COLD CLIMATE HOUSING RESEARCH CENTER

CCHRC

Promoting and advancing the development of healthy, durable and sustainable shelter for Alaskans and other circumpolar people.

Performance of Photovoltaic Arrays

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Array Two
Solar World 165
(tracking)

Array Four
Solar World 165
(fixed)

Introduction

The Cold Climate Housing Research Center (CCHRC) operates four solar photovoltaic (PV) arrays and has continuously monitored their performance since November 2007. The general goals of this project are to examine and report issues that affect solar PV performance in high latitudes, and to move CCHRC's Research and Testing Facility (RTF) closer to becoming a "net-zero" energy building. The four solar PV arrays are part of a more comprehensive renewable energy project located at the RTF named the Hybrid Micro-Energy Project (HMEP) which enables CCHRC to research and demonstrate combinations of renewable energy systems that can provide year-round heat and power in high latitude cold climates.

This document summarizes our initial evaluation of the performance of two arrays. Each array consists of sixteen Solar World 165 panels with one array set to track the sun on two axes (Array Two) from March through November, while the other (Array Four) is in fixed, south-facing position year-round. Analysis topics include: total and reflected insolation; performance of tracking versus non-tracking arrays; and estimates of the capacity factor and simple payback. Insolation is the amount of sun intensity measured in watts/m^2. The data set for these analyses is comprised of data collected between November 5, 2007 and June 17, 2009, except that capacity factor and simple payback are calculated for calendar year 2008.

Recorded Insolation Levels and General Observations

Graph 1 shows total and reflected insolation values for Array Two between the period November 5, 2007 and June 17, 2009. The graph demonstrates several important points. First, from November through January the insolation values are at the lowest levels, ranging from a low daily average of 1 watt/m^2 to 165 watts/m^2. Second, in the months May through June, insolation reaches its highest level with a high daily average of 633 watts/m^2 on June 13, 2008. The highest hourly average in the data set is 1,094 watts/m^2, recorded on June 11 at 1 p.m. Third, in March and April reflected insolation is higher than any other months, largely due to increased exposure to the sun and the reflective quality of snow. This hypothesis is supported by snow melt data collected at the Fairbanks International Airport that shows a decline in snow levels corresponding to the decline in reflected insolation values.

Related Topics:

Website Solar Monitoring

- www.cchrc.org/webcasts-data-logs

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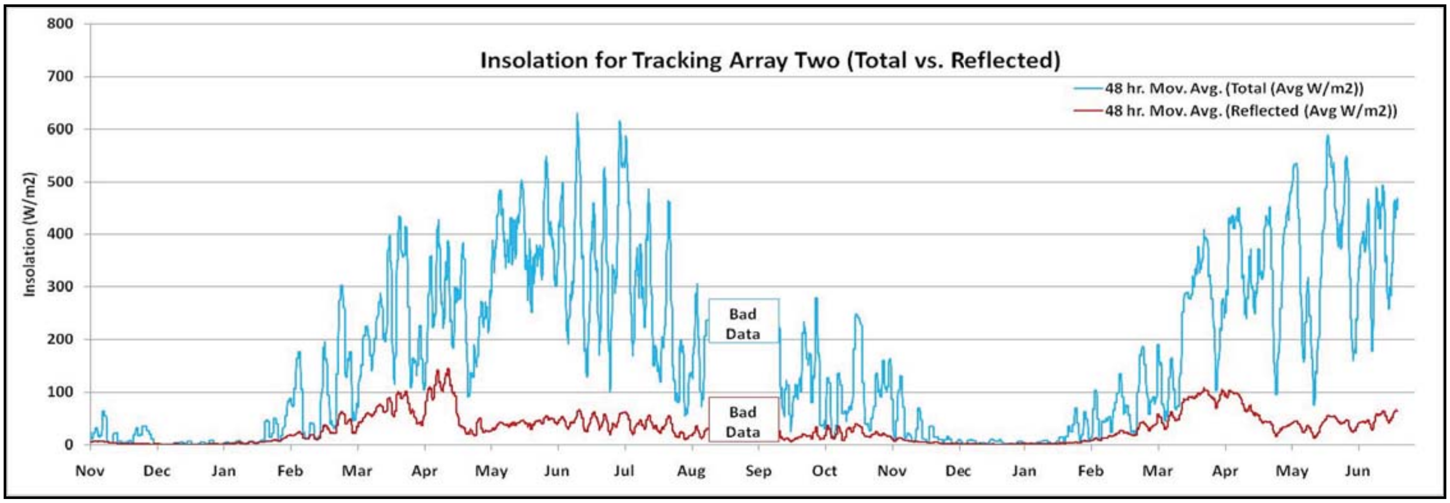
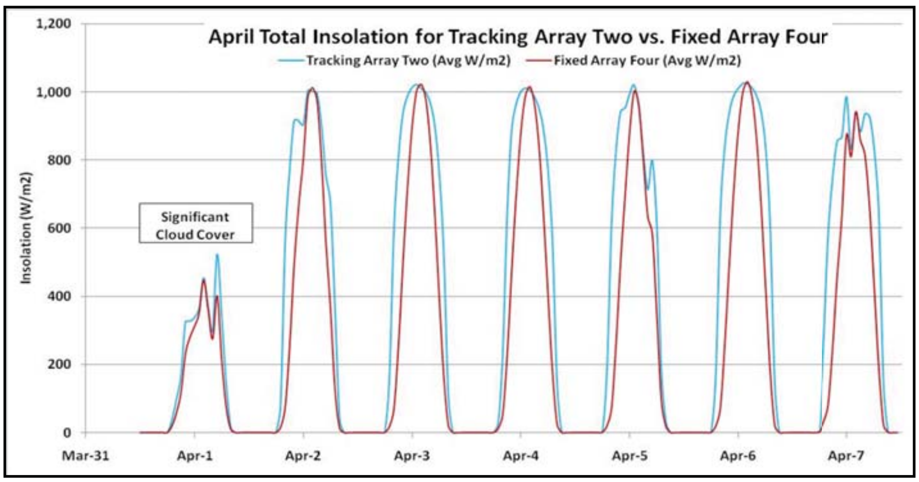
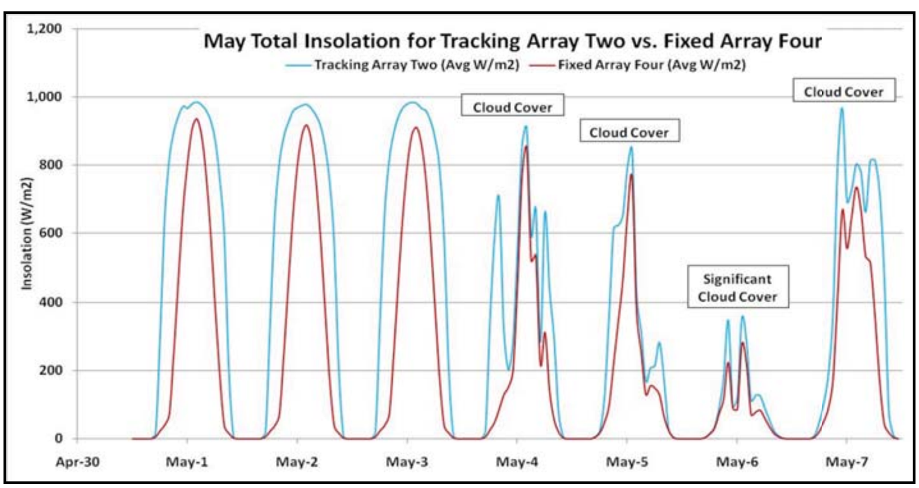


Graph 1: Total and Reflected Insolation

Note: Data is missing between 1 p.m. August 11 and 5 p.m. September 12, 2008. This data gap accounts for the low values over this period of time.



Graph 2: April 2009 Insolation – Array Two vs. Array Four

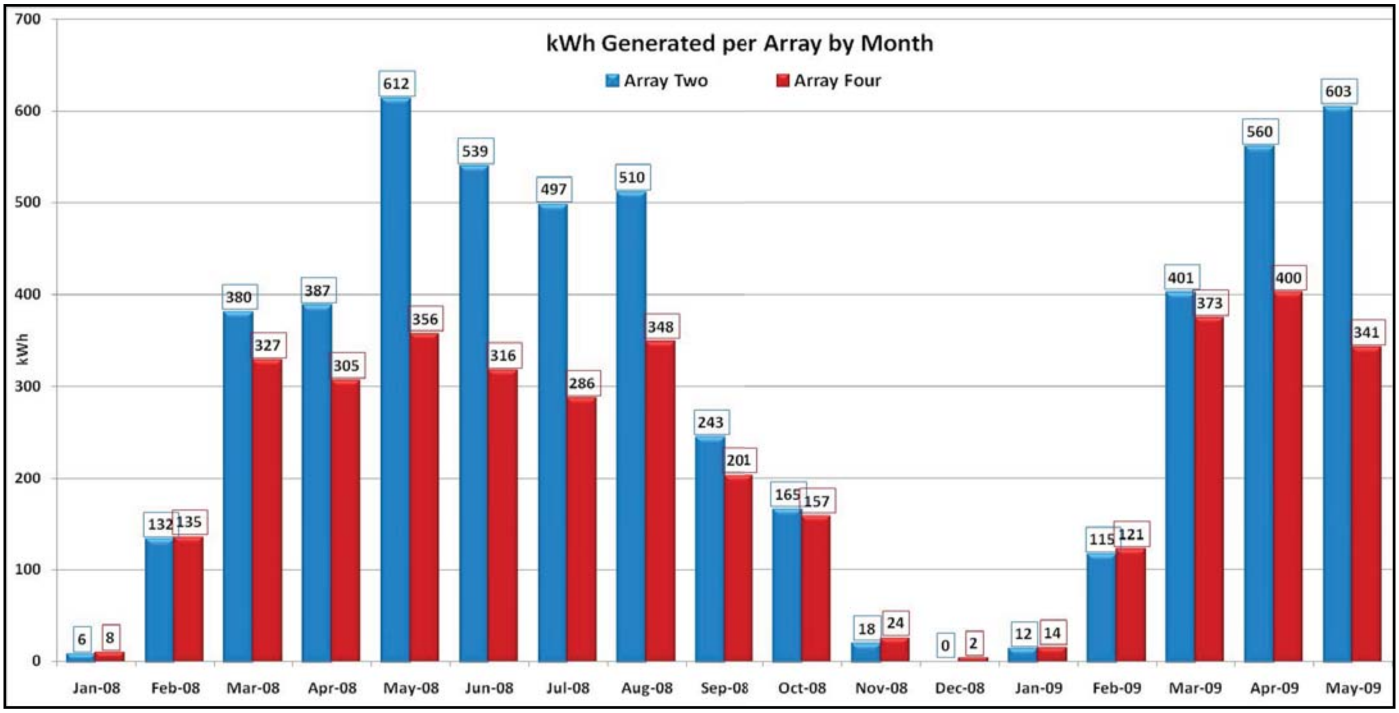


Graph 3: May 2009 Solar Radiation - Array Two vs. Array Four

Tracking and Fixed Arrays: Insolation, Power Production, and Initial Observations

Graphs 2 and 3 show a comparison of total insolation data recorded for arrays Two and Four over one week periods in early April and May. The data set for Graph 2 extends from April 1 to April 8, 2009, while the data set for Graph 3 extends from May 1 to May 8, 2009. Graph 2 demonstrates that the peaks for arrays Two and Four are approximately the same height during the first week in April, but the shapes of the peaks for Array Two are wider, which indicates more insolation is captured early and late in the day to provide more overall kWh. Graph 3 demonstrates that Array Two produces a wider and taller peak, which indicates higher kWh production from tracking Array Two as it tracks the sun on both axes.

Graph 4 displays a comparison of the kWh produced from arrays Two and Four. Graph 4 chiefly illustrates the difference in power production between arrays Two and Four by time of year. Graph 4 also adds a quantitative dimension to the trends seen in Graphs 2 and 3. A key observation is in the months May, June, and July: tracking Array Two outperformed fixed Array Four by 70-75%.



Graph 4: Total kWh Production of Tracking Array Two vs. Fixed Array Four

Capacity factor compared to Actual Production

Table 1 shows the comparison of National Renewable Energy Laboratory's (NREL) PV Watts estimate for production from Array Two to its actual measured production in 2008. The capacity factor for actual production exceeded the PV Watts estimate by approximately 3.4%. In Table 2, PV Watts estimate for production from the fixed Array Four is compared to its actual measured production in 2008. Again the capacity factor for our actual production exceeded the PV Watts estimate by approximately 8.1%. PV Watts can be a useful tool in estimating solar PV performance, however actual performance will vary depending on weather, site conditions, and other factors specific to the installation.

Table 1. PV Watts (kWh) vs. Actual Production (kWh) Array Two

Month	PV Watts AC Energy (kWh)	Actual AC Energy (kWh)
1	32	10
2	143	167
3	354	285
4	474	474
5	490	646
6	499	534
7	483	475
8	381	520
9	263	211
10	171	176
11	89	11
12	11	0
Year	3,389	3,509
CF	14.6%	15.1%

Table 2. PV Watts (kWh) vs. Actual Production (kWh) Array Four

Month	PV Watts AC Energy (kWh)	Actual AC Energy (kWh)
1	29	13
2	125	171
3	276	246
4	336	374
5	285	376
6	268	313
7	286	273
8	256	354
9	197	175
10	146	168
11	79	14
12	10	2
Year	2,293	2,478
CF	9.9%	10.7%

Simple Payback of Array Two and Array Four

The simple payback for Array Two is nine years compared to 9.4 years for Array Four (see Table 3). The similarity in simple payback, despite the increased power production from tracking Array Two, is owed to the higher capital expense associated with the tracking components. The basis of the simple payback calculation is Golden Valley Electric Association (GVEA) SNAP (a voluntary, consumer-funded subsidy of small scale renewable power producers who contribute to the grid) rate plus GVEA's avoided cost rate, which equaled 72 cents in 2008.

Table 3. Arrays Two and Four Summary	**Array Two** 	**Array Four** 
Array	Solar World 165	Solar World 165
Panels	16 @ 165W	16 @ 165W
Configuration	2640W 2-axis tracking	2640W fixed
Cost (Equip)	$22,489	$16,619
Capacity Factor	15.1%	10.7%
Annual kWh Production	3,488.52	2,465.58
Assumed SNAP and Avoided Costs ($/kWh)	$0.72	$0.72
Simple Payback (years)	**8.95**	**9.36**

Conclusion

The kWh production from the tracking array proved to be higher than the fixed array, although is similar in terms of simple payback (see Table 3). Reflected insolation was a higher factor in overall energy production during April and May, likely due to reflection off the snow. The tracking array was able to gather greater amounts of solar energy because of its ability to optimize its angle to the sun. Finally, PV Watts can be a useful tool to estimate solar PV performance, however actual performance will vary depending on weather, site conditions, and other factors specific to the installation.

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