

무인자동 일사측정시스템의 개발 및 독도에서의 성능평가

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The Un-Manned Automated Weather(Insolation) Station at the Island "Dok-do"

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요 약

우리나라의 오지 또는 섬 등지에 태양에너지 이용기기의 설치는 대체에너지 이용차원에서라도 실현되어야 할 분야이다. 이러한 태양에너지 이용기기의 설계를 위한 필수자료는 신뢰성있는 일사량의 측정 및 그의 분석이다. 그러나 국내에는 15개 지역에 일사량을 측정할 수 있는 시스템이 설치되어 있지만 전력수급이 쉽지 않은 오지에서의 정확한 일사량의 평가는 불가능하다.

따라서 본 연구를 통하여 무인자동일사량 측정시스템(KIER 시스템)을 개발하여 기존의 HWS 시스템과 같이 우리나라의 독도에 설치하여 그 성능을 비교하였다. 그 결과 절대오차가 3% 내외로 신뢰도가 높았으며, 1989년 10월 부터 8개월 동안의 전 일사량의 평균치는 약 $2,330\text{W}/\text{m}^2 \text{ day}$ 로 독도에서 태양에너지 이용시스템의 설치 및 활용가능성이 높은 것을 알 수 있었다. 본 KIER 시스템은 앞으로 독도 이외의 오지지역에도 설치를 추진할 예정이다.

ABSTRACT

There are fifteen solar radiation measurement stations over the entire country in Korea. However, they are not capable of supplying reliable solar radiation data for remote areas including islands. The un-manned automated insolation measurement station is suitable for these areas due to the electric power shortage and the maintenance problems at these isolated areas. Our main aim in this work is to develop a solar radiation measurement system which collects and stores data by itself utilizing a PV module and a battery as power source for entire system irregardless of the environmental condition.

A developed KIER's prototype system along with an independent HWS reference system has been installed at the designated remote island, Dok-do. Global solar radiation has been measured every hour for a 6-month period of time by both systems at this site. A comparison between the measured solar radiation data by each system indicates that there is an excellent agreement showing average 3.0% of an absolute error. It has been observed that the 8-month average global solar radiation was 2,330 W/m² day at this island. We came to the conservative conclusion that the developed KIER system is applicable for measuring solar radiation and for supplying reliable fundamental design data for solar energy utilization system at the remote areas.

1. Introduction

With the gradual interest in solar energy utilization, much efforts have been directed to correctly evaluate the relationship among different components of the solar radiation. It has been recognized that the insolation is of a fundamental importance for designing solar thermal systems, evaluating performance of solar conversion systems and monitoring climatic and environmental changes in various countries.

In Korea, the solar radiation has been measured and evaluated at nationally spreaded fifteen different stations since 1982. However, since all of the solar radiation networks are located at in-land, the accurate evaluation of solar utilizability can not be achieved due to the lack of reliable solar radiation data for designing solar conversion systems at far remote areas including islands. It is essential that the un-manned automated measurement device should be installed at these areas because of an electric power shortage and a little maintenance.

Regarding these circumstances, we have dealt with the development of cheaper but reliable solar radiation measurement system which collects and stores data by itself utilizing PV panel and battery as its power source. In order to investigate the performance of our developed system, denoted as KIER system from now on, it has been installed at the designated remote island on September, 1989. However, the

Handar weather station(HWS) has been installed as a reference in three months advance at the same site.

In this paper, the characteristics of both HWS system and KIER system have been described briefly, and the measured insolation data from each system have been compared to verify the feasibility of KIER system. Although the HWS measures seven different kinds of climatological parameters, we are going to focus on the global solar radiation over a horizontal plane.

All the meteorological parameters have been measured every hour by both systems for a 6-month period between October, 1989 and March, 1990 because one also needs to know the radiation values at hourly intervals while designing solar energy systems. The weekly and monthly average global solar radiation data are also presented, and the monthly average insolation data has been compared with those values at four different sites in in-land.

2. Measurement Systems

In the design and evaluation of solar conversion systems for isolated remote areas, the demand for an accurate and a reliable measurement of meteorological parameters stimulated the installation of un-manned automated weather station. As the first step to complete this work, the HWS system and our developed KIER system have been installed at the desig-

nated remote island, "Dok-do" which lies 240km E. from Samchuk city (Latitude=37°14'N, Longitude=131°52'E, Altitude=98m above sea level) as illustrated in Fig.1.

The observation site for systems affords an appropriate exposure to the sensors without any major obstacles for the incoming solar radiation.

The complete HWS system consists of the

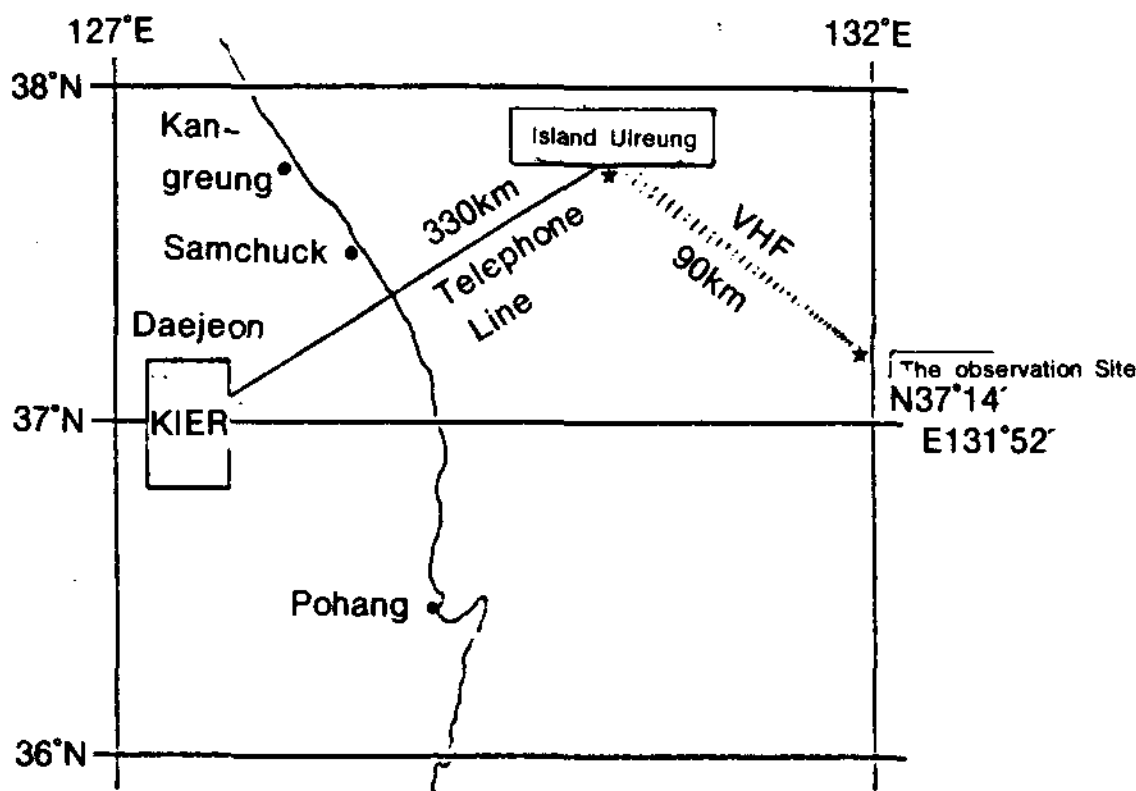


Fig.1 Solar radiation data treatment network

Table 1. Specification of the HWS system

Components	Characteristics	Remark
Pyranometer	Accuracy: within +5%	Licor solar radiometer
PV module	output voltage: 16.5V output current: 0.55A	9Wp, Regulator Ni-Cd Alkali battery included storage capacity: 5days
Data Acquisition system	Memory capacity: 144Kbyte Input voltage: 0-5V	12A, 12V battery installed
Wireless system	Frequency: 159.28MHz(Duplex)	Distance: about 200km
Other sensors	ambient temperature, humidity, wind speed, wind direction, barometric pressure, precipitation	Handar products
Portable data collection system	Memory capacity: 128Kbyte	Handar product

seven different measuring sensors such as solar radiation, ambient temperature, wind speed, wind direction, barometric acquisition system, PV module, voltage regulator and rechargeable battery. More details about sensors characteristics and device specifications are listed in Table 1.

Among sensors, the measurement of solar radiation over a horizontal surface has been made with a Licor solar radiometer. Fig.2 shows the schematic diagram of the HWS operating process. Data acquisition system plays a role of not only collecting and storing data from each sensor regularly, but also transferring stored data to the regional weather station in Ulreung island which lies 90km NW from the observation site with the aid of VHF system. Then, those data have been received by telephone line from Ulreung island and have been analyzed at KIER in Daejeon as also shown in Fig.1.

Meanwhile, the KIER system consists of the same components as the HWS system but only one sensor for insolation as illustrated in Fig.3. As shown in Fig.3, specified components sur-

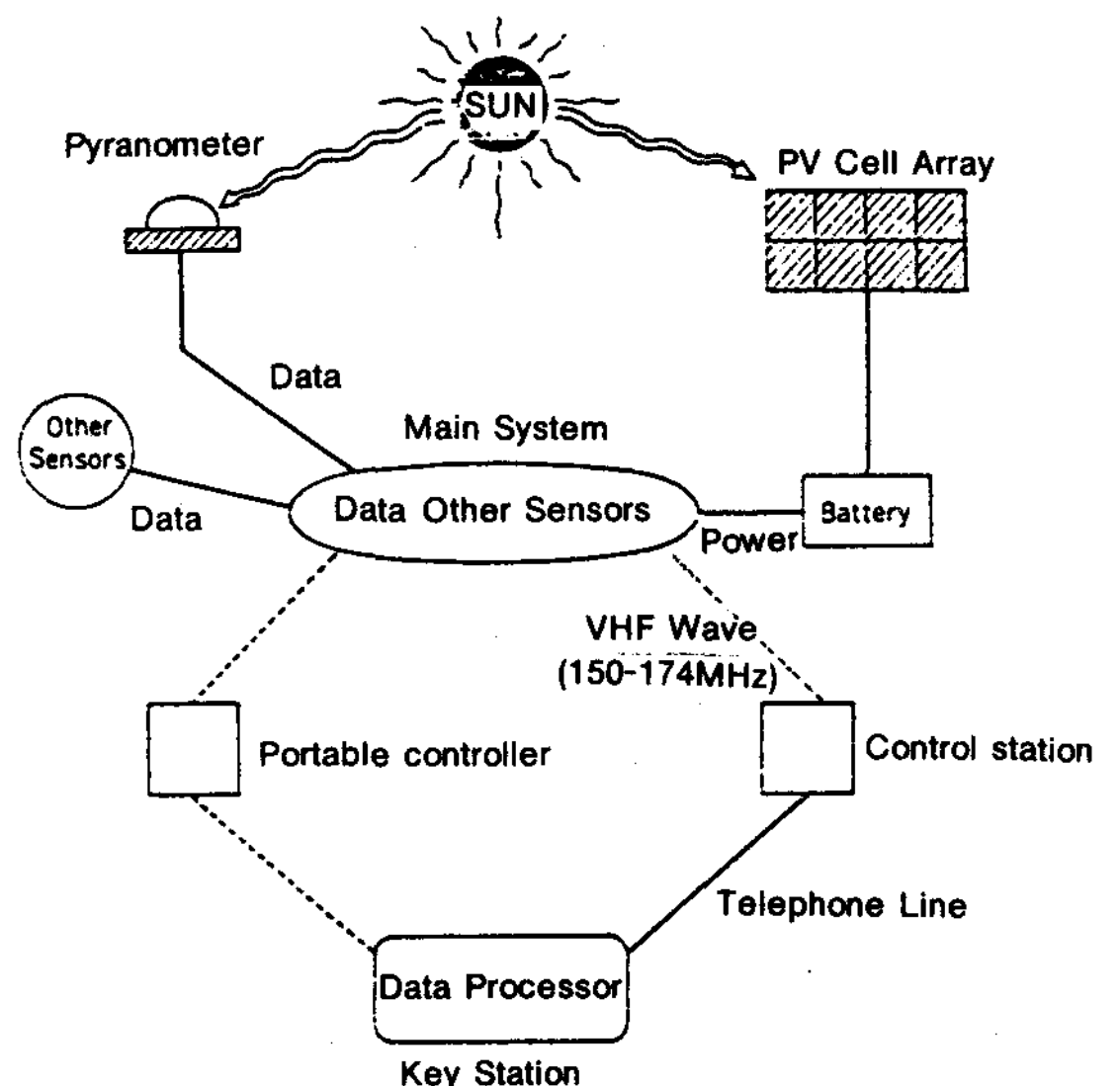


Fig.2 Schematic diagram of the HWS operating process

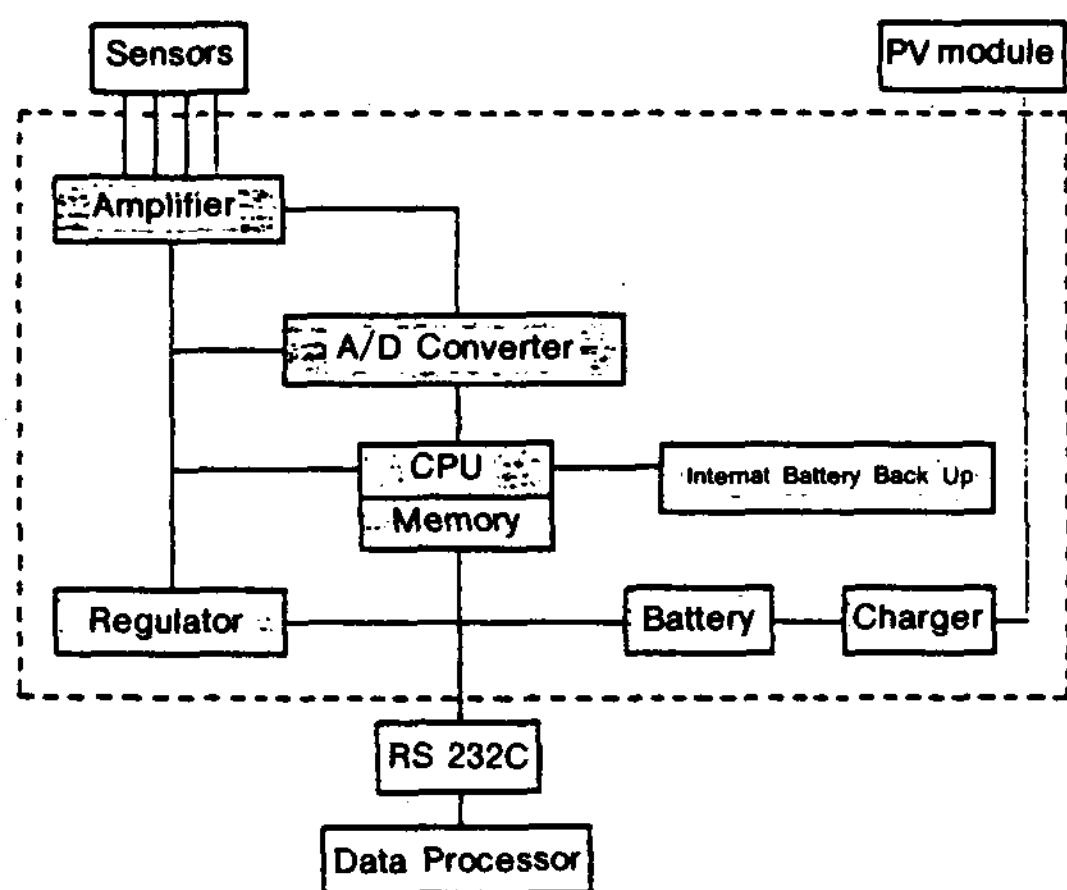


Fig.3 Schematic diagram of the KIER system operating process

rounded by the broken line have been designed at KIER. We have employed an Eppley PSP pyranometer, and a PV module(Model : GL 130 /M 65) for supplying power to a data acquisition system, which has been manufactured by ARCO Solar Company, U.S.. However, we have designed and constructed a data acquisition system for collecting and storing data.

All the specifications and operating ranges are described in detail in Table 2. We are planning to expand the memory capacity to increase the number of channels for measuring the diffuse solar radiation, the direct solar radiation and the solar radiation over a tilted surface.

Before the commencement of the experiment, both a Licor radiometer and a PSP pyranometer were calibrated in factory. In order to insure the accuracy of measured data the sensors were calibrated periodically against the standard Eppley PSP solar radiometer which was kept inside the laboratory at KIER. It has been found that there is no significant change in the calibration factors for both solar radiometers.

3. Analysis of Measured Data

While calibrating a Licor solar radiometer and

Table 2. Specification of KIER system

Components	Characteristics	Remark
Pyranometer	Linearity : +0.5%	Eppley PSP black and white pyranometer
PV module	Max.output voltage : 14.5V Max.output current : 2.9A	ARCO Solar Co. Model: GL 130/M65
Data Acquisition system	Channel: 1 Processor: Intel 8085 CMOS 8bit Input voltage: 0-20mV Memory: 8K ROM 32K RAM Rechargeable 12V, 6A battery	KIER model

an Eppley PSP at KIER, global solar radiations over a horizontal surface also have been measured outdoors. Their values have been compared to insure the accuracy of each sensor before installing them at the selected site, "Dok-do" island. Although solar radiation data measured by an Eppley PSP showed slightly higher values than by a Licor, it can be said that there is in good agreement between them.

As mentioned previously, meteorological parameters have been measured by both systems every hour for a 6-month period between October 1989 and March 1990 at the island "Dok-do". Among various climatic parameters, the weekly average global solar radiation on a horizontal surface for both systems have been evaluated from October 15, 1989 to March 31, 1990 and have been plotted in Fig.4.

Fig.4 shows marginal difference between insolation data measured by two systems. However, it is also found that solar radiation measured by a Licor solar radiometer shows higher values. The weekly average insolation data and estimated deviation also have been tabulated in Table 3.

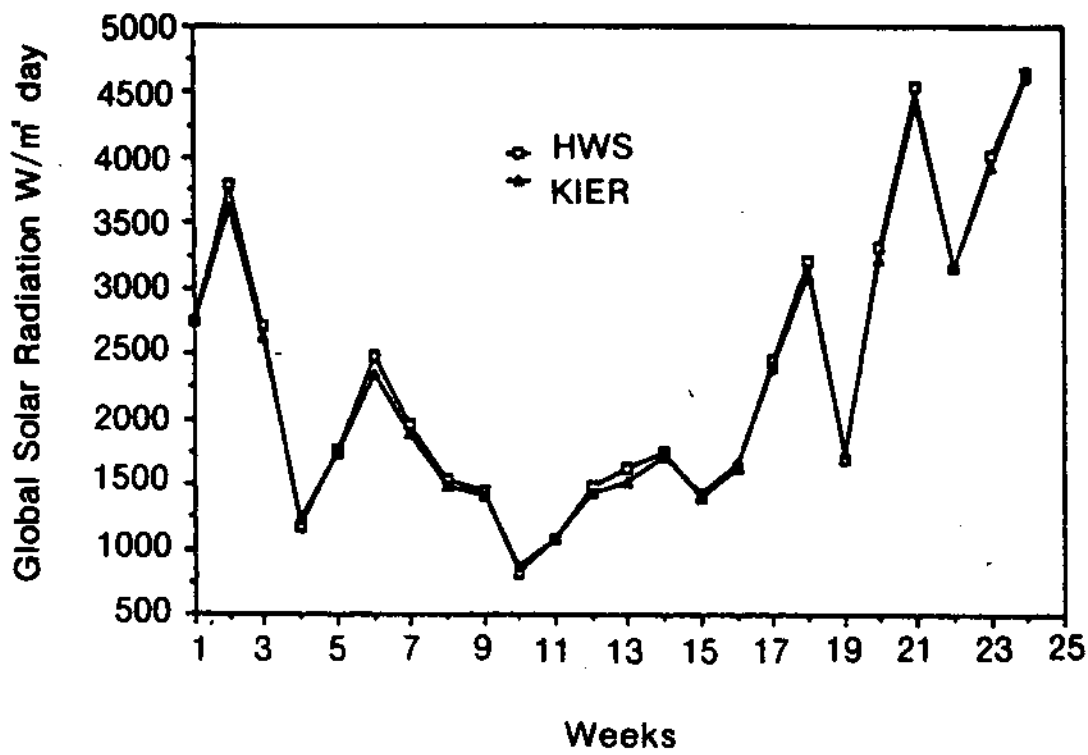


Fig.4 The weekly average solar radiation measured by the HWS and KIER systems from October 15, 1989

Table 3. Comparison of global solar radiation measured by the HWS and KIER systems

(W/m² day)			
Period	KIER	HWS	Error %
1989			
Oct.15-21	2,743	2,745	-0.7
Oct.22-28	3,618	3,790	-4.5
29-Nov.4	2,621	2,722	-3.7
Nov. 5-11	1,235	1,176	5.0
Nov.12-18	1,733	1,767	-1.9
Nov.19-25	2,340	2,494	-6.2
26-Dec.2	1,890	1,963	-3.7
Dec. 3- 9	1,489	1,543	-3.5
Dec.10-16	1,412	1,451	-2.7
Dec.17-23	877	821	6.8
Dec.24-30	1,088	1,073	1.4
31-1990	1,440	1,491	-3.4
1990			
Jan. 7-13	1,516	1,621	-6.5
Jan.14-20	1,716	1,755	-2.2
Jan.21-27	1,434	1,392	3.0
28-Feb.3	1,668	1,624	2.7
Feb. 4-10	2,402	2,443	-1.6
Feb.11-17	3,110	3,110	-3.2
Feb.18-24	1,742	1,695	2.8
25-Mar.3	3,231	3,308	-2.3
Mar. 4-10	4,403	4,535	-2.9
Mar.11-17	3,162	3,151	0.3
Mar.18-24	3,936	4,013	-1.9
Average	2,309	2,351	absolute 3.0

Monthly average solar radiation data at this island also have been compared with insolation data measured at Kangreung, Pohang, Taegu, Chuncheon stations for the same period of time in Table 4. As indicated in Table 4, monthly average solar radiation data at this island are higher than those in in-land cities for most of months except December, 1989 and January,

Table 4. Comparison of monthly average solar radiation measured for eight months. (kcal/m² day)

Month	Global Solar Radiation				Avg.	The Observation Site
	Kangreung	Pohang	Taegu	Chuncheon		
1989						
9	2,592	2,108	2,686	3,285	2,668	2,913
10	2,771	2,618	2,817	2,541	2,687	3,140
11	1,856	1,636	1,757	1,777	1,756	1,847
12	1,594	1,556	1,651	1,511	1,578	1,328
1990						
1	1,932	1,674	1,820	1,184	1,810	1,487
2	1,697	1,205	1,685	2,483	1,767	2,633
3	2,978	2,399	2,978	3,290	2,911	3,879
4	4,001	2,983	4,076	3,969	4,008	4,891
Average					2,398	2,765

1990. Moreover, a 8-month average solar radiation at this is land is higher than combined in-land average insolation for the same period of time.

Based on the results from the comparison of the measured global solar radiation data for eight months, it is possible to say that these figures characterize the potential utility of solar energy utilization systems at this island. However, it is strongly recommende that the high quality data for extraterrestrial solar radiation, diffuse solar radiation and clearness index should be provided for more detailed studies of the seasonal solar radiation under local climate conditions.

4. Conclusions

In summarizing the results obtained with regard to the global solar radiation measurement using both the HWS and KIER systems at the designated remote island "Dok-do", it may be concluded that:

1. The HWS and KIER system demonstate an excellent agreement as the average absolute error range within 3.0% between their measured solar radiations.

2. The prototype KIER system can be employed to evaluate solar energy utilization for the remote areas including islands.
 3. The monthly average global solar radiation for eight months was about $2,330 \text{ W/m}^2$ day, and it is possible to predict that the solar energy can be utilized as an alternative energy source for electric power generation and other thermal systems at this island.
 4. Since among climatological parameters, the global and diffusional solar radiation are of vital importance being the forcing functions for climate and a supplement to the more conventional and non-renewable source of energy, measurement of diffuse solar radiation as well as global solar radiation should be performed at this site for more detailed study on solar radiation and solar utilizability.
- If all successful, improved prototype system

will be installed at the other remote areas for further applied solar energy utilization research such as desalination, hydroponic system and power generation system, which consists of PV panels and wind generator in near future.

Acknowledgment

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References

1. Johnson K.E., Solar Radiation Data Sources, Applications and Network Design, Environmental and Energy Center, The University of Alabama(1978).
2. Nast P.M., Solar Energy, 31(1983), 279.

ABSTRACTS

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Experimental Studies for Solar Drying System of Agricultural Products(I)

—Solar drying characteristics for radish—

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Experiments for drying radish were carried out to analyze the drying characteristics and quality evaluation between solar heated-air drying and natural air drying system. Solar heated-air drying system consists of a small fan, a solar air heater and a tunnel dryer.