Proceedings of the 2010 IEEE
International Conference on Information and Automation
June 20 - 23, Harbin, China

Data acquisition and analyzing of solar energy resource

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Abstract **As the precondition of exploiting solar energy resource, solar energy resource assessment is the key of solar energy power plant site selection. The main parameters and the testing instrument for solar energy resource assessment were analyzed. Comparing different data for solar energy resource assessment from different areas, solar energy resource of typical area were analyzed based on actual data in this paper.**

Keywords **Data acquisition, analyzing, solar energy resource**

I. INTRODUCTION

Development and utilization of large scale solar energy is not only reasonable style of energy resource utilization in the future but also effective measure of adjust to energy resource frame and improving energy resource crisis. There is different solar resource in different area, season, weather condition and so on because of so many influence factors. Assessment of solar energy resource is the key of large scale development and utilization of solar energy. The difference of resource assessment result will bring to great effect to large scale development and utilization of solar energy. Effective assessment of solar energy resource at different place can not only reasonable develop and utilize solar energy resource but also save money and improve the utilization rate of solar energy.

Accuracy of solar energy resource data acquisition is very important, different instruments to obtain data on the solar energy resource can produce different results and have a significant impact on the large-scale solar energy development and utilization. At present, the main data of solar energy resource assessment is from the satellite scanning and field measurements. Satellite scanning is mainly through the use of satellite data of meteorological satellites to scan the surface from time to time to carry out near-infrared and visible light spectrum to be scanned and analized by altitude, ozone density, water vapor, aerosols, suspended particles and other parameters to obtain the relevant data. Greater coverage of satellite data, a longer record time, can be obtained ten or twenty years of satellite scan data, but precision is low and the effective area is about several hundred square kilometers; In contrast, field measurements can be measured in accordance with the specific positioning survey sites solar resources, the effective range and accuracy of the data better than the satellite data, but the measurement range is limited , only the test data of limited regions and limited time period can be gotten.

Solar energy resources data with different test equipment in the course of testing will be different, it will directly affect the accuracy of resource assessment. In this paper, the use of solar energy resources of different test instruments to obtain solar radiation data as a measurement parameters of the surface total radiation.

Instrument A: Solar energy resources was tested by instrument A in typical region A from Inner Mongolia, the sensitivity of instruments ranging from 7~14μV•W-1m2, response time<35s(99% response), annual stability≤ ± 2%. Latitude and longitude coordinates of A test sites are: longitude 105° 37'51.1", latitude 38° 49'04.6", the test of time since March 2007 to February 2008.

Instrument B: Solar energy resources was tested by instrument B in typical region B from Inner Mongolia, the total surface radiation measurement accuracy range of ±5%, the cumulative monthly value of less than 1.5%. Latitude and longitude coordinates of B test sites are: Tokyo, 106° 42'23.0 ", latitude39 °55'47.9", the test of time since October 2007 to Apr. 2008.

Shown in Figure 1, A and B points of the measured values are with the corresponding change in the trend of satellite data, Five months of the highest value of radiation in the February of 2008 and five months of the minimum value in the December of 2007.

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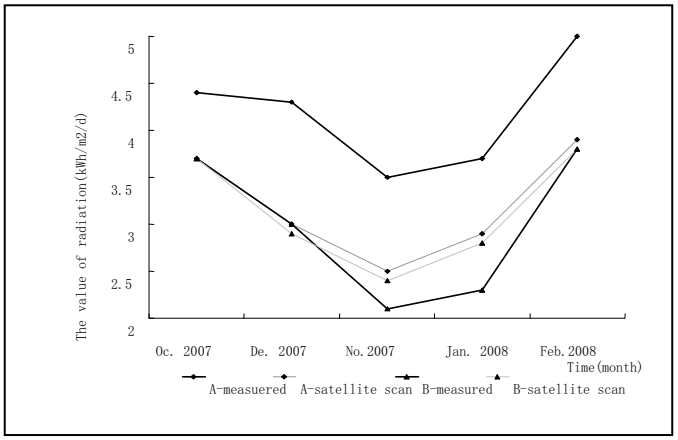

Figure 1. Comparation of testing data and satellite data at different site

A and B-points are respectively compared to the correspond ing measured values of the satellite, Point A value of the measu red data and satellite scanning's margin is much larger than the measured value of point B's, in order to further analysis as the basis of satellite data, using root-mean-square error and offset e rror of the A, B two different test results and satellite scan data were analyzed. Formula is as follows [2]:

$$\mathrm{RMSE} = \frac{100}{\overline{D}} \sqrt{\sum_{i=1}^{N} (D_{ic} - D_{ir})^2 / N} \qquad (1)$$

$$\mathrm{MBE} = \frac{100}{\overline{D}} \left[\sum_{i=1}^{N} (D_{ic} - D_{ir}) / N \right] \qquad (2)$$

Where RMSE-root mean square error,%; MBE-offset error, %; Dic-section i of satellite scan values; Dir-section i of the fiel d measured value; $\overline{D}$ - the average of measured values; N-the n umber of filed measured data.The error results show that A-poi nt root-mean-square error is 23.88%, B-point root-mean-square error is 8.82%, A-point offset error is -23.33%, B-point offset error is 8.82%, the error analysis shows that point B of the mea sured value is more reasonable than point A.

According to the result above mentioned, instrument B is m uch better than instrument A, so instrument B was selected for t esting the solar resource.

II. TEST ON SITE

A. *Essential information*

The testing work was done in three areas(A:E109°06′19.0″,N38°45′41.2″;B:E107°05′11.2″,N40°1 5′13.8″;C:E106°42′23.0″,N39°55′47.9″)in Inner Mongolia from October 2007 to April 2008.

B. *Instrument*

The Meteorological Station from Germany was chosen to provide automated measurements of some meteorological data. The main purpose of the Meteorological Station is to measure the solar resource of three chosen location. The station will be installed on remote sites and will be operated self-sufficient. Therefore the station needs a solar power supply and a cellular network modem to retrieve data. The meteorological station which is calibrated by Aerospace Center Germany from June 1st 2007 to August 7th 2007, and period of validity is two years. The pyranometer sensor was chosen for measuring Global Horizontal Irradiation(GHI), at the same time ambient temperature and wind speed are also measured in the Meteorological Station. The index of the instrument as follows Table Ⅰ.

TABLE I. Index of the Meteorological Station

NO.	Index of the Meteorological Station		
	Item	Accuracy	Range
1	GHI	±5%	0～2000 W/m^2
2	Tem.	±0.9	-40～+70
3	Wind Speed	0.1m/s	1～96m/s

C. *Data collection and processing*

Data collection was done by the data logger which is placed inside the box of the Meteorological Station. The data logger is programmed to scan all sensors once per second, and to produce output records with various averages, totals and maxima. The software used for data collection which was developed by Campbell Scientific allows connecting to the data logger directly or by using the GSM modem line. The software also allows scheduled data collection and programming of the data logger.

III. COMPARATIVE ANALYSIS

A. *Testing data on site and satellite data*

According to the outcome of data processing and satellite data from National Aeronautics and Space Administration, taking the Global Horizontal Irradiation (GHI) as main parameter, solar radiation satellite data of different period and the solar radiation testing data on site were compared in the Figure 1, 2, 3.

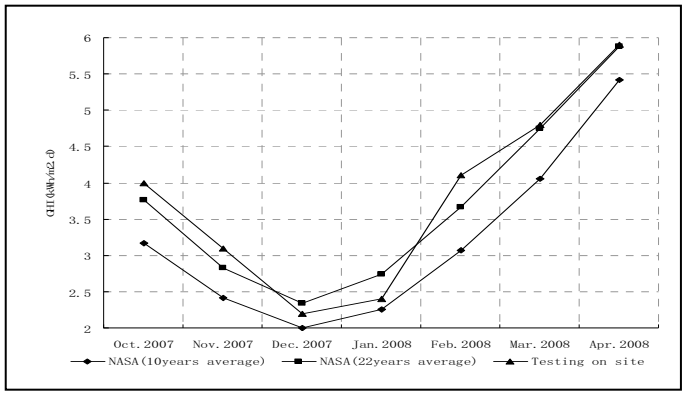

Figure 2. Comparing between satellite data and testing data on site B

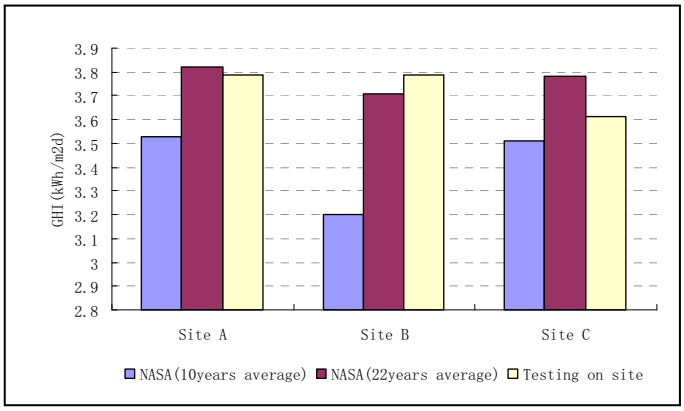

Figure 3. Comparing different medium value data in seven months among

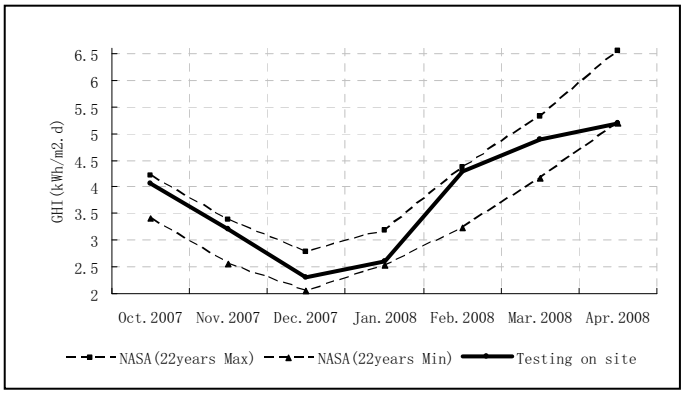

Figure 4. Comparing between maximum value and minimum value of satellite data and testing data on site A

As can be seen from Figure 1, 2, 3, the testing data and satellite data have almost the same change trend in seven months, in addition to December and January the testing data on site are also above satellite data in seven months. The medium value of satellite data in twenty-two years which is close to the testing data on site is above the medium value of satellite data in ten years. The testing data on site A is fall in between maximum value and minimum value of satellite data in twenty-two years.

B. Testing data among different site

(1) Global Horizontal Irradiation (GHI)

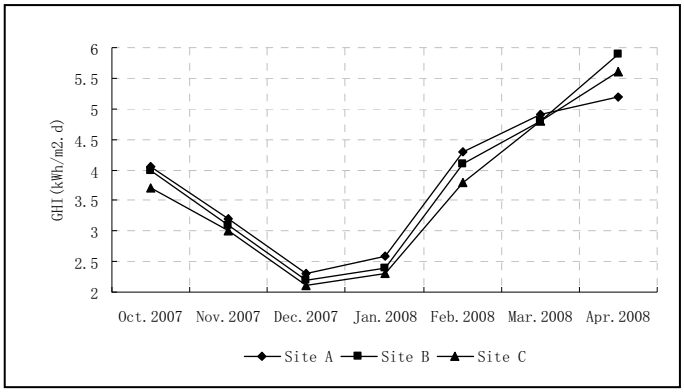

Figure 5. Comparing GHI among three sites

Comparing the testing data from three sites as follows Figure 4, the Global Horizontal Irradiation has almost the same change trend in seven months, except in April the value from site A is above the value from site B and site C in other six months.

(2) Maximal Wind Speed

As can be seen from the statistics of maximal wind speed as follows Figure 5, the medium value in seven months from site B(19.21m/s) is greater than site A(18.33m/s) than site C(17.37m/s). Maximum of wind speed is 25.1m/s which occurred on site B in December 2007.

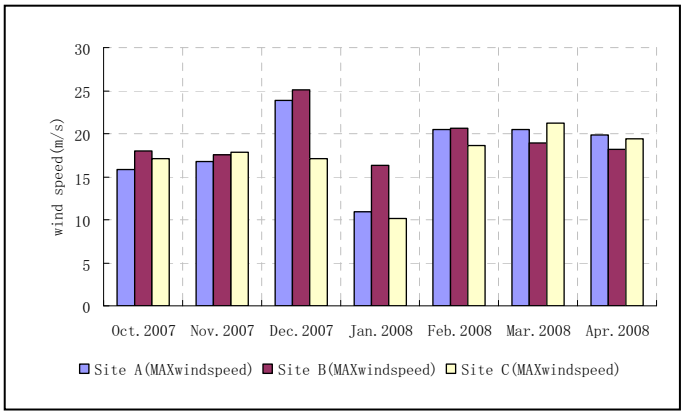

Figure 6. Comparing wind speed among three sites

(3) Extreme Value of Temperature

As can be seen from the statistics about extreme value of temperature as follows Figure 6, the medium value of maximal temperature in seven months from site C(16.14) is greater than site A(15.00) than site B(14.43). Maximum of temperature is 30 which occurred on site B and site C in April 2008, the medium value of minimal temperature in seven months from site C(-18.00) is lower than site B (-16.57) than site A (-15.29). Minimum of temperature is -33 which occurred on site C in January 2008.

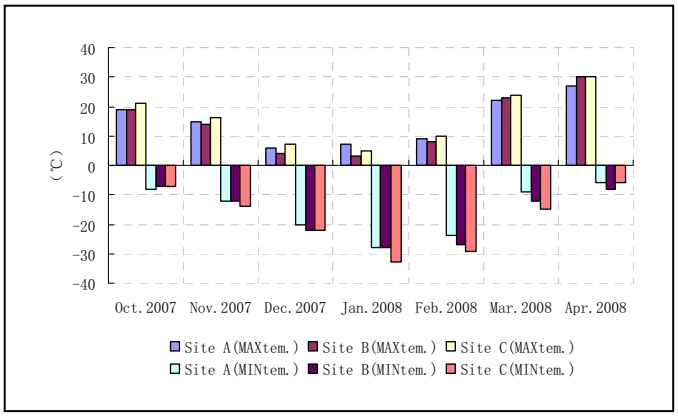

Figure 7. Comparing extreme value of temperature among three sites

IV. CONCLUSION

(1)Taking the Global Horizontal Irradiation (GHI) as main parameter, radiation intensity of solar energy shows an up trend from 1983 to 2004 by comparing the medium value of satellite data in twenty-two years with satellite data in ten years. It will

contribute to development and utilization of solar energy in terms of resource development in the future.

(2)Testing data fell in between maximum value and minimum value of satellite data in twenty-two years, which shows that the testing data is valid which can be used for solar energy resource assessment and the correlation analysis can be done between testing data and satellite data.

(3) Maximal difference value of Global Horizontal Irradiation is 0.7kWh/d/m2 by comparing the testing data from three sites. Difference value of Global Horizontal Irradiation will reach to 70,000 kWh every day if utilization area of solar energy was increased to 1km2. Strict solar resource assessment will bring to the great effect to the large scale utilization and utilization of solar energy.

(4) The value of Global Horizontal Irradiation from site B is greater than site C than site A in April 2008 although the value of Global Horizontal Irradiation from site A is greater than site B than site C from October 2007 to March 2008. What is the main influencing factor can not be determined. So some other parameters such as humidity, atmospheric pressure, air density should be tested for analyzing the influencing factor of solar energy radiation intensity on solar energy resource assessment.

(5)Wind speed will influence the strength of system used for solar energy, and temperature will influence the working performance of system used for solar energy, so wind speed and temperature should be also paid more attention about solar energy resource assessment.

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