CABLE-BASED SOLAR WINGS TRACKING SYSTEM: TWO-AXIS SYSTEM AND PROGRESS OF ONE-AXIS SYSTEM

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ABSTRACT: Tracking PV modules towards the sun offers gain in yield of 15% to over 35% relative to fixed mounted PV installations. To reduce material costs and to offering the double use of land, the Solar Wings tracking system was developed using cables to serve as mounting platform and to use cables to move the module toward the suns position. Up to know a prototype of a one-axis System was installed in Dec 2009 and the prototype of the two-axis system started operation in 2010. The excellent track record of the one-axis Solar Wings installation is proofen by a overall system performance ratio of 92.3% in the complete first year of operation and 91.7% since the beginning of 2010 till this date of report in August 2010. Without any interruption of operation the annual yield of 1308 kWh/kW could be reached for that site in southern Germany. The gain of 23% due to one-axis Solar Wings tracking was measured by comparison the yearly the readings of a tracked irradiance sensor and a fixed mounted sensor run by the Fraunhofer ISE lab. In 2010 a two axis Solar Wings tracking system was installed and also operates without any shot down. In 2011 a one-axis Solar Wings tracking system will be installed on top of a small ski-lift in Switzerland.
Keywords: Photovoltaic Mounting System, Tracking, Balance of System

1 INTRODUCTION

Several concepts are on the market to track PV modules towards the sun offering a gain in energy yield ranging from 15% to 35% relative to fixed mounted PV installations depending on the design and the location of the installation. By the use of cables with a length of about 300 meters, material costs of the mounting platform are reduced. Additionally less intermediate foundations are needed to hold the module platform. In spring 2008 a prototype has been installed and in December 2008 the first one-axis Solar Wings tracking system was set into operation at the Lonza solar park in Waldshut, Southern Germany. [1,2]

Figure 1: 650kW Solar Wings Plant at Lonza Solar Park in Waldshut, Germany. Polycrystalline Silicon modules (230Wp) are mounted in groups of 8 modules on of the 310m long mounting and tracking cable. 6 standard AC motors powering the standard linear drive to move the one axis tracking cables.

Figure 2: Solar Wings tracking system at the Lonza Solar Park with a mounting distance of the WINGS of about 5m.

2 PERFORMANCE REPORT OF THE 650kW SOLAR-WINGS ONE-AXIS PLANT

The Solar Wings Lonza Solarpark was continuously feeding PV electricity into the AC grid since the start of operation at the end of December 2009 (see Fig. 3).

The electrical performance of the one-axis Solar Wings Systems was calculated by the use of PVSYST and an increase in AC energy yield of 17% relative to fixed installation was predicted. [2, 3] It will be shown that in the analysis of the present measurement results that the above simulation value was exceeded by 5%.

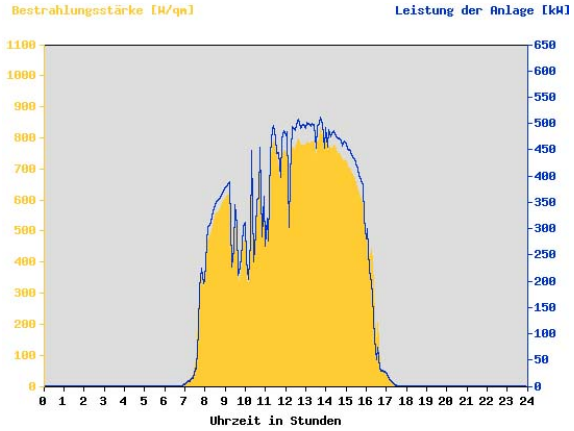

Figure 3: Webshot from the public ISE Sunways online monitoring portal showing the solar irradiance characteristics in the tracked module plane (left axis W/m2) together with the AC power feed into the grid (right axis kW) at the 19th of Oct 2009.[4]

2.1 Measured performance of 650kW prototype

The performance of the first Solar Wings plant in Waldshut is monitored by the Fraunhofer ISE since first of January 2009. The first results Jan to Aug 2009 were published in the previous EUPVSEC conference proceedings.[1] Now the completely year 2009 is available an will be analysed here. The following values are measured: relevant electrical DC and AC values, the reading of cryst. Silicon irradiance sensors, one fixed at the same inclination angle than the tracking axis (22°) and one sensor mounted in the tracked module plane, as well as readings of ambient and module temperature sensors are monitored.[4]

In Fig. 4 the measured temperature of the modules is found to be about 18°C higher at 800W/m2 and linear extrapolated to become about 24.6°C higher at 1000 W/m^2 relative to the ambient temperature as an yearly average. Analyzing the data form July 2009 it is found that the average module temperature of about 40°C at 800W/m2 is much lower than the given NOCT of 45°C due to the better cooling conditions of the modules mounted about 2.5m above ground.[2]

The measured average yearly efficiency of the inverter (Sunways PK30) was 96.5% and is in accordance within the measurement uncertainties and the given euro efficiency value of 97% by the manufacturers data sheet.

The measured performance values of the 650kW plant are given in table I and II for each month since the first month of operation.

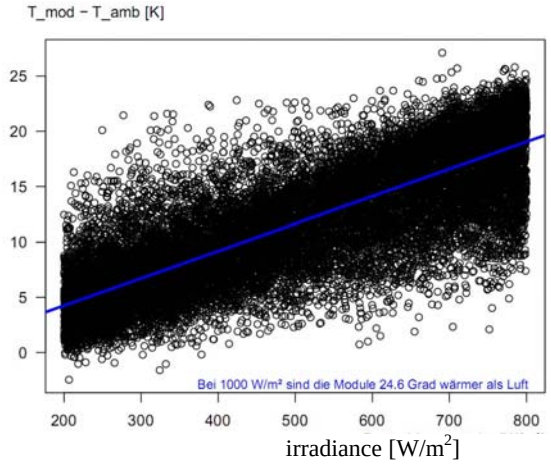

Figure 4: Measured temperature difference between PV modules and ambient temperature versus irradiance [W/m^2] during 2009 (average module temperature during day time was 25.1°C and average ambient temp 11.2°C [4]

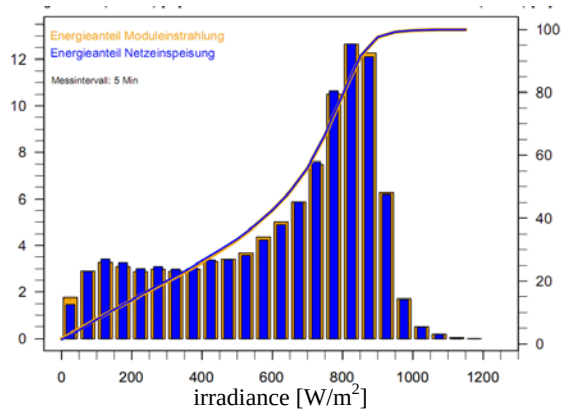

Figure 5: Density distribution of the measured irradiance in five minutes intervals [4]

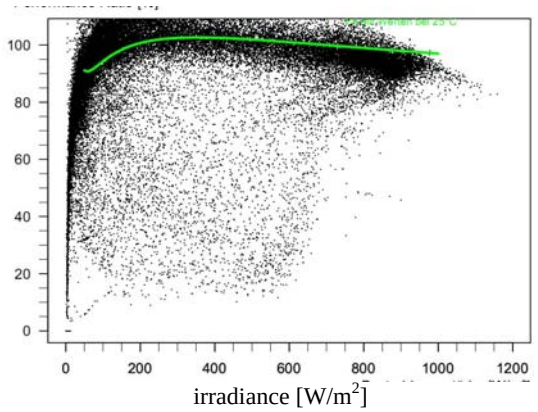

Figure 6: Measured Performance Ratio of the PV plant during the whole year 2009 with an average value of 92.5 for the 654.3kW nominal power[4]

Table I: Performance data of 2009 the first year of operation of Solar Wings one axis tracking system Lonza Solarpark [1] with an average performance ratio of 92.5% (relative to tracked irradiance sensor). The irradiance measured by a crystalline ISE reference sensor mounted in a fixed position with a inclination of 30° and oriented at the same azimuth of as the tracking axis.

First year of operation	Solar input fix 22° [kWh/m2]	AC yield [Wh/Wp]
Jan 09	27.9	29.2
Feb 09	54.3	54.4
Mrz 09	80.1	92.8
Apr 09	133.7	153.0
Mai 09	151.8	167.1
Jun 09	156.3	177.1
Jul 09	151.9	170.0
Aug 09	162.1	182.4
Sep 09	110.4	132.9
Oct 09	72.5	87.9
Nov 09	29.5	35.2
Dec 09	22.5	26.6
Sum	1153	1308

Table II: Performance data of 2010 of Solar Wings one axis tracking system Lonza Solarpark [1] with an average performance ratio in the first months of 2010 of 91.7% (relative to tracked irradiance sensor). (see Tab I).

2010	Solar input fix 22° [kWh/m2]	AC yield [Wh/Wp]
Jan 10	22.7	27.2
Feb 10	41.0	47.0
Mrz 10	95.9	114.4
Apr 10	134.3	163.1
Mai 10	113.2	123.3
Jun 10	140.4	159.5
Jul 10	169.3	183.1
Aug 10	125.2	145.1

In 2009 the yearly measured solar irradiance was 1153 kWh/m2 by the use of a crystalline Silicon sensor (ISE Standard) mounted in a fixed, non-tracked position, tilted by the same angle to the horizontal plane than the tilted axis of the tracker. A same type of reference sensor was tracked to the sun by mounting on the solar wings system in the module plane performed with 23% higher irradiance reading over the year. Thus the performance ratio was calculated to be at excellent values of 92.5% in 2009 and 91.7% in 2010 from Jan to Aug (see Tab. I and II).

If we calculate a so called fixed performance ratio by dividing the AC yield by the measured irradiance in a fixed non tracked position, a performance ratio of 1.135 is found according to Table I (in 2009). If we compare this value with the performance ratio of a roof mounted system using the same components assuming a performance ratio of 0.9 for that system, an increase in produced AC-power relative to fixed will be about 23% due to one-axis tracking. Thereby an uncertainty value of about 4% including sensor uncertainty of 2% is assumed.

With that excellent high performance ratios well above 90% in 2009 and 2010 the Solar Wings tracking system performed excellent. Such high PR values are only possible if together with the perfect tracking system the other system components like inverter and PV modules are of highest quality.

3 TWO AXIS SOLAR WINGS PROTOTYPE PLANT

In 2010 the first Solar Wings two-axis tracking system was installed in Flums, Switzerland. Again 8 polycrystalline Silicon PV modules each 230Wp nominal power (Sharp) are mounted on a module beam, Aluminum profile with 9 meter in length hold on two supporting cables with intermediate pillows separated again by 40 meters. The angle of the mounting bar for the two supporting cables can be set with an additional linear drive motor between +/-35° enabling full two axis tracking (Fig. 5). Totally 7 inverters, offering a nominal power of 10kW (Sunways NT10 000) each are feed the AC power into the grid. This Solar Wings two axis prototype has a nominal power of 70kW. The first yearly performance data will be presented in the next conferences.

Figure 7: First Solar Wings 70kW two-axis tracking system installed at the Flumroc AG, Flums Switzerland and in operation since spring 2010.

4 SOLAR WINGS SKI-LIFT PROTOTYPE

The Solar Wings concept to use the advantage of double use of land will be demonstrated by installing the first solar ski-lift in the Safiental Switzerland. Again the PV modules are mounted on top of two cables supported by the standard ski-lift supporting stand and the one-axis tracking is realsized by another parallel cabel.

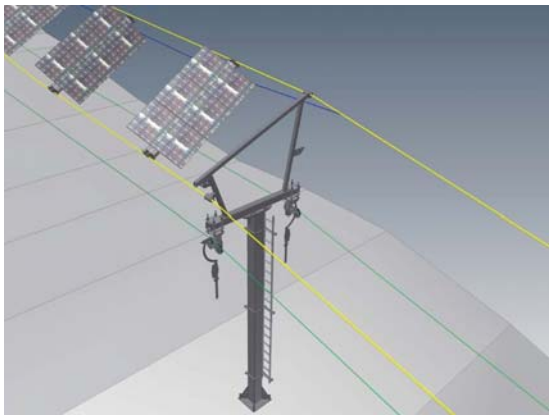

Figure 8: Solar Wings one-axis 60kW Ski-lift will be installed at the end of 2011 in the skiing area of Safiental, Switzerland.[5]

4 SUMMARY and OUTLOOK

The first Solar Wings one-axis tracking system installed in December 2008 with a nominal power of 650kW reveals an excellent average performance ratio of 92% over a continuously perfect operation record in the first one and a half year. Relative to fixed mounted PV installations the gain in produced AC power of 23% during the first year of operation was demonstrated.

The first two-axis Solar Wings prototype is in operation since 2010. The first Solar Wings ski-lift will be installed at the end of 2011 in Switzerland.

Development work will going on to design a Power Wing prototype as a further development of two axis Solar Wings tracking and low light concentration by mirrors tracked on parallel axis.

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[5] solar ski lift safiental
http://www.skilift-tenna.ch
television Switzerland see:
http://www.sendungen.sf.tv/einstein/Sendungen/Einstein/Archiv/Sendung-vom-25.03.2010