Recent Experiments to Extend Operating Time of Radios During Electrical Power Blackouts after an Earthquake.

- Dr. Richard Wheeler [AI6RW]
- President Wheeler Enterprises
- www.wheeler.com/ai6rw/
- Richard@wheeler.com
- San Jose Area Council ERC Specialist

SJC & OAK/SFO Areas

How to power radio equipment for 1 to 4 week power blackout after Category 7 earthquake on Hayward Fault

- Propane vs Gasoline Inverter Generators
- Lithium-Ion Battery Power Station
- Combining Propane and Battery Power Stations
- Solar vs Propane Battery Charging
- Can Small Propane Generator Start Refrigerator?
- Conclusion
- Q&A

Propane vs Gasoline Generators

- Gasoline Generator
  - Less Expensive
  - Readily Available
  - Inverter type is quiet
- Cons
  - Extremely Flammable liquid
  - Pouring Gasoline on hot engine ☹
  - Gas turns to varnish over time
  - Anti-syphon screen on newer cars
  - Gas station needs power to pump gas

•Propane Generator
  –Several models now available
  –Propane doesn't change over time
  –NO power needed to pump gas
  –BBQ tank cage easily available
  –Automatic tank switch-over
  –Inverter type is quiet
  –Easy to measure gas consumption
•Cons
  –More expensive

Propane Generator Vault

Home Laboratory Power Wall

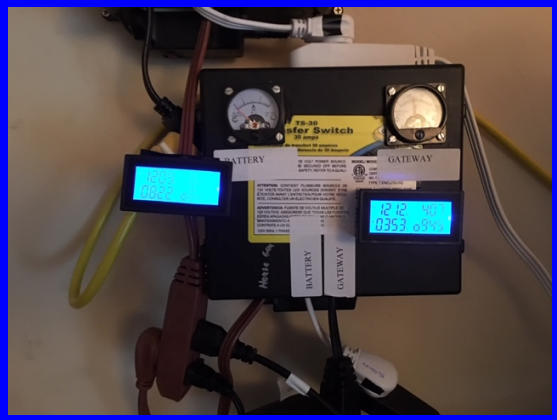
Lab Power Wall

Yeti 400 Repeater Power

ViaSat Modem

Renogy 1000 W-Hr Lithium

House to Gen Transfer Switch



Solar Battery Transfer Switch

Two Propane Generators

Genconnecxdirect.com
Honda EU2200i Propane
2200 Watts Peak
1800 Watts Average
$1500

Home Depot
Ryobi 900 Watt Propane
900 Watts Peak
700 Watts Average
$300

Honda EU2200i Propane Generator

Ryobi 900 Watt Propane Generator

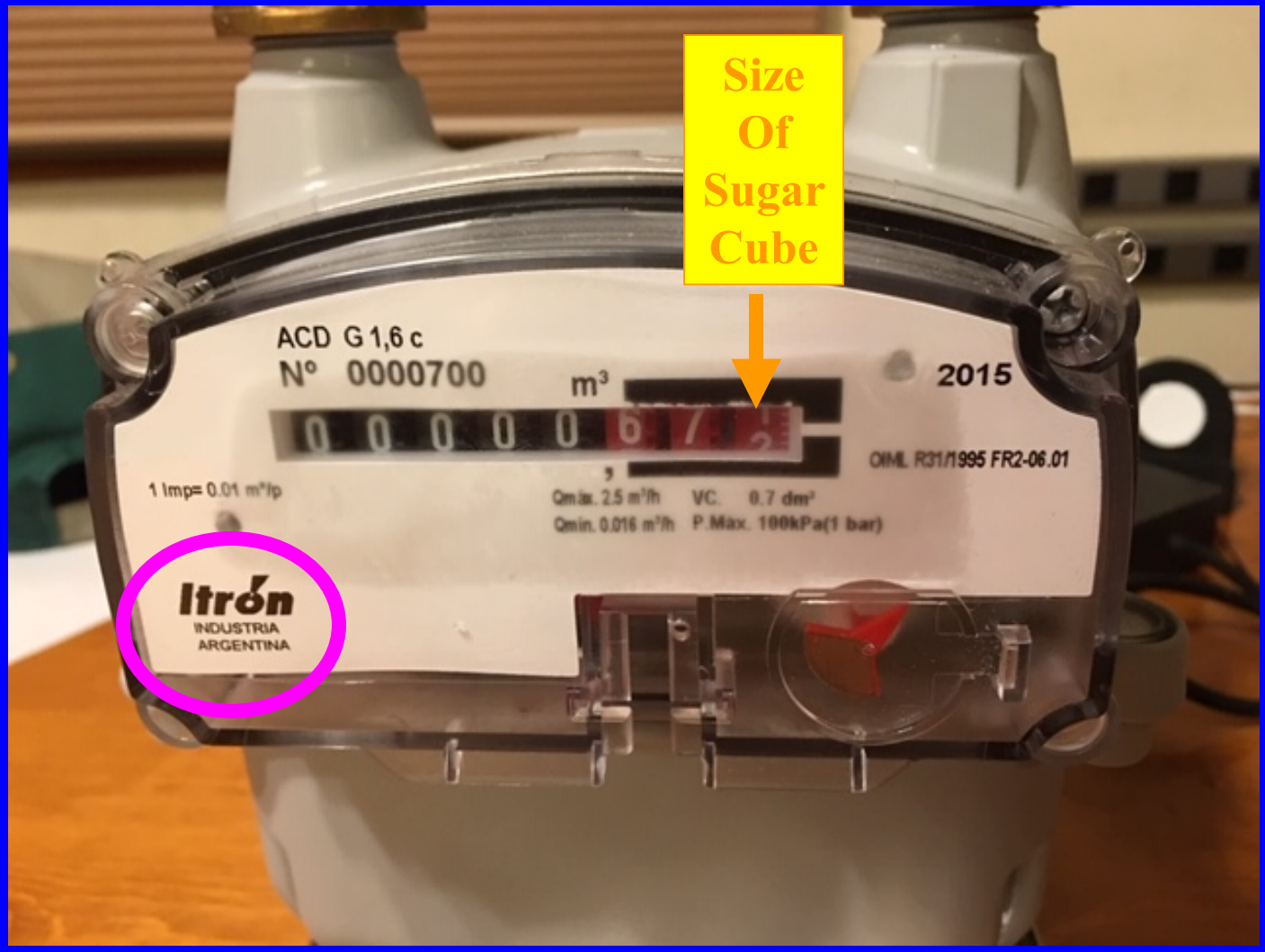
Gallons per Minute, Gallons, Watts, Watt-Hours, KW-Hr

<u>Fill-up</u> Rate Volume	Gallons / Min Gallons	Cubic Meters / Min Cubic Meters	Watts Watt-Hours KW-Hr
<u>Discharge</u> Rate Volume	Gallons / Min Gallons	Cubic Meters / Min Cubic Meters	Watts Watt-Hours KW-Hr

Power
Energy
K means 1000X

Power
Energy

Itron ACD G1.6 Gas Meter



Propane Gas Flow Measurements

Two Propane Generators

$1500 / 1800 Watts $300 / 700 Watts

One BBQ Propane Bottle Will Run Generator…

	Watts	/ Hours / Days	Watts	/ Hours / Days
	Idle	48 / 2.0	Idle	72 / 3.0
Goal→	60	43 / 1.8	60	59 / 2.4
	170	37 / 1.5	170	48 / 2.0
	400	24 / 1.0	400	34 / 1.4
	800	15 / 0.6	600	24 / 1.0

Two Propane Generators KW-Hr

$1500 / 1800 Watts $300 / 700 Watts

One BBQ Propane Bottle Will Run Generator…

	Watts / Hours / Days / KW-Hr		Watts / Hours / Days / KW-Hr	
	Idle	48 / 2.0	Idle	72 / 3.0
Goal→	60	43 / 1.8 / 2.6	60	59 / 2.4 / 3.5
	170	37 / 1.5 / 6.3	170	48 / 2.0 / 8.2
	400	24 / 1.0 / 9.6	400	34 / 1.4 / 13.6
	800	15 / 0.6 / 12.0	600	24 / 1.0 / 14.4

Two Generator's Efficiency

Two Generators — Honda 2000

Watts Electricity	Watts Engine	Engine increase	Watts Total	Efficiency	Hours	Days	Prop Tank KW-Hr	KW-Hr Effective
0	450	1.00	450	0	48	2.00	22	0.0
60	455	1.01	515	12	43	1.79	22	2.6
170	463	1.03	633	27	37	1.54	23	6.3
400	480	1.07	880	45	24	1.00	21	9.6
600	495	1.10	1095	55	20	0.83	22	12.0
1800	585	1.30	2385	75				

Ryobi 900

Watts Electricity	Watts Engine	Engine increase	Watts Total	Efficiency	Hours	Days	Prop Tank KW-Hr	KW-Hr Effective
0	300	1.00	300	0	72	3.0	22	0.0
60	309	1.03	369	16	59	2.5	22	3.5
170	326	1.09	496	34	48	2.0	24	8.2
400	360	1.20	760	53	34	1.4	26	13.6
600	390	1.30	990	61	24	1.0	24	14.4

Two Generator's Charging Efficiency

Two Generators — Honda 2000

Watts Electricity	Watts Engine	Engine increase	Watts Total	Efficiency	Hours	Days	Prop Tank KW-Hr	KW-Hr Effective	Days Per Tank Charge @ 600W Run @ X Watts
0	450	1.00	450	0	48	2.00	22	0.0	
60	455	1.01	515	12	43	1.79 ←	22	2.6	8.3 ←
170	463	1.03	633	27	37	1.54	23	6.3	2.9
400	480	1.07	880	45	24	1.00	21	9.6	1.3
600	495	1.10	1095	55	20	0.83	22	12.0	0.8
1800	585	1.30	2385	75					

Ryobi 900

Watts Electricity	Watts Engine	Engine increase	Watts Total	Efficiency	Hours	Days	Prop Tank KW-Hr	KW-Hr Effective	Days Per Tank Charge @ 600W Run @ X Watts
0	300	1.00	300	0	72	3.0	22	0.0	
60	309	1.03	369	16	59	2.5 ←	22	3.5	10.0 ←
170	326	1.09	496	34	48	2.0	24	8.2	3.5
400	360	1.20	760	53	34	1.4	26	13.6	1.5
600	390	1.30	990	61	24	1.0	24	14.4	1.0

Solution: Combine Ryobi Generator With Goal Zero Yeti Lithium Portable Power Station.

Goal Zero Lithium Power Station

Model	Yeti 400 Lithium	Yeti 1000 Lithium	Yeti 1400 Lithium	Yeti 3000 Lithium
Capacity (W-Hr)	400	1000	1400	3000
Continuous (Watts)	300	1500	1500	1500
Surge (Watts)	1200	3000	3000	3000
Max Charge (W)	120	600	600	600
Chg Time (Hrs)	3.3	1.7	2.3	5.0
List Price ($)	600	1300	1800	3000
Sale Price ($)	600	1300	1400	2400
Start Refrigerator?	NO	YES	YES	YES

Ryobe plus Yeti 3000 Lithium

$300 / 700 Watts

$2400 3.0 KW-Hr

	Watts	Hours	Days	KW-Hr
Old Goal→	60	59	2.4	3.5
	170	48	2.0	8.2
	400	34	1.4	13.6
NewGoal→	600	24	1.0	14.5

Battery Charge Time (Hours)	Bat Charges per tank	Days per tank@60W
50.0	1.2	2.4
17.6	2.7	5.7
7.5	4.5	9.4
5.0	4.8	10.1 (Best)

Ryobe plus Yeti 1400 Lithium

$300 / 700 Watts

$1400 1.4 KW-Hr

	Watts / Hours / Days / KW-Hr	Battery Charge Time (Hours)	Bat Charges per tank	Days per tank@60W
Old Goal→	60 59 / 2.4 / 3.5	23.3	2.5	2.4
	170 48 / 2.0 / 8.2	8.2	5.9	5.7
	400 34 / 1.4 / 13.6	3.5	9.7	9.4
NewGoal→	600 24 / 1.0 / 14.5	2.3	10.4	10.1 (Best)

Ryobe plus Yeti 1000 Lithium

$300 / 700 Watts

$1300 1.0 KW-Hr

	Watts / Hours / Days / KW-Hr	Battery Charge Time (Hours)	Bat Charges per tank	Days per tank@60W
Old Goal→	60 59 / 2.4 / 3.5	16.7	3.5	2.4
	170 48 / 2.0 / 8.2	5.9	8.3	5.7
	400 34 / 1.4 / 13.6	2.5	13.6	9.4
NewGoal→	600 24 / 1.0 / 14.5	1.7	14.5	10.1 (Best)

Propane Charging at 600 Watt Level into Yeti Lithium Power Station

One BBQ Propane Bottle Will Run Generator…

	Watts	Hours / Days		Watts /	Hours / Days	
	Idle	48 / 2.0		Idle	72 / 3.0	
Goal----→	60	43 / 1.8 / 8.3	←	60	59 / 2.4 / 10.0	←
	170	37 / 1.5 / 2.9		170	48 / 2.0 / 3.5	
	400	24 / 1.0 / 1.3		400	34 / 1.4 / 1.5	
	600	20 / 0.8 / 0.8		600	24 / 1.0 / 1.0	

How to Charge Yeti Lithium Generator Batteries?

Typical Power Supply Current Spikes

20X→

←1X

Volts 121 Watts 371
Amps 5.21 VA 630
PF 0.59

←

Typical PS Has Low Power Factor

20X→

←1X

Volts 121 Watts 371
Amps 5.23 VA 633
PF 0.59

←

Power Factor Corrected Supplies

20X→

←1X

Volts 122 Watts 357
Amps 2.94 VA 359
PF 0.99

←

Mean Well Power Supplies For Charging Yeti Lithium Power Stations

Meanwell Model Type	RSP-150-15	HRP-300-15	NES-350-15	LRS-350-15
Voltage range (Volts)	14.3-16.5	13.5-18	13.5-18	13.5-18
Current Range (Amps)	0 - 10	0 - 22	0 - 23.2	0 - 23.2
Rated Power (Watts)	150	330	348	348
Power Factor	0.98	0.99	**0.59 !!!**	**0.59 !!!**
Current Overload Protection	Constant Current	Constant Current	Constant Current	Hickup Mode Shutdown!!!
Cooling	No fan	Fan	Fan	Fan
Cost ($)	49	79	48	38

It is DIFFICULT to find a good charger! ☹

Most Common Power Supply

If it doesn't say "constant current" or "power factor corrected" it is NOT!!!

RSP-150-15

INPUT	VOLTAGE RANGE Note.5	85 ~ 264VAC 120 ~ 370VDC							
	FREQUENCY RANGE	47 ~ 63Hz							
	POWER FACTOR (Typ.)	PF>0.93/230VAC PF>0.98/115VAC at full load							
	EFFICIENCY (Typ.)	81.5%	87%	88.5%	90%	87.5%	88.5%	89%	89.5%	90%
	AC CURRENT (Typ.)	1.6A/115VAC 0.8A/230VAC							
	INRUSH CURRENT (Typ.)	COLD START 45A/230VAC							
	LEAKAGE CURRENT	<2mA / 240VAC							
	OVERLOAD	105 ~ 135% rated output power Protection type : Constant current limiting, recovers automatically after fault condition is removed							

» RSP-75~500 Series

Wattage : 75W~500W

Features :

- 1U Low profile with active PFC function: 75W~320W: 30 mm, 500W: 40.5 mm
- Built-in constant current limiting circuit (RSP-75/100/150)
- Built-in remote ON/OFF control (RSP-75/100/150/500)
- Built-in remote sense (RSP-500 only)

Model

: RSP-75 / RSP-100 / RSP-150 / RSP-200 / RSP-320 / RSP-500

Hiccup Chargers

HRP-300-15

INPUT	VOLTAGE RANGE Note.5	85 ~ 264VAC 120 ~ 370VDC						
	FREQUENCY RANGE	47 ~ 63Hz						
	POWER FACTOR (Typ.)	PF>0.95/230VAC PF>0.99/115VAC at full load						
	EFFICIENCY (Typ.)	80%	82%	86%	88%	88%	87%	88%	89%
	AC CURRENT (Typ.)	3.5A/115VAC 1.8A/230VAC						
	INRUSH CURRENT (Typ.)	35A/115VAC 70A/230VAC						
	LEAKAGE CURRENT	<1.2mA / 240VAC						
PROTECTION	OVERLOAD	105 ~ 135% rated output power Protection type : Constant current limiting, recovers automatically after fault condition is removed						

NES-350-15

Missing PF

INPUT	VOLTAGE RANGE Note.4	90 ~ 132VAC / 180 ~ 264VAC by switch 254 ~ 370VDC							
	FREQUENCY RANGE	47 ~ 63Hz							
	EFFICIENCY (Typ.)	74%	78%	80%	83%	84%	87%	88%	87.5%	87.5%
	AC CURRENT (Typ.)	7A/115VAC 4A/230VAC							
	INRUSH CURRENT (Typ.)	40A/115VAC 60A/230VAC							
	LEAKAGE CURRENT	<3.5mA / 240VAC							
	OVER LOAD	105 ~ 135% rated output power							
		Protection type : Constant current limiting, recovers automatically after fault condition is removed							

LRS-350-15

Missing PF

INPUT	VOLTAGE RANGE	90 ~ 132VAC / 180 ~ 264VAC by switch			240 ~ 370VDC	(switch on 230VAC)		
	FREQUENCY RANGE	47 ~ 63Hz						
	EFFICIENCY (Typ.)	79.5%	81.5%	83.5%	85%	86%	88%	88.5%	89%
	AC CURRENT (Typ.)	6.8A/115VAC		3.4A/230VAC				
	INRUSH CURRENT (Typ.)	60A/115VAC		60A/230VAC				
	LEAKAGE CURRENT	<2mA / 240VAC						
	OVER LOAD	110 ~ 140% rated output power						
		Protection type : Hiccup mode, recovers automatically after fault condition is removed						

Hiccup or Shut Down Mode

Can a Small Propane Generator Start And Run a Refrigerator?

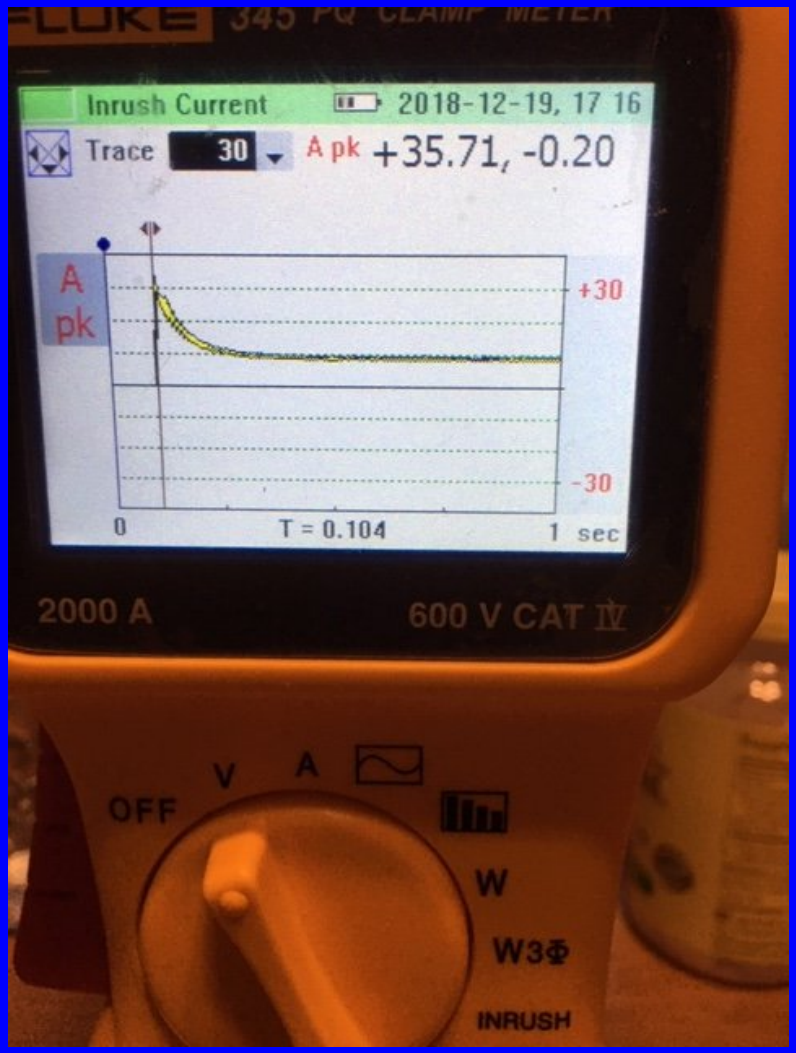
Yes!

Goal Zero Yeti
1000, 1400 and 3000
Lithium will do it.

Other Lithium generators
also might do it

Refrigerator Start-up Current

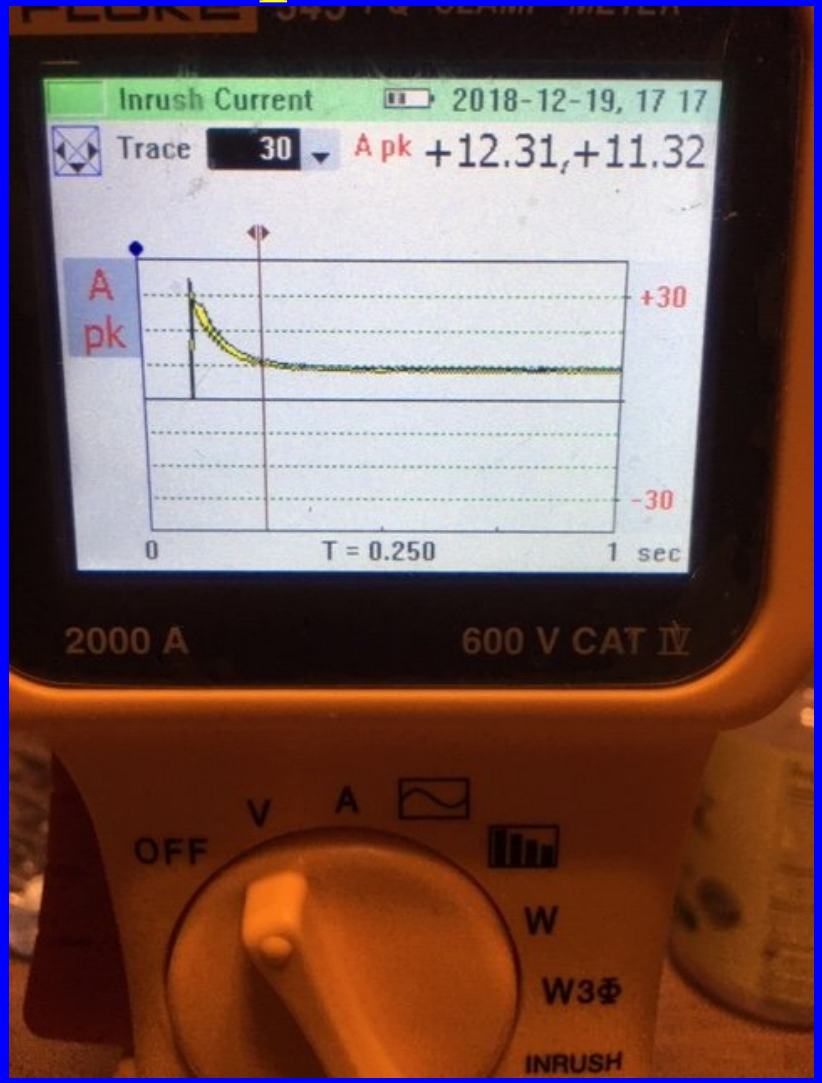
10X→



Starting Current 3.57 Amps
Starting Power 428 Watts

Start-up duration = 0.250 Seconds

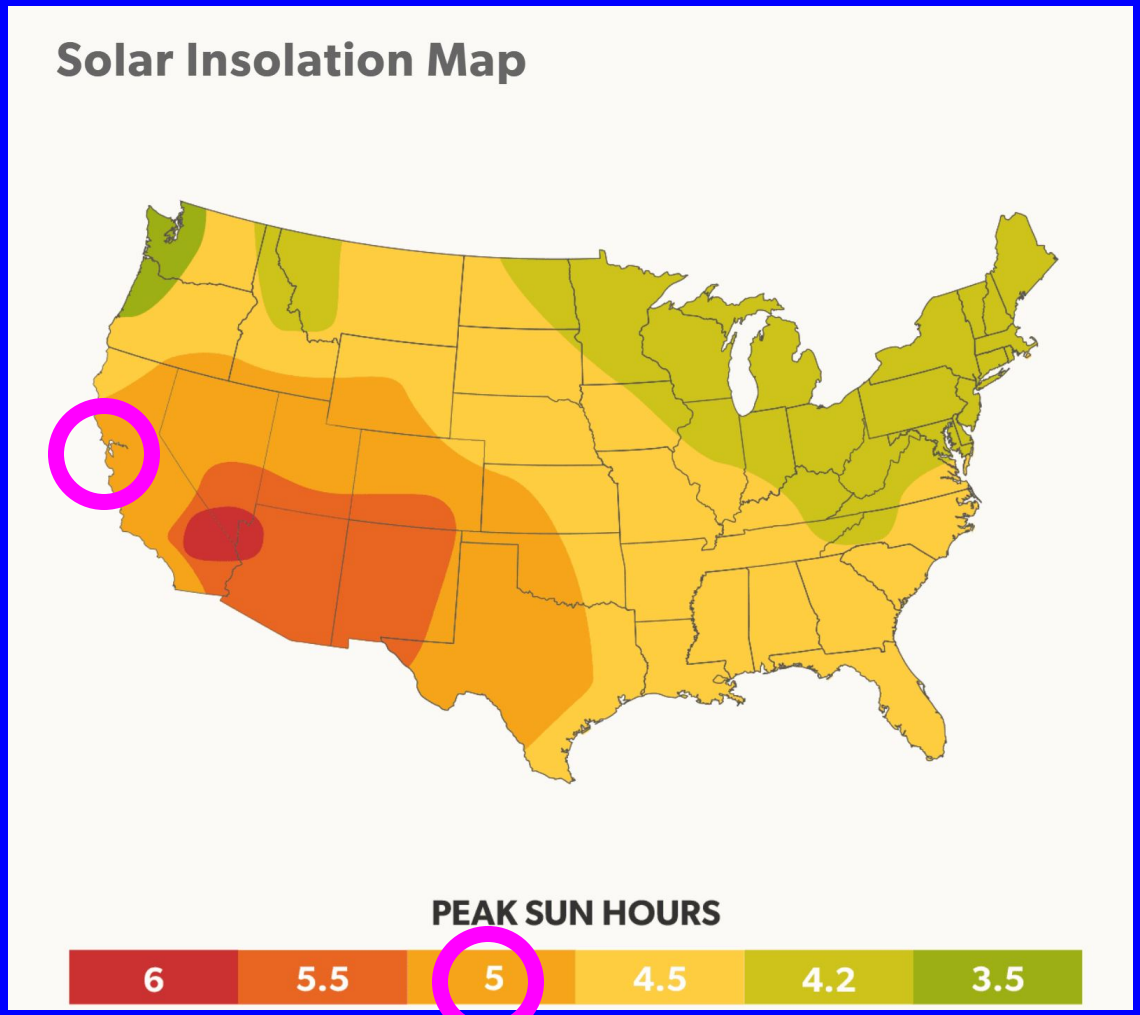
10X→



Run Current = 1.23 Amps
Run Power = 148 Watts
Average Power = 120 Watts

How Long Will it Take The Sun to Charge Depleted Lithium Batteries?

Peak Sun Hours Per Day



Sun Energy per day

- Peak Sun 5 hours in Bay Area
- Solar Panels @ 50% de-rating: (Typical)

- 100W * .5 * 5 = 250W-Hr per day
- 600W * .5 * 5 = 1500W-Hr per day
  - This is 6 ea 100 Watt Solar Panels

One BBQ Propane Tank Energy Storage:
14.4 KW-Hr available @ 600 Watt Ryobi Level
4.8 charges of Yeti 3000 Generator or 10 Days @ 60 Watts
10.3 charges of Yeti 1400 Generator or 10 Days @ 60 Watts

How many Sunlight days? Solar Efficiency: February 2017

- Clear 8 100%
- Part cloudy 4 50%
- Cloudy or rainy 16 0%

Conclusion:

Next Step: I Want Larger Lithium-Ion Battery Pack

- Sufficient energy for weeks
- Portable – Movable on Wheels
- Waterproof
- Reliable
- Readily Available
- Easy to charge
- Etc…

Answer: Tesla Model S "Battery Pack" – 85 KW-Hr ☺

P.S. Virginia (KI6VPW) allows me to do all this as long as it will work for her ELECTRIC BLANKET at night! ☺

Q&A

Richard@wheeler.com