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중국 티베트지역의 100kWp급 태양광발전시스템 실증연구

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Installation and Performance Evaluation of 100kWp PV System in Tibet

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Key words : Photovoltaic(태양광발전), Solar Cell(태양전지), Inverter(인버터), BOS(balance of system, 주변기기)

Abstract : This paper presents the isolation and performance evaluation of PV systems installed at Tibet area of China in order to identity the key factors that determines system operation at a severe climate conditions and promote the cooperation of PV technology between Korea and China. The installed systems consist of 100kW on-grid connected PV systems, BOS(balance of systems), data acquisition and transmission equipments. The Korea side supplied the solar cell, BOS like as inverter, control box and monitoring system. And the Chinese side assembled solar module by using Koreans solar cells, constructed site and built control house.

1. Introduction

Recently, the world PV market is remarkbly growing and Korea have made an intensive effort in research and development on PV technology over the last 15 years. So the core technology has been developed and now preparing to be commercialized. In order to promote the commercialization which bring up the industry, we realizes that a good sized PV market should be pioneered. China is of the most important countries in terms of energy production and consumption. Moreover China heavily dependent on coal as the main source of energy, the enviromental issue is becoming concern as its economic situation improve. So the development of renewable energy could be the most important thing. Among the renewable energy, the photovoltaic(PV) could be an ideal source of electricity in China where the population is distributed over the vast area . And PV is respected to play a significant role in China's electricity portfolio. Therefore, it is believed that China has a huge potential PV market. Although China's manufacturing capability and the technology level in on the way of fast growth, the urgent need for the electrification in the remote areas, as like Tibet, could only be met by a cooperative effort with other countries such as Korea. In addition to this, desert area in China is expected to be one of the most promising candidate sites for implementing VLS-PV

systems specified by the IEA PVPS Task 8 Program [1]. The Korea-China Cooperative agreement includes establishment a 100 kWp on-grid PV demonstration site in Tibet, China by utilizing the technologies and development in Korea. This paper presents the installation site, the specification of module and BOS that is supported by Korean industry, and installation.

2. Installation Site

Figure 1 shows the location of Tibet where this system installed. Tibet lies at the center of Asia and a original name is Xizang. It has an average altitude of 13,000 feet above sea level. The latitude of the region is 27-36 degrees north and the longitude is 75-100 degrees east. The annual precipitation in this area amounts to 250 mm below. It has the long sunshine duration which is 1.5times longer than the domestic sunshine duration and the average temperature is low. Prearranged installation area is Yangbijing of Damxung province in Lhasa. The latitude of the region is 30°.05'north and the longitude is 90°.30' east. and It has an average altitude of 4,205 m above sea level. The earth is composed of mud and gravel. The annual mean wind pressure is 6w/m and maximum is 40w/m . Also the annual mean wind velocity is 2.4m/s and the maximum is 23m/s. It has 7 Richter scale earthquake. The maximum rainfall is 458mm and the maximum snowfall is 12cm during May-October. The average temperature is 1.7℃ and the maximum is 26.5℃ and the minimum is -32.5℃. The sunshine duration is above 7 hours per day. It is possible area for satellite communication.

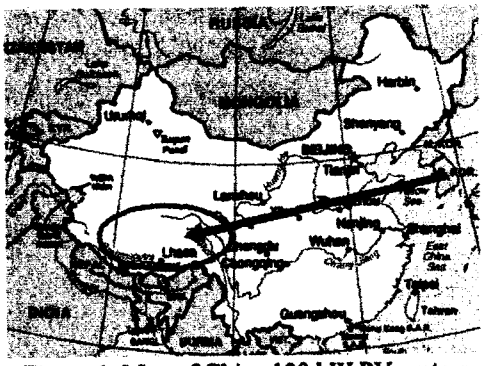

Figure 1. Map of China 100 kW PV system is installed at Yangbijing, DamXung Province, Lhasa, China, 70km away from Lhasa City

Figure 2 shows the general view of installation site. The nature of the soil is mud and it is needed a ground readjustment. And because PV power generation systemcan be seen at a newly established railroad, a marketing effect is good. Also maintenance work becomes easy after installing and grid-connection is advantageous because the power plant is located nearby.

Figure 2. General view of Yangbijing a site proposed

3. System Design and Installation

As it is mentioned in agreement, Korea prepared Solar cell and BOS like as inverter, control system, junction box, and DC cabinet and China is in charge of module assembling, construction, AC distribution cabinet, and transformer to the grid.

The design specification of 100 kWp PV system can be divided two parts, one is electrical properties and the other is structural properties. First, the electrical properties is determined by that of solar module, inverter and connection. And Table 1 (a) shows the specification of the solar cell and (b) PV module, (c) shows the specification of inverter which is manufactured by Korean company (Hex Power System). The module are manufactured by Suntech Co.(China). The details about specification of component, type of junction box, and the status of electrical connection are as follow;

-PV module : 160Wp

-Number of Modules : 616 pc

-Solar cell parallel construction : 11/series, 14/rows, 4groups

-Connection between solar cell modules and Junction box construction using terminal block, Hughes, breaker not included diodes

-Junction box arrangement : small junction-box(outdoor), large junction- box(indoor)⇒ select a small junction- box(outdoor)

-Installation of inverter : installation at indoor after constructing administration building.

-Connection between modules and inverter: 38㎟cable

-Conditions on-site electricity

-Lighting and surge protection facilities : lighting rod, reflection of grounding design.

Table 1 (a) Specification of the solar cell

Grade	A	B	C
Eff.(%)	15.3-15.0	14.9-14.5	14.4-14.0
Jsc	4.90±2%	4.85±2%	4.85±2%
Voc	0.600±0.01	0.600±0.01	0.590±0.01
Vmax	0.495	0.492	0.490
Imax	4.44	4.35	4.25
Pmax	2.25~2.20	2.19~2.14	2.13~2.10

(b) Specification of the PV module

Items	Specification
Voc	43.2 V
Isc	5 A
Vmp	34.4 V
Imp	4.65 A
Pmp	160 Wp
Size	1580 x 808 x 50 mm
Weight	16kg
Condition: AM1.5, 1000W/m^2, Tc = 25℃	

(c) Specification of the inverter

Item	Spec
Nominal DC	DC 348V
DC Input Voltage	DC 280V~450V
Phase	3
Rated Output	50kW
AC Rated Voltage	220V+/-10%
AC Input Frequency	50/60Hz
Current Harmonics	< 5%
System Efficiency	< 94%
Overload	<110%, < 10min
Power Factor	<0.95
Cooling System	Forced Fan Cooling
Dimensions	750x800x1588mm
Weight	450 kg
Humidity	95%(non-condensing)
Ambient Temp	-20 to +40℃
Protection	OVR,UVR,UFR,OFR
	Anti-Islanding
Communication	RS232/485

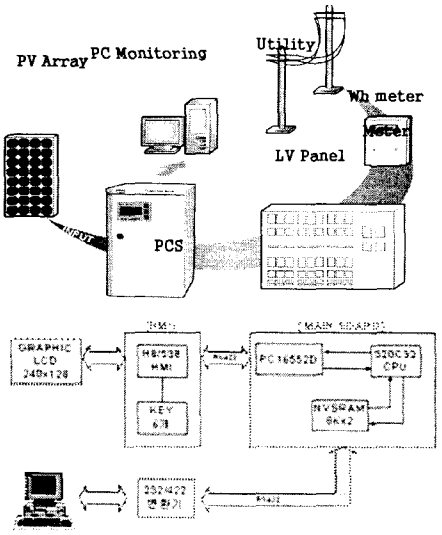

Figure 3. Schematic diagram grid-connected PV power generation system and flow chart of system control.

These are applied to this 100 kWp system. Second, the structural properties of array are as follows.

-Angle : 23°

-Quantity : composed of 616 , installation of 4 groups

-Terminal block : composed of as a circular pipe structure

The monitoring systems for meteorological and system data are also included in this hybrid systems. The daily generated power and weather data are transmitted to Korea by satellite communication. Through in-vivo monitoring, it is possible to check system operation in Korea.

The performance of this system and second installation of 100 kWp system will be presented in the conference.

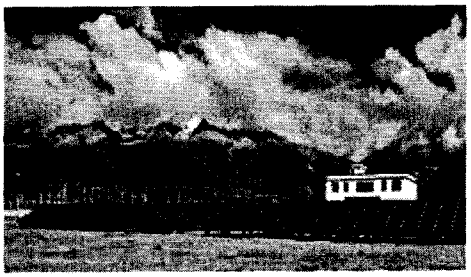

Figure 4 shows the 100 kWp PV system in Tibet

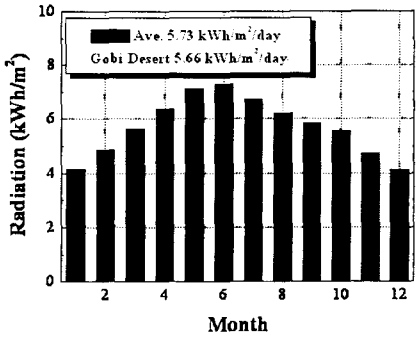

Figure 5 Average radiation vs. month in Tibet area

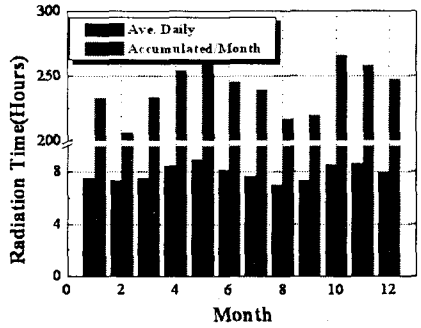

Figure 6 Average radiation time vs. month in Tibet area

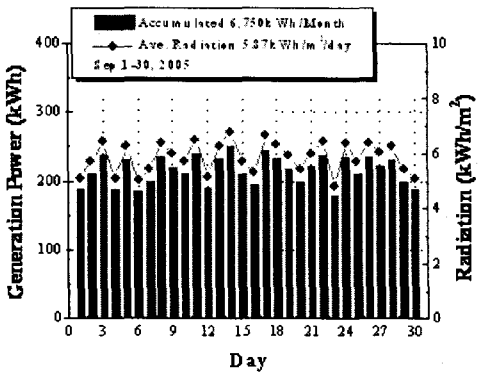

Figure 7 Daily energy demand in Sept. 2005 for Tibet.

Obviously the energy demand remains quite constant during the day and peeks in the daily hours as expected. A more detailed analysis id being carried out on the basis of the data collected. System utilization efficiency is expressed by the following formula.

PV system utilization efficiency = Generated energy of the day[kWh/day]/(PV capacity.24hours)

The system utilization efficiency is influenced largely by irradiation condition. In September 2005 to May 2006 when irradiation was good, the PV array which contributed to generation best showed a very high value above 20%.

4. Conclusions

In this paper, we designed and installed 100kW PV system as the parf of Korea-China cooperative project: 100 kWp PV system installation for performance evaluation in Tibet area. The installed systems consist of 100 kWp on-grid connected PV systems, BOS(balance of systems), data acquisition and transmission equipments. The Korean side supplied the solar cell BOS like as inverter, control box and monitoring system. And the China side assembled solar module by using Koreans solar cells, constructed site and built control house. We should investigate the performance and stability of the system as the condition of weather. In based on the result of this project, we expect that Korean made products such as PV cells, inverter and/ or control system will be exported to China so that they will be applied to the 500~1000kWp system which will be installed in Tibet from 2006. And royalty and exports of Korean made products will be expected when 3~5MWp PV system will be installed at Tibet. Finally, this project of installation and demonstration will give us a better chance to go into the Chinese market which is in shortage of PV cells.

5. Reference

[1] Jinsoo Song, Kosuke Kurokawa, 'Potential of Very Large Scale PV Power 'Generation System on Desert', *12th International PV Solar Energy Conference, Jeju, Korea, June, 2000, p. S-1.*