Solar performance summary

Great River Energy compiles energy production, capacity factor of solar arrays

The 250-kilowatt (kW) solar project installed last summer at Great River Energy's headquarters in Maple Grove demonstrates solar technology from three panel manufacturers and three inverter manufacturers. The solar panels produce DC power, which is converted to AC power through an inverter.

The three arrays consist of the following equipment:

- 54 kWdc of Sharp solar panels power a 50 kWac Solectria inverter
- 121.77 kWdc of tenKsolar solar panels power 108 kWac of tenKsolar inverters
- 95.4 kWdc of Suniva solar panels power a 100 kWac Advanced Energy inverter

Solar energy production and capacity factor

The table shows the month-to-month energy production in kilowatt hours (kWh) of AC energy and capacity factor for each of the three arrays from June 2014 through January 2015. The capacity factor measures the percentage of energy produced as compared to the energy that ideally could be produced if the solar array was capable of producing its maximum energy output 24 hours per day, every day.

All three solar arrays have significantly higher capacity factors and energy production in the summer and fall than in the winter. The winter capacity factors observed to date have been 6.3 percent or less and the summer capacity factors have ranged from 15.9 percent to 21.7 percent.

		SHARP		TENKSOLAR		SUNIVA
	kWdc	54	**kWdc**	122	**kWdc**	95
	Tilt	26°	**Tilt**	28°	**Tilt**	20°
	DC:AC	1.08:1	**DC:AC**	1.13:1	**DC:AC**	0.95:1
MONTH	**kWh**	**CAPACITY FACTOR**	**kWh**	**CAPACITY FACTOR**	**kWh**	**CAPACITY FACTOR**
June 2014	7,455	19.2%	14,910	17.0%	12,730	18.5%
July 2014	8,734	21.7%	17,742	19.6%	15,159	21.4%
August 2014	7,169	17.8%	14,431	15.9%	12,654	17.8%
September 2014	6,787	17.5%	14,351	16.4%	11,330	16.5%
October 2014	6,010	15.0%	11,957	13.2%	9,744	13.7%
November 2014	1,756	4.5%	4,747	5.4%	4,306	6.3%
December 2014	1,187	3.0%	2,499	2.8%	2,547	3.6%
January 2015	1,572	3.9%	4,952	5.5%	4,270	6.0%
Total	**40,669**	**12.8%**	**85,590**	**12.0%**	**72,740**	**13.0%**

Data analysis shows that capacity factor varies based on cloudy weather, snow coverage, panel tilt angle, and the array's DC:AC ratio. The DC:AC ratio compares the DC rating of the solar panels to the AC rating of the inverter. A higher DC:AC ratio will produce a flatter power output curve in the middle of the day, but it will limit the total kWh production of the solar panels to the maximum output of the inverter.

Panels installed in Minnesota at less than a 45 degree tilt angle are designed for higher summer production; panels installed at 45 degrees seek to maximize spring and fall production; and panels installed at a slope greater than 45 degrees seek to maximize winter production. All three arrays are designed to maximize summer production.

Winter performance

The winter production of all three arrays is significantly lower than the summer production. This is due to winter providing fewer sunny days, lower energy intensity of available sunlight, lower sun angles, fewer hours of sunlight, and snow coverage on the panels. From Dec. 19, 2014, through Jan. 3, 2015, there were six days of cloud cover and snowfall, followed by eight days of sun before the panels could completely shed the snow and recover to full production. The maximum power output during this time interval was 15 percent of capacity, with most of the days operating at less than 10 percent of capacity.

A variety of solar technologies and configurations are being tested at Great River Energy's headquarters site. The 250-kW installation includes panels made by Sharp (two rows pictured at bottom), tenKsolar (three square-shaped clusters) and Suniva (three rows closest to the building).

Electrical impacts

One of the primary observed impacts that the solar array has on the electrical system is significant power swings. The graph below shows an ideal power output curve from a solar array and a typical output curve from the Maple Grove solar array, as observed to date. From June 2014 through January 2015, the array has produced an "ideal" output curve on 15 of the 245 days, or 6 percent of the time. All of the "ideal" output days occurred between Sept. 16, 2014, and Jan. 13, 2015, with no ideal output curves produced in the summer months.