# Energy Choices and Emergency power for the Ham

### Sterling Park ARC Nov 2020







## **ARRL Book - Power and Energy!**

Energy Choices for the

Radio

Ama

#### 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) Conventional Backup and Emergency Power

for Home

- 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
- Life's Major Energy Milestones
   Making the Switch to Clean Renewable Energy
   Amateur Satellites and Thermal Energy Balance

High Voltage DC Emergency and Backup Power

The Powerwall and Grid Battery Storage

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.





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

### 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 *griddown 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-inverterbased 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 www.arrl.org QST May 2019 1



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.

# 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
- 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

The Saga of The Elect-Reck



#### My Background



Energy!

←1965







1990







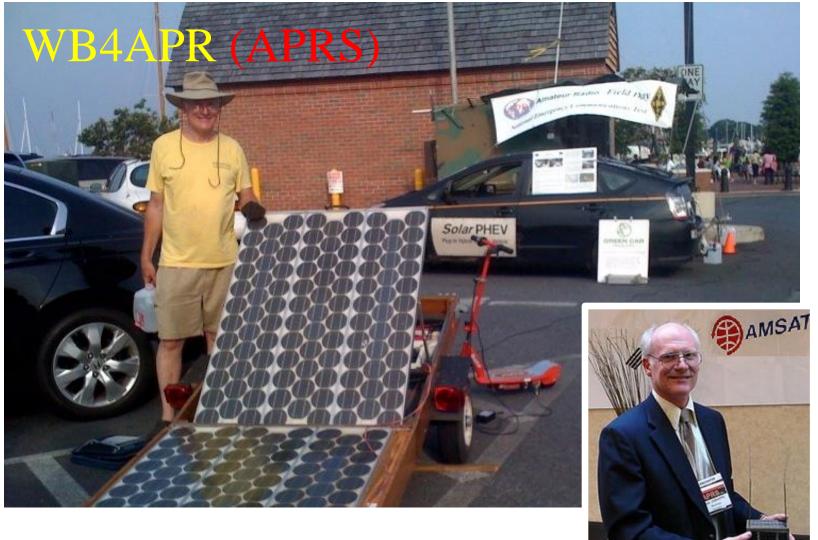




### **Emergency Power and Energy!**



Emergency Response depends on Power & Energy! It's a whole new world of Power



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





3 year old offlease used is only \$9,000

Bolt = 60 batts

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

#### 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

0: + Plug-in

## SERIOUS Generator Power Plugin Hybrids = 50 kW generator



Plug-in Hybrids have at least 50 kW generators.

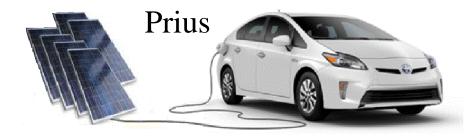
Can power a house for a week or a month



Chrysler Pacifica Minivan

Same as 1 Tesla Power wall costing \$7,000 + Generator! <sup>13</sup>

# Solar and EVs – The Perfect Marriage 9 Panels (\$1200)





Pacifica Minivan

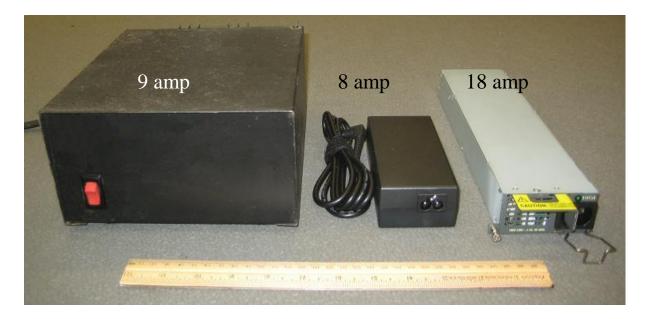
# Can fully charge a plugin everyday... FOREVER!

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

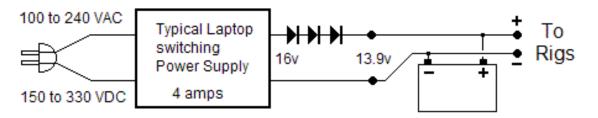


Power Systems have CHANGED!

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

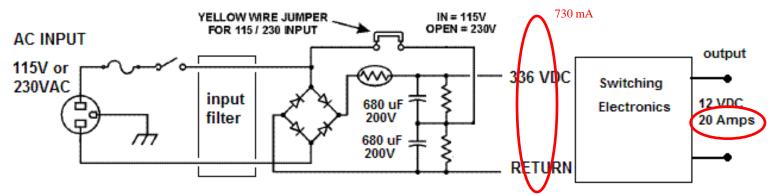
and only 10% of the mass and works 100-240 VAC

AND **70-330 VDC** 



## Power Distribution@ 330 VDC

#### Nearly ALL modern switching supplies will run on VDC



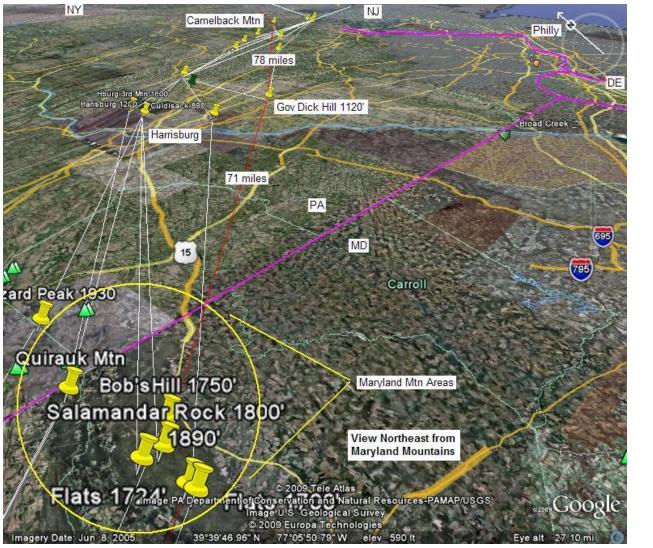
Almost all dual-voltage switching power supplies use this kind of input circuit. The single jumper or 115/230 volt switch converts the supply for use on 115 or 230 volts. On 115 volts AC, the capacitors and diodes act like a 60 Hz Voltage Doubler to give operating voltge of over 300 volts DC to the switching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

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 VACEliminaRectify to 330 VDC for deliveryDistribution

Eliminate 75% of Distribution losses

### Field Example - Golden Packet Event

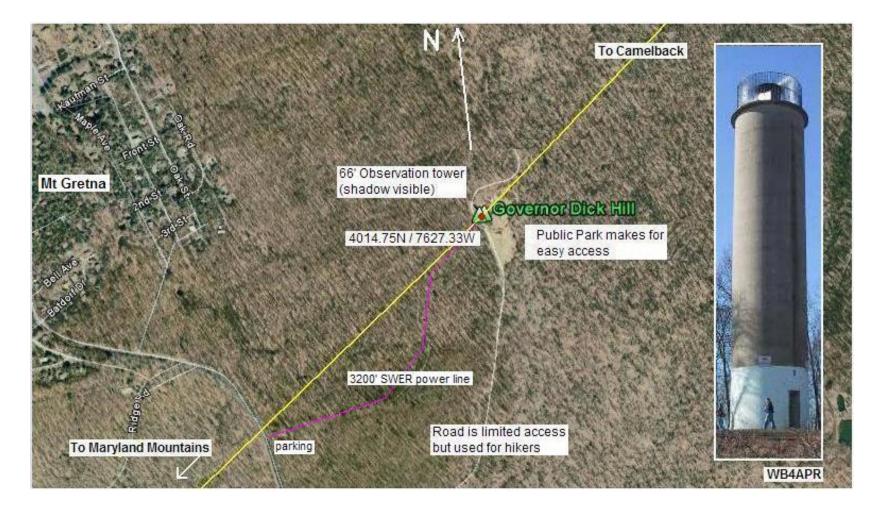


21 July 2018

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

#### Emergency Power: Single Wire Earth Return

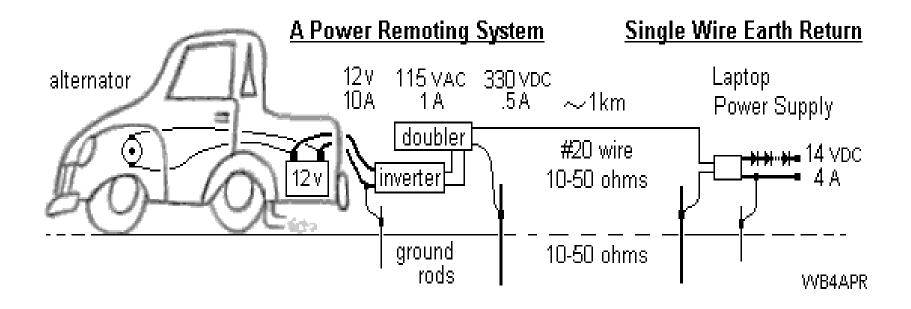


Left to right: 12v Inverter to 115 VAC, Doubler to 330 VDC, 3200' wire, Outlet box, Laptop Power Supply 18v at 4.5 amps.

3200' system fits in laptop bag

#### Not approved by NEC

Emergency Power: Single Wire Earth Return

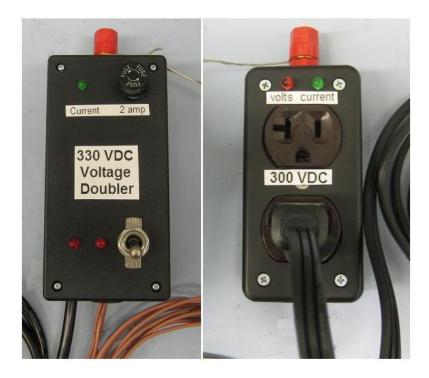


Double to 230 VAC at sourceNot approved by NECRectify to 330 VDC for delivery

	Earth	ing resis	stance					
Type of soil	Ground	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	1	-	-					
Moist gravel	160	80	48					
Dry sandy soil	330	165	100					
Dry gravel	330	165	100					
Stoney soil	1000	500	300					
Rock	-	-	-					

http://www.newarkinone.thinkhost.com/brands/ promos/Earth\_Ground\_Resistance.pdf

### Emergency Power: Single Wire Earth Return



Not approved by NEC

#### And 3200' of #22 = 50 ohms



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)





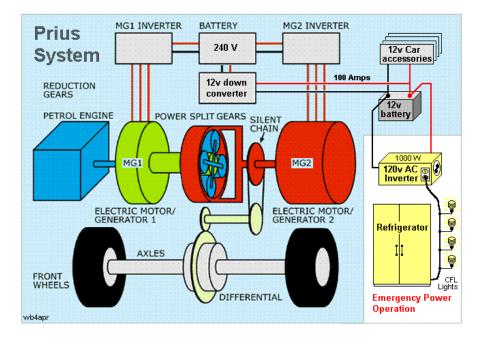


About 500W of Field Day solar power

## Typical Backup solutions Generators & Batteries



## **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



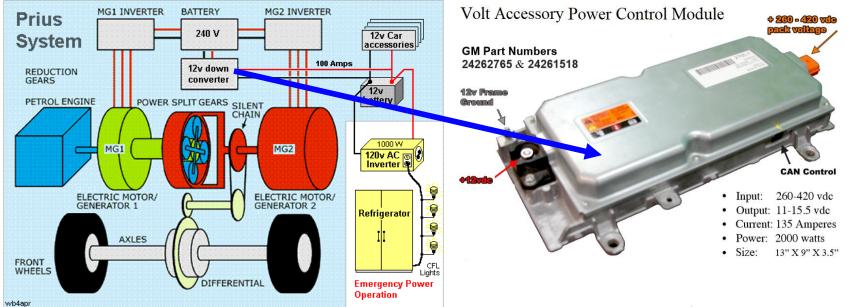
Same 5kWh/gal as a good Honda generator (because it only runs when needed)



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 has 2 kW!

260-420 VDC input12v @ 135 Amps out2000w from 12v system

# 220/330 VDC distribution



#### 50 kW peak (10 kW average)



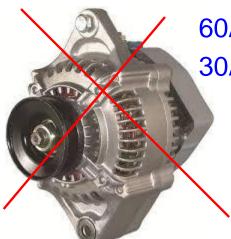


Safe, cheap connectors

(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)..."



Any 12v car can do this

Can't do Whole House

But only with the motor ALWAYS running.

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

### EVs can power homes during blackouts



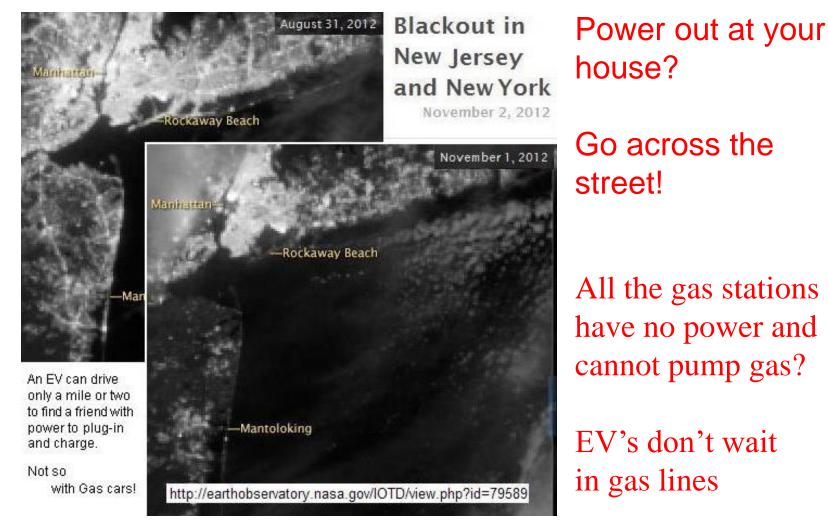
#### EV's don't wait in gas lines

Bob Bruninga, PE

http://aprs.org/payin-to-plugin.html 30

IEEE Transportation Committee

### EVs can power homes during blackouts



Bob Bruninga, PE

IEEE Transportation Committee

http://aprs.org/payin-to-plugin.html 31

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

	Base Price	fund Price	[m]		Speed (mph)			9
Laro 3 278.4	\$13,345	111,945	26	3.6	95	462		. 1
Branna Emplis	\$34,995	314,995	86	38.2	110	-	\$19	
Mitsubishi 1 (I-MRIV)	532,885	\$13,485	42	38	80	112	548	1
Smart electric	\$25,000	\$17,500	88	17.6	78	387	546	
Chevy Spark EV	\$24,885	\$18,385	82	23.8	90	139	\$47	
Nissan LKAF	\$29,050	\$21,510	84	34	95	134	546	
Ford Pocus Dectrie	\$28,170	\$21,470	24	.23	84	325	\$50	
Flat 500x	\$31,800	\$34,800	87	24	85	114	546	
tia Soul EV	\$83,700	\$24,200	80	29	90	325	550	
Www.Golf	\$25,445	\$27,945	83	24	47	534	546	
Handa Fit EV	\$258/ma	free end	82	39	90	238	\$42	
BRAW IS (ran-west)	\$41,850	\$33,890	81	22	. 83	3.24	\$42	
Mercades B-Class	\$41,450	\$23,950	87	28	385		\$58	
Toyota SAVEEV	\$48,800	\$42,300	\$00	41.8	3.08	78	\$47	
Taola Mudal 5 85	\$78,900	\$72,400	345	85	1.15		354	
Faula Model # 85	-	-	245	85	125		558	
Toyota Price Plug-in	\$29,990	\$27,490	11-an	4.4	132	95	554	
Ford C-Max Energy	\$81,770	\$27,768	20-an	2.6	362	48	\$71	
Chevy Yolt	\$34,170	\$24,470	38-44	37.3	100	98	\$67	
Ford Fusion Energi	\$34,800	\$30,799	20-gas	2.8	304		\$73	
Hunda Accord Progra	\$38,780	\$34,354	15-94	6.7	854	\$15	568	
Audi A3 a trun	-	-	11 -	8.8	140	95	-	
Cadillac ELA	\$75,000	\$67,500	87-44	18.5	306	82	\$79	
Parathe Cayanne	\$76,400	\$72,065	54-ger	35.8	151	47	\$142	
VSA VTRUK (Party	\$79,000	\$75,500	4ć 194	28	85		\$76'	
Persche Panamere	\$14,500	\$91,348	26-ge	9.4	167	50	\$525	
SMW IB	\$135,700	\$131,907	15-an	2.4	180	26	\$108	
Parache \$18 Spyder	5845.000	5841,858	\$2-mm	6.8	210	67	5138	

- •Refuel at home
- •Independence fm 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









<u>Most of what we think</u> <u>we know about EV's</u> <u>is likely wrong and</u> <u>Outdated</u>



- 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

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





### 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 3



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

		Base Price (USO) <sup>1</sup>	Net Price	Range [mi]		Speed (mph)		Fuel/	QK QK
	Zero 5 279.4	\$13,345	\$13,345	.76	9.4	95	462		
	Bramino Empulse	\$36,995	\$14,995	80	30.2	130		\$19	
	Mitsubishi i (I-Milly)	\$22,995	\$15,495	62	16	80	112	\$48	
	Smart electric	\$25,000	\$17,500	68	17.6	78	307	546	
	Chevy Spark EV	\$26,885	\$29,585	82	21.8	90	119	\$42	
	Nissan LEAF	\$29,010	\$21,510	84	24	95	334	546	
	Ford Focus Electric	\$29,170	\$21,670	26	23	84	305	\$50	
đ	Flat 500e	\$33,800	\$24,300	87	24	#5	316	546	
	Eia Soul EV	\$33,700	\$38,200	93	27	90	305	\$50	
	Www.Golf	\$35,445	\$27,945	83	24	82	116	\$46	
	Honda Fit EV	\$259/ma	lines while	82	20	90	118	\$42	7
	BMW (3 (* ger synt.)	\$41,350	\$33,850	81	22	93	324	\$42	
	Mercedes B-Class	\$41,450	\$33,950	87	28	101	64	\$58	
	Toyota RAVA EV	\$49,800	\$42,800	100	41.6	103	76	\$67	
	Tesla Model 5 85	\$79,900	\$72,400	265	85	125	89	\$58	
	Faula Model X 85			265	85	125	89	\$58	
	Toyota Prius Plug-in	\$29,990	\$27,490	11-gas.	4.4	132	95	\$58	
	Ford C-Max Energi	\$31,770	\$27,768	20-get	7.6	102	-88	\$71	
	Chevy Volt	\$34,170	\$28,870	38-ga	17.1	100	98	\$67	
	Ford Fusion Energi	\$54,800	\$30,799	20-ges	7.6	104	88	\$71	
1	Honda Accord Physic	\$39,780	\$36,154	13-gas	6.7	134	115	563	1
1	Audi A3 e-fron			311 <sup>°</sup> 1990	0.0	140	95		
	Cadillac ELR	\$75,000	\$67,500	37-gas	16.5	306	82	\$79	
	Parsche Cayenne	\$76,400	\$71,065	14-ges	30.8	151	47	\$142	
	VSA VTRUX (Part)	\$79,000	\$71,500	43' 1 (1	23	\$5		\$76	
	Porsche Panamera	\$94,500	\$91,348	18-ges	9.4	167	50	\$125	1
	BMW IB	\$135,700	\$1\$1,907	15-ges	7.5	160	76	\$108	1
	Porsche 918 Spyder	\$845,000	\$841,838	12-gm	6.3	230	67	\$138	1

### 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 \$23k Toyota Prius Prime 630 29 \$20k 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 8 \$62k Mercedes GLE550e 460 450 12 \$92k Mercedes \$550e 450 18 \$48k Volvo XC60 T8 440 30 \$68k Cadillac CT6 Plug-In 8 \$44k Mercedes C350e 410 410 21 \$59k Volvo \$90 T8 380 53 \$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 47 \$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
- 238 EV \$29k Chevy Bolt
- 220 EV \$28k Tesla 3 std
- 180 97 \$41k BMW i3 Range Extender
- 151 EV \$22k 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	Less	than \$35k Avg Gas Car
330	14 \$143k	BMW i8	380	16 \$35k Audi A3 e-tron
240	37 \$123k	Karma Revero	580	33 \$33k Chrysler Pacifica hyb.
560	24 \$93k	Porsche Panamera	270	12 \$33k MINI Cooper S E Countr
450	12 \$92k	Mercedes S550e		29 \$30k Kia Optima Plug-In
295	EV \$89k	Tesla X 100D		27 \$30k Hyundai Sonata PHEV
335	EV \$87k	Tesla 100D	310	22 \$29k Mitsubishi Outlander
340	14 \$86k	BMW 740e xDrive		EV \$29k Chevy Bolt
480	14 \$75k	Porsche Cayenne	220	EV \$28k Tesla 3 std
238	EV \$72k	Tesla X 75D	114	EV \$27k BMW i3
440	30 \$68k	Cadillac CT6 Plug-In	610	21 \$27k Ford Fusion Energi
		Tesla S 75D	380	53 \$26k Chevy Volt
460	8 \$62k	Mercedes GLE550e	340	47 \$26k Honda Clarity PHEV
350	19 \$60k	Volvo XC90 T8	111	EV \$26k Kia Soul Electric
410	21 \$59k	Volvo S90 T8	89	EV \$26k Honda Clarity Electric
540	13 \$59k	BMW X5 xDrive40e	84	EV \$26k Fiat 500e
450	18 \$48k	Volvo XC60 T8	640	25 <b>\$23k</b> Toyota Prius Prime
372	16 \$48k	BMW 530e	580	26 \$23k Kia Niro PHEV
410	8 \$44k	Mercedes C350e	460	20 \$23k Ford C-Max Energi
350	22 \$42k	BMW 330e	125	EV \$23k VW e-golf
180	97 \$41k	BMW i3 Range Extender	151	EV \$22k Nissan Leaf
		Tesla 3 extended range		EV \$22k Hyundai Ioniq Electric
			115	EV \$22k Ford Focus Electric
			630	29 \$20k Hyundai Ioniq PHEV
				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

Bolt		Net Price	-			MPG	500e
	II Electric	(USD) <sup>1</sup>	(mi) <sup>2</sup>	(kWh)	(sec)	equiv <sup>2</sup>	ES 6
Che	evy Bolt	\$34,745	259	66	6.5	118	
Niro Fiat	500e	\$25,960	84	24	8.9	112	Clarity
Ho	nda Clarity Elec.	(lease only)	89	25.5		114	6
Hyu	undai Ioniq Elec.	\$24,500^	170	38.3	9.5	133	
Soul Hyu	undai Kona Elec.	\$29,690	258	64	6.4	120	Ioniq
	Niro EV	\$31,000	239	64	7.8	112	Sector-
Kia	Soul EV	\$27,500^	243	64	7.6	114	
MII	NI Electric	\$22,400	110	32.6	6.9		Kona
Nis	san LEAF S	\$24,100	150	40	7.4	112	100
-48	S Plus	\$30,700	226	62	6.4	108	- 9
LEAF VW	e-Golf	\$24,395	123	35.8	8.5	113	MINI
Audi Ave	erage U.S. Gasoline C		\$35,0				IVIIIVI A
	di e-tron	\$67,300	204	95	5.5	74	10
Mushana	W I3	\$36,950	153	42.2	7.2	113	
Widstang O For	d Mustang Mach-E		230	76	6.1		VW
20861 CU	uar I-Pace	\$62,350	234	90	4.5	76	
L Dace	estar 2	\$55,500	275	78	4.7		-
I-Pace Z Por	sche Taycan 45	\$96,300	170^	79.2	3.8	70^	i3
- 63	Turbo	\$143,400	201	93.4	3.0	69	85.00
	ian R1S 135	\$75,000^	310	135	3.0		
	ian R1T 135	\$71,500^	300	135	3.0		
tar 2	a Cybertruck Dual	\$49,900	300	120^	4.5		XC40
Tes	la Model 3 Std.	\$35,000	220	50	5.6	131	
	Std. Plus	\$39,990	250	54	5.3	141	5
	Long Range AWD	\$48,990	322	75	4.4	121	Model S
	la Model Y Long		300	75^	5.5		-
	la Model S	\$79,990	373	100	3.7	111	8
80	la Model X	\$84,990	328	100	4.4	96	100
viodel 3	la Roadster	\$200,000	620	200^	1.9		Model Y
Vol	vo XC40 Recharge	\$47,500*	200	78	4.7		Model X
1. Net	price after Fed ta	ax credit. S	tate cre	dits ma	y also	apply.	

# 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

Plug-in Hybrid Electric         Net Price (USD) <sup>1</sup> Range (mi) <sup>2</sup> Batt.         0-60         MPG (wWh)         Source           Fusion Ionin Sonata         Ford Fusion Plug-in Honda Clarity PHEV         \$32,498         16         7.4         82           Sonata         Honda Clarity PHEV         \$21,957         24+gas         9         8.0         103           Sonata         Honda Clarity PHEV         \$21,957         24+gas         9.8         9.1         101           Hunda Clarity PHEV         \$21,957         24+gas         9.8         9.1         100           MININI Cooper s E countr.         \$32,900         17+gas         10.6         7.7         110           Milsubishi Outlander         \$20,500         17+gas         10.6         7.7         110           Milsubishi Outlander         \$32,900         17+gas         10.6         7.7         110           Milsubishi Outlander         \$23,250         25+gas         8.8         13.3         90           BMW 330e         \$39,1644         30+gas         12.2         5.8         90'           BMW 330e         \$39,1644         30+gas         12.2         5.8         90'           BMW 330Fire30e         \$42,714			lectric Vehicle A Greater Washin evadc.org			12	0	20	2 鎽
Fusion       Chrysler Pacifica hp.b.       532,495       32+895       16       7.4       82         Ford Fusion Plug-In       530,391       26+828       9       8.0       103         Honda Clarity PHEV       525,900       48+828       17       7.7       110         Hyundai loniq PHEV       526,481       28+825       9.8       9.6       99         Kia Niro PHEV       523,900       17+828       8.9       9.1       101         Hyundai Sonata PHEV       523,290       17+828       8.8       9.0       105         Kia Niro PHEV       533,495       22+825       12       9.2       74         Subaru Crosstek Hyb.       530,645       17+828       8.8       30       90         Toyota RAVA Prime       523,250       25+825       8.8       10.5       133         Toyota RAVA Prime       523,000       39+828       12.4       5.6          BMW 330e       \$30,1644       30+4281       12.4       5.6          BMW 330e       \$30,1644       20+428       12.6       6.3          BMW 330e       \$30,1644       20+428       12.6       6.3          BMW 33 A	Ż	_							
Fusion       Ford Fusion Placinantys.       530,931       24 gas       16       7.4       62         Ford Fusion Placinantys.       530,931       26 tegas       9       8.0       103         Sonata       Honda Clarity PHEV       525,900       48 tegas       9.8       9.9       103         Windai Ioniq PHEV       523,957       26 tegas       8.9       9.9       106         Hyundai Ioniq PHEV       523,900       17 tegas       8.8       9.9       106         Milini Cooper s E count.       532,900       17 tegas       8.8       9.9       100         Milsubishi Outlander       530,645       17 tegas       8.8       8.05       133         Toyota RAVA Prime       523,250       25 tegas       8.8       105       133         Toyota RAVA Prime       523,9000       12 tegas       12       5.6          BMW 330e       533,1644       30'+gas       12'-       5.6          BMW 330e       539,1644       30'+gas       12'-       5.6          BMW 330e       \$39,1644       30'+gas       12'-       5.6          BMW 330e       \$39,1714       16+gas       12       4.9		ł	Plug-in Hybrid Electric	(USD) <sup>1</sup>	(mi) <sup>2</sup>	(kWh)	(sec)	equiv <sup>2</sup>	0
Ioniq       Ford Fusion Plug-In       \$30,391       Zebegas       9       8.0       103         Monda Clarity PHEV       \$25,900       48+gas       17       7.7       110         Hyundai Ioniq PHEV       \$21,957       29+gas       8.9       8.9       19         Hyundai Sonata PHEV       \$26,481       28+gas       9.8       7.6       99         Kia Niro PHEV       \$23,957       26+gas       8.9       90       105         MINI       Kia Optima Plug-In       \$31,171       28+gas       9.8       91       106         MINI Cooper s E countr.       \$32,900       17+gas       10       6.7       73         Mitsubishi Outlander       \$30,645       17+gas       8.8       8.05       133         Toyota RAV4 Prime       \$23,250       25+gas       8.8       10.5       133         Toyota RAV4 Prime       \$32,000       12+gas       12-       5.6          BMW 330e       \$34,064       21+gas       12-       5.6          BMW 83       \$141,831       17-gas       1.6       4.2       69         BMW 18       \$141,831       17-gas       8.7       6.2       5.8       51     <	Fusion		Chrysler Pacifica hyb.	\$32,495	32+gas	16	7.4	82	
Sonata       Hyundai Ioniq PHEV       \$21,957       29rgas       8.9       119         Hyundai Sonata PHEV       \$26,481       28rgas       9.8       7.6       99         Kia Niro PHEV       \$23,957       26rgas       8.9       9.0       105         Kia Niro PHEV       \$23,957       26rgas       8.9       9.0       105         Kia Niro PHEV       \$23,957       26rgas       8.9       9.0       105         MINI Cooper s E countr.       \$32,900       17rgas       10       6.7       73         Mitsubishi Outlander       \$30,459       22rgas       12       9.2       74         Subaru Crosstek Hyb.       \$30,645       17rgas       8.8       8.3       90         Toyota RAV4 Prime       \$29,000       39 <sup>2</sup> rgas       16^h       5.8       90 <sup>+</sup> BMW 30e       \$39,164       30 <sup>+</sup> rgas       12^h       5.6          BMW 30e       \$39,164       30 <sup>+</sup> rgas       12.6       5.7       56         BMW 30e       \$48,064       12 <sup>+</sup> gas       12.6       9       9         BMW 30e       \$42,714       20 <sup>+</sup> rgas       12.6       9       9         BMW X3 xDrive30e       \$42,714<	Ionia		Ford Fusion Plug-In	\$30,391	26+gas	9	8.0	103	Pacifica minivan
Sonata       Hyundai Sonata PHEV       \$26,481       28+gas       9.8       7.6       99         MINI       Kia Niro PHEV       \$23,957       26+gas       8.9       9.0       105         MINI       Cooperation       \$31,171       28+gas       9.8       9.0       105         MINI       Cooperation       \$32,900       17+gas       10       6.7       73         MISUbishi Outlander       \$30,459       22+gas       12       9.2       74         Subaru Crosstek Hyb.       \$30,645       17+gas       8.8       8.3       90         Toyota Prius Prime       \$23,250       25+gas       8.8       10.5       133         Toyota RAV4 Prime       \$29,000       39+gas       16^6       5.8*       90'         Neerge U.S. Gasoline Car Price       \$35,000       25+gas       12.4       5.6          BMW 330e       \$39,164       30+gas       12.9       50       50         BMW 330e       \$39,164       17+gas       12.4       5.6          BMW 330e       \$41,00       126+gas       12.4       5.9       60         BMW X3 xDrive30e       \$42,714*       20*gas       14.5       5.5			Honda Clarity PHEV	\$25,900	48+gas	17	7.7	110	
Hyundai Sonata PHEV       \$26,481       28+gas       9.8       7.6       99         Kia Niro PHEV       \$23,957       26+gas       8.9       9.0       105         MINI Cooper 5 € Countr.       \$32,900       17+gas       10       6.7       73         MINI Cooper 5 € Countr.       \$32,900       17+gas       8.8       8.3       90         Subaru Crosstek Hyb.       \$30,645       17+gas       8.8       8.3       90         Toyota ARV4 Prime       \$22,200       25+gas       8.8       10.5       133         Toyota RAV4 Prime       \$23,050       25+gas       8.8       10.5       133         Average U.S. Gasoline Car Price       \$30,064       17+gas       12.       5.6          BMW 330e       \$48,064       21+gas       12.       5.6          BMW 330e       \$48,064       21+gas       12.       5.0          BMW 330e       \$48,064       12+gas       12.       5.0          BMW X3 x Drive30e       \$42,714       20 <sup>+</sup> gas       42.2       8.0       100         BMW X3 x Drive30e       \$42,714       20 <sup>+</sup> gas       13.6       5.3          S30e			Hyundai Ioniq PHEV	\$21,957	29+gas	8.9	8.9	119	
MINI       Kia Optima Plug-In       \$31,171       28+gas       9.8       9.1       101         MINI Cooper s E countr.       \$32,900       17+gas       10       6.7       73         Mitsubishi Outlander       \$30,459       22+gas       12       9.2       74         Subaru Crosstek Hyb.       \$30,645       17+gas       8.8       8.3       90         Toyota Prius Prime       \$23,250       25+gas       8.8       10.5       133         Toyota RAV4 Prime       \$29,000^/       39+gas       16^/       5.8       90'         Nerage U.S. Gasoline Car Price       \$35,000       126+gas       12       5.9       69         BMW 330e       \$39,164/       30^+gas       12       5.9       69         BMW 745e xDrive       \$89,714       16+gas       12.       6.3          BMW 13 Range Extender       \$40,800       126+gas       4.2       8.0       100         BMW X3 xDrive30e       \$42,714/       20'+gas       12.6       5.5       56         BMW X5 xDrive45e       \$62,500       40^+gas       8.5       5.4       70         Mercedes GLC350e       \$46,190       10+gas       8.7       6.2       56     <	Sonata		Hyundai Sonata PHEV	\$26,481	28+gas	9.8	7.6	99	Honda Clarity PHEV
MINI       Kia Optima Plug-In       \$31,171       28+gas       9.8       9.1       101         MINI Cooper s E countr.       \$32,900       17+gas       10       6.7       73         Mitsubishi Outlander       \$30,459       22+gas       12       9.2       74         Subaru Crosstek Hyb.       \$30,645       17+gas       8.8       3.9       90         Toyota Prius Prime       \$23,200       39+gas       166       5.8       90'         Toyota RAV4 Prime       \$29,000       39+gas       166       5.8       90'         Average U.S. Gasoline Car Price       \$35,000       126+gas       12       5.9       69         BMW 330e       \$39,164       30*gas       12.6       5.6          BMW 330e       \$39,164       30*gas       12.6       5.6          BMW 330e       \$39,164       126+gas       12.2       5.9       69         BMW 330e       \$39,171       16+gas       12.6       4.2       69         BMW 33 Abrive30e       \$42,714       20+gas       12.6       5.5       56         BMW X3 xbrive30e       \$42,714       20+gas       1.6       4.2       69         BMW X5	A 3	ġ	Kia Niro PHEV	\$23,957	26+gas	8.9	9.0	105	and and
MINI Cooper s E countr.       \$32,900       17+gas       10       6.7       73         Mitsubishi Outlander       \$30,459       22+gas       12       9.2       74         Subaru Crosstek Hyb.       \$30,645       17+gas       8.8       8.3       90         Toyota Prius Prime       \$22,250       25+gas       8.8       10.5       133         Toyota RAV4 Prime       \$29,000       30*gas       16^       5.8       90'         Average U.S. Gasoline Car Price       \$39,164^       30*gas       12       5.6          BMW 330e       \$39,164^       30*gas       12       5.6          BMW 330e       \$39,164^       30*gas       12       5.6          BMW 330e       \$39,164^       10*gas       12       5.6          BMW 330e       \$39,164^       10*gas       12       5.6          BMW 330e       \$39,164       10*gas       12       5.6          BMW 33 Range Extender       \$40,800       126+gas       12       5.5       56         BMW X5 xDrive45e       \$62,500       40*gas       13       6.3       42         Mercedes G1C350e       \$46,	MINI	ap			28+gas	9.8			
Mitsubishi Outlander       \$30,459       224gas       12       9.2       74         Subaru Crosstek Hyb.       \$30,645       174gas       8.8       8.3       90         Toyota Prius Prime       \$23,250       254gas       8.8       10.5       133         Toyota RAV4 Prime       \$29,000       39 <sup>+</sup> ggs       16 <sup>A</sup> 5.8 <sup>+</sup> 90 <sup>+</sup> Verage U.S. Gasoline Car Price       \$35,00       90 <sup>+</sup> 90 <sup>+</sup> 90 <sup>+</sup> 90 <sup>+</sup> Nercedes Salo       \$48,064       21+gas       12       5.6        90 <sup>+</sup> BMW 330e       \$39,164 <sup>+</sup> 30 <sup>+</sup> +gas       12.4       5.6        90 <sup>+</sup> BMW 745e xDrive       \$89,714       16+gas       12       4.9       56       90 <sup>+</sup> BMW 33 xDrive30e       \$42,714 <sup>+</sup> 20 <sup>+</sup> +gas       11.6       4.2       69       X3       20 <sup>+</sup> X3       20 <sup>+</sup> 25       56       56       57       56       57       56       57       56       57       56       57       56       57       56       57       56       57       56       57       56       57       56       57       56       57       56		ave							Kia Niro
Toyota Prius Prime       \$23,250       25+gas       8.8       10.5       133         Toyota RAV4 Prime       \$29,000^/       39'+gas       16^/       5.8'       90'         Average U.S. Gasoline Car Price       \$35,000       12^/       5.6          BMW 330e       \$48,064       21+gas       12       5.9       69         BMW 745e xDrive       \$89,714       16+gas       12       4.9       56         BMW 745e xDrive       \$89,714       16+gas       12.       4.9       56         BMW 745e xDrive       \$89,714       16+gas       12.       4.9       56         BMW 745e xDrive       \$89,714       16+gas       12.       4.9       56         BMW 33 xDrive30e       \$42,714^/       20'+gas       12.4       5.5       56         BMW X3 xDrive45e       \$62,500       40'+gas       14.5       5.5       56         Mercedes GLC350e       \$46,190       10+gas       8.7       6.2       5.8       51         Mercedes GLC350e       \$46,190       10+gas       8.7       6.2       56       56         Mercedes GLC350e       \$46,190       10+gas       8.7       6.2       56       56							1 Contract		
Toyota Prius Prime       \$23,250       25+gas       8.8       10.5       133         Toyota RAV4 Prime       \$29,000^       39'+gas       16^       5.8'       90'         Average U.S. Gasoline Car Price       \$35,000       30^++gas       12^       5.6          BMW 330e       \$39,164^       30^++gas       12       5.6          BMW 530e       \$48,064       21+gas       12       5.9       69         BMW 745e xDrive       \$89,714       16+gas       12       4.9       56         BMW 13 Range Extender       \$40,800       126+gas       4.2       69         BMW X3 xDrive30e       \$42,714       20'+gas       12^       6.3          BMW X5 xDrive45e       \$62,500       40^+gas       24       5.5^       56         Karma Revero GT       \$127,500       61+gas       28       4.5       70         Land Rover sport P400e       \$71,913       19+gas       13       6.3       42         Mercedes GLC350e       \$46,190       10+gas       8.7       6.2       56         Mercedes GLC350e       \$103,750       20+gas       13.5^       4.7       65         Volvo S60 T8       \$51		Drid			3.957 - <b>76</b> 29 - 3	1 10000	20101		Kis Ontime
Average U.S. Gasoline Car Price       \$35,000       Prius Prime         RAV4       BMW 330e       \$39,164^3       30^4gas       12       5.6          BMW 530e       \$48,064       21+gas       12       5.9       69       69         BMW 745e xDrive       \$89,714       16+gas       12       4.9       56          BMW 13 Range Extender       \$40,800       126+gas       42.2       8.0       100         BMW 13 Range Extender       \$40,800       126+gas       12.       6.9       69         BMW 13 Range Extender       \$40,800       126+gas       42.2       8.0       100         BMW X3 xDrive30e       \$42,714^2       20'+gas       11.6       4.2       69         BMW X5 xDrive45e       \$62,500       40^+gas       24       5.5^       56         Karma Revero GT       \$127,500       61+gas       28       4.5       70         Mercedes GLC350e       \$46,190       10+gas       8.7       6.2       5.6         Mercedes GLC350e       \$62,240       8+gas       8.8       5.3       43         Mercedes S560e       \$103,750       20+gas       13.5^4       4.7       65^4         Volv				100 D 0.08 0		1. 2. 1	1.25	17170	Kia Optima
Average U.S. Gasoline Car Price \$35,000       Prius Prime         RAV4       BMW 330e       \$39,164^{A}       30^{+}gas       12       5.6          BMW 530e       \$48,064       21+gas       12       5.9       69         BMW 745e xDrive       \$89,714       16+gas       12       4.9       56         BMW 13 Range Extender       \$40,800       126+gas       4.2       80       100         BMW X3 xDrive30e       \$42,714^{A}       20 +gas       12.6       6.3          BMW X3 xDrive30e       \$42,714^{A}       20 +gas       12.6       6.3          BMW X5 xDrive45e       \$62,500       40^4+gas       2.4       5.5^{A}       56         Sobe       Karma Revero GT       \$1127,500       61+gas       2.8       4.5       70         Land Rover sport P400e       \$71,913       19+gas       13       6.3       42       4.9       56         Mercedes GLC350e       \$46,190       10+gas       8.7       6.2       56       56       56       56       56       56       56       56       56       56       56       56       56       56       56       56       56       56       56	ander	ese		AND DESCRIPTION OF A DE					
BMW 330e       \$39,164^{14}       30^{4} + gas       12^{15}       5.6          BMW 530e       \$48,064       21 + gas       12       5.9       69         BMW 745e xDrive       \$89,714       16+gas       12       4.9       56         BMW 13 Range Extender       \$40,800       126+gas       42.2       8.0       100         BMW 13 Range Extender       \$40,800       126+gas       42.2       8.0       100         BMW 13 Range Extender       \$40,800       126+gas       12.6       6.3          BMW X3 xDrive30e       \$42,714^{1}       20'+gas       12.6       5.5^{56}       56         Karma Revero GT       \$127,500       61+gas       28       4.5       70         Mercedes C350e       \$45,394       8+gas       6.2       5.8       51         Mercedes GLC350e       \$66,190       10+gas       8.7       6.2       56         Mercedes S560e       \$103,750       20+gas       13.5^{5}       4.7       65^{5}         Porsche Panamera       \$97,130       14+gas       14.1       4.7       47         Volvo S60 T8       \$51,043       22+gas       10.4       4.3       69         Vo		-			39 +gas	16^	5.8	90"	Prius Prime
RAVA       BMW 530e       \$48,064       21+gas       12       5.9       69         BMW 745e xDrive       \$89,714       16+gas       12       4.9       56         BMW 13 Range Extender       \$40,800       126+gas       4.2       80       100         BMW 13 Range Extender       \$40,800       126+gas       4.2       6.0       100         BMW 13 Range Extender       \$40,800       126+gas       12.4       6.3          BMW X3 xDrive30e       \$42,714^2       20+gas       12.6       6.3          BMW X5 xDrive45e       \$62,500       40^+gas       24       5.5^       56         Karma Revero GT       \$1127,500       61+gas       28       4.5       70         Land Rover sport P400e       \$71,913       19+gas       13       6.3       42         Mercedes GLC350e       \$46,190       10+gas       8.7       6.2       56         Mercedes GLE550e       \$62,240       8+gas       8.8       5.3       43         Mercedes S560e       \$103,750       20+gas       14.1       4.7       47         Porsche Cayenne       \$74,430       14+gas       14.1       4.7       65		4			204				13
AVA       BMW 745e xDrive       \$89,714       16+gas       12       4.9       56         BMW 13 Range Extender       \$40,800       126+gas       42.2       8.0       100         BMW 18       \$141,831       17+gas       11.6       4.2       69         BMW X3 xDrive30e       \$42,714^2       20+gas       12^2       6.3          BMW X5 xDrive45e       \$62,500       40^+gas       24       5.5^5       56         BMW X5 xDrive45e       \$62,500       40^+gas       28       4.5       70         BMW X5 xDrive45e       \$62,500       40^+gas       28       4.5       70         Land Rover sport P400e       \$71,913       19+gas       13       6.3       42         Mercedes GLC350e       \$46,190       10+gas       8.7       6.2       5.8       51         Mercedes GLE550e       \$62,240       8+gas       8.8       5.3       43       4.7         Porsche Cayenne       \$74,430       14+gas       14.1       4.7       4.7         Porsche Panamera       \$97,130       14+gas       14.1       4.4       51         Volvo S60 T8       \$58,843       21+gas       10.4       4.8       60	Antonio Internet	(SE							
BMW 745e xDrive       \$89,714       10+gas       12       4.9       56         BMW 13 Range Extender       \$40,800       126+gas       42.2       8.0       100         BMW 18       \$141,831       17+gas       11.6       4.2       69         BMW X3 xDrive30e       \$42,714^       20+gas       12^       6.3          BMW X5 xDrive45e       \$62,500       40^+gas       24       5.5^       56         BMW X5 xDrive45e       \$62,500       40^+gas       28       4.5       70         Karma Revero GT       \$127,500       61+gas       28       4.5       70         Land Rover sport P400e       \$71,913       19+gas       13       6.3       422         Mercedes GL350e       \$46,190       10+gas       8.7       6.2       5.8       51         Mercedes GL550e       \$62,240       8+gas       8.8       5.3       43         Porsche Cayenne       \$77,130       14+gas       14.1       4.7       47         Porsche Panamera       \$97,130       14+gas       10.4       4.8       60         Volvo S60 T8       \$52,298       22+gas       10.4       4.3       69         Volvo S00 T8		-					1.20	1000	
30e       BMW X3 xDrive30e       \$42,714 <sup>2</sup> 20 + gas       12 <sup>4</sup> 6.3          BMW X3 xDrive45e       \$62,500       40 <sup>4</sup> + gas       24       5.5 <sup>4</sup> 56         BMW X5 xDrive45e       \$62,500       40 <sup>4</sup> + gas       28       4.5       70         BMW X5 xDrive45e       \$62,500       61+gas       28       4.5       70         Land Rover sport P400e       \$71,913       19+gas       13       6.3       42         Mercedes G1C350e       \$45,394       8+gas       6.2       5.8       51         Mercedes G1C350e       \$46,190       10+gas       8.7       6.2       56         Mercedes G1C350e       \$62,240       8+gas       8.8       5.3       43         Mercedes S560e       \$103,750       20+gas       13.5 <sup>5</sup> 4.7       65 <sup>5</sup> Porsche Cayenne       \$74,430       14+gas       14.1       4.7       47         Porsche Panamera       \$97,130       14+gas       10.4       4.3       69         Volvo S60 T8       \$52,298       22+gas       10.4       4.8       60         Volvo X60 T8       \$62,298       19+gas       10.4       4.9       57 <t< td=""><td></td><td></td><td>BMW 745e xDrive</td><td>\$89,714</td><td>16+gas</td><td>12</td><td>4.9</td><td>56</td><td>i8</td></t<>			BMW 745e xDrive	\$89,714	16+gas	12	4.9	56	i8
30e       BMW X3 xDrive30e       \$42,7114 <sup>2</sup> 20 <sup>+</sup> gas       12 <sup>-</sup> 6.3          30e       BMW X3 xDrive45e       \$62,500       40 <sup>+</sup> gas       24       5.5 <sup>+</sup> 56         30e       BMW X5 xDrive45e       \$62,500       40 <sup>+</sup> gas       24       5.5 <sup>+</sup> 56         30e       BMW X5 xDrive45e       \$62,500       40 <sup>+</sup> gas       24       5.5 <sup>+</sup> 56         30e       Karma Revero GT       \$127,500       61+gas       28       4.5       70         45e       Mercedes G1C350e       \$46,190       10+gas       8.7       6.2       5.8       51         Mercedes G1C350e       \$62,240       8+gas       8.8       5.3       43         Mercedes S560e       \$103,750       20+gas       13.5 <sup>+</sup> 4.7       65 <sup>+</sup> Porsche Cayenne       \$74,430       14+gas       14.1       4.7       47         Porsche Panamera       \$97,130       14+gas       10.4       4.3       69         Volvo S60 T8       \$52,298       22+gas       10.4       4.3       69         Volvo X60 T8       \$62,298       19+gas       10.4       4.3       69         Volvo X60 T8       \$49,59		ecti	BMW i3 Range Extender	\$40,800	126+gas	42.2	8.0	100	S= A
BMW X3 xDrive30e       \$42,714^{^2}       20'+gas       12^{^6}       6.3          BMW X5 xDrive45e       \$62,500       40^+gas       24       5.5^{^5}       56         Karma Revero GT       \$127,500       61+gas       28       4.5       70         Land Rover sport P400e       \$71,913       19+gas       13       6.3       42         Mercedes C350e       \$45,394       8+gas       6.2       5.8       51         Mercedes GLC350e       \$46,190       10+gas       8.7       6.2       56         Mercedes GLE550e       \$62,240       8+gas       8.8       5.3       43         Mercedes S560e       \$103,750       20+gas       13.5^{^4}       4.7       65^{^4}         Porsche Cayenne       \$74,430       14+gas       14.1       4.7       47         Porsche Panamera       \$97,130       14+gas       14.1       4.7       77         Volvo S60 T8       \$51,043       22+gas       10.4       4.8       60         Volvo S60 T8       \$62,298       22+gas       10.4       4.8       60         Volvo XC60 T8       \$49,593       19+gas       10.4       4.9       57         Volvo XC60 T8		-	BMW i8	\$141,831	17+gas	11.6	4.2	69	-
S30e       Narma Revero GT       \$127,500       61+gas       28       4.5       70         S30e       Land Rover sport P400e       \$71,913       19+gas       13       6.3       42         Mercedes C350e       \$45,394       8+gas       6.2       5.8       51         Mercedes GLC350e       \$46,190       10+gas       8.7       6.2       56         Mercedes GLE550e       \$62,240       8+gas       8.8       5.3       43         Mercedes S560e       \$103,750       20+gas       13.5^A       4.7       65^A         Porsche Cayenne       \$74,430       14+gas       14.1       4.7       4.7         Porsche Panamera       \$97,130       14+gas       14.1       4.4       51         Volvo S60 T8       \$51,043       22+gas       10.4       4.8       60         Volvo S90 T8       \$58,843       21+gas       10.4       4.8       60         Volvo XC60 T8       \$49,593       19+gas       10.4       4.9       57         Volvo XC90 T8       \$61,998       18+gas       10.4       5.9       55         Mercedes GLC350e       \$61,998       18+gas       10.4       5.9       55         Me	330e -	ic le	BMW X3 xDrive30e	\$42,714^	20 +gas	12^	6.3		X3 / 10
3000 De       Jand Rover sport P400e       \$71,913       19+gas       13       6.3       42         Mercedes C350e       \$45,394       8+gas       6.2       5.8       51         Mercedes GLC350e       \$46,190       10+gas       8.7       6.2       56         Mercedes GLC350e       \$62,240       8+gas       8.8       5.3       43         Mercedes S560e       \$103,750       20+gas       13.5^A       4.7       65^A         Porsche Cayenne       \$74,430       14+gas       14.1       4.7       4.7         Porsche Panamera       \$97,130       14+gas       14.1       4.4       51         Volvo S60 T8       \$51,043       22+gas       10.4       4.8       60         Volvo S90 T8       \$58,843       21+gas       10.4       4.8       60         Volvo XC60 T8       \$62,298       22+gas       10.4       4.3       69         Volvo XC60 T8       \$49,593       19+gas       10.4       4.9       57         Volvo XC60 T8       \$49,593       19+gas       10.4       4.9       57         Volvo XC90 T8       \$61,998       18+gas       10.4       5.9       55         Mercedes GLC350e		Veh	BMW X5 xDrive45e	\$62,500	40^+gas	24	5.5^	56	
350e       350e       550e       \$71,913       19+gas       13       6.3       42         Mercedes C350e       \$45,394       8+gas       6.2       5.8       51         Mercedes C350e       \$46,190       10+gas       8.7       6.2       56         Mercedes GLC350e       \$62,240       8+gas       8.8       5.3       43         Mercedes S560e       \$103,750       20+gas       13.5^A       4.7       65^A         Porsche Cayenne       \$74,430       14+gas       14.1       4.7       4.7         Porsche Panamera       \$97,130       14+gas       14.1       4.4       51         Volvo S60 T8       \$51,043       22+gas       10.4       4.8       60         Volvo S90 T8       \$58,843       21+gas       10.4       4.8       60         Volvo X60 T8       \$62,298       22+gas       10.4       4.3       69         Volvo X60 T8       \$62,298       19+gas       10.4       4.3       69         Volvo XC60 T8       \$49,593       19+gas       10.4       4.9       57         Volvo XC60 T8       \$49,593       19+gas       10.4       5.9       55         Wolvo XC90 T8 <td< td=""><td>F20a</td><td>S</td><td>Karma Revero GT</td><td>\$127,500</td><td>61+gas</td><td>28</td><td>4.5</td><td>70</td><td></td></td<>	F20a	S	Karma Revero GT	\$127,500	61+gas	28	4.5	70	
745e       Mercedes G1C350e       \$45,394       8+gas       6.2       5.8       51         Mercedes G1C350e       \$46,190       10+gas       8.7       6.2       56         Mercedes G1C350e       \$62,240       8+gas       8.8       5.3       43         Mercedes S560e       \$103,750       20+gas       13.5^{A}       4.7       65^{A}         Porsche Cayenne       \$74,430       14+gas       14.1       4.7       477         Porsche Panamera       \$97,130       14+gas       14.1       4.4       51         Volvo S60 T8       \$51,043       22+gas       10.4       4.8       60         Volvo S90 T8       \$58,843       21+gas       10.4       4.8       60         Volvo X60 T8       \$62,298       22+gas       10.4       4.3       69         Volvo X60 T8       \$62,298       22+gas       10.4       4.3       69         Volvo XC60 T8       \$49,593       19+gas       10.4       4.3       69         Volvo XC60 T8       \$49,593       19+gas       10.4       4.9       57         Volvo XC90 T8       \$61,998       18+gas       10.4       5.9       55         Mercedes G1C350e       <		ec	Land Rover Sport P400e	1000 B 100	19+gas	13	6.3	42	X5
745e       Mercedes GLC350e       \$46,190       10+gas       8.7       6.2       56         Mercedes GLE550e       \$62,240       8+gas       8.8       5.3       43         Mercedes GLE550e       \$62,240       8+gas       1.1       4.7       65^A         Porsche Cayenne       \$74,430       14+gas       14.1       4.7       47         Porsche Panamera       \$97,130       14+gas       14.1       4.4       51         Volvo S60 T8       \$51,043       22+gas       10.4       4.3       69         Volvo S90 T8       \$58,843       21+gas       10.4       4.8       60         Volvo V60 T8       \$62,298       22+gas       10.4       4.9       57         Volvo XC60 T8       \$49,593       19+gas       10.4       4.9       57         Volvo XC60 T8       \$49,593       19+gas       10.4       4.9       57         Volvo XC60 T8       \$49,593       19+gas       10.4       5.9       55         Mercedes GLC350e       \$61,998       18+gas       10.4       5.9       55         Mercedes GLC350e       \$61,998       18+gas       10.4       5.9       55         Mercedes GLC350e <td< td=""><td></td><td></td><td>and the second second</td><td>States States</td><td></td><td></td><td></td><td></td><td>500-1</td></td<>			and the second	States States					500-1
Mercedes GLE550e       \$62,240       8+gas       8.8       5.3       43         Mercedes GLE550e       \$62,240       8+gas       8.8       5.3       43         Mercedes S560e       \$103,750       20+gas       13.5^A       4.7       65^A         Porsche Cayenne       \$74,430       14+gas       14.1       4.7       47         Porsche Panamera       \$97,130       14+gas       14.1       4.4       51         Volvo S60 T8       \$51,043       22+gas       10.4       4.3       69         Volvo S60 T8       \$52,298       22+gas       10.4       4.8       60         Volvo V60 T8       \$62,298       22+gas       10.4       4.9       57         Volvo XC60 T8       \$49,593       19+gas       10.4       4.9       57         Volvo XC60 T8       \$49,593       19+gas       10.4       4.9       57         Volvo XC90 T8       \$61,998       18+gas       10.4       5.9       55         Mercedes GLC350e       Mercedes GLC350e       Mercedes GLC350e       Mercedes GLC350e	745e	ybr			and the second				Karma
A       Miercedes S500e       \$103,750       204gas       13.54       4.7       654         Porsche Cayenne       \$74,430       144gas       14.1       4.7       47         Porsche Panamera       \$97,130       144gas       14.1       4.4       51         Volvo S60 T8       \$51,043       22+gas       10.4       4.3       69         Volvo S90 T8       \$58,843       21+gas       10.4       4.8       60         Volvo V60 T8       \$62,298       22+gas       10.4       4.3       69         Volvo XC60 T8       \$49,593       19+gas       10.4       4.9       57         Volvo XC60 T8       \$61,998       18+gas       10.4       5.9       55         Mercedes GLC350e       Mercedes GLC350e       Mercedes GLC350e       Mercedes GLC350e		H							- A
A       Mercedes S500e       \$105,750       204gs       13.54       4.7       654         Porsche Cayenne       \$74,430       144gas       14.1       4.7       47         Porsche Panamera       \$97,130       144gas       14.1       4.4       51         Volvo S60 T8       \$51,043       22+gas       10.4       4.3       69         Volvo S90 T8       \$58,843       21+gas       10.4       4.8       60         Volvo V60 T8       \$62,298       22+gas       10.4       4.3       69         Volvo XC60 T8       \$49,593       19+gas       10.4       4.9       57         Volvo XC60 T8       \$61,998       18+gas       10.4       5.9       55         Mercedes GLC350e       Mercedes GLC350e       Mercedes GLC350e       Mercedes GLC350e		-Bn			100		1000	1000	
Porsche Panamera         \$97,130         14+gas         14.1         4.4         51         Mercedes C350e           Volvo S60 T8         \$51,043         22+gas         10.4         4.3         69           Volvo S90 T8         \$58,843         21+gas         10.4         4.8         60           Volvo V60 T8         \$62,298         22+gas         10.4         4.3         69           Volvo X60 T8         \$62,298         22+gas         10.4         4.3         69           Volvo X60 T8         \$62,298         10.4         4.3         69           Volvo XC60 T8         \$61,998         18+gas         10.4         57           Volvo XC90 T8         \$61,998         18+gas         10.4         5.9         55		T		CONTRACTOR OF THE OWNER			2012	1000	
Volvo S60 T8         \$51,043         22+gas         10.4         4.3         69           Volvo S90 T8         \$58,843         21+gas         10.4         4.8         60           Volvo V60 T8         \$62,298         22+gas         10.4         4.3         69           Volvo XC60 T8         \$49,593         19+gas         10.4         4.3         69           Volvo XC60 T8         \$49,593         19+gas         10.4         4.9         57           Volvo XC90 T8         \$61,998         18+gas         10.4         5.9         55		ż							69 69-
Volvo S60 18         551,043         22*gas         10.4         4.3         69           Volvo S90 T8         \$58,843         21+gas         10.4         4.8         60           Volvo S90 T8         \$62,298         22+gas         10.4         4.3         69           Volvo V60 T8         \$62,298         22+gas         10.4         4.3         69           Volvo XC60 T8         \$49,593         19+gas         10.4         4.9         57           Volvo XC90 T8         \$61,998         18+gas         10.4         5.9         55	30 - I	Ŧ		\$97,130				51	Mercedes C350e
Volvo V60 T8         \$62,298         22+gas         10.4         4.3         69         Mercedes S560e           Volvo XC60 T8         \$49,593         19+gas         10.4         4.9         57           Volvo XC90 T8         \$61,998         18+gas         10.4         5.9         55           Volvo XC90 T8         \$61,998         18+gas         10.4         5.9         55	ve		Volvo S60 T8	\$51,043	22+gas	10.4	4.3	69	TELES
Volvo XC60 T8         \$49,593         19+gas         10.4         4.9         57           Volvo XC90 T8         \$61,998         18+gas         10.4         5.9         55           Wordd         Mercedes GLC350e         Mercedes GLC350e         Mercedes GLC350e         Mercedes GLC350e	ai		Volvo S90 T8	\$58,843	21+gas	10.4	4.8	60	
Volvo XC90 T8 \$49,593 19+gas 10.4 4.9 57 Volvo XC90 T8 \$61,998 18+gas 10.4 5.9 55 Mercedes GLC350e			Volvo V60 T8	\$62,298	22+gas	10.4	4.3	69	Mercedes S560e
Hybrid Mercedes GLC350e	brid		Volvo XC60 T8	\$49,593	19+gas	10.4	4.9	57	
brid			Volvo XC90 T8	\$61,998	18+gas	10.4	5.9	55	·0 0
50 Volvo S60 Volvo S90 Volvo XC60 Mercedes GLE550e		1	AZZ O.			0		0	

# EV Pickups are Here! (2020)

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



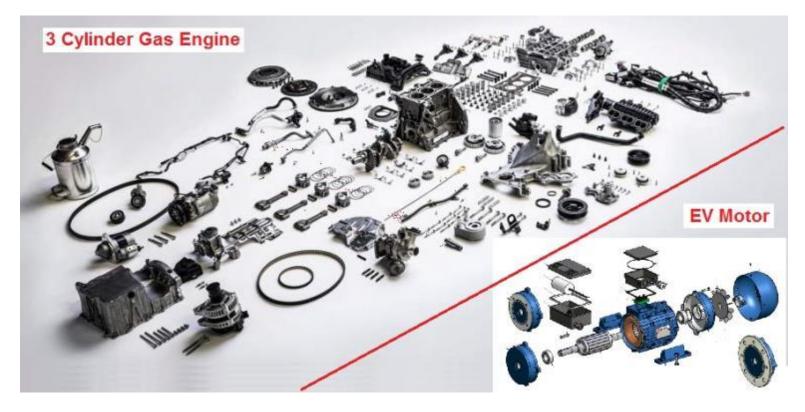
#### Better Torque, Field Electrical Power



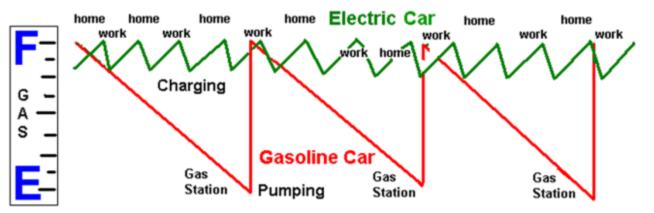


### EV engines have Only ONE moving part!

- 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 <u>while parked</u> <u>And are FULLL every morning</u>



Bob Bruninga, PE IEEE Transportation Committee Our Legacy experience

People see this And think \$40





Oh the Horror!

Reality with EV's is



20¢/hr \$1 a day



(\$10 for Tesla 250mi)

Bob Bruninga, PE IEEE Transportation Committee

Every EV can charge from any 120v outlet

Every EV comes with a 120v charge cord





Exist or \$15 each

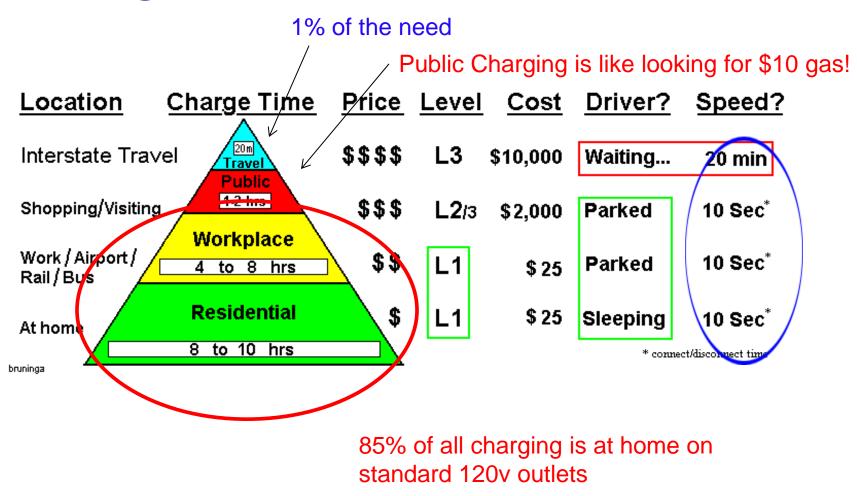
Charging stations for every EV is not sustainable at-work:



\$8000 installed

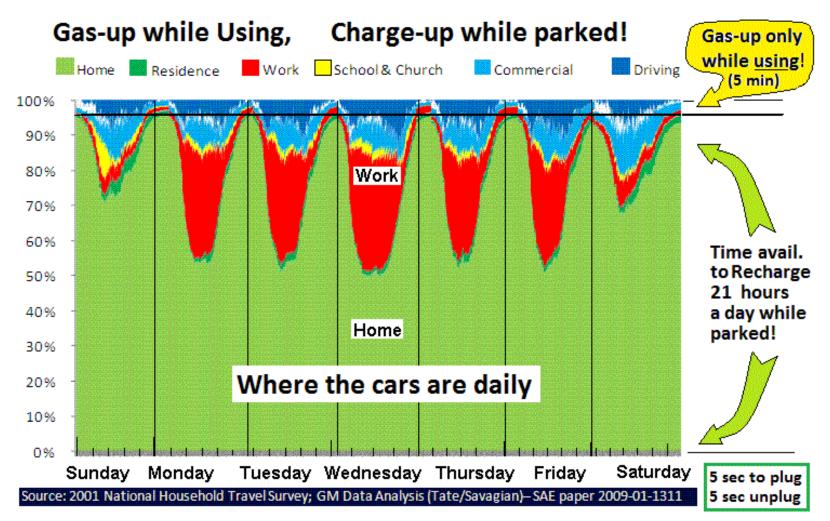
Bob Bruninga, PE IEEE Transportation Committee

## Charge at Home (and at work)



IEEE Transportation Committee

### Charging While Parked (21 hrs/day)



Bob Bruninga, PE

IEEE Transportation Committee

### 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 50

### **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



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

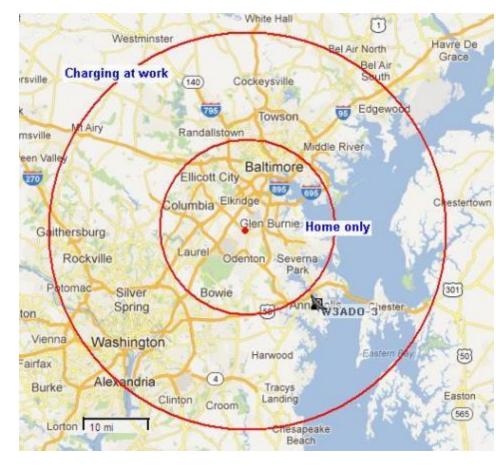
#### Pay \$20/mo For 20mi commute

Bob Bruninga, PE IEEE Transportation Committee

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

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

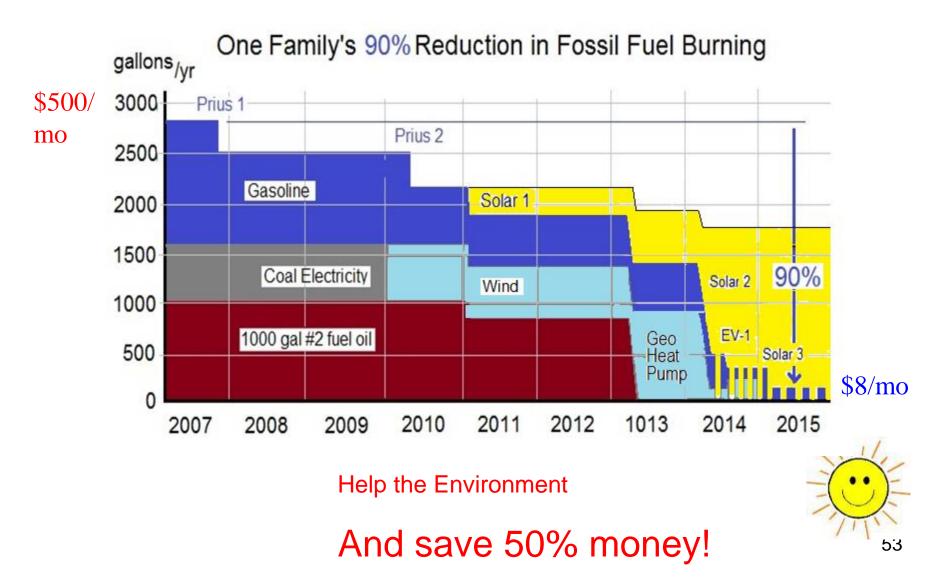
Charge L1 at work/home = 64 mi range





### Going Renewable Energy is Easy!

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



#### 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 <u>\$1500/yr</u> \$6000/yr 300/yr? \$

**AFTER:** Heatpump, Solar, LEDs & EV

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)





• My concept of solar always included batteries:



# Grid-tie Revolutionized Solar

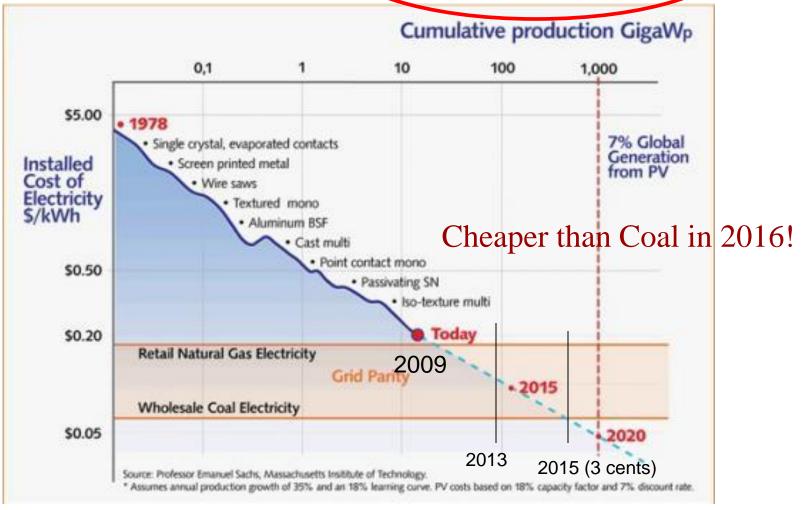
• No Batteries!

#### **Grid-Tie**



Every Watt Produced is valued at full Retail Rates! ZERO MAINENANCE and storage costs FOR LIFE!

#### Solar Cost! Equaled Utility in 2010 Half the Utility in 2013



#### Now Cheaper than wholesale coal!

# Falling Prices 10-to-1

#### A 3 kW array 200 W \$15,000 2007 \$9,000 2010 Panel Plar 220 W 10'on \$6,000 2012 ground \$3,000 2013 250 W Solar Panels 39" x 65" 45 lbs = 3 lbs/saf 2' snow load \$ 2,000 2014 Total factor-of-2 safety loading 30 lbs/sqf \$ 1,500 2015 (300W) 23'

Panel

#### Array Cost

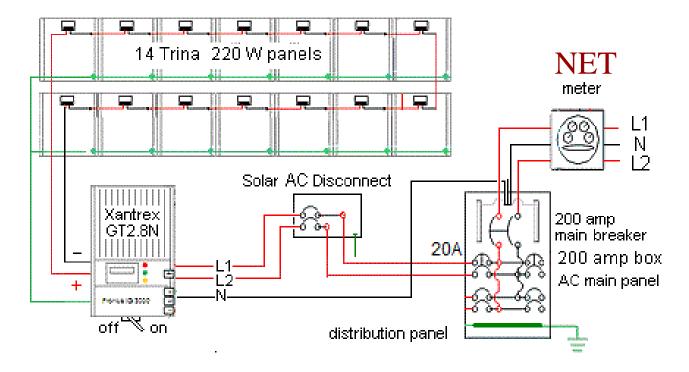
\$5/watt down to 50c/watt\* for panels in only 10 years

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

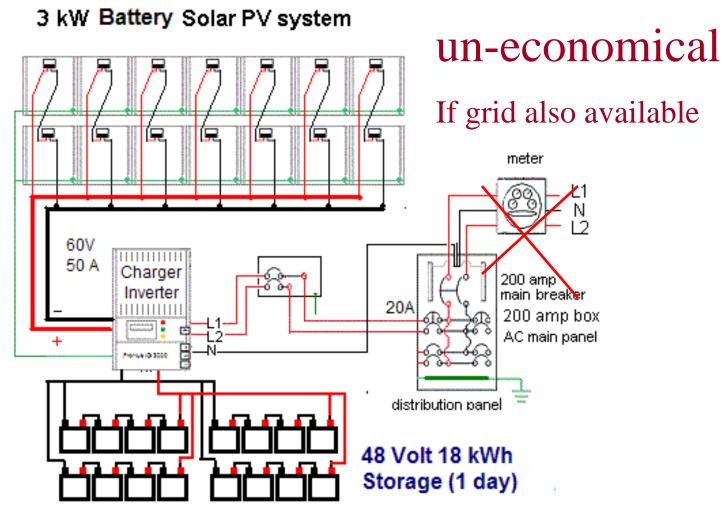
# What is Grid-tie Solar?

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

3 kW Grid-Tie Solar PV system

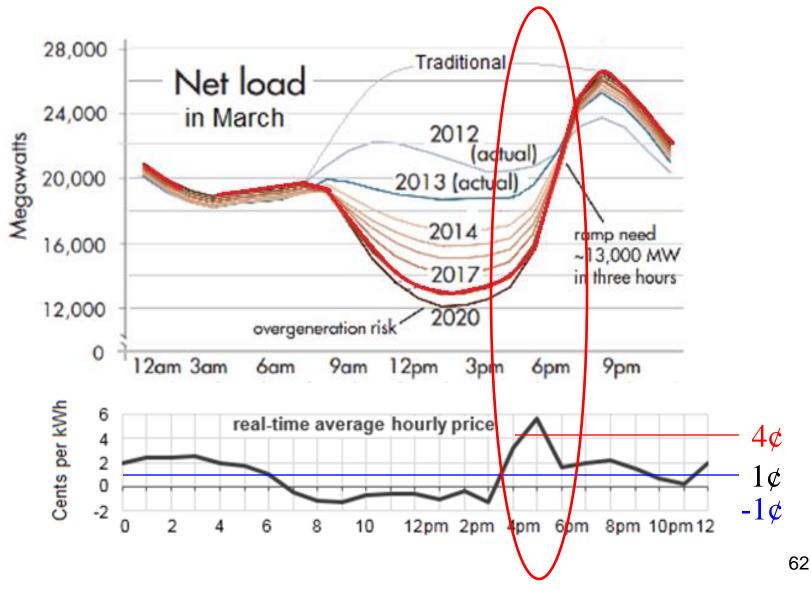


### Off-Grid costs 3 times as much



#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)





\$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)





\$10,000

Value = 60 cents

### 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!

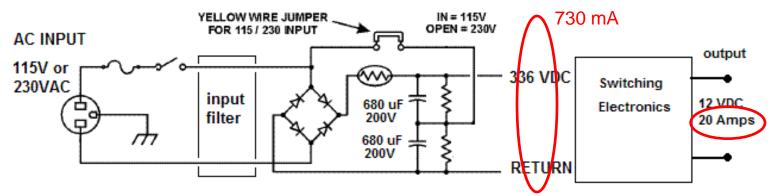




Just a cigarette lighter 120v inverter can power at least 20 LED bulbs in your house. A larger 1000W inverter clipped to the battery can power all the lights and the refrigerator too!

### 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 voltge of over 300 volts DC to the switching ciruitry.

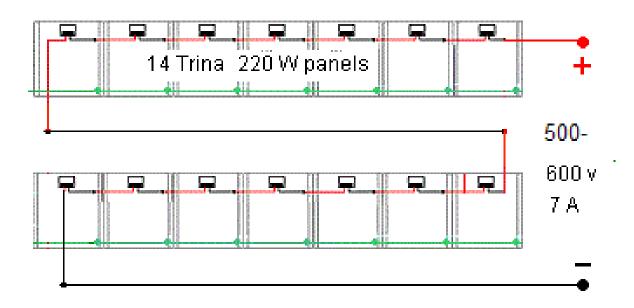
With the jumper removed, the 220 VAC is simply rectified to directly give the + 300 VDC. On 220 VDC the switching circuitry will work directly, but probably with only 2/3rds of the overall output capacity.

Doubles 120 to 230 VAC Eliminate 75% of Rectify to 330 VDC for delivery **Distribution** losses

# Standard Grid-tie Solar (Series)

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

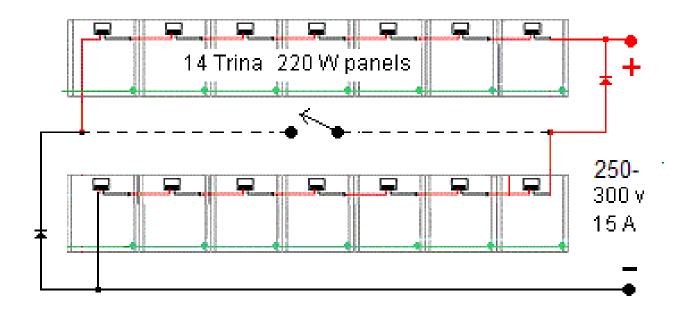
#### 3 kW Grid-Tie Solar PV system



# **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 (incandescentseries)
- Anything with SW/PS



# #1 DIY backup Power Need

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





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

200-300VDC Series solar

50 kW generator Hybrid!

# Grid-down Solar Power

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





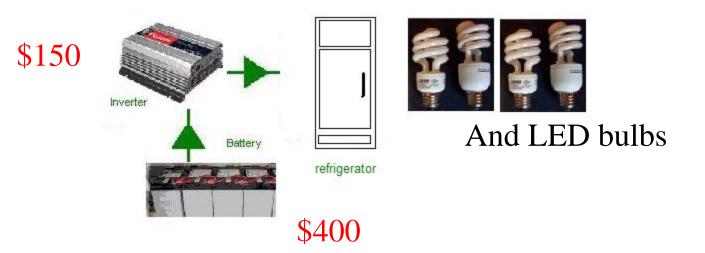
Leaf-to Home: 6 KVA – 24 kWh battery

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

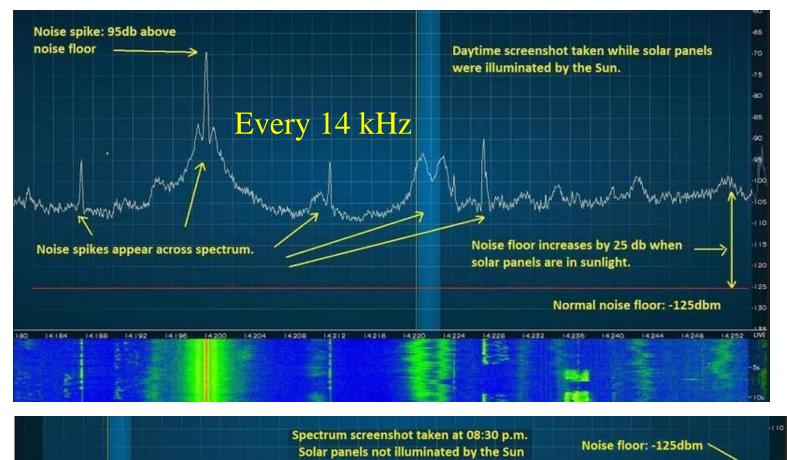


## **But BEWARE of Solar RFI!**



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

# **BEWARE of Solar RFI!**



Man and a second and

14212 14216 14220 14224 14228 14232 14236 14240 14244 14248 14252 14256 14260 14264 14268 14272 14276 14280 14284 14 LWE



**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!



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.

#### Especially OPTIMIZERS! By Solar Edge! ARGH!

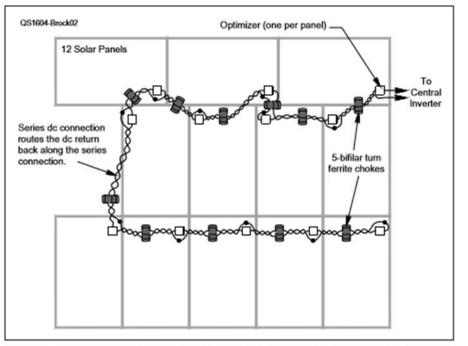
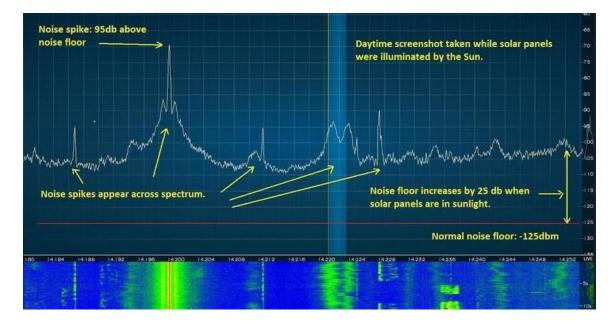


Figure 2 — New wiring configuration shows a closed loop of a twisted pair of conductors, and ferrite beads to suppress common mode currents.

# Talk to your neighbor!... NOW



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

You've lost HF hobby (Daytime) forever

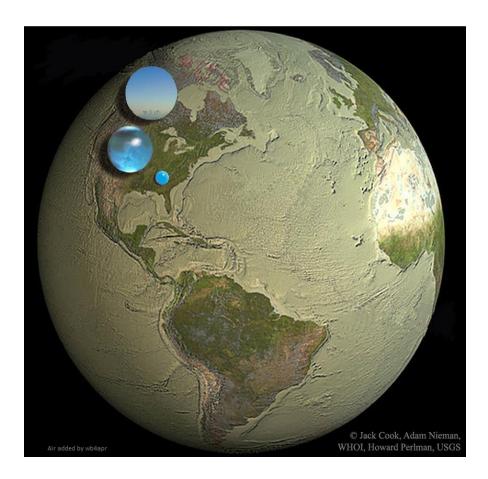
#### 7,000,000,000 people sharing the Air and Water

The Clock is ticking All the Air on Earth

All the Water on Earth

All the fresh water on Earth

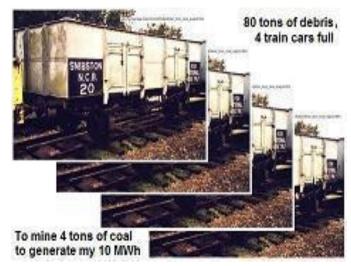
And every cubic foot of air has passed through a combustion engine at least once in the last 200 years



Bob Bruninga, WB4APR

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





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!

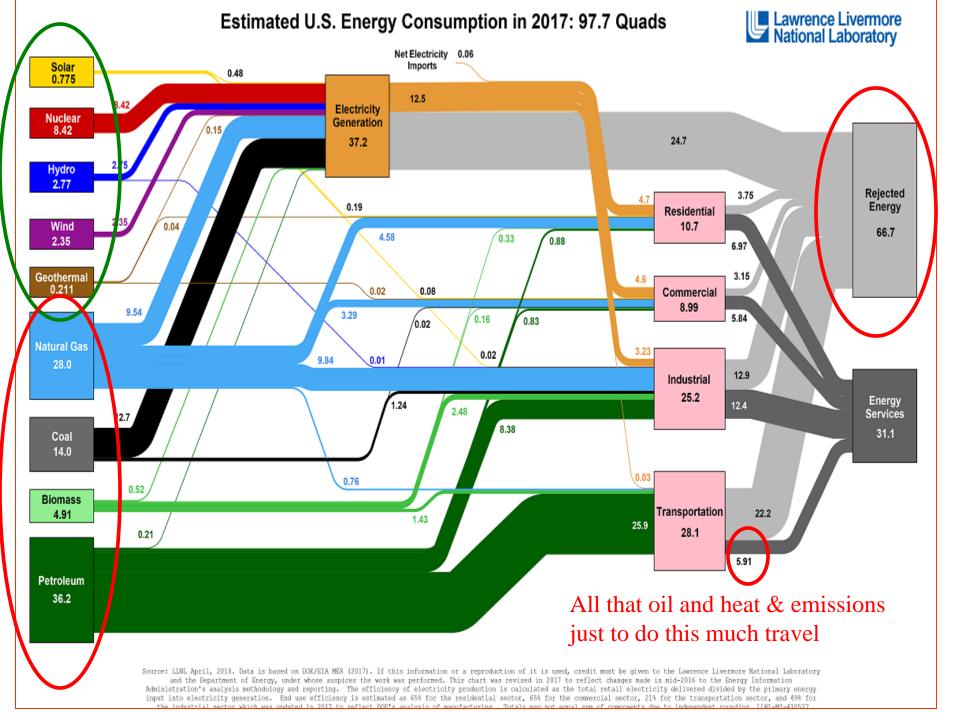
# Mining for Energy

Coal

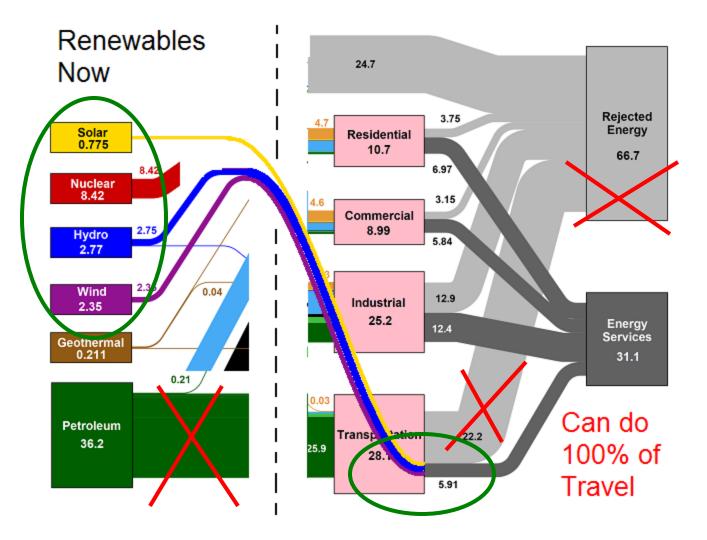
#### Lithium



83



## 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

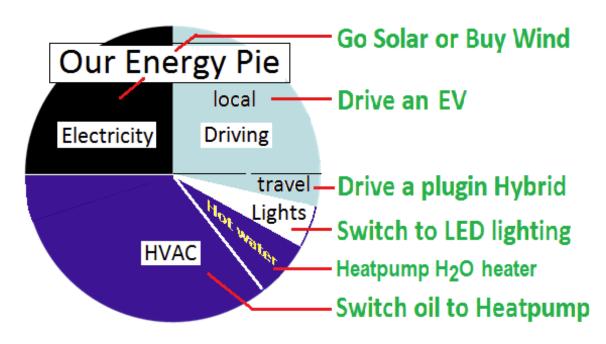
#### Having a prepared mind is essential

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!**

 $12_{\text{Panels can fully}}$ 

charge Average American 40 miles daily Forever!

	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
5	Volvo XC90 T8	13+gas
g	VIA VTRUX (fleet)	40 <sup>*</sup> +gas
ð о	Porsche Cayenne	14+gas
B	Mercedes C350e	18"+gas
ĭ	Mercedes S550e	12+gas
	Porsche Panamera	15+gas
	BMW i8	14+gas
	Porsche 918 Spyder	12+gas
Jas	Chevy Volt	53+gas
ð	Chrysler Pacifica hyb	30°+gas
2	Cadillac ELR	40+gas
5	VIA VTRUX (fleet)	40 <sup>*</sup> +gas

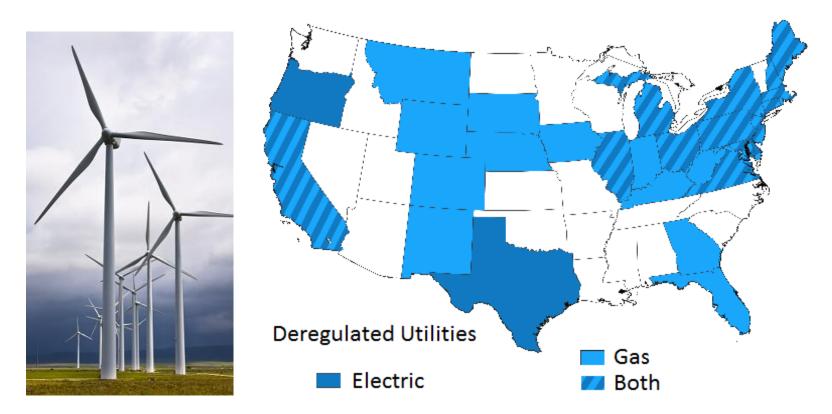
3 kW \$2000



# 40 mi/day average commuter Forever!

		e Price ISD) <sup>1</sup>	Net Price (USD) <sup>2</sup>	Range (mi) <sup>3</sup>	Batt. (kWh)	Speed (mph)	MPG equiv <sup>3</sup>	Fuel / Mo.4	Q
Mitsubishi i (i-M	1iEV) \$2.	2,995	\$15,495	62	16	80	112	\$50	-
Smart electric	\$2	5,000	\$17,500	68	17.6	78	107	\$50	
Chevy Spark EV	\$2	5,120	\$17,620	82	21.3	90	119	\$50	
VW e-Golf	\$2	8,995	\$21,495	83	24.2	87	116	\$46	
Ford Focus Elect	tric \$2	9,170	\$21,670	76	23	84	105	\$50	
Fiat 500e	\$3	1,800	\$24,300	84	24	85	112	\$50	
Kia Soul EV	\$3	1,950	\$24,450	93	27	90	105	\$50	
Nissan LEAF SV	\$34	4,200	\$26,700	107	30	95	112	\$50	
Chevy Bolt (2017)	) \$3 <sup>°</sup>	7,500	\$30,000	200	60	91			
Mercedes B250	e \$4	1,450	\$33,950	87	28	101	84	\$67	
BMW i3 (+ gas opt	e.) \$4:	2,400	\$34,900	81	22	93	124	\$46	
Tesla Model S	85 \$8	0,000	\$72,500	265	85	140	89	\$62	
Tesla Model X	90D -			257	90	155	92	\$58	

# 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



#### Only 3 in 4 households do it!

Now LEDs

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

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

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



I Love it!

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





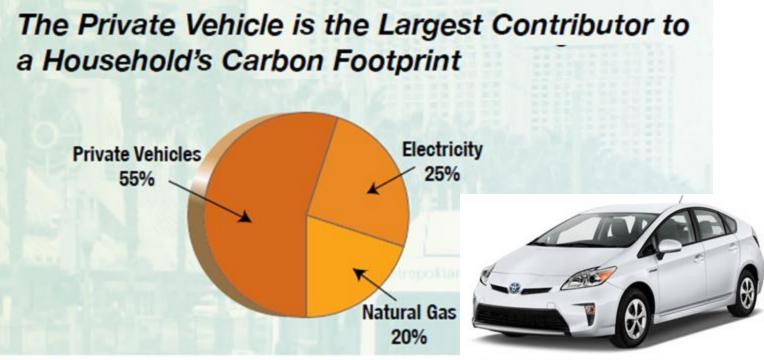




\* Toxicity, carcinogens, etc (not carbon)

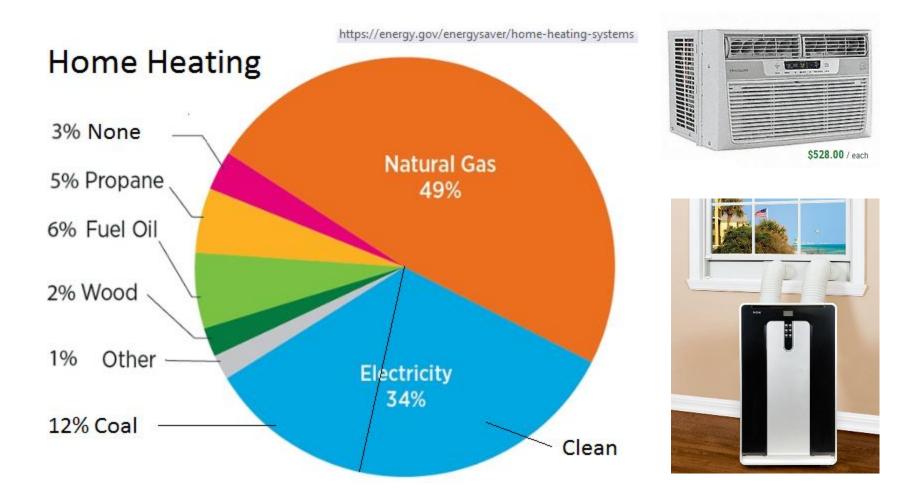
# 4<sup>th</sup> The easiest step – Buy a Plugin





https://www.apta.com/resources/reportsandpublications/documents/greenhouse\_brochure.pdf

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



# Easy Heatpumps

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

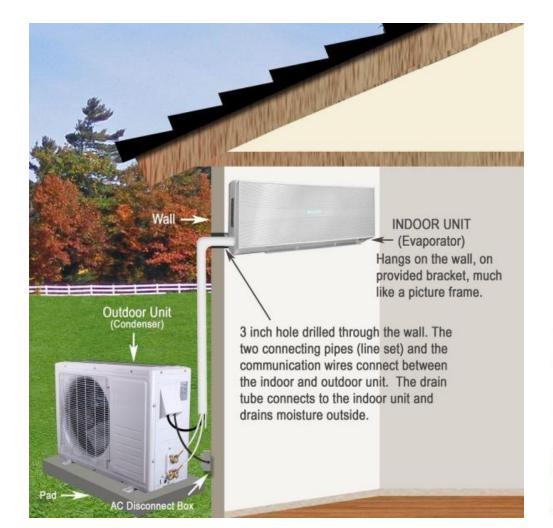


Easy DIY - No Ductwork!



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

\$1,19900/bundle



**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

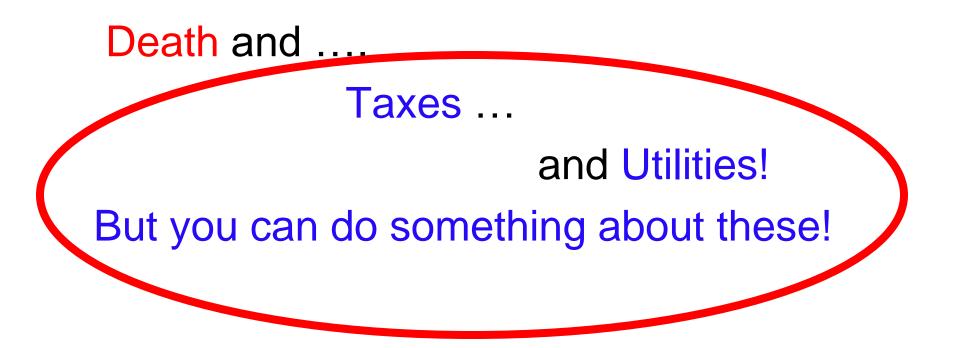
Solar Air Conditioner Heat Pump ACDC12b SOLAR AC SAVE >90% ON COOLING / HEATING COSTS



Or make your own from a new variable speed HVAC

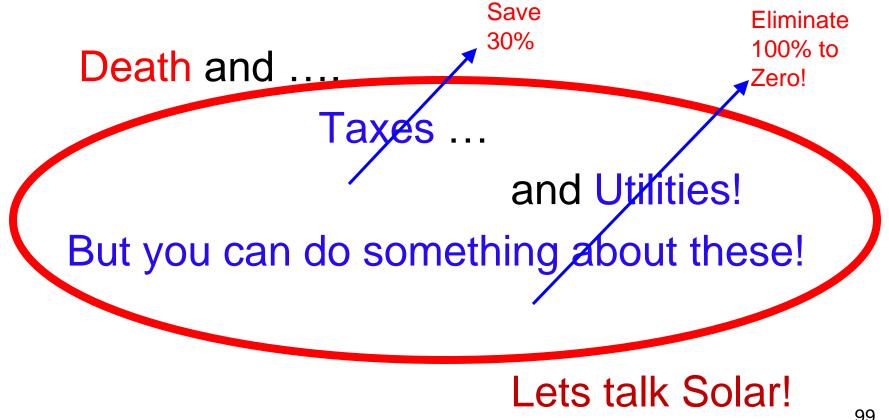
# Finish this Sentence:

• There is nothing certain in life except

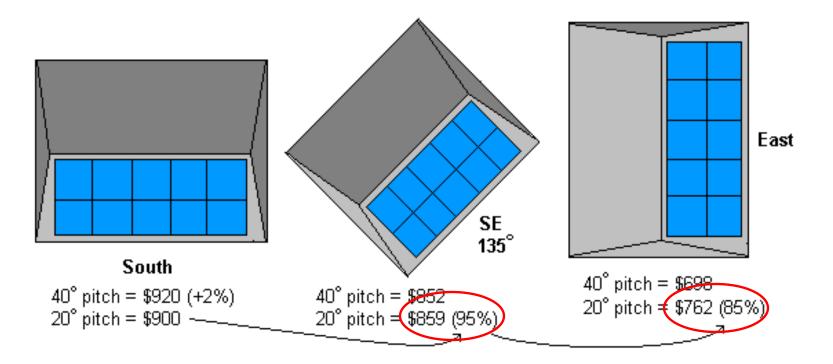


# Finish this Sentence:

There is nothing certain in life except



### Direction - not important with Grid-Tie

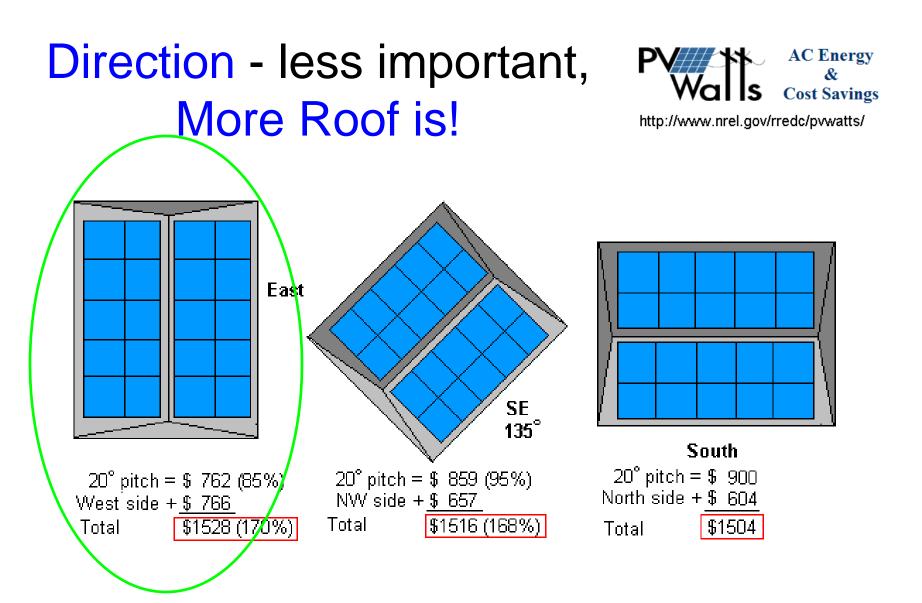


Amazing, even due East, you still get 85% effectiveness!

AC Energy

ost Savings

http://www.nrel.gov/rredc/pvwatts/



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

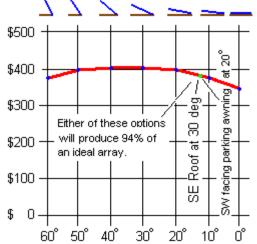
#### Tilt Angle not important\* with Grid-tie



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

#### 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)

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

# 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!



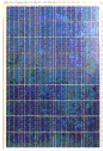


#### 8 Trees Eliminate these Pollutants /yr

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 Sulfer 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

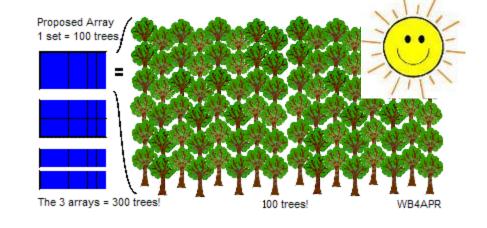
Bob Bruninga, WB4APR



#### Clean Energy, SOLAR

#### Carbon Equivalence!

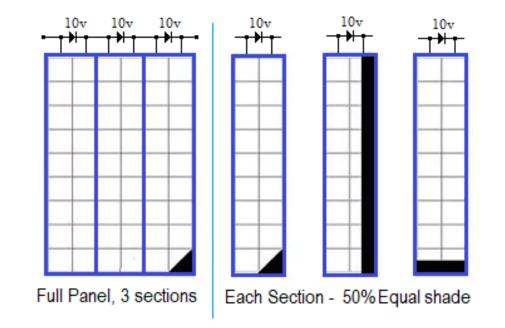
#### Each Panel = 8 Trees.



Our system = 312 trees!

= (3 acres of trees)

# Shade on a cell takes out whole section (1/3<sup>rd</sup>) of panel



Same effect on both String arrays <u>AND Microinverters!</u>

<u>10% or more annual Return on</u> <u>Investment for Life!</u>

- Federal gives 30% tax credit. No limit
- State Grants (was \$5000 in 2011, \$100



x21633867 fotosearch.com

- 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)



109

vour mileage may vary

In bank @ 1%	
Pay \$1200/yr for electricity forever*	Buy 6 kW solar \$16k equity
BANK	Get back \$4000 immediately on taxes (OPM)Get back \$600/yr in SRECs (5 yrs)\$3,000Get \$1200 free electricity/yearGet \$1000 from state? County? City?
<pre>\$ 0 Equity left 10 yrs <u>\$ 1200 Earned interest</u></pre>	\$12,000 System Value \$ 5,000 Tax refund <u>\$ 3,000 SREC's</u>
Own nothing Continue \$1200/yr utility for life \$ 0 after 1 more year 11 yrs	<pre>\$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!</pre>
	* Apples and Oranges 109

#### The Value of \$12,000 Savings?

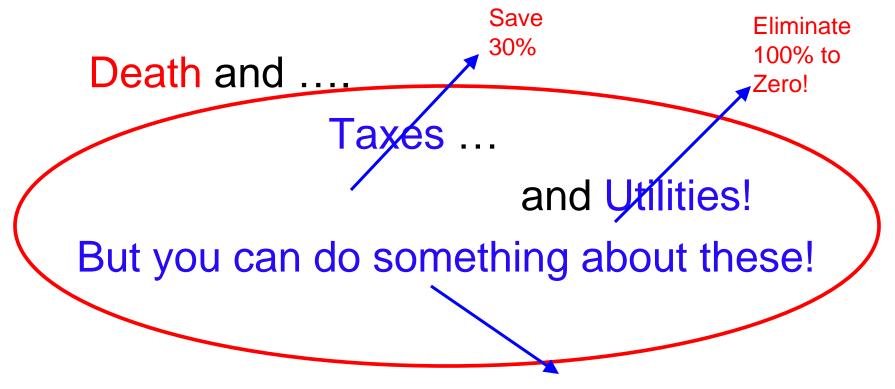
For Someone with a \$100/mo elec bill (\$1200/yr)



In bank @ 1%	
Pay \$1200/yr for electricity forever*	Buy 6 kW solar \$16k equity
	Get back \$4000 immediately on taxes (OPM)
BANK	Get back \$600/yr in SRECs (5 yrs) \$3,000
	Get \$1200 free electricity/year
	Get \$1000 from state? County? City?
	\$12,000 System Value
\$ 0 Equity left 11 yrs	\$ 5,000 Tax refund
	<u>\$ 3,000 SREC's</u>
	\$20,000 Equity
Own nothing	Avoided \$12,000 in electric bills
Continue owing \$1200/yr utility	You own your own Energy system
for life	Net value \$32,000* 10 yrs
	NO utilities for life!
	* Apples and Oranges 110

## Remember:

• There is nothing certain in life except



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.



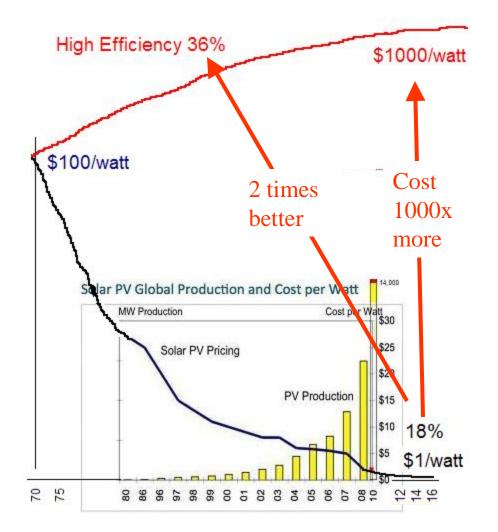
## Buy or lease Solar?

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?

•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...





## 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:**

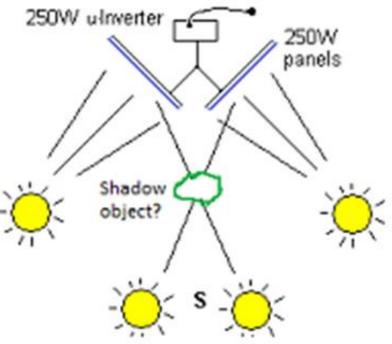
Contract a small system Get Net Meter - \$2.50/W

Add your panels - \$0.30/W & plugin GT inverters - \$0.30/W



## <u>Another DIY Tip:</u> – 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!?



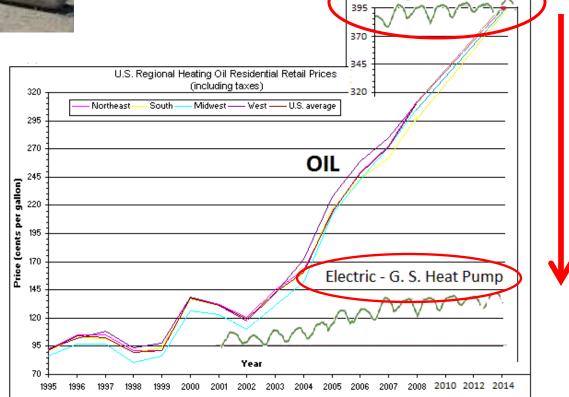


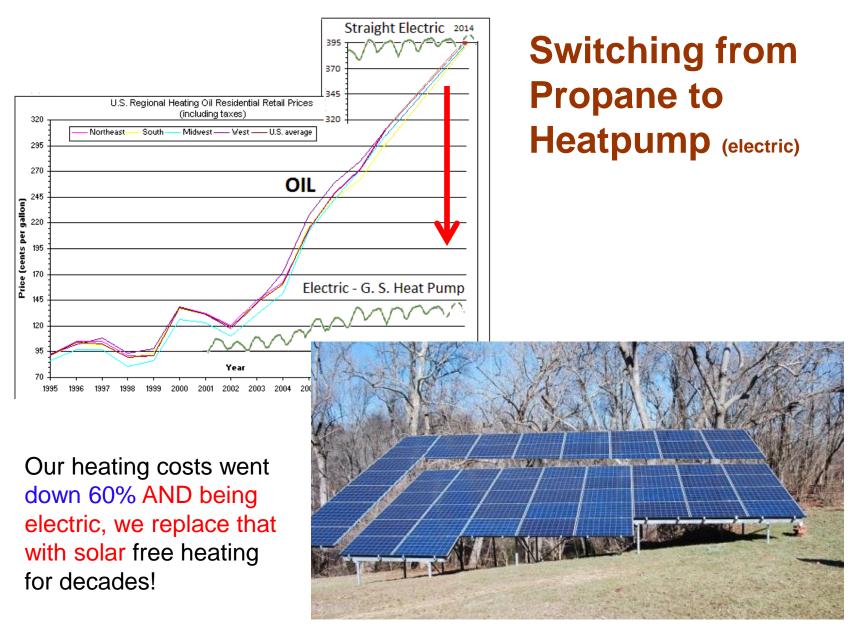
#### Heating Costs – Oil, Propane...

Straight Electric 2014

Actually our biggest Energy cost is our Propane heating.

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





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

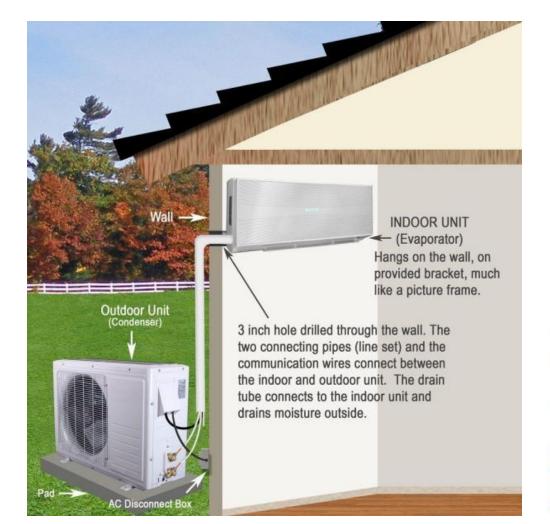








#### **Ductless Heatpumps** Anywhere!







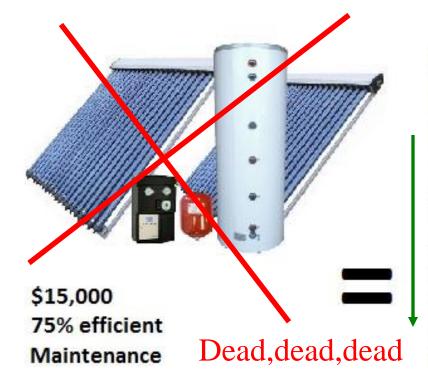
12,000 BTU 1 Ton Ductless Mini Split Air Conditioner and Heat Pump - 208-230V/60Hz

\$1,19900/bundle



Add To Cart

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



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



\$5,000 15% efficient

Heatpump 250% efficient

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 <u>http://www.aprs.org/AFM-environment.html</u> 410-293-6417







## Summary You can do something

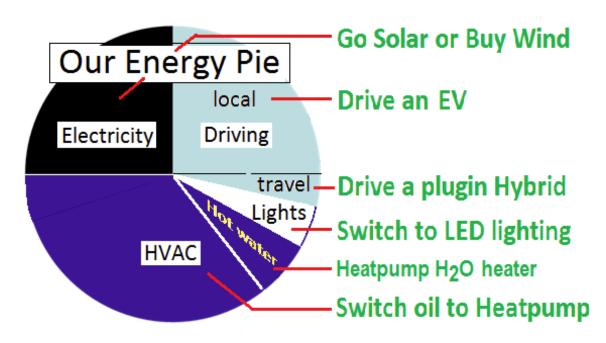
- Pre-think your next personal energy decision.
- If you have sun, solar is best investment ever...
- Everyone\* can sign up for WIND power!
- Water heater dies get a heatpump one
- Heating dies get a heat pump (and solar)
- AC dies Get a heatpump
- Car ages get an EV for commuting
- Put charging signs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

Its cheaper and cleaner!



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

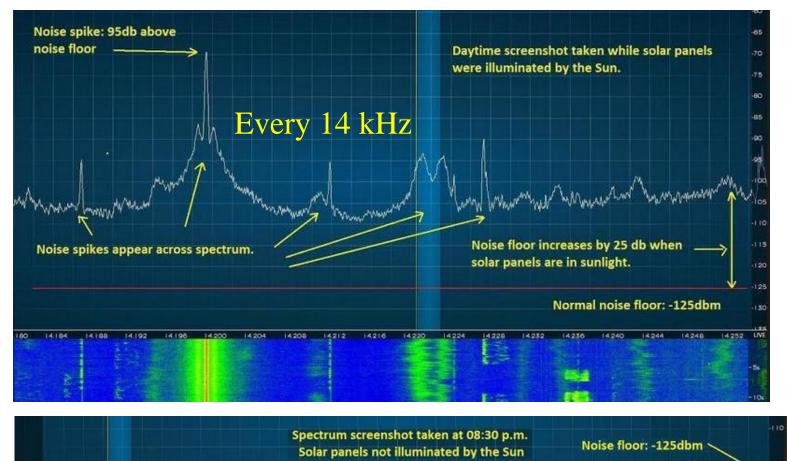
A prepared mind is essential





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

## **BEWARE of Solar RFI!**



We wanter where and a second wanter and a second of the se

14212 14216 14220 14224 14228 14232 14236 14240 14244 14248 14252 14256 14260 14264 14268 14272 14278 14280 14284 14UK

## Backup slides follow



## Who's Talking \* \* \*

# OUR PRESENT LIFESTYLE IS NOT SUSTAINABLE!



Are we part of the problem?







Or part of the Solution?



#### When is the Payback ??? Picture! When is the Breakeven ???



Big



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



#### When is the Payback ??? Picture! When is the Breakeven ???



Big





Paying for Sewage Plants – was from Day ONE !

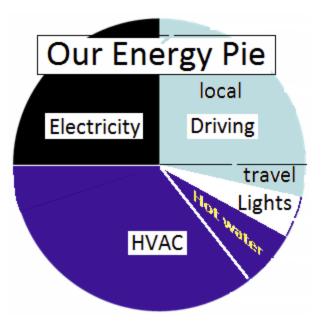


## Big<br/>Picture!When is the Payback ???When is the Breakeven ???



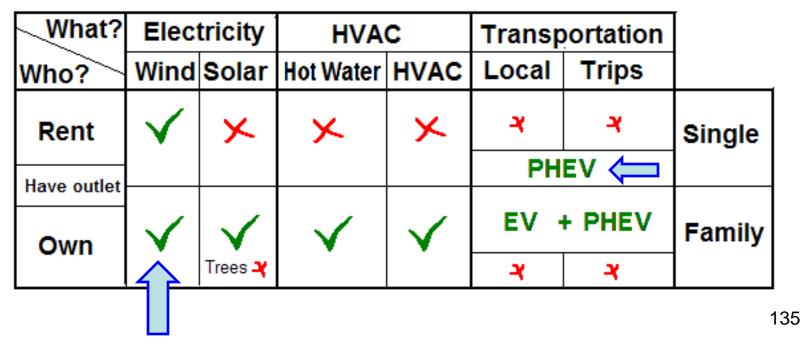
Investing in Solar Power - is from Day ONE ! Because that's when we Stop Beating Mother Nature and stealing from our kids future.





## Who, What, When, Why, How

Homeowners can do the most



### Power Distribution 330 VDC

Nearly ALL modern switching supplies will run on VDC

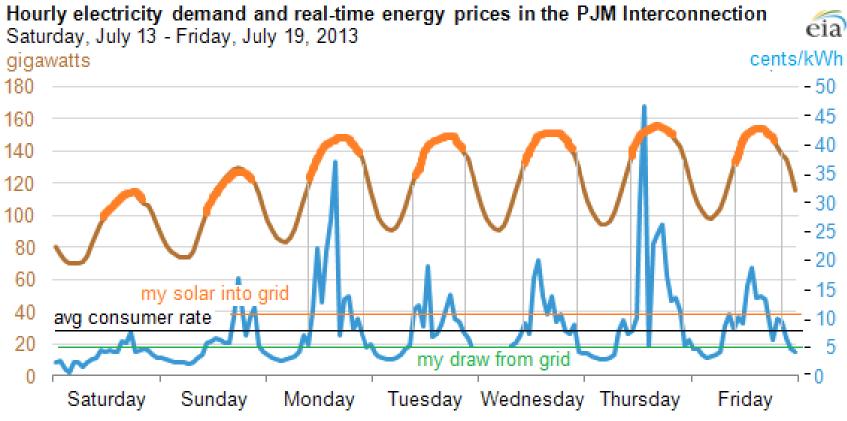




Kenwood 115 VAC only supply Actually has internal jumper

Eliminate 75% of Distribution losses

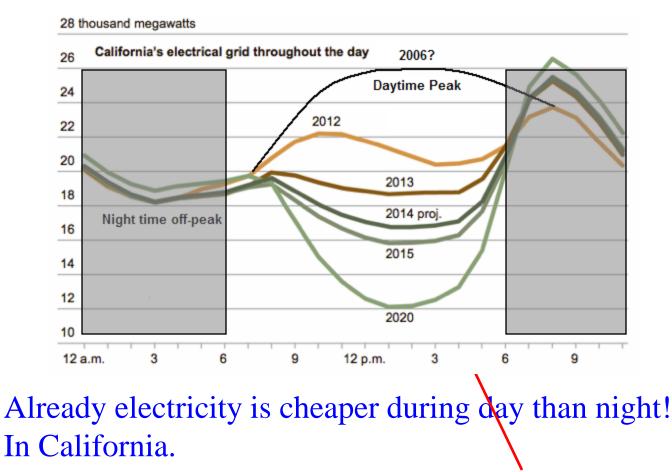
## What is fair in Net Metering?



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

#### Rapid Change is happening all around you!

#### The Duck's Back



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

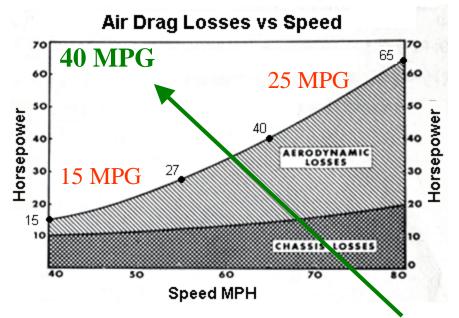




- Micro Inverters On every panel.
  - Made sense when panels were \$1200 and M.I. was \$250.
  - But now panels are \$120!
  - Dozens of elex modules on roof (-10F to +160F extremes)
  - Costly to repair/replace!
  - Some brands might Generate RF hash on nearby radios?
- Optimizers Cheaper but all the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

Volvo GM	ALL models will be electrified by 2019 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

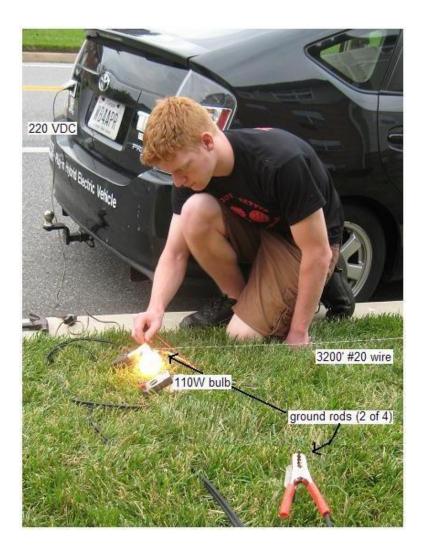
- There is an EV or PHEV replacement for every car model on the market.
- That cost less than the average gas car (\$35k) avg new or under \$10k used,
- That have any range from 100 to 600 miles (EV, PHEV)
- Go faster, but with less cost to operate and maintain





We cannot keep doing this!

#### Power Distribution **SWER**

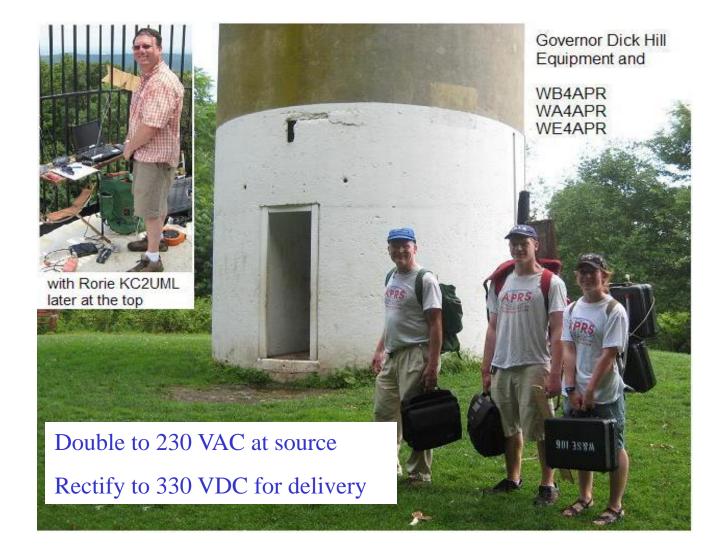


#### Emergency Power: Use Single Wire Earth Return



#### Not approved by NEC

#### Power Distribution **SWER**



Single Wire Earth Return

Not approved by NEC (when grid connected)