RECENT DEVELOPMENTS IN THE ACQUISITION AND PROCESSING OF SOLAR RADIATION DATA IN CYPRUS. RESULTS AND FUTURE ACTIVITIES

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ABSTRACT

The work of the Meteorological Service to set up a network of stations to collect radiation data is described. Data on the radiation characteristics of Cyprus are presented.

THE ACTIVITIES AND CONTRIBUTION OF THE METEOROLOGICAL SERVICE IN THE SECTOR OF RENEWABLE ENERGIES

The Meteorological Service of the Ministry of Agriculture and Natural Resources is actively involved in national programmes on the development of solar and wind energy. Its main responsibility is to secure the collection of the relevant meteorological data and the processing of these data for various applications and studies.

The Service plays an important part in the selection of suitable instruments and their proper installation, operation and maintenance, including calibration of radiation instruments.

At the beginning of 1985 the Meteorological Service was collecting radiation data at seven locations, sunshine duration data at 12 locations and wind data at 17 locations. Further improvements in this network of stations are under consideration.

The data collected at these stations are processed and published regularly and statistical summaries prepared.

THE RADIATION CENTRE

Early in 1984 a key prerequisite for the collection of reliable solar radiation data had been fulfilled. A radiation centre was established near Nicosia. It includes the necessary instrumentation for establishing national standards for calibration purposes.

There are three pyranometers for global and diffuse irradiation on a horizontal surface and global irradiation on an inclined surface, one net radiometer for radiation balance on a horizontal surface and one sunshine recorder. The reference instruments are a pyranometer and a net radiometer.

The various radiation components are measured hourly. Other meteorological parameters are measured at the site of the centre. Robitzsch bimetallic actinographs are operated at six locations recording daily global irradiation on a horizontal surface.

In 1984 a schedule for the testing and calibration of the radiation instruments was introduced. Radiation equipment is at the radiation centre and instruments at the outstations are tested and calibrated once a year against the standard instruments at the radiation centre. The calibration period for each instrument is at least two weeks.

The existing network of radiation stations is considered satisfactory for the basic needs. However, for special applications and studies additional data are required.

PROCESSING OF THE RADIATION DATA

The radiation components measured at the radiation centre are integrated and printed on an hourly basis. The hourly values are entered into special forms and the daily totals and the hourly means are extracted manually. Sunshine duration records are analysed on an hourly basis.

Planimetric computation of data from the bimetallic actinographs is done manually. The relevant data are fed into an electronic computer for the calculation of the daily totals and means.

RESULTS AND OTHER RELEVANT CALCULATIONS

Existing radiation data and other relevant parameters are summarised in Table 1. Calculated parameters were produced using the guide lines provided during the training workshop held in Seychelles in 1983.

Clear days

Using an Angstrom Compensation Pyrheliometer the hourly values of direct irradiance at normal incidence in Nicosia were measured on carefully selected clear days in each month. Subsequently the hourly values of direct irradiation on a horizontal surface and on surfaces inclined 35° and 50° to the horizontal and a vertical surface facing the Equator were calculated.

The daily diffuse irradiation on a horizontal surface was found from the known values of the global and direct irradiation. Using isotropic approximation for the diffuse irradiation the daily totals of the diffuse and global irradiation were calculated for the above mentioned inclined surfaces. Their ratios were calculated in relation to those on a horizontal surface.

Using measured values of direct irradiance at normal incidence on clear days and the algorithm relating these values to the extraterrestrial irradiance at normal incidence, the Linke turbidity factor was calculated. The arithmetic mean of the calculated hourly Linke turbidity factor varies from 2.7 in January (mid-winter) to 4.0 in July (mid-summer).

The global irradiation on a horizontal surface on clear days varies from 3.2 KW.H/m^2 (11.5 MJ/m^2) in December to 7.9 KW.H/m^2 (28.6 MJ/m^2) in June.

The diffuse irradiation on a horizontal surface on clear days varies from 13% of the global in June to 21% of the global in December.

The ratio of the global irradation on horizontal surface on clear days to the irradiation at the top of the atmosphere is about 0.70, defining in this way the value of the sum of the regression constants a and b in the Angstrom formula for this set of data.

The calculated amounts of global irradiation falling on various inclined surfaces facing the Equator (using isotropic approximation for the diffuse irradiation and not taking into account the ground reflected radiation) showed that for Cyprus,

at latitude 35°N, the optimum tilt angle, in the sense that a surface receives the maximum possible global irradiation, varied from nearly zero degrees in June and July to 55° in December.

For the cold period of the year an inclination of 50° to the horizontal is the best angle for fixing flat plate solar collectors, which are widely used in Cyprus for water heating. On clear days in December the amount of the global irradiation on a surface inclined 50° to the horizontal and facing south is nearly 6 KW.H/m^2 (21 MJ/m^2) and corresponds to 184% of the global on a horizontal surface. In June the corresponding value is 69%.

A vertical surface facing the Equator receives global irradiation which varies from about 162% of that received on a horizontal surface in winter to about 17% of that received on a horizontal surface in summer.

For vertical surface facing the Pole the corresponding values are about 10% in winter and 15% in summer and for vertical surfaces facing East or West these are about 52% in winter and 42% in summer.

Overcast days

The amount of overcast sky diffuse irradiation on a horizontal surface was calculated at about 0.7 KW.H/m^2 (2.5 MJ/m^2) in mid-winter to 1.6 KW.H/m^2) in mid-summer. This accounts for 14% of the irradiation at the top of the atmosphere. The value of 0.14 corresponds to the regression constant a in the Angstrom formula.

From this value and from what has been mentioned about the sum of the constants a and b it is concluded that the regression constants in the Angstrom formula for this set of data are a = 0.14 and b = 0.56.

Average weather conditions

In the plain areas of Cyprus the mean daily sunshine duration varies from about 5.5 hours in mid-winter to 12.5 hours in mid-summer or 55% to 85% of the astronomical day length, respectively.

With these climatic conditions the mean daily global irradiation on a horizontal surface varies from about 2.2 KW.H/m^2 (7.9 MJ/m^2) in mid-winter to 7.2 KW.H/m^2 (25.9 MJ/m^2) in mid-summer.

On high ground the corresponding values for sunshine duration are about 4 hours and 11 hours, respectively and for global irradiation 1.8 KW.H/m^2 (6.5 MJ/m^2) and 6.4 KW.H/m^2 (23.0 MJ/m^2), respectively.

Measurements carried out during 1984 at the radiation centre in Nicosia gave the following results. Global irradiation varied from 2.1 KW.H/m^2 (7.5 MJ/m^2) in November to 7.4 KW.H/m^2 (26/6 MJ/m^2) in June. Diffuse irradiation was as low as 13% of the global in September and as high as 46% of the global in March when hazy conditions prevailed. Global irradiation by a pyranometer inclined at 50° to the horizontal and facing the Equator varied from 77% of the global on a horizontal surface in June to 186% of the global on a horizontal surface in December. Radiation balance on a horizontal surface measured with a net radiometer varied from 1.4 KW.H/m^2 (5.0 MJ/m^2) in mid-winter to 4.0 KW.H/m^2 (14.4 MJ/m^2) in mid-summer. The radiation balance was about 60% of the global irradiation on a horizontal surface.

The regression analysis of the radiation data collected at a coastal station at an elevation of 45m in the period May 1982 to April 1983 gave the following values for the regression constants in the Angstrom formula:

$$a=0.16,\ b=0.56,\ a+b=0.72,\ \text{corr.} = 0.966$$

The analysis of data collected during 1984 gave the following results. For the radiation centre, an inland station in the central plain at an elevation of 155m:

$$a=0.19,\ b=0.49,\ a+b=0.68,\ \text{corr.} = 0.883$$

For an inland station on the mountains at an elevation of 640m:

$$a=0.15,\ b=0.55,\ a+b=0.70,\ \text{corr.} = 0.985$$

For another inland station in the mountains at an elevation of 1380m:

$$a=0.10,\ b=0.67,\ a+b=0.77,\ \text{corr.} = 0.978$$

APPLICATIONS AND FUTURE ACTIVITIES

Solar radiation data and other relevant information are extensively used in developing flat plate solar collectors which are widely used in Cyprus for water heating for domestic purposes, for pre-heating/heating of water for boilers in hotels and for heating the water in swimming pools. Passive architecture is another sector in which information on solar radiation are applied. Radiation data are also applied in the methods for estimation of the water requirements of crops.

Future activities include the improvement of the network of radiation stations and the systematic development of radiation statistics including radiation on inclined surfaces. The Meteorological Service will participate in a government project on renewable energy/energy conservation.

CONCLUSIONS

The radiation centre has now been established and the calibration of the radiation instruments are carried out regularly. Through measurements at the centre itself and a basic network of radiation stations routine data are made available on solar radiation in Cyprus on a daily and monthly basis. Achievements have been satisfactory and provide the basis for the further development and improvement of radiation statistics for Cyprus.

TABLE 1 - Solar radiation data for Cyprus (based on data for 1984)

Parameter	Mid-Winter		Mid-summer	
On clear days				
Global	11.5	MJ/m^2	28.6	MJ/m^2
Diffuse/Global	21%		13%	
Global/Extraterrestrial	0.70		0.70	
Global (Incl. 50^o, S)/Global	1.84		0.69	
Linke Turbidity Factor	2.7		4.0	
On overcast days				
Diffuse (calculated)	2.5	MJ/M^2	5.8	MJ/m^2
Diffuse/Extraterrestrial	0.14		0.14	
Average weather				
Global	7.9	MJ/m^2	25.9	MJ/m^2
Sunshine Duration	5.5 hr	(55%)	12.5 hr	(85%)

Regression analysis

Station	Elevation (m)	a	b	a+b	Corr.
Akhelia-Western coast	45	0.16	0.56	0.72	0.966
Nicosia-Inland, plain	155	0.19	0.49	0.68	0.883
Saittas-Inland, mount.	640	0.15	0.55	0.70	0.985
Prodhromos-Inland, mount.	1380	0.10	0.67	0.77	0.978