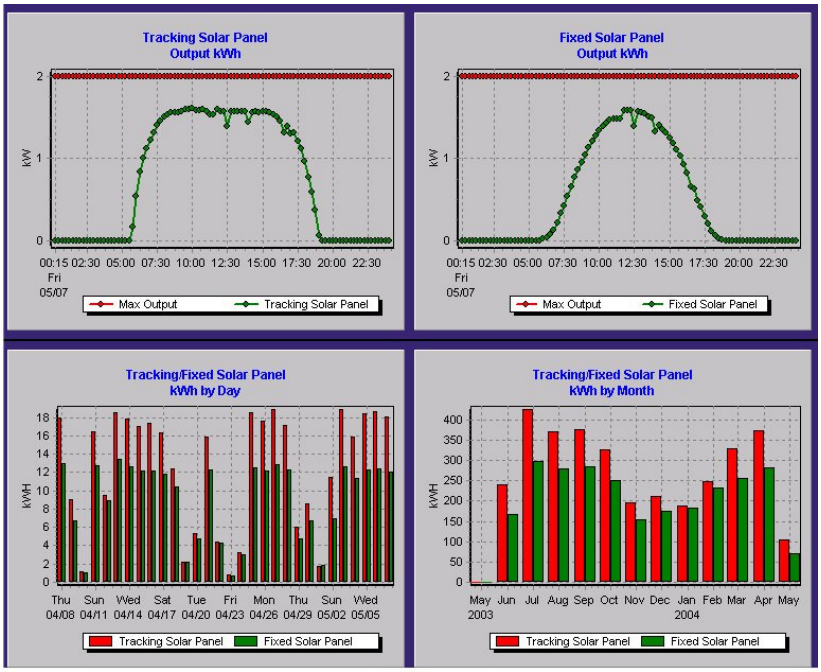
TRACKED VS FIXED:
PV SYSTEM COST AND AC POWER PRODUCTION COMPARION

LOCATION:	MADISION, WI USA
MODELING SOFTWARE:	PVWATTS
ARRAY TYPES:	TRACKED, FIXED POLE TOP, & GROUND MOUNT

It is well known that if you compare identical arrays, one fixed and the other tracked, that the tracked array will annually outperform the fixed array. In the USA the annual improvement can range from 29 to 42 percent depending on the location and solar resource.



IDENTICAL ARRAYS:
TRACKED VS FIXED

The tracked array rises up to quickly to full power and stays there on a clear sunny day. The fixed array only maintains the maximum power for a few hours in the middle of the day.

The goal of this paper is compare the cost of PV Systems that generate the same amount of delivered annual AC power. That means that the tracked array will be smaller in wattage than the fixed mount arrays. The primary question to be answered: “Can adding a tracker reduce the system cost and still provide the power required?”

The following three tables are outputs from the web based PV system analysis program, PVWATTS. Two fixed tilt arrays and a dual-axis tracked array are evaluated using the web based NREL Software, PVWATTS -Version 1.

PVWatts * * * * *

AC Energy
&
Cost Savings

* * * * *

FIXED ARRAY: TILT = 35 DEGREES

Station Identification	
City:	Madison
State:	WI
Latitude:	43.13° N
Longitude:	89.33° W
Elevation:	262 m
PV System Specifications	
DC Rating:	4.00 kW
DC to AC Derate Factor:	0.770
AC Rating:	3.08 kW
Array Type:	Fixed Tilt
Array Tilt:	35.0°
Array Azimuth:	180.0°
Energy Specifications	
Cost of Electricity:	9.1 ¢/kWh

Results			
Month	Solar Radiation ($kWh/m^2/day$)	AC Energy (kWh)	Energy Value ($)
1	3.06	312	28.39
2	4.21	381	34.67
3	4.50	436	39.68
4	4.87	433	39.40
5	5.90	528	48.05
6	6.11	514	46.77
7	6.09	519	47.23
8	6.03	519	47.23
9	4.79	411	37.40
10	4.00	363	33.03
11	2.82	258	23.48
12	2.79	277	25.21
Year	4.60	4952	450.63

Output Hourly Performance Data

PVWATTS PROGRAM LINK: http://rredc.nrel.gov/solar/codes_algs/PVWATTS/

PVWatts * * * * *

AC Energy
&
Cost Savings

* * * * *

FIXED ARRAY: TILT = 55 DEGREES

Station Identification	
City:	Madison
State:	WI
Latitude:	43.13° N
Longitude:	89.33° W
Elevation:	262 m
PV System Specifications	
DC Rating:	4.00 kW
DC to AC Derate Factor:	0.770
AC Rating:	3.08 kW
Array Type:	Fixed Tilt
Array Tilt:	55.0°
Array Azimuth:	180.0°
Energy Specifications	
Cost of Electricity:	9.1 ¢/kWh

Results			
Month	Solar Radiation (kWh/m^2/day)	AC Energy (kWh)	Energy Value ($)
1	3.42	348	31.67
2	4.54	411	37.40
3	4.53	438	39.86
4	4.51	399	36.31
5	5.15	456	41.50
6	5.22	432	39.31
7	5.25	440	40.04
8	5.48	469	42.68
9	4.63	396	36.04
10	4.12	374	34.03
11	3.07	280	25.48
12	3.15	314	28.57
Year	4.42	4758	432.98

Output Hourly Performance Data

PVWATTS PROGRAM LINK: http://rredc.nrel.gov/solar/codes_algs/PVWATTS/

PVWatts * * * * *

AC Energy
&
Cost Savings

* * * * *

DUAL-AXIS TRACKED ARRAY

Station Identification	
City:	Madison
State:	WI
Latitude:	43.13° N
Longitude:	89.33° W
Elevation:	262 m
PV System Specifications	
DC Rating:	3.00 kW
DC to AC Derate Factor:	0.770
AC Rating:	2.31 kW
Array Type:	2-Axis Tracking
Array Tilt:	N/A
Array Azimuth:	N/A
Energy Specifications	
Cost of Electricity:	9.1 ¢/kWh

Results			
Month	Solar Radiation (kWh/m^2/day)	AC Energy (kWh)	Energy Value ($)
1	3.87	298	27.12
2	5.39	368	33.49
3	5.54	406	36.95
4	6.14	416	37.86
5	7.96	546	49.69
6	8.17	524	47.68
7	8.21	534	48.59
8	7.89	520	47.32
9	5.97	390	35.49
10	4.90	338	30.76
11	3.53	243	22.11
12	3.58	269	24.48
Year	5.93	4852	441.53

Output Hourly Performance Data

PVWATTS PROGRAM LINK: http://rredc.nrel.gov/solar/codes_algs/PVWATTS/

COMPARISON OF DELIVERED POWER USING THE PVWATTS DATA

There are four systems described below - three 4.0 kW fixed mounts and one 3.2 kW Dual-Axis Tracked array. Note that System 3 is a combination of Systems 1 and 2. The tilt of System 3 is adjusted twice a year. The seasonal adjustment is a typical solar practice to maximize the annual electricity harvest.

	System 1 (Tilt = 35)		System 2 (Tilt = 55)	
Month	4 kW fixed @ 35 Deg.		4 kW fixed @ 55 Deg.	
	AC kWh	Value ($)	AC kWh	Value ($)
JAN	312	$ 28.39	348	$ 31.67
FEB	381	$ 34.67	411	$ 37.40
MAR	436	$ 39.68	438	$ 39.86
APR	433	$ 39.40	399	$ 36.31
MAY	528	$ 48.05	456	$ 41.50
JUN	514	$ 46.77	432	$ 39.31
JUL	519	$ 47.23	440	$ 40.04
AUG	519	$ 47.23	469	$ 42.68
SEP	411	$ 37.40	396	$ 36.04
OCT	363	$ 33.03	374	$ 34.03
NOV	258	$ 23.48	280	$ 25.48
DEC	277	$ 25.21	314	$ 28.57
YEAR	AC kWh	Value ($)	AC kWh	Value ($)
	4952	$ 450.63	4758	$ 432.98

	System 3 (Best Tilt)		System 4 (DA Tracked)	
Month	4 kW fixed @ Best Tilt		3 kW DA Tracked	
	AC kWh	Value ($)	AC kWh	Value ($)
JAN	348	$ 31.67	298	$ 27.12
FEB	411	$ 37.40	368	$ 33.49
MAR	438	$ 39.86	406	$ 36.95
APR	433	$ 39.40	416	$ 37.86
MAY	528	$ 48.05	546	$ 49.69
JUN	514	$ 46.77	524	$ 47.68
JUL	519	$ 47.23	534	$ 48.59
AUG	519	$ 47.23	520	$ 47.32
SEP	411	$ 37.40	390	$ 35.49
OCT	374	$ 34.03	338	$ 30.76
NOV	280	$ 25.48	243	$ 22.11
DEC	314	$ 28.57	269	$ 24.48
YEAR	AC kWh	Value ($)	AC kWh	Value ($)
	5089	$ 463.09	4852	$ 441.53

Tilt @ 35 for May-Sep
Tilt @ 55 for Oct-Apr

The delivered power of all four arrays is nearly identical. The largest gap lies between System 3 and System 4. System 4, the 3 kW Dual-Axis Tracked array produces about 95% of the power of System 3. System 3 is adjusted in the Spring and Fall to improve performance. For the purposes of this discussion, the arrays are equivalent in delivered power production.

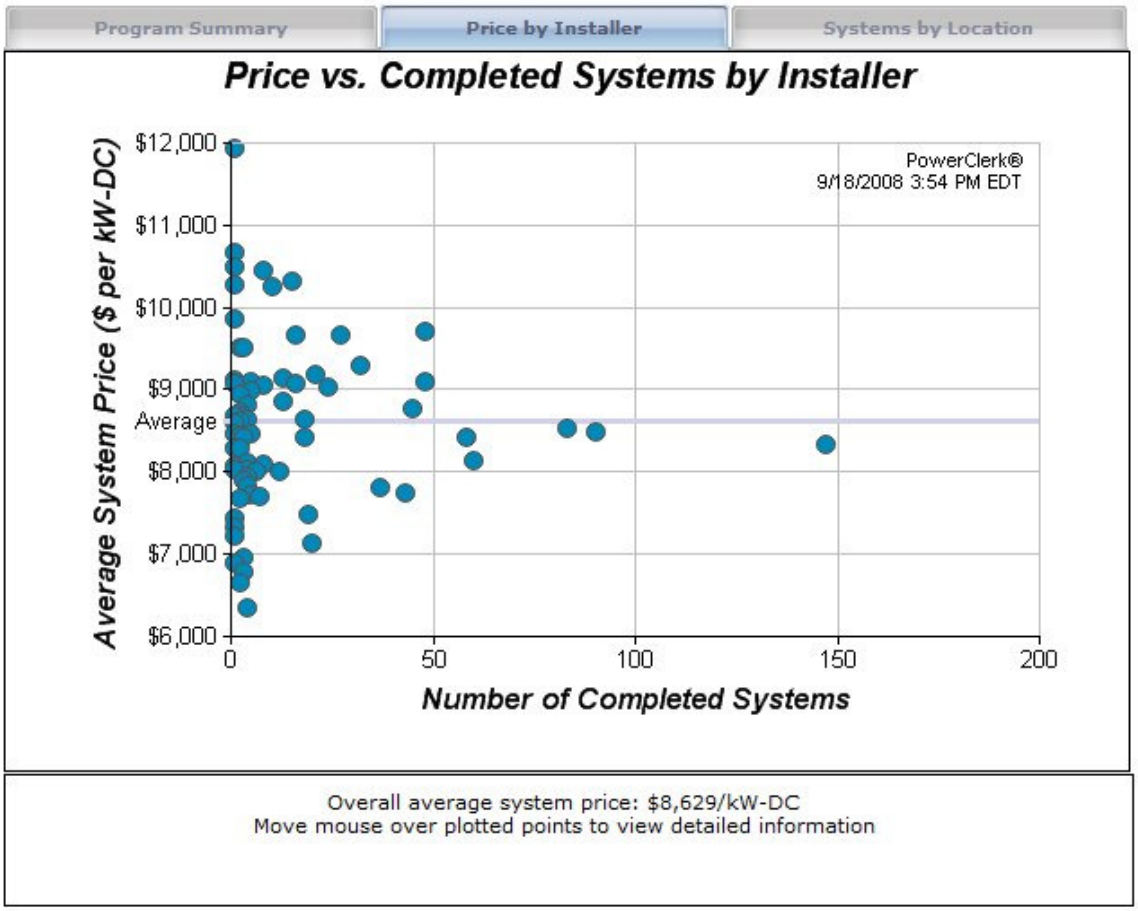
INSTALLED COSTS OF RESIDENTIAL PV SYSTEMS

Currently, the average installed cost of PV Systems in the USA is about $8.50 to $ 9.50 per Watt (DC). System prices vary widely due to the geographic location and individual nature of each installation. Regardless of the local average price, the economic relationship of fixed versus tracked systems can always be evaluated.

The graph below is a screenshot from recent data published by New York State and seems typical of nationwide pricing. For purposes of calculating system prices the figure of $ 8.63 per DC Watt will be used.

(Link - http://www.clean-power.com/PowerNaturally/Default.aspx)

NYSERDA PV Incentive Program Status



Note: Some variations in price are due to differences in system types (i.e., battery vs. non battery or ground mounted vs. roof mounted), travel costs for installers, unusual installation requirements, customer requests for more sophisticated monitoring equipment, labor reductions for installers own systems, etc.

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ADDITIONAL COST CONSIDERATIONS: MODULES AND MOUNTING STRUCTURES

The other cost used in this analysis is the price of the specific module racking for Systems 3 and 4. System 3 is 4kW, seasonally-adjusted fixed mount and System 4 is the 3 kW Dual-Axis Tracked array. Solar modules vary in size and power rating. Racking capacity is determined by the choice of specific PV module.

A Sanyo 200 watt module is typical of a high end, readily available power-dense module. The array wattage for the fixed mounts is 4 kW DC and holds 20 Sanyo modules. Standard retail prices of the leading Albuquerque, NM fixed mount manufacturers shows that the typical racking price is about $ 3,620.00 or $ 0.91 per racked DC Watt for a 4 kW system.

A Wattsun AZ-225 Dual-Axis Tracker will hold 16 of the Sanyo 200 watt modules. That yields an array of 3.2 kW DC. A retail price for a Wattsun Dual-Axis Tracker that mounts 16 Sanyo's is $7,175. That amounts to $ 2.24 per racked DC Watt.

FIXED RACK SYSTEM 3 *VS* TRACKED SYSTEM 4 COST BREAKDOWN

The "tracking price" is $2.24 per DC Watt. Compared to a fixed mount, the additional cost per watt or premium to track is $1.33 per watt ($2.24- $0.91). That increases the installed cost for a tracked PV System from $8.63 to $9.96 per DC watt.

It might appear that tracking is a luxury addition to a PV System. However, it can be less expensive when viewed from a power production standpoint.

The installed cost of System 3 is quick to calculate:

DC Watts X ($ per Watt Fixed Rack) = Total Cost
(4000 DC watts) X ($8.63 / DC Watt) = $34,520.00

Similarly the cost of System 4 is quick to calculate:

DC Watts X ($ per Watt Tracked) = Total Cost
(3200 DC Watts) X ($9.96 / DC Watt) = $31,872.00

Simply put, the by reducing the array size and using a Wattsun Dual-Axis Tracker, the cost of the system is reduced by $2,648. Tracking provides the same level of delivered annual AC power and saves a significant amount of your money on the installation.

This is a very basic economic analysis of tracking benefits. Each residential PV system design is unique. Your Wattsun Tracker Dealer will aid you in your decision making and the cost/benefit ratio of tracking your PV system.

NOT INCLUDED IN THIS ANALYSIS

MOUNTING POLE AND FOUNDATIONS

The mounting pipe(s) and foundation(s) cost. That cost is roughly the same for large arrays, whether pole top or ground mounted.

ROOFTOP PV SYSTEMS.

This comparison does not include building or residential roof mounted racks. Roof mounted arrays operate at a higher temperature and can suffer up to a 5% loss of power in the summer. The rooftop of an existing building might not have optimum orientation. The topography, trees and views might also override the ability to provide practical electric generation. Similarly, new homes that integrate PV's into the building are beyond the scope of this comparison. The PV Systems described here are all assumed to be pole mounted or ground mount arrays. This allows for an "apples to apples" cost comparison.