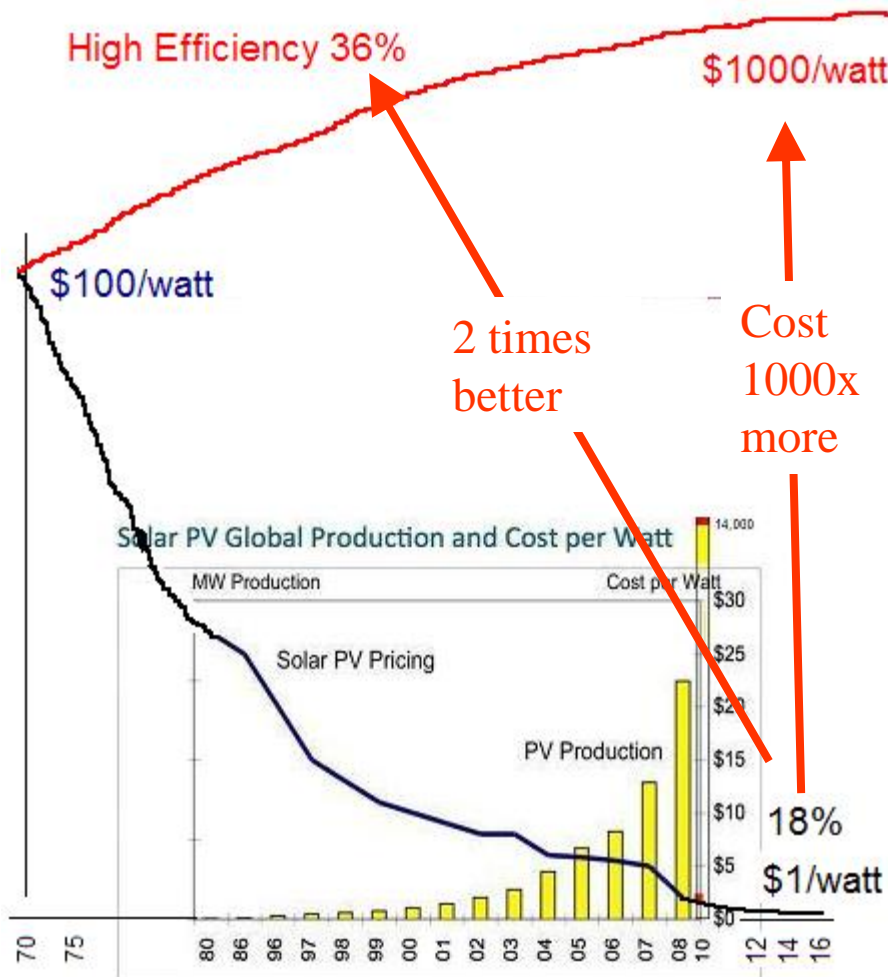
Facebook

# Buy or lease Solar?

Personal Decision based on your situation

- Do nothing – Pay utility/month Forever (FOSSILS)
- Lease – Pay ~ 15% less for 20 years (clean)
- Buy via Loan – about 25% less?
- Buy – From savings – about 50% less? } You Own!
- Get Three estimates (don't trust me!)

# Waiting for Higher Solar Efficiency is a Fools Errand



High efficiency prices ONLY go up since the space industry will pay anything for each additional 1 percent.

Home panel prices only go **down** since homeowners will not buy anything but the cheapest

# Rapid Change is happening all around you!

**Just in 2008 they were saying the grid cannot handle more than 2% solar/wind**

2013 **Hawaii** hit 40% on a weekend, **Germany** hit 60%,

2014 **Netherlands** and **Spain** hit 100% for a day

2015 many countries hit days of 100% solar wind

2015 In one year **China** installed more wind than USA to-date

2016 Saudi Arabia began largest solar, **cheaper than coal**

**2017 Oil rich Texas** hit 100% wind/solar for a day

2017 Denmark was 63% solar & wind for the whole year!

2018 Germany

**Now 100% is common!**

\* Facts are correct, dates are from memory...



by grid



time

# The Great Ham DIY Solar Paradox!

Solar is a Fantastic Investment for the Ham (grid Tie)  
But, Solar Grid Tie is impossible DIY:

- Building & Electrical permits, Utility Inspections

## **DIY Solution:**

Contract a small system

Get Net Meter - \$2.50/W

Add your panels - \$0.30/W

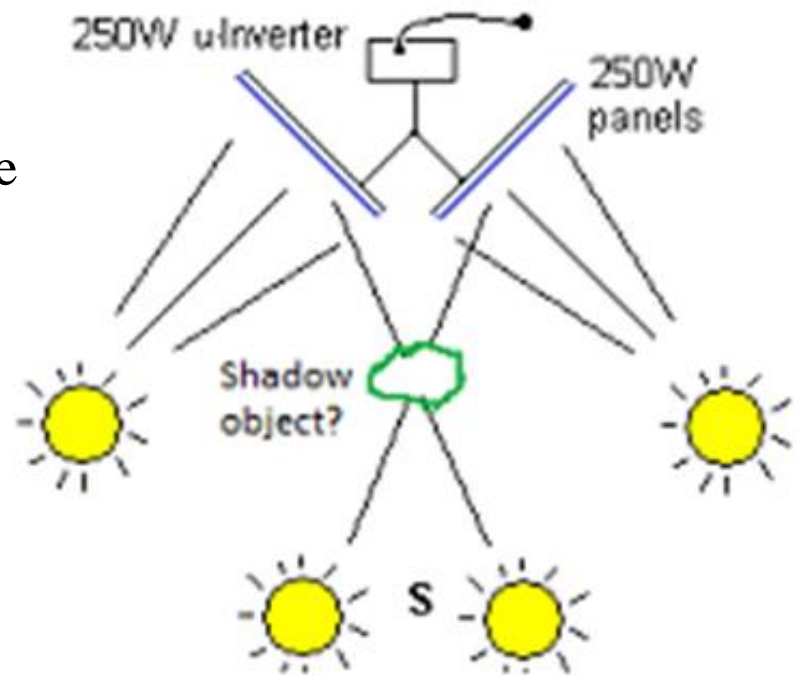
& plugin GT inverters - \$0.30/W



## Another DIY Tip:

### – Double your GT Inverter Power!

- Double panels at 90 degrees
- Parallel to same inverter
- Inverter rating remains the same
- BUT FOR TWICE AS LONG



# Big Picture!

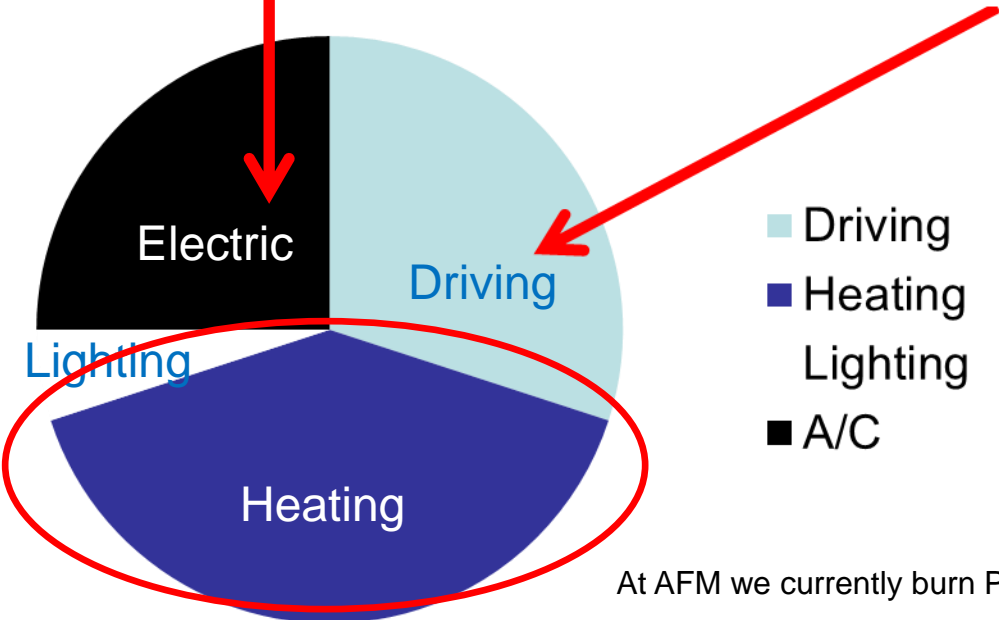
# Burning Fossils for Heat!?



Solar Power for Electricity



Electric Vehicle Support



We include EV's because about half of our easily-fixed energy is spent driving

At AFM we currently burn Propane for heat



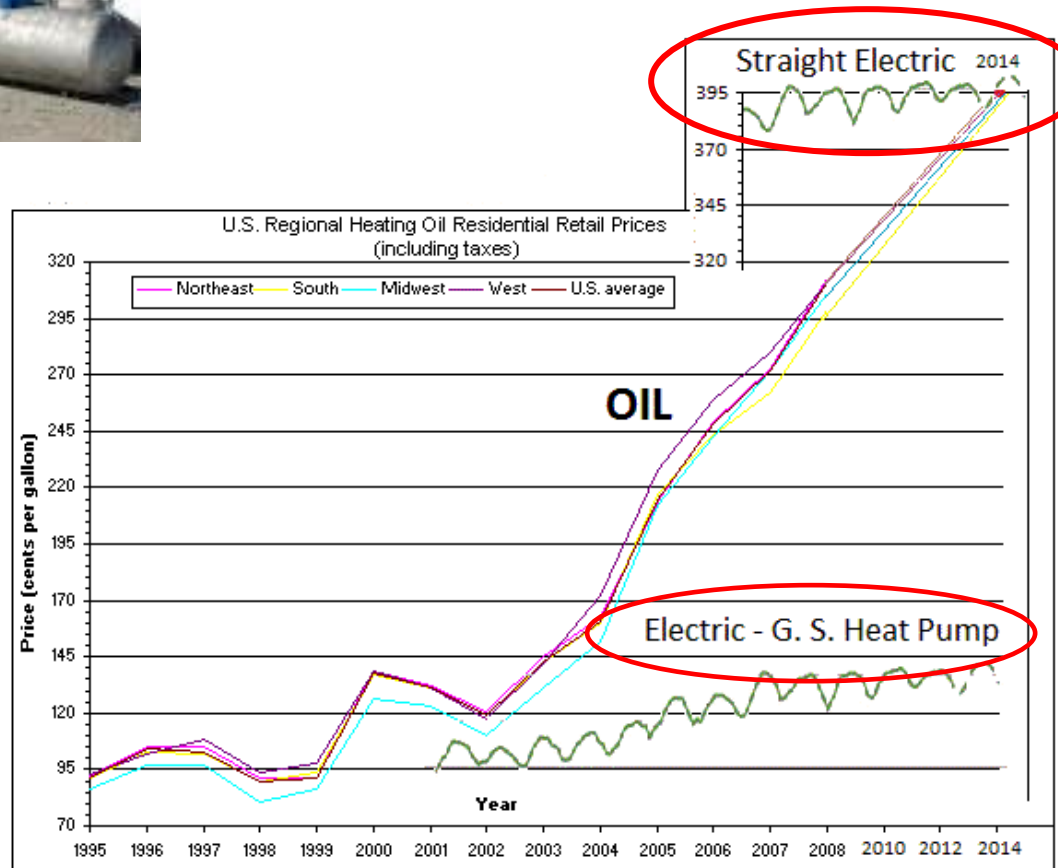


# Heating Costs – Oil, Propane...

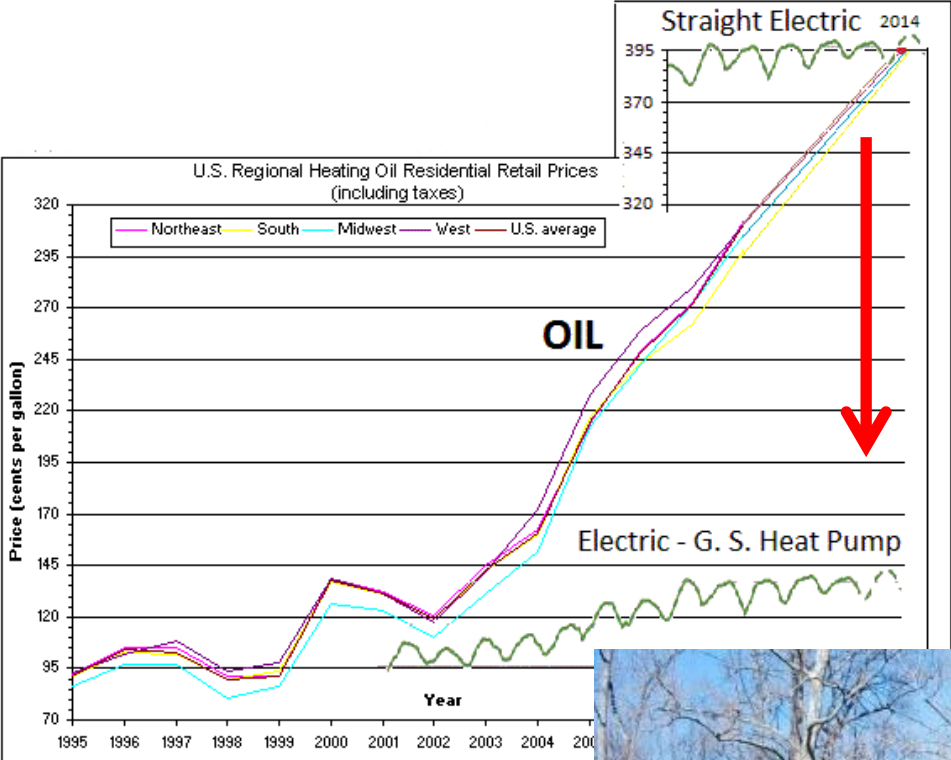


Actually our biggest Energy cost is our Propane heating.

Switching to Heatpump can **save 60%** of our energy costs!



# Switching from Propane to Heatpump (electric)



Our heating costs went down 60% AND being electric, we replace that with solar free heating for decades!



# Never Buy another Air Conditioner Again

When the old AC dies **GET A HEATPUMP** to replace it.!

A Heatpump is same as AC unit but with a **reversing valve**.

Only adds 10-20% cost but can replace 80% of fossil Heat

When the old furnace dies, **GET A HEATPUMP**

**Heatpumps save 2 or 3-to-1** on Energy costs

**AND** they can run on **100% fossil free energy!**

Window units, Split units, Duct units, etc

# Easy Heatpumps

- Window Units
- Portable Units
- Mini-Split units
- Hot Water Units



# Ductless Heatpumps Anywhere!




12,000 BTU 1 Ton  
Ductless Mini Split Air Conditioner  
and Heat Pump - 208-230V/60Hz

**\$1,199<sup>00</sup>** /bundle

✓ Shipping available

[Add To Cart](#)


# Solar PV now **BETTER** than Thermal hot water... !



**\$15,000**  
**75% efficient**  
**Maintenance**

**Dead,dead,dead**

=



**\$5,000**  
**15% efficient**

**Heatpump**  
**250% efficient**

**Grid Tie**

100% hot water not used EVERYDAY  
... Excess solar every day is lost

100% of solar energy = full retail value  
Independent of how you use it!

# So, choose forward with clean Energy



Bob Bruninga, WB4APR  
Annapolis, MD 21401  
<http://www.aprs.org/AFM-environment.html>  
410-293-6417





# Summary

You can do something

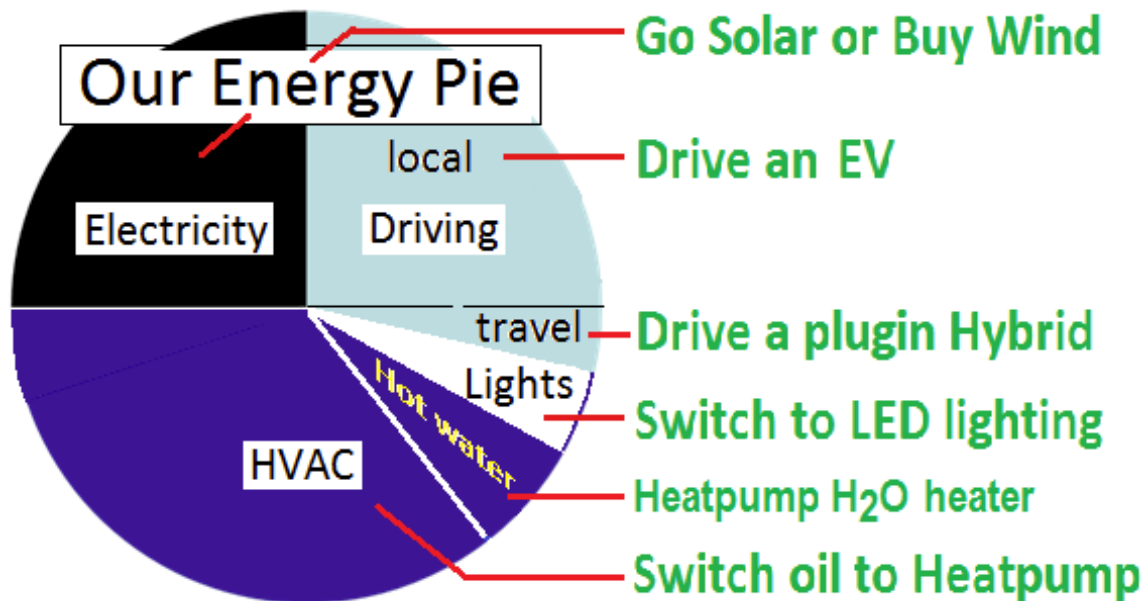
- **Pre-think** your next personal energy decision.
- If you have sun, **solar is best investment** ever...
- **Everyone\*** can sign up for **WIND** power!
- Water heater dies – **get a heatpump one**
- Heating dies – **get a heat pump** (and solar)
- AC dies – **Get a heatpump**
- Car ages – **get an EV** for commuting
- Put charging signs on **outdoor outlets**
- **Power them for life with Solar! \$\$\$**



**Its cheaper and cleaner!**

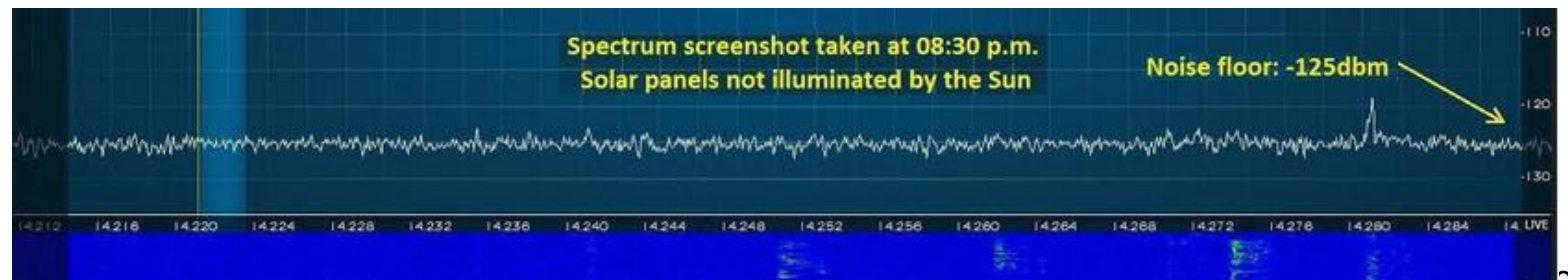
# Every 2 years you face a major **Energy Decision....**

A prepared mind is essential



A clean energy investment is better in the long run and cheaper too!

# BEWARE of Solar RFI!



Backup slides follow

WB4APR



Who's Talking \* \* \*

# OUR PRESENT LIFESTYLE IS NOT SUSTAINABLE!



Are we  
part of  
the  
problem?



Or part  
of the  
Solution?



Big  
Picture!

# When is the Payback ??? When is the Breakeven ???



Paying for at-home Garbage Pickup -  
was from Day ONE !



Big  
Picture!

# When is the Payback ??? When is the Breakeven ???



Paying for Sewage Plants –  
was from Day ONE !



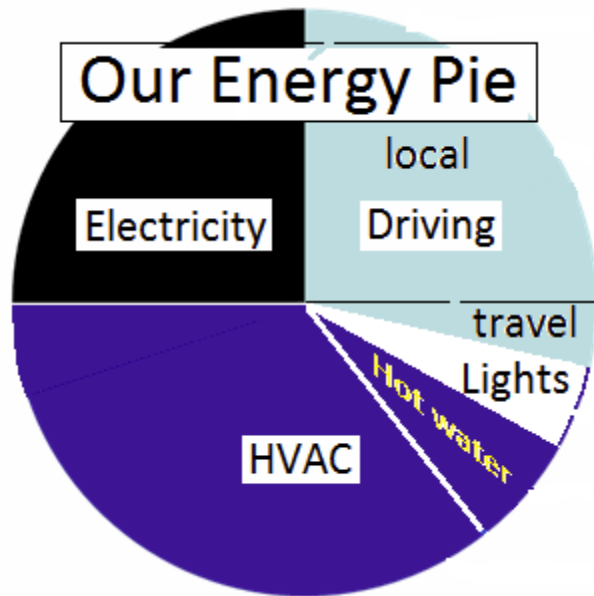
Big  
Picture!

# When is the Payback ??? When is the Breakeven ???



Investing in Solar Power - is from Day ONE !  
Because that's when we Stop Beating Mother  
Nature and stealing from our kids future.

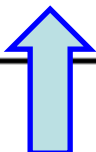




# Who, What, When, Why, How

Homeowners can do the most

Who? \ What?	Electricity		HVAC		Transportation		
	Wind	Solar	Hot Water	HVAC	Local	Trips	
Rent	✓	✗	✗	✗	✗	✗	Single
Have outlet					PHEV ←		
Own	✓	✓	✓	✓	EV + PHEV		Family
		Trees ✗			✗	✗	



# Power Distribution 330 VDC

Nearly ALL modern switching supplies will run on VDC

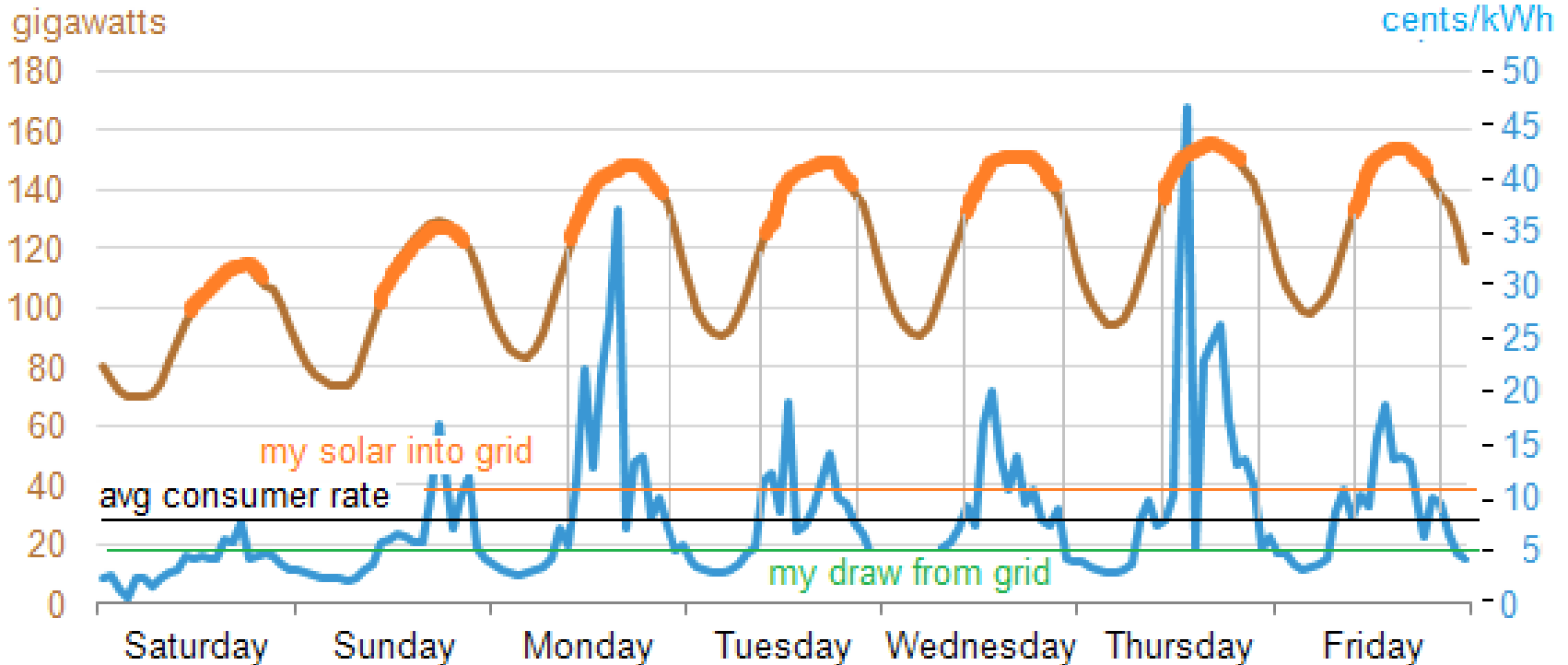


Kenwood 115 VAC only supply  
Actually has internal jumper

Eliminate 75% of  
Distribution losses

# What is fair in Net Metering?

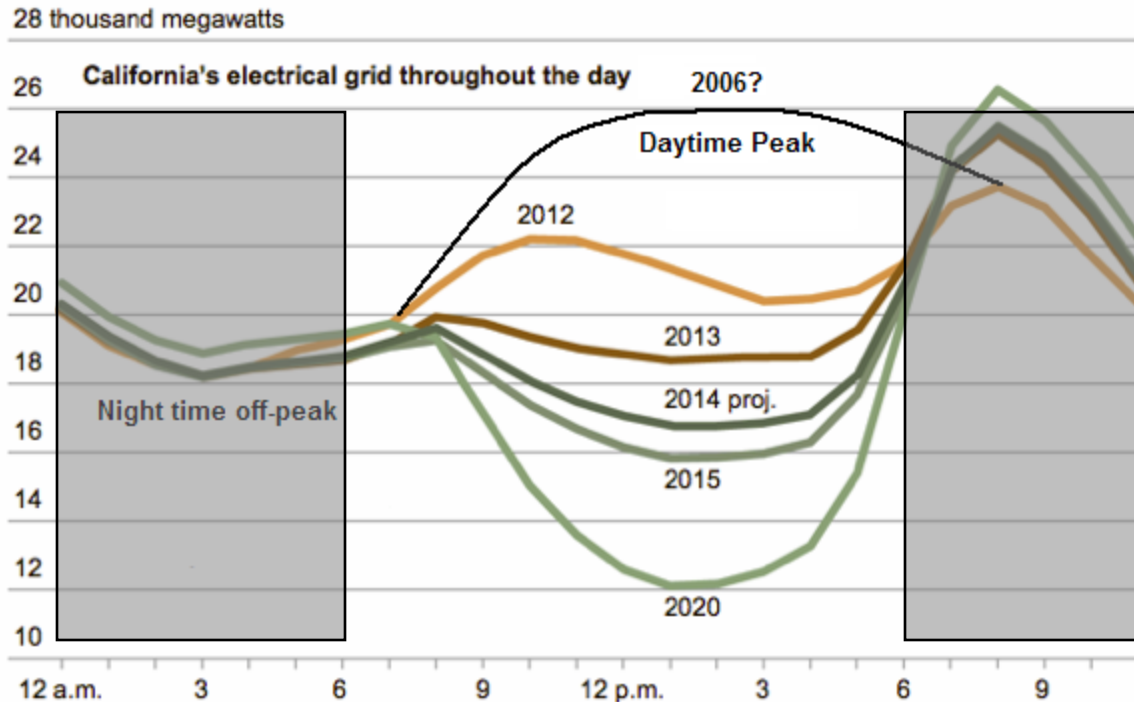
Hourly electricity demand and real-time energy prices in the PJM Interconnection  
Saturday, July 13 - Friday, July 19, 2013



Source: U.S. Energy Information Administration based on PJM data

# Rapid Change is happening all around you!

## The Duck's Back



Already electricity is cheaper during day than night!  
In California.

And that means **Charging-at-work!**  
And Massive opportunity for demand Response

# Solar Grid-tie Inverter Types

- **String Inverter** – simple, efficient, one big box on the wall in the basement/utility room. \*RF quiet. easy to replace maintain. Cheapest – less profit for installer.



My three inverters or AFM's one



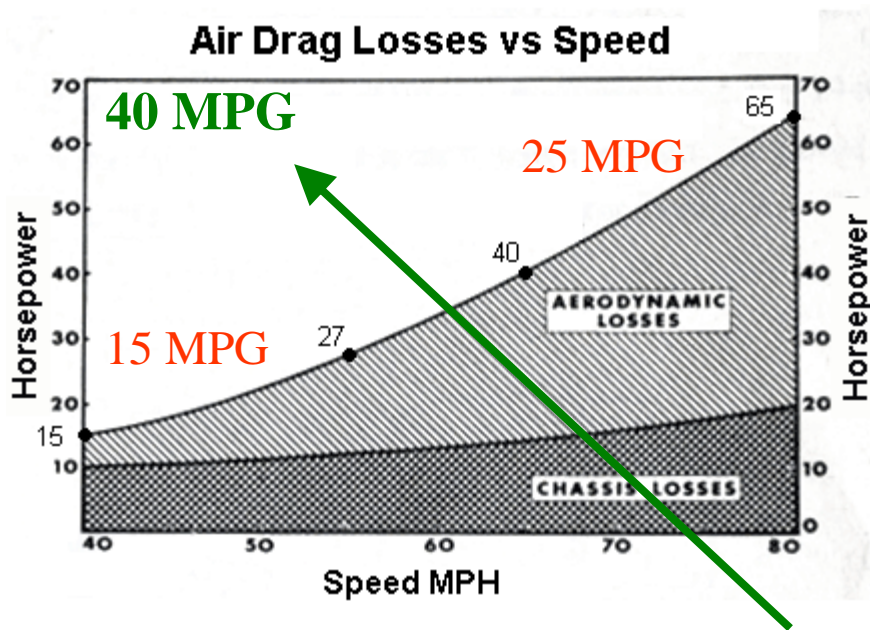
# Solar Grid-tie Inverter Types



- **Micro Inverters** – On every panel.
  - Made sense when panels were \$1200 and M.I. was \$250.
  - But now panels are \$120!
  - Dozens of elec modules on roof (-10F to +160F extremes)
  - Costly to repair/replace!
  - Some brands might Generate RF hash on nearby radios?
- **Optimizers** – Cheaper but all the same disadvantages and definitely known to be RF noisy.

# 4<sup>th</sup> Learn to Drive Efficiently

- Double your range -IN ANY CAR



So why do we get better MPG on the highway?

Duh, it's the brakes!

They burn up energy as heat.

**Coast to the next light and save all that energy!!!**

Or in a hybrid or an EV, 90% of braking energy is saved

# Solar and EVs – The Perfect Marriage

## 6 Panels (\$1200)



Can fully charge a Prius **plugin**  
everyday... FOREVER!

No more \$2,000,000,000 per day for overseas oil

No more foreign **dependence**, no more **price fluctuation**

No more **oil**, no more **insecurity**, no more **oil wars**

# Over 45 EV's now on Market!

(in just 8 years!)

And now 500 committed to in the next 6 yrs

Volvo	ALL models will be electrified by 2019
GM	10 EV models in China by 2020 (2 years from now)
Mercedes Benz	Electric versions of ALL Models by 2022 (4 years)
Ford	More than half will be Electric by 2022 (including F150)
Nissan Group	12 new EV's by 2022
Hyundai	12 new EVs by 2022
BMW	25 Electric models by 2025 (7 years from now)
VW Group	80 EV models by 2025, 16 new plants 3 million/year

All car purchasers today should at least checkout the potential of an EV to meet their driving need

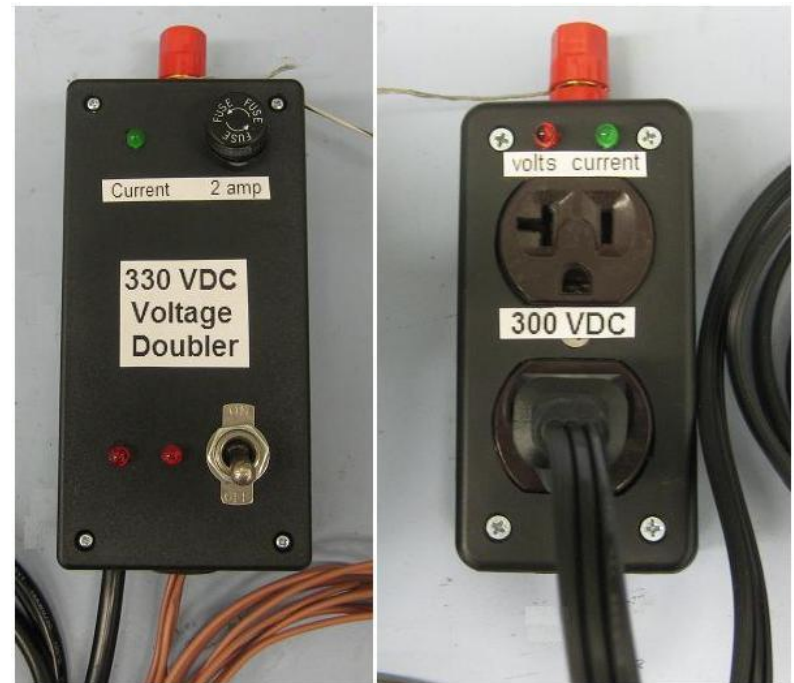
- There is an EV or PHEV replacement for every car model on the market.
- That **cost less** than the average gas car (\$35k) avg new or under \$10k used,
- That have any **range from 100 to 600 miles** (EV, PHEV)
- Go **faster**, but with less **cost to operate and maintain**



**We cannot keep doing this!**

# Power Distribution SWER

Emergency Power: Use Single Wire Earth Return

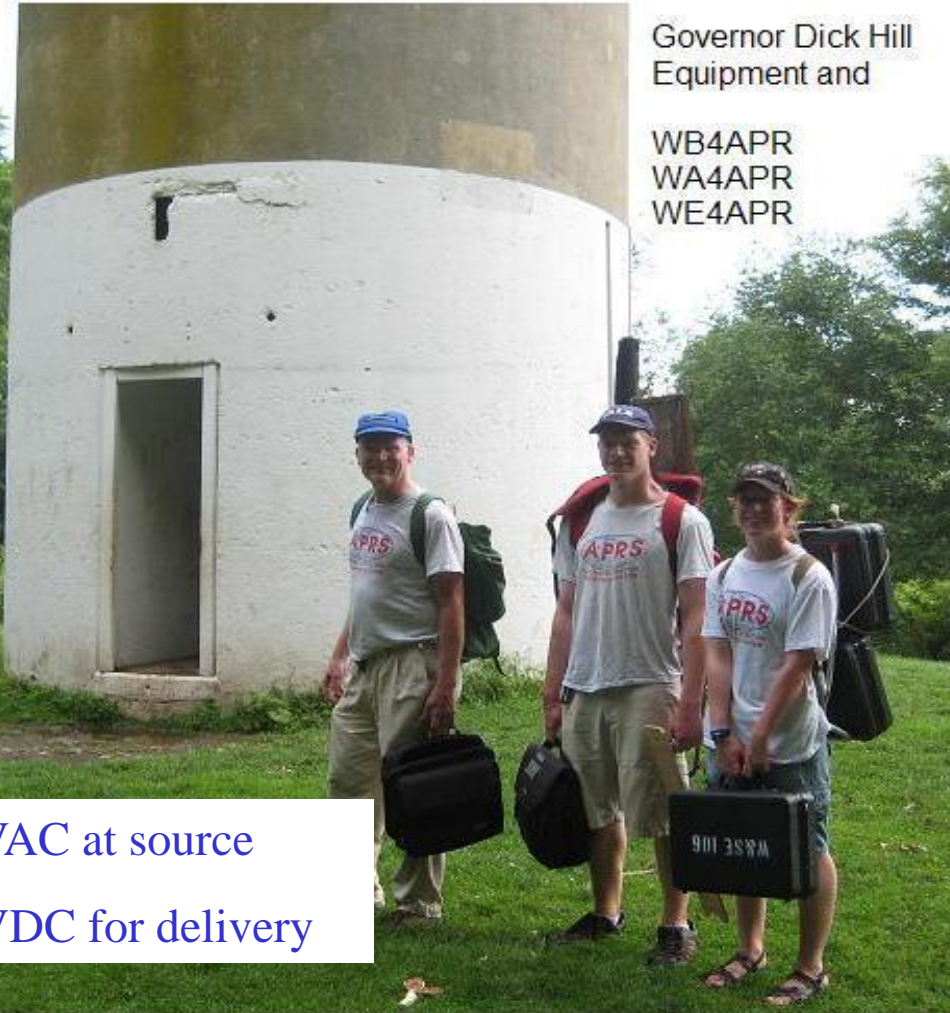


Not approved by NEC

# 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

Not  
approved  
by NEC  
(when grid  
connected)