

Solar Power for Home...

...and making sure it does not interfere with ham
radio hobby.

XARC meeting September 8, 2016
Steve Verzulli
KA1CNF

Topics covered

- Types of Panels
- Is it practical for our area
- How to choose a vendor
- Considerations
- Solar – one year later – quick analysis

Some interesting Facts

- Largest solar power plant in the world is in the Gujarat Solar Park in India, 605 MW, 4,900 acres. Mojave desert in California, 1000 acres largest in US
- In one hour the sun provides more energy to the earth than the whole world uses in one year, 1,366 watts/square meter
- 10,000 square miles in the southwestern US would generate enough energy to meet the needs of the entire country
- Earth gets 174 petawatts of incoming solar radiation at any given moment
- Germany is the world's top solar panel installer but gets as much sunshine as Alaska producing 31% of world's renewable energy
- Per Kevin Williams, Rochester gets more sunshine than Miami does during the summer due to the "reverse lake effect".

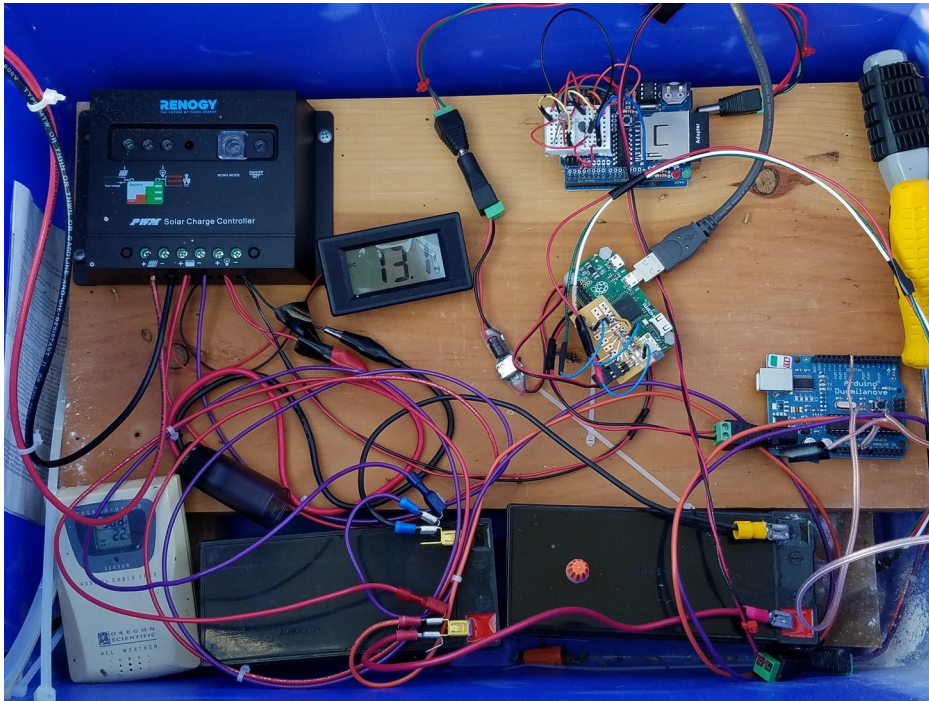
Experimental Solar Setup



- 51 W Panel. Cost: \$225
- Voltage: 16.9 volts
- Current: 3.02 amps
- Cost/Watt: \$4.41
- Manufactured at energy loss
- Installed July 2014

 WARNING ELECTRICAL HAZARD AT PANEL TERMINALS BY POTENTIAL SHOCK AND SPARKS.	
 太陽電池モジュール (PHOTOVOLTAIC MODULE)	
種類 (TYPE)	多結晶 (MULTI-CRYSTAL)
型式 (MODEL)	LA361G51S
最大出力 (MAXIMUM POWER)	51.0 W
最大出力動作電圧 (MAXIMUM POWER VOLTAGE)	16.9 V
最大出力動作電流 (MAXIMUM POWER CURRENT)	3.02 A
外形寸法 (DIMENSION)	988X448X52mm
製造番号 (SER. No.)	95505087
製造年月 (DATE)	1995. 5
KYOCERA CORPORATION MADE IN JAPAN	

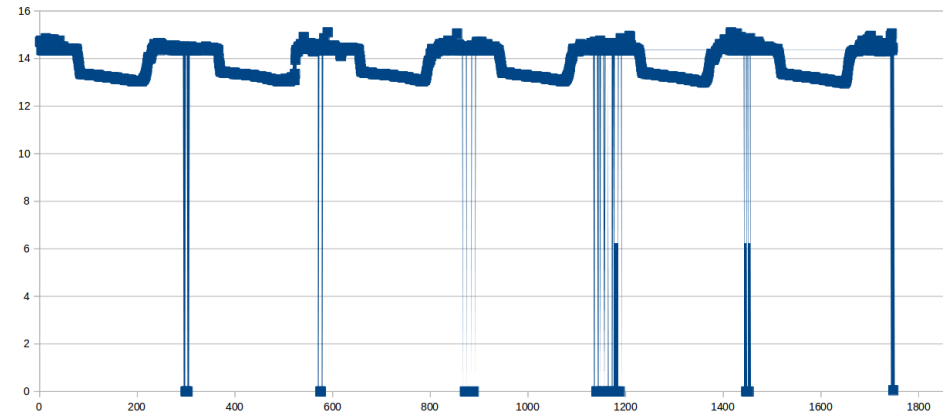
What is inside the Blue box?



- Started with (1) 12V, 7 AH battery added a second
- (2) Arduino unos
- (1) Raspberry Pi Zero with internet connectivity
- APRS – Baofeng (subsequently uninstalled)
- Current draw approx. 350 ma.

Lots of data (csv) from “blue box”

- Voltage
- Current
- Calculated watt hours
- Light hours
- Temperature
- First Charge controller defective after 3 months
- Ran 24/7 except for 2 weeks in December 2014
- Bottom line – solar is practical for Rochester!



Solar (photovoltaic, PV) Panels

- Crystalline

- More expensive
- More efficient (12-20%)
- Recommended for home
- Best of power vs space
- Rigid, flat mount construction
- Mature technology

- Thin Film

- Less expensive
- Less efficient (6-10%)
- Requires more area for equivalent power generated
- Deformable/Flexible

Types of Crystalline Panels

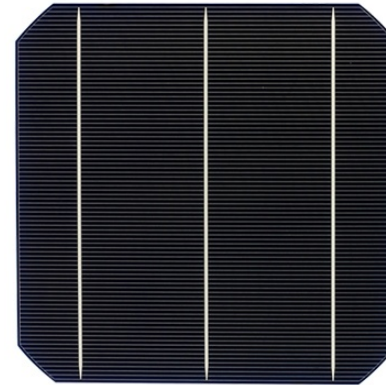
- Polycrystalline

- Less expensive (\$300)
- Less efficient
- Performance varies between manufacturer and models



- Monocrystalline

- More expensive (\$800)
- More efficient
- Performance varies between manufacturer and models

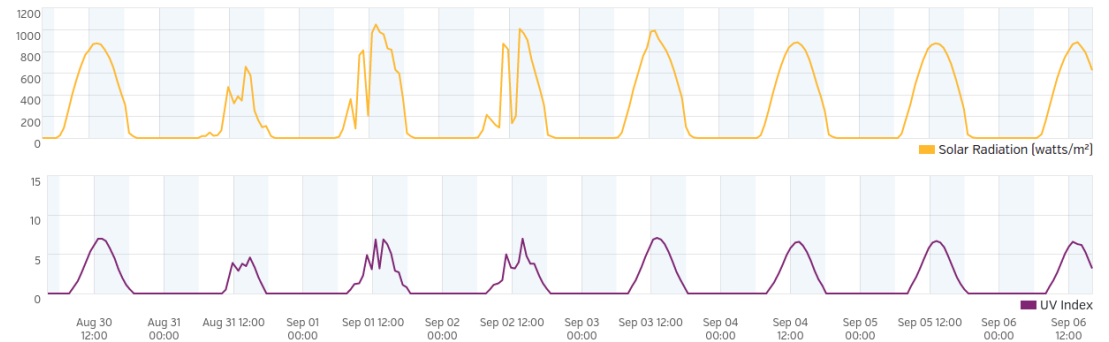
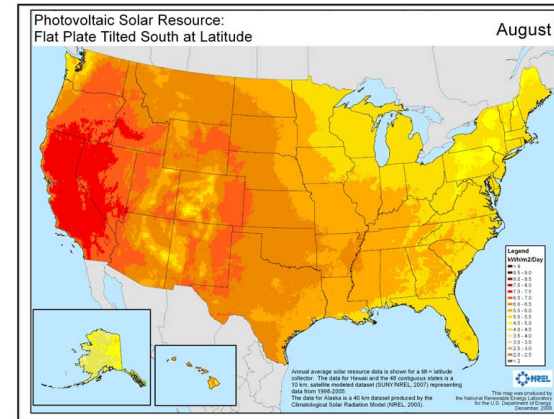
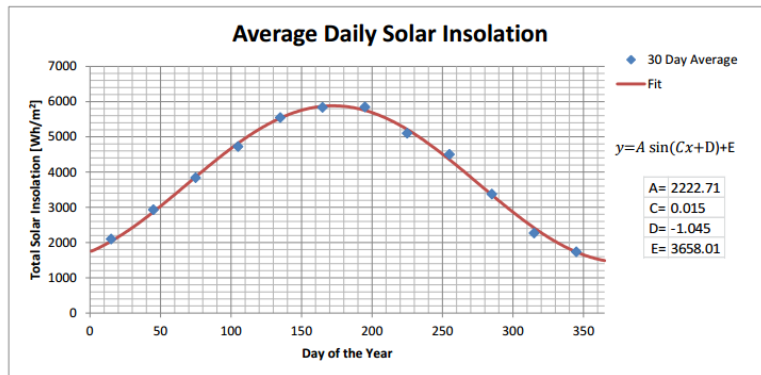
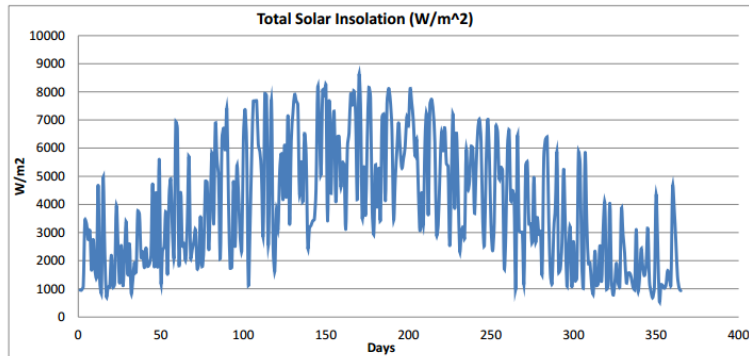


Solar Insolation for Rochester

(data from http://rredc.nrel.gov/solar/old_data/nsrdb/1961-1990/redbook/atlas/)

TMY3 Data:

This data provides hourly temperature and Solar Insolation Readings for Rochester NY taken at the Airport. This data represents the typical meteorological year for Rochester, NY. Below are the Daily values for average temperature and the total solar insolation for each day of the year calculated from this data set. A smooth sinusoidal fit was also calculated for these two graphs and used in the sensitivity analysis which is discussed later.



Solar for the home

- Net Metering
- Solar feeds grid when more power generated than used
- Dual reading meter
- Incentives (\$0.70/watt)
- Tax credits (30% Fed, \$5K state)

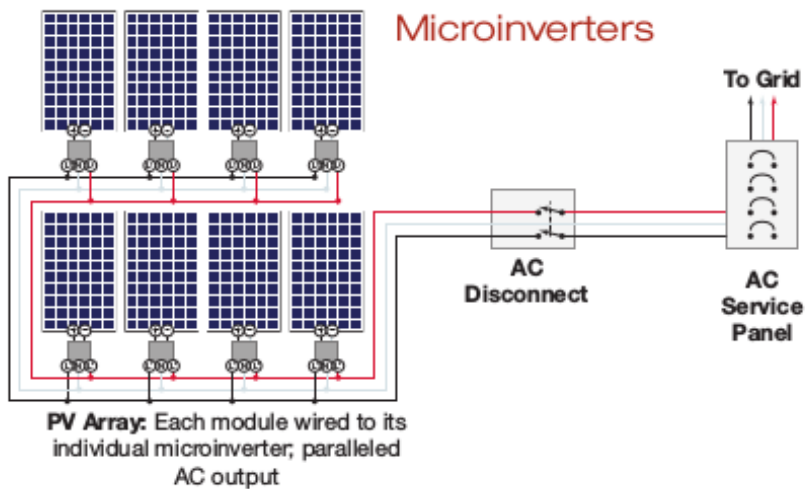
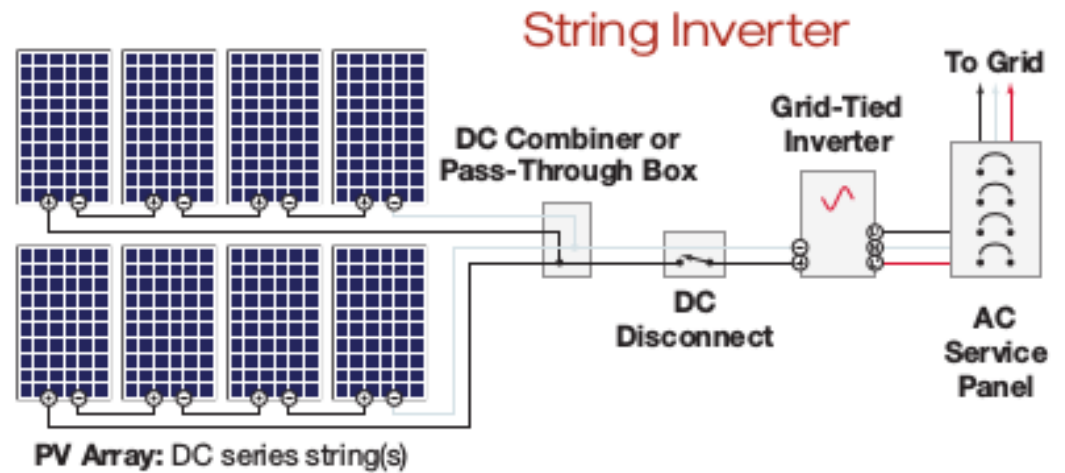
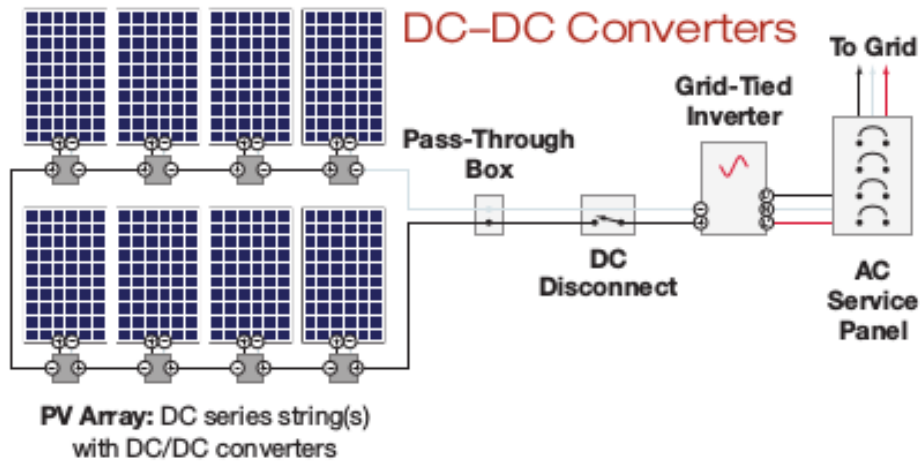


How much Solar?

Date	History Read by	kW used
07/21/15	<u>RGE</u>	1735
06/18/15	EST	2214
05/20/15	<u>RGE</u>	258
04/20/15	EST	2443
03/19/15	<u>RGE</u>	831
02/18/15	EST	1704
01/20/15	<u>RGE</u>	1364
12/18/14	EST	1159
11/18/14	<u>RGE</u>	1246
10/20/14	EST	1166
09/18/14	<u>RGE</u>	2332
08/19/14	EST	1724
07/21/14	<u>RGE</u>	5337
06/18/14	EST	2170
05/19/15	<u>RGE</u>	1028
04/17/15	EST	932
03/19/14	<u>RGE</u>	2426
02/19/14	EST	981
01/20/14	<u>RGE</u>	1259
12/19/13	EST	1137
11/19/13	<u>RGE</u>	1158
10/18/13	EST	1064
09/19/13	<u>RGE</u>	1826

- You can install anything up to 120%
- Consider payback time
- How long will you stay in present house
- Site survey
- Roof or ground
- Shading

Grid-Tied PV System Types



Our system

- Goal was to cover 90% of electric usage for year – 15.6 kW
- Installer selected SED, Sustainable Energy Developments, Ontario, NY
- 60 Kyocera 260 watt panels -25 year warranty
- One SMA 7,000 watt string inverter & One SMA 6,000 watt string inverter. Best reliability, web interface, display, longest warranty, RFI tested. 3000 watts available if grid goes down (secure power supply). Premium cost compared to other vendors -20 yr. warranty
- Iron Ridge Support system, concrete sono tubes vs pound-in brackets. Fixed 30 degrees -25 yr. warranty
- South facing, 180 degrees, no shade, 30 degree fixed tilt angle, Ideal conditions.
- No microinverters or optimizers!

15.6 kW Solar Array



- 260 W Panels \$300 ea.
- Approx. 1107 sq. footage
- 85 feet long
- Kyocera brand*
- Voltage: 31 volts
- Current: 8.39 amps
- Cost/Watt: \$1.15
- In 6 months produced the energy used to manufacture panels.
- **Fine print-data sheet: 1000W/sq.m, 25 degrees C, AM 1.5 spectrum*

KYOCERA PHOTOVOLTAIC MODULE				
MODEL	KD2606X-LFB2			
SERIAL NO.	152AKT4M0013605		MAXIMUM SYSTEM VOLTAGE	600 V
IRRADIANCE AND CELL TEMPERATURE	1000W/m ² AM 1.5 25° C	800W/m ² AM 1.5 45° C	MASS	20.0 Kg
P _{max}	260 W	187 W	SERIES FUSE	15 A
V _{pmax}	31.0 V	27.9 V	FIRE RATING CLASS	C
I _{pmax}	8.39 A	6.71 A	FIELD WIRING	STRANDED COPPER ONLY
V _{oc}	38.3 V	-	10~14AWG	
I _{sc}	9.09 A	-	INSULATED FOR 90°C MIN.	

WARNING **AVERTISSEMENT**

E) Photovoltaic modules generate electricity when exposed to light. Hazardous electricity can shock, burn or cause death.
F) Les modules photovoltaïques produisent du courant lorsqu'ils sont exposés à la lumière. Le courant électrique est dangereux, il peut causer un choc, brûler ou provoquer la mort.
E) Do not touch terminals when exposed to light.
F) Ne pas toucher les connecteurs lorsque le module est exposé à la lumière.
E) When connected or disconnected to the output cable, upper surface should be shaded from light.
F) Lorsque vous connectez ou déconnectez les câbles de sortie, veillez à ce que la face supérieure avec les cellules soit ombragée.
E) Must comply with local safety standards prior to installation.
F) Doit être conforme aux normes de sécurité locales avant l'installation.

UL LISTED 9P22 PHOTOVOLTAIC MODULE

JET

MADE IN MEXICO

(FMT2910)

Module Type Designation Rev. III, 1703 ed. 3

String Inverters

- SMA 7000 Watt
 - Channel A, 11 modules in series
 - Channel B, 11 modules in series then in parallel with 11 modules
- SMA 6000 Watt
 - Channel A, 9 modules in series
 - Channel B, 9 modules in series then in parallel with 9 modules

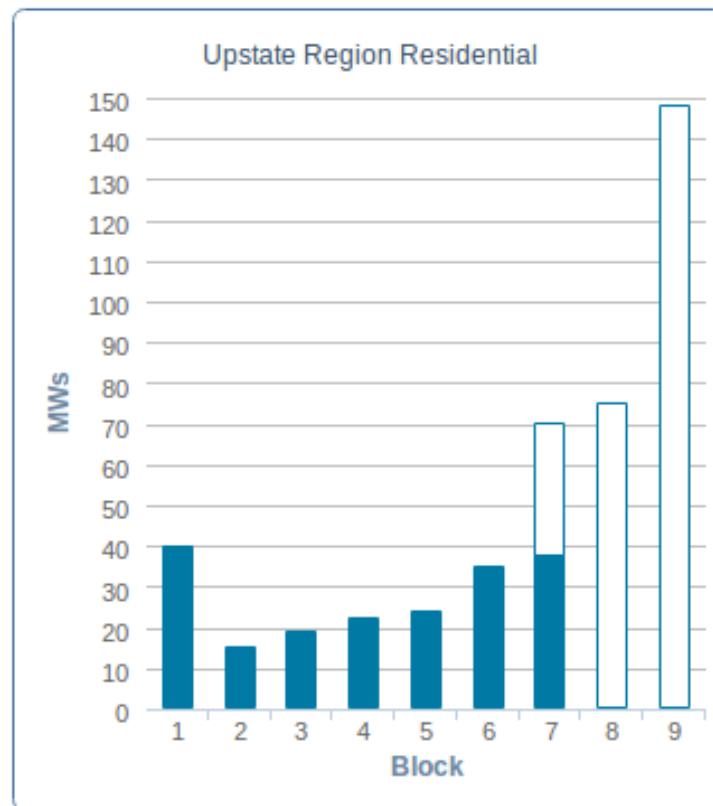


NYSERTA Incentives

Upstate Residential Block Structure

BLOCK	MEGAWATTS	INCENTIVE/WATT
1	40	\$1.00
2	15	\$0.90
3	19	\$0.80
4	22	\$0.70
5	24	\$0.60
6	35*	\$0.50
7	70	\$0.40
8	75	\$0.30
9	148	\$0.20

*Revised 12/30/2015

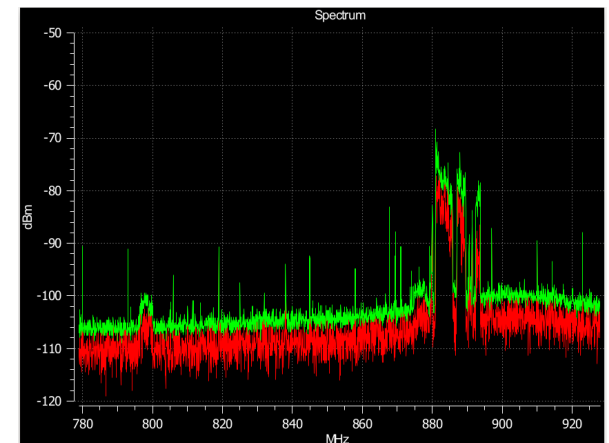
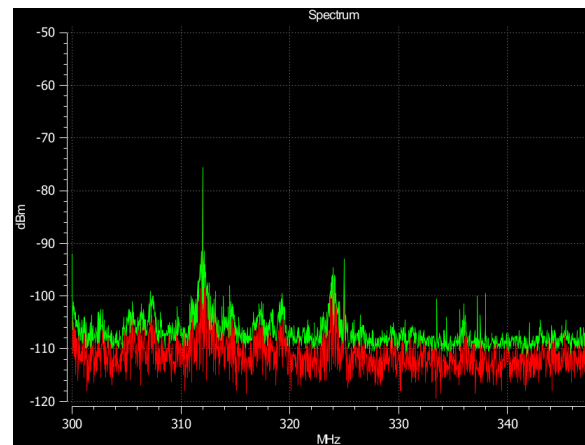
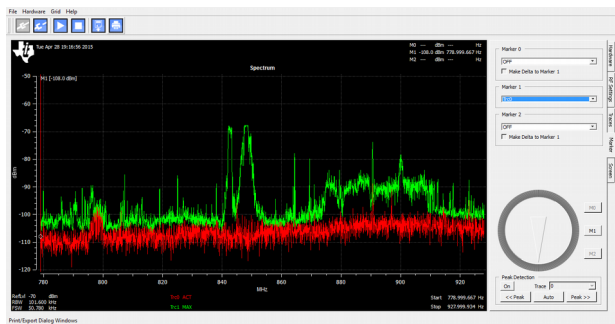
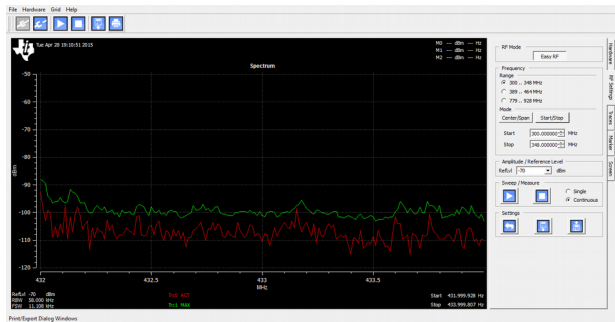


Submitted Available

System Selected but will it generate RFI?

- Google search
- Talked to vendors
- Decided to do my own testing
- SED arranged for a visit to existing solar installation with 5K SMA string inverters
- Spectrum Analyzer up to 1 Ghz
- AM shortwave radio
- Various handheld Dual band radios

Spectrum Plots at test home with 5kW and 3kW inverters



Estimated and Actual Production

(data from <http://pvwatts.nrel.gov/pvwatts.php>)

RESULTS



19,023 kWh per Year *

System output may range from 18,458 to 19,624kWh per year near this location.
Click [HERE](#) for more information.

Month	Solar Radiation (kWh / m ² / day)	AC Energy (kWh)	Energy Value (\$)
January	2.19	945	123
February	3.29	1,279	166
March	4.02	1,674	218
April	5.00	1,911	248
May	5.51	2,102	273
June	6.13	2,194	285
July	5.92	2,180	283
August	5.47	2,014	262
September	4.89	1,791	233
October	3.37	1,324	172
November	2.12	851	111
December	1.78	759	99
Annual	4.14	19,024	\$ 2,473

- **1 year savings: \$2,713**
- **9.3 yr payback**

Month	Year	kWh Produced
Aug	2015	2231.822
Sep	2015	2025.014
Oct	2015	1533.527
Nov	2015	1127.134
Dec	2015	584.702
Jan	2016	617.978
Feb	2016	927.999
Mar	2016	1587.775
Apr	2016	2000.88
May	2016	2415.521
Jun	2016	2560.888
Jul	2016	2482.101
	First Year Total	20095.341

Lessons Learned and Take-aways

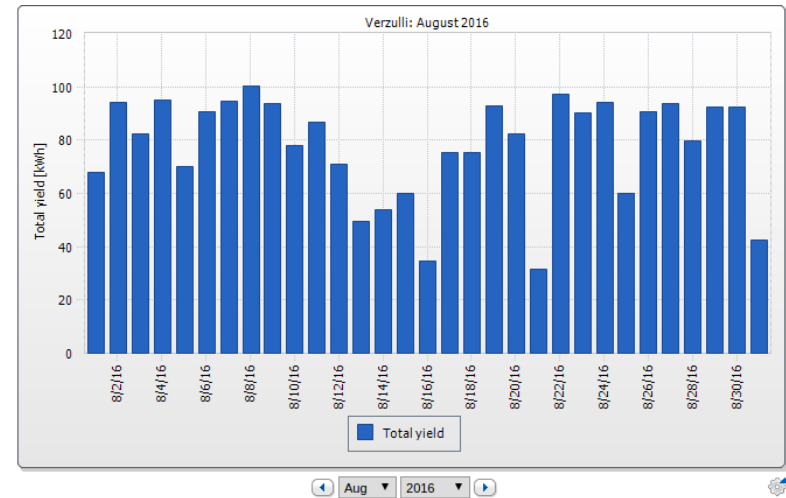
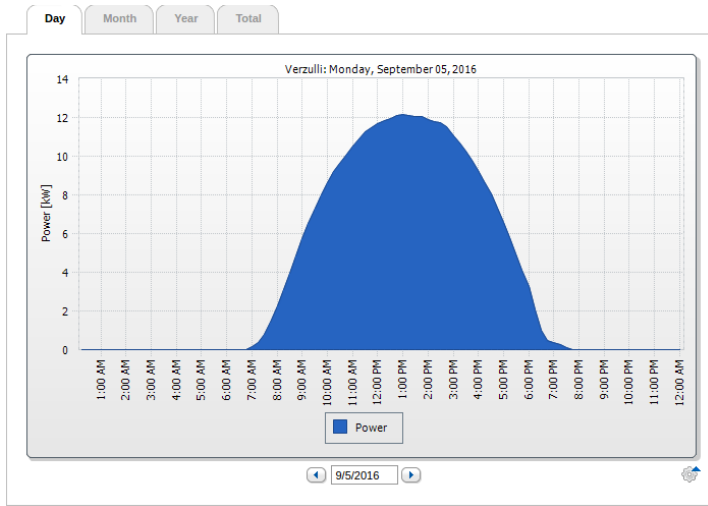
- Project will take twice as long as estimated
- Plan for future expansion
- System can be size for shorter payback times
- Allow for system inefficiencies 15.6 kW – 13.6 kW actual
- Technology is always improving, ie. cheaper, more efficient, more reliable
- Batteries might be viable in the future but not yet for us
- For lowest possible RFI, EMI, use string inverters, metal conduit, ground points
- Snow cover will severely limit your output!
- Allow for ground clearance with snow!
- True up time is very important!
- You might loose your negotiating position with your electric supplier
- RGE will not credit you on electric production until their inspection
- Inspect your bills. Do not trust utility with readings or calculations
- Increase home resale value? Check back in 25 years...
- What if we had invested the \$ in the stock market for 25 years...

Ah Winter...

- Up to 3 inches will melt off
- But plan to remove snow if more than 3 inches and you want output



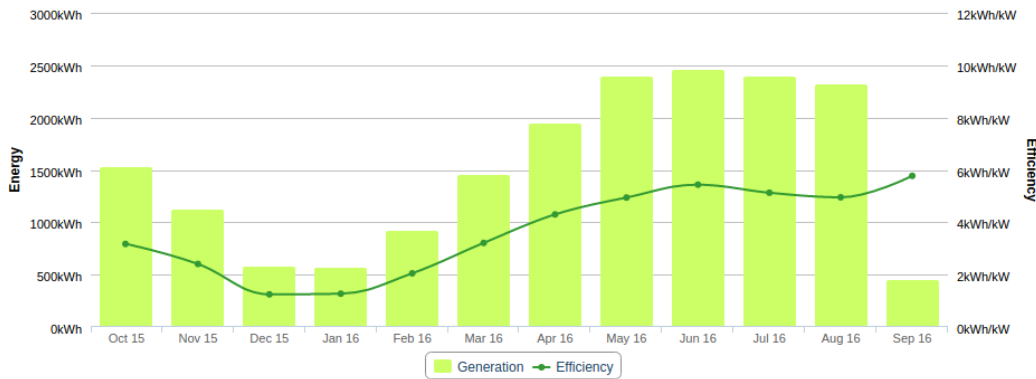
Perfect Solar Days!



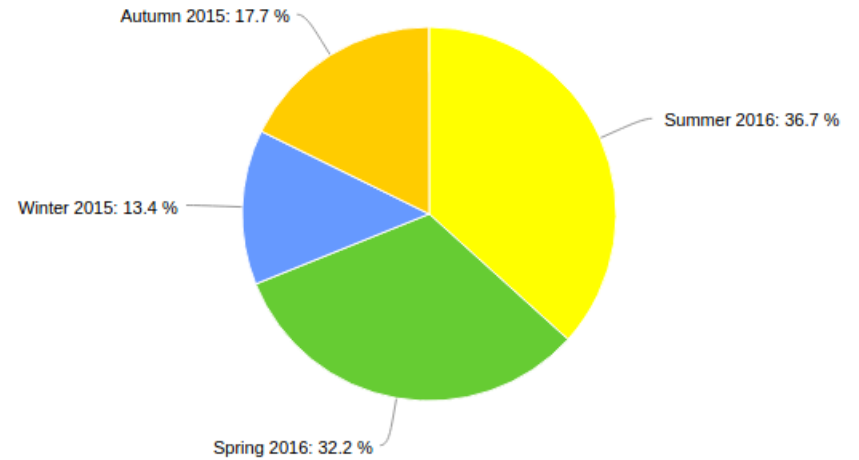
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Monthly - Pasta Power 15.600kW
01/10/15 to 05/09/16



Seasonal Generation Average - Pasta Power 15.600kW
Northern Hemisphere: Rolling Year



Links

- <http://www.nrel.gov/gis/solar.html>
- <http://pvwatts.nrel.gov/>
- <http://pvoutput.org/>
- <https://www.nyserda.ny.gov/All-Programs/Programs/NY-Sun/Project-Developers/Residential-Small-Commercial-MW-Block>
- <http://www.homepower.com/>
- <http://kuzyatech.com/solar-a-year-later>
- <https://www.eevblog.com/2015/03/16/eevblog-724-home-solar-power-system-analysis-update/>

Going Green

*following Environmental summary provided by SED

Based on the annual production of your new solar energy system you will be providing the following environmental benefits:

Emissions Reductions:

132 pounds of sulfur dioxide emissions

43 pounds of nitrous oxide emissions

30,765 pounds of carbon dioxide emissions,
every year.

To put these numbers in perspective, this reduction in annual carbon dioxide emissions is equivalent to:

Driving 18,378 fewer miles each year or

Planting 368 trees.

Over the expected 25 year lifetime of your Solar Energy System:

Driving 459,450 fewer miles or

Planting 9,189 trees.

Questions?