PV System with Micro-Inverters in Some Shade

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For many years I have wanted to add a PV system to our house in Blacksburg, Virginia. The house was built in 1983 and we bought it in 1995. We had the deep crawl space and the high attic enclosed to be part of the house envelope, which reduced our energy consumption.

In 2011 the Solarize Movement was begun in Portland, Oregon (http://www.nrel.gov/tech_deployment/ss_solarize.html); it then spread across the U.S. The movement reduces the cost of residential PV system by bulk buying and nearby installations.

In 2014 Solarize Blacksburg was initiated as the first Solarize project in Virginia and 56 locations with a total of 303.5-kW peak power have had PV installed, which almost doubled the solar PV in Blacksburg. After that many other towns and cities in Virginia have started Solarize projects with help from Solarize Blacksburg.

Our house had a 5.4-kW 20-panels system installed in August 2014 through the Solarize Blacksburg Project. A web page is available that describes the installation and operation of this PV system: http://www.roperld.com/science/roperpvsystem.htm .

We and our neighbors have many large trees, so shade was a problem which required using micro-inverters instead of a string inverter. The micro-inverters, about the size of a tablet computer, reside under the top middle of each panel. That turned out to be a boon for a person like me who likes to manipulate data; the Enphase micro-inverters enabled me to keep track of the output of each PV panel and thus enabled me to figure out how to add more panels to the system up to 30 panels eventually.

This shows some of the shade problem. Three trees were cut down to eliminate some of the shade.

The house faces about 20° west of south and the roof tilts about 40° from horizontal at latitude N37.205° and longitude W80.455°.

The PV system is comprised of the following components:

- 20 SolarWorld Sunmodule Plus SW 270W mono (made in Oregon, USA)
- 20 Enphase M250 micro-inverters
- Pro-Solar roof mounting hardware
- Delta LA-302 Lightning Arrestor

- Cumulative energy meter for the PV array

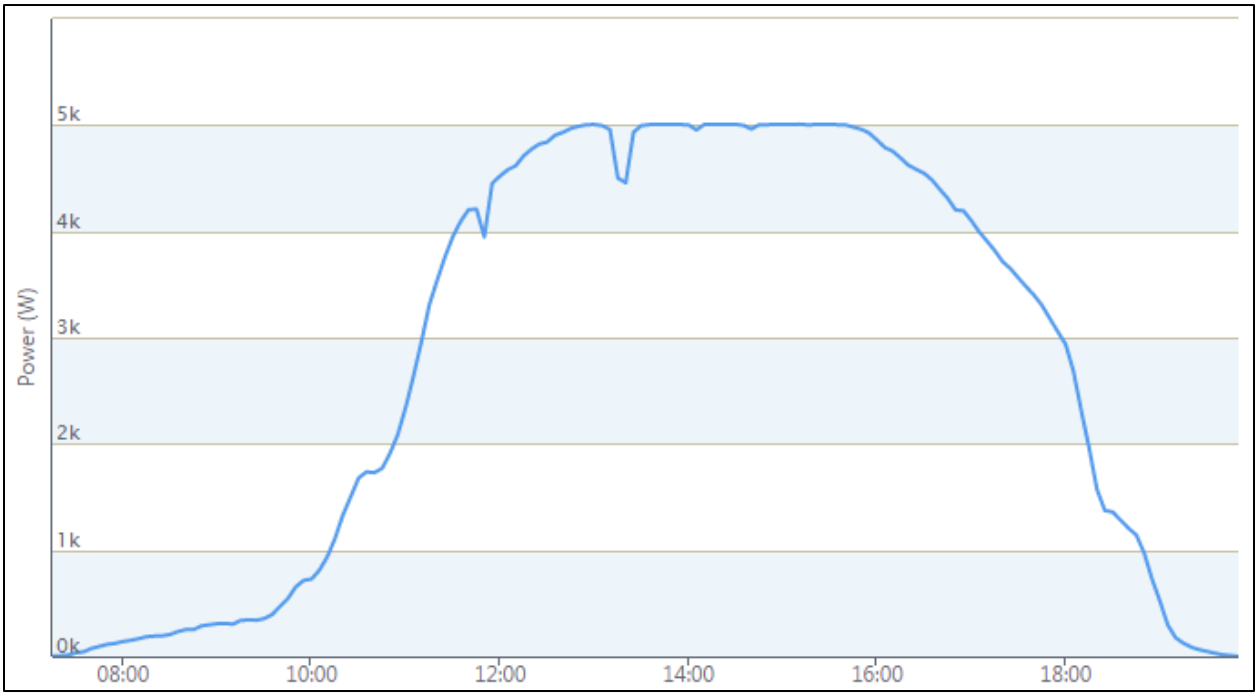
Some data for the first year of operation (September 2014 through August 2015) are:

Used (kWh)	Collected (kWh)	Bought (kWh)	Sold (kWh)	$/kWh	Saved	Bill	Carbon Saved
23,160	6,345	18,914	2,099	$0.1154	$740.25	$2,181.84	4.831 tons
Collected /Used	Collected /Bought	Sold /Collected	SRECs				
27.8%	33.5%	33.1%	6				

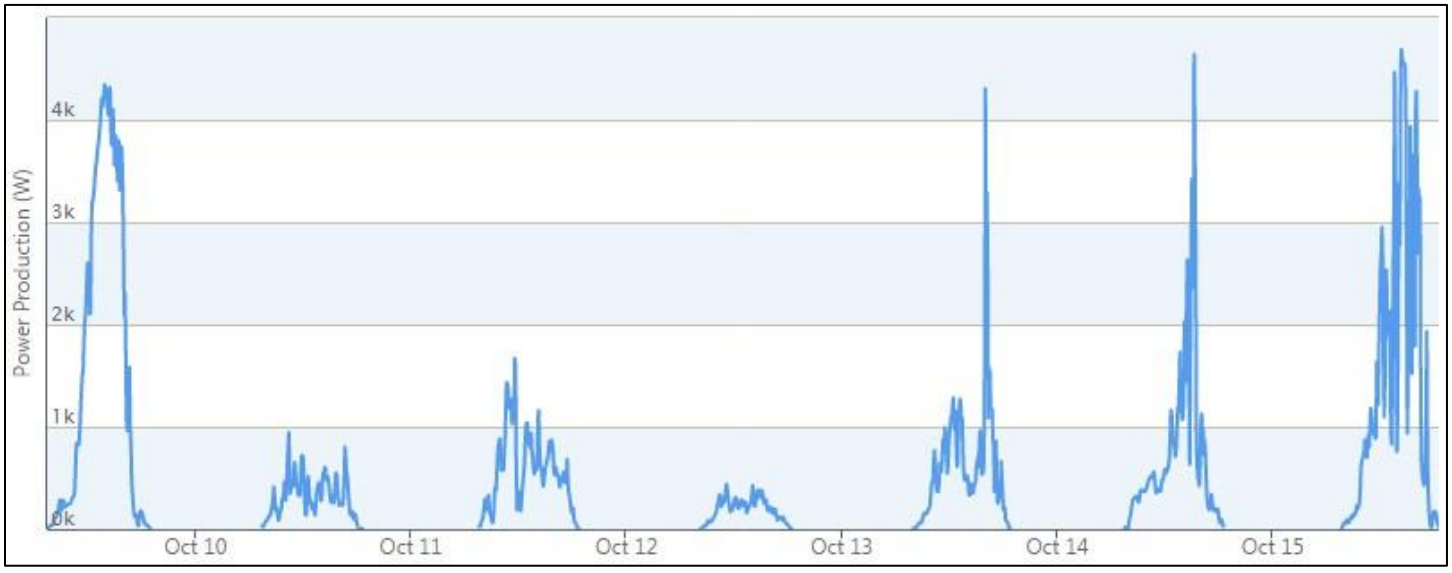
SREC: https://en.wikipedia.org/wiki/Solar_Renewable_Energy_Certificate

I used about one-third of the collected solar energy to charge my Nissan LEAF.

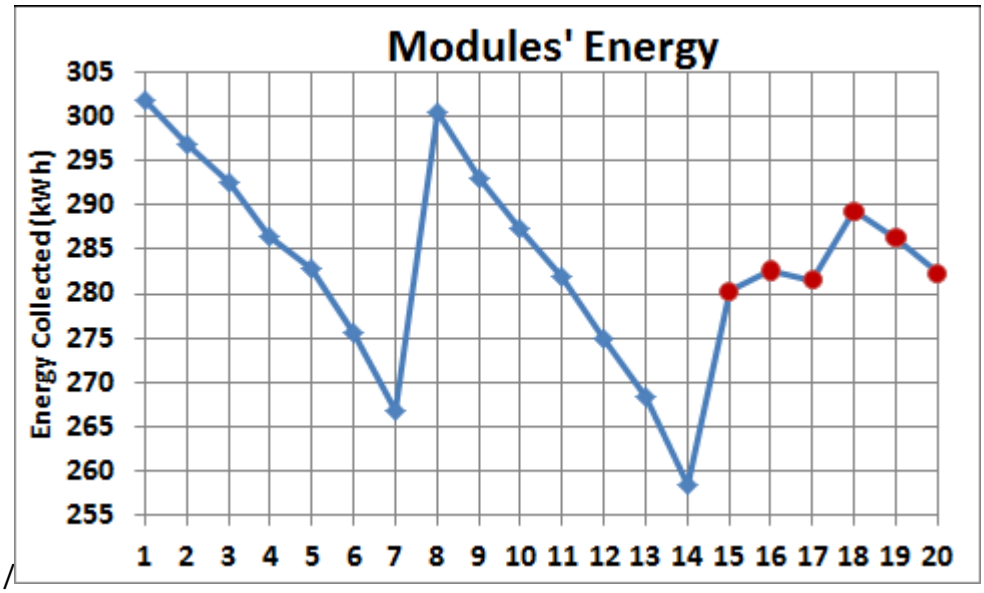
One of the best collection days (34.901 kWh) was 4 April 2015; its power curve versus hour of day is:



One of the lowest collection weeks (60.74 kWh) was 9-15 October 2014: its power curve is:

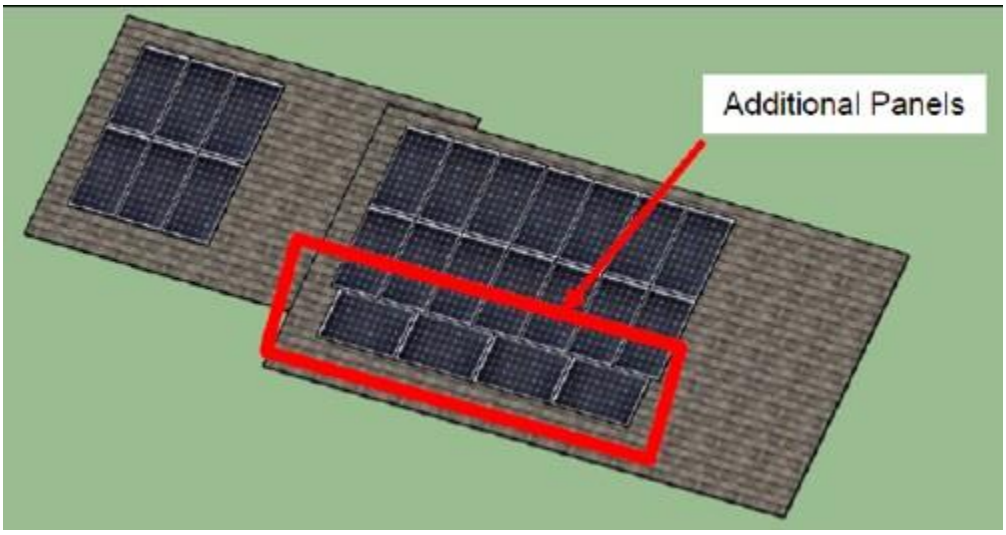


The following graph shows the solar-energy collection for the 20 panels for the first 11 months of operation:



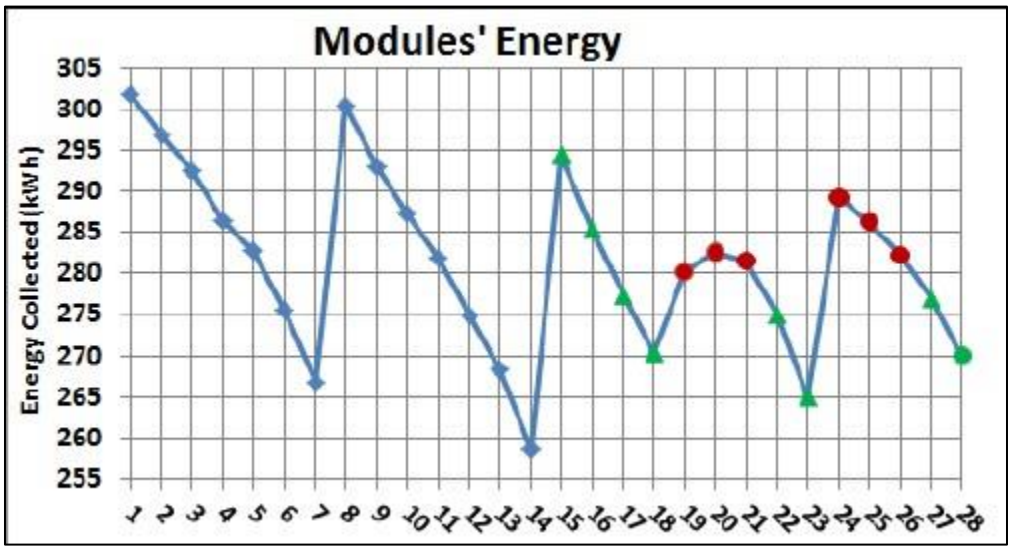
- The first 7 blue points are for the top row on the house.
- The second 7 blue points are for the bottom row on the house.
- The first 3 red points are for the top row on the garage.
- The second 3 read points are for the bottom row on the garage.

This graph enabled me to decide that I could add 4 more panels sideways below the 14 panels on the house:



The plan is to add these 4 panels in November 2015. They will be 285-kw panels instead of 270-kW panels.

The following graph shows estimates (green points) of the solar-energy collection for 4 more panels to be added below the 14 house panels/ and 4 more panels to be added to the right of the 6 panels on the garage; the latter to be added in 2016:



I think I can add 2 or 3 more panels on a small dormer roof behind the garage roof:

The angle will probably be 10° toward the south.

It is a great feeling to watch the number of tons of carbon not spewed into the atmosphere accumulate and to drive my electric LEAF using solar energy instead of fossil-fuels energy.

I have signed up for a 10-kWh Tesla Powerwall battery (http://www.nrel.gov/tech_deployment/ss_solarize.html)to attach to a special circuit in our house for powering certain items when the grid is down.