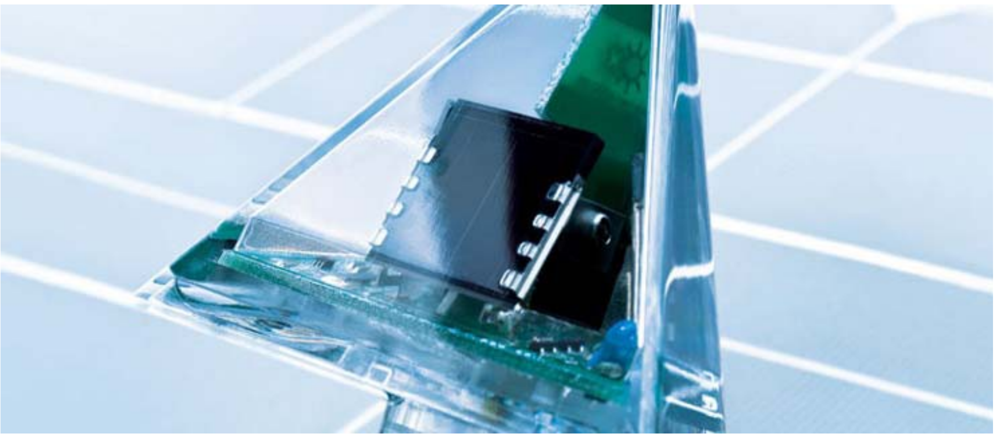
Dual Axis Tracker Energy Output of a Solar PV installation in the UK

21 August 2013



MLD Sensor Used on site to orientate the system

This report looks at the performance of a Solar PV tracker system during the months of January 2013 to July 2013 and investigated the extremely high 'actual' output of a dual axis tracking system compared to the 'expected' output. For the period the system produced 165% more electrical output than a fixed roof-mounted system. This is an increase of 34% above expected outputs. This was during in a period with only 96% of the average sunshine hours.

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Background

Williams Renewables installed a dual axis tracker system comprising of five Deger Energie dual axis trackers with a total of 208 x Kyocera KD240GH-2PB panels giving a 49.92kWp system. Each tracker is connected to a SMA Sunny Tripower 10000TL-10 inverter. The system is wired back to the export meter for the site. The location of these panels is 3 miles from Cirencester with the nearest Met office weather station located 30 miles North West of the panel location were sunshine hours have been taken from.

Figure 1 - Tracker system

Tracker Systems controls

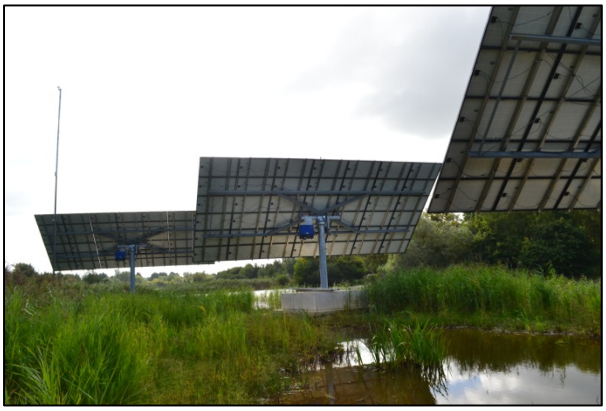


Figure 2 - Typical tracker system

Here is an extract from DEGER ENERGIE sales litriture explaining how the tracking system works on site. *"The maximum light detection or as we call it MLD principle, consists on the most accurate, fastest and energy-saving movement of modules, to the most energy-loaded positions. This is due to the patented control component, the DEGERconecter. The control*

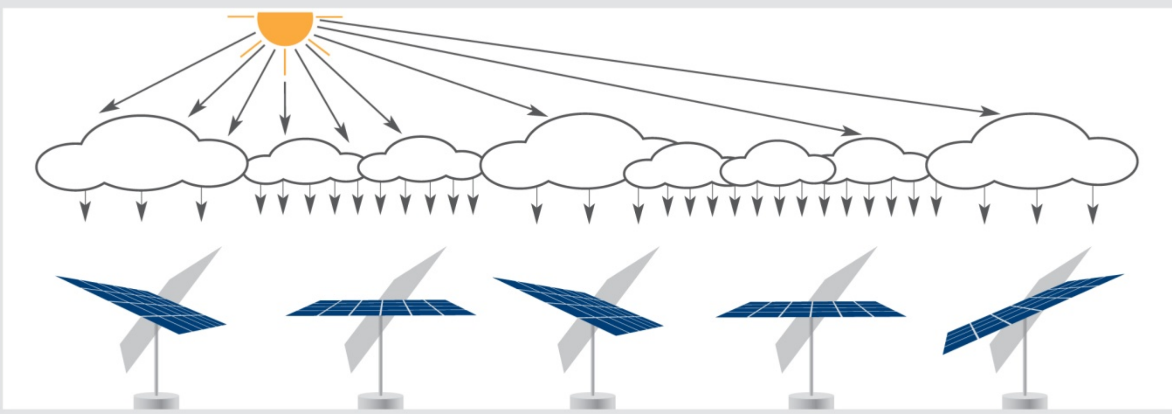
Component continually measures intensity and angle of the incoming light, and moves the installation with the solar modules in the most advantageous way. The DEGERconecter thereby, takes into account not only the solar irradiation, but for example, light that is reflected off snow, water or bright rock, it also considers the diffuse solar irradiation that penetrates clouds.

For the operation of the DEGERconecter, two sensor cells deliver reference values, which are processed and evaluated by the integrated logic chip of the control component. A differential amplifier controls the transition from the logarithmic characteristic during strong solar irradiation, to *a linear characteristic curve during low currents (as they occur in diffuse light). The logic module places a much higher value on the linear characteristic line, than on the logarithmic one. This leads to a significant increase in the readjustment accuracy, at decreasing brightness. The differential voltage is additionally charged with a load, whereby the cut-off threshold is set down to around 30 watts per square meter, and thus far into the evening hours. A third sensor cell, on the back of the DEGERconecter, ensures that the system is automatically set back again in the morning, in the direction of sunrise. In order to prevent both drives in dual-axis systems from running simultaneously, the system is designed in order that the east-west (azimuth) drive has priority over the north-south (elevation) drive.*

Each dual-axis tracking system is equipped with two DEGERconecters. Due to the automatic tracking of each individual system, a central controller and a wiring of the park with datalines, is unnecessary. This has significant effects on the profitability of solar parks: MLD controls and directs every system independently, at all times in the entire park, this is to optimize the position for maximum results, it is prepared to act, even in fast and different changing levels of cloud cover. Each system achieves the highest possible level of energy efficiency, in each case. In addition, there is a safety factor: in case of a failure, only one system is affected; the remaining systems of the park continue to operate normally."

The system would be expected to generate about 38%[i] more energy than a conventional roof or ground mounted system facing south at the optimum installation angle as it can keep the panel s at an optimum angle throughout the day. Tracker systems are popularly for solar farms in very sunny areas of the world where the projected 35% to 45% increase in output is based.

The added advantage of using the irradiance sensor is that during cloudy weather when the light is diffused the panels can be turned to the optimum angle to collect this energy, which is often near 0^o to the horizon (the panels would face straight up) see Figure 3 below.



Varying light conditions: Because of different levels of cloudiness, the light conditions in solar parks vary for each DEGERtraker. The individual control makes sure every DEGERtraker is optimally oriented to the brightest source of irradiation. This guarantees the highest energy yield possible.

Figure 3

Solar Data for the Period

	Output kWh	Predicted kWh*	Variance	Month sunshine Correction**	Corrected Gain
Jan-13	2,650	1,464	181%	103%	75%
Feb-13	1,961	2,366	83%	78%	6%
Mar-13	3,559	3,920	91%	50%	81%
Apr-13	6,844	4,662	147%	82%	80%
May-13	7,730	5,212	148%	89%	68%
Jun-13	8,567	5,126	167%	89%	88%
Jul-13	11,101	5,233	212%	154%	38%

Table 1
*** Prediction is based on SMA prediction software based on a ground mounted at the optimum angle facing south.**
**** Percentage difference of recorded sunshine hours from last 10 years average.**

Table 1 shows the raw output of the solar tracker system next to the predicted output, as designed through the SMA prediction software that uses local weather data to calculate the system output as if it was a perfectly orientated ground mounted system. The final column shows the corrected performance as a percentage above the predicted output when sunshine hours[ii] have been factored into the actual output. With the exception of February, the system has performed well above the expected yields. Further investigation for the low results in February revealed there was failure and replacement of several inverters on the system due to a manufacturing fault. As a precaution all inverters were replaced after two failures.

The July 2013 the raw output figure looks very impressive but when corrected the gain is significantly down compared to the previous months. The weather in July will be remembered for its very long sunny days and it was not until the end of the month that the weather became unsettled in the evenings. The tracker manufacturer predicted that the system would produce 38% [no conclusion / correlation should be made to this figure matching the July 2013 figure as this is only one year's data] more energy than a ground mounted system, this predication is heavily based on very sunny location in the world.

In Figure 4 below you can see during full sunny days the system collects the extra energy as expected in the same pattern as observed in sunny locations throughout the world.

The data for the other months, that are far more typical of British weather, seem to show the system performing better than predicted and thereby increasing financial returns. Further investigation needs to be carried out in the UK to see if output from trackers fitted with sensors like the DEGERconecter, could actually be higher than expected due to our changeable weather and the added advantage of the solar Irradiance sensor. Further data would also be need from single axis and astronomically controlled trackers as the gain could be due to sunnier mornings and evenings in this location.

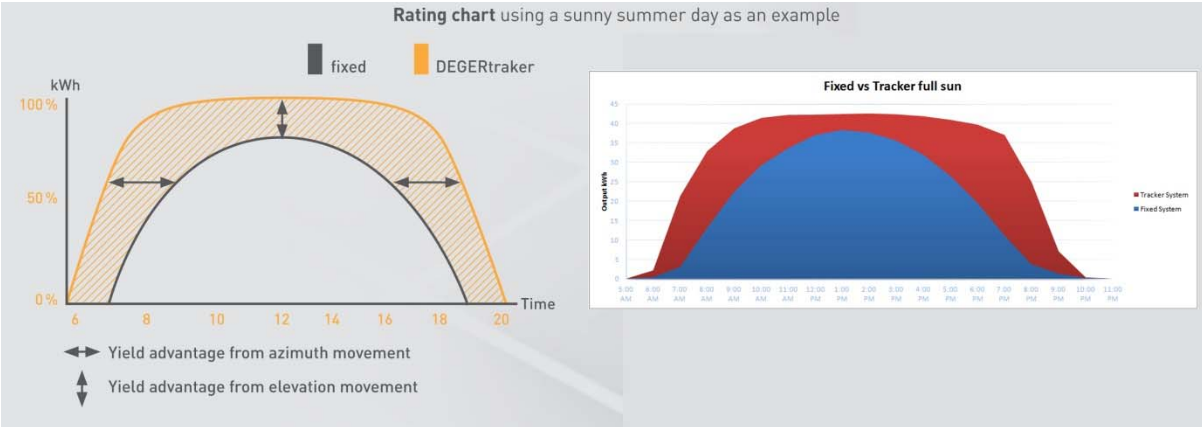


Figure 4 – Left Sales Literature. Right Actual data. 9th July 2013

Figure 4 shows on the left an extract from DEGER ENERGIE sales literature and on the right the actual output for 9th July 2013, comparing the tracker system near Cirencester with a fixed roof mounted 49.98kWp system 50 miles away in Warwick. The trends are very similar due to the good even sun throughout the day. The tracker system can angle its array and gain the expected 38% increased output. The tracker system produced 10 hours of energy within 90% of its peak for the day,whereas the fixed system only produced for 4 hours, but surprisingly both systems produce energy for the same amount of time during daylight hours.

Where the tracker seems to be performing better is on a more changeable day; this is not a scientific comparison as the weather at each location is not the same and the Warwick fixed-roof installation is not at an optimum orientation. Further investigation is needs to be carried out on a few sites to see if the tracker system will produce sustained higher yields in the UK weather conditions.

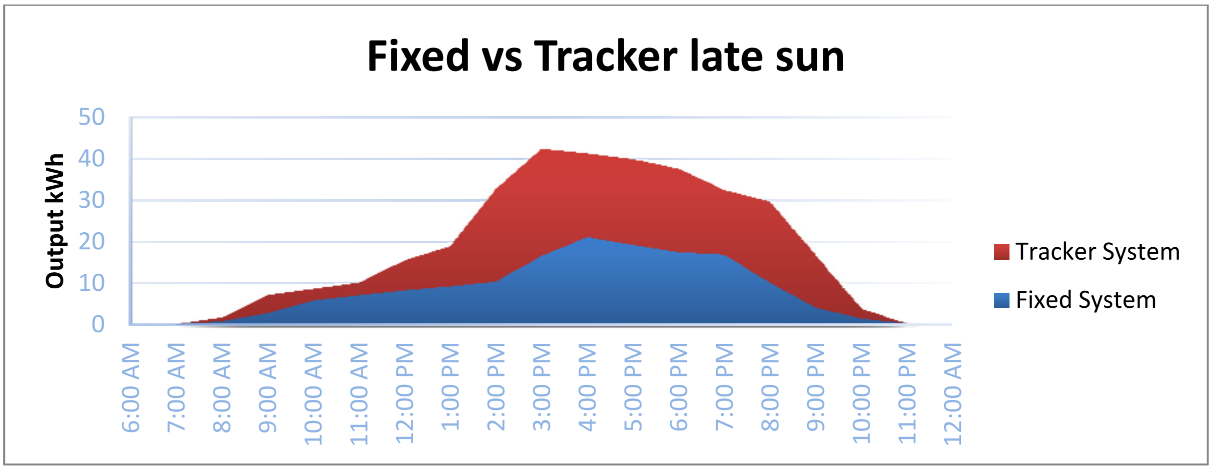


Figure 5 - Changeable day 21th July 2013

Figure 5 shows that the peak solar output changed throughout the day and it was in the evening that the highest irradiance levels were archived. The fixed system output rises at 4pm as if there was full sun (shown in Figure 5 in blue) but the tracker system saw this weather about ½ hour earlier and was able to take full advantage of this late sunny spell. Over the day the tracker system managed to produce 108%[iii] more energy than the fixed system, even after corrected for installations differences.

Conclusion

Further investigation is required into tracker systems in the UK, as through our observations the predicted yields at this site seem to suggest that with Britain's changeable weather conditions and a control system like the DEGERconecter outputs could see significantly increased yields compared with ground mounted simulations, well above the extra 30-40% general expectations.

Better modelling software would also help but solar irradiation data would need to be at very small intervals to achieve this.

None of the data is verified and is over a very short sample period; more scientific studies are needed to be carried out before any firm conclusions of expected yields can be made including the results from single axis trackers and Astronomical controlled systems.

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[i] As stated in the sales literature from Deger Energie based on latitude

[ii] The number of sunshine hours is only an indication of solar irradiance as this only measures when the location has full sun. Sunshine hours were recorded at Ross-on-Rye weather station. Data was down loaded from the Met office official web site.

[iii] 108% is based on the raw output of the site and a correction factor of 8% added to the fixed data to correct the reduced output due to the mounting angle.

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