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SOLAR RADIATION MEASUREMENTS FOR THE FUTURE ASSESSMENT OF SOLAR POWER GENERATION

by

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A Submission to the Minister of Science in response to the Green paper entitled 'Towards new perspectives for Australian Meteorological Services'.

SCOPE. This submission concerns the activities of the Bureau of Meteorology in the measurement of solar radiation and subsequent processing and recording of the data.

The interest of the group I represent stems from the group's research into methods of generating power from solar energy, methods which we believe are close to being economically viable for some remote townships and which will be generally viable in a few decades.*

Several properties of solar radiation are currently measured in a selection of localities. However these properties are not altogether suitable for use in assessing proposals for generating solar power.

USEFUL MEASUREABLE PROPERTIES OF SOLAR RADIATION. The total radiation intensity received at a point on the earth's surface is called 'global' radiation. It is divided into two components: 'direct' radiation which is that part which travels in a straight line from the sun, and 'diffuse' radiation which is that part coming from the sky and clouds.

Global radiation is currently measured by the Bureau in a number of localities and, in a less number, the diffuse component. However the direct component is not measured anywhere by the Bureau.

It is theoretically possible to compute the direct component from the global radiation and diffuse component. We in this group have done this in special instances but, following my representations to the Bureau, there is now hope that computed estimates of direct radiation will become generally available from this source. However, due to the compounding of the small errors in individual measurements, and the nature of the mathematical formulae, it is not possible to compute accurate values of direct radiation: the Bureau's own estimate of the error ranges up to 12% for clear skies and is above this for cloudy days including a systematic error which the Bureau states would not be feasible to correct.

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* The work of the group is described in a recent submission to the Senate Standing Committee on National Resources entitled 'Mass Utilization of Solar Energy'.

The only way to avoid these inaccuracies is to make specific measurements of direct radiation using sun-tracking pyrheliometers.

In addition to the several components of radiation described above there are several methods of processing and recording the data. The current method, which we will refer to as long interval integration, is to sum the radiation over prescribed intervals, e.g. each half hour, and thus present data effectively as an average radiation over the summing interval.

A difficulty often arises with data presented in this fashion due to the fact that the degree of variation in radiation during the summing interval is lost. In order to overcome this difficulty several alternative methods of effective continuous recording may be employed:

(a) The summing time may be reduced to a few seconds. This enables the recording of all significant variations since it is found that actual radiation does not alter greatly during intervals shorter than this. This method is referred to as short interval integration.

(b) Instantaneous samples of radiation are measured and recorded at regular short intervals of a few seconds. This is called continuous sampling.

(c) The time and appropriate level at which the monitored radiation equals one of a set of predetermined levels are recorded. The number of these predetermined levels is selected as a result of compromise between considerations of cost and accuracy of interpretation of the resulting data. For example a choice of 20 equally spaced predetermined levels might be expected to yield an acceptable 5% accuracy of interpretation. This method is referred to as event recording.

METHODS OF PRODUCING SOLAR POWER AND CONSEQUENT REQUIREMENTS FOR SOLAR RADIATION MEASUREMENTS. There are several current proposals for generating power from solar energy that are close to being economically viable particularly for remote townships

where present energy costs are much higher than those in metropolitan areas. These proposals are as follows:

(a) Direct radiation from the sun is collected by means of an array of steerable mirrors and transformed to high temperature heat. This in turn is used to produce steam and generate power in the conventional manner.

(b) Direct radiation from the sun is collected as before and transformed into electricity by means of high intensity solar cells.

In addition, a break-through in production methods for ordinary solar cells could reduce their price to the point where an additional method is viable.

(c) Direct radiation from the sun together with radiation from the sky and clouds is collected and converted to electricity by a stationary array of low intensity solar cells.

In order to make an economic assessment of any one of these proposals it is necessary to have reasonably accurate estimates of appropriate properties of solar radiation for the selected site over a period of about ten years. Such estimates could be inferred from actual measurements taken at nearby meteorological stations.

The properties required to be measured for each of the above power generation methods are, for:

(a) The direct component of radiation using long interval integretion, or preferably short interval integration (interval about 5 minutes or less). Continuous sampling at 5 second intervals and 20 level event recording would also be satisfactory.

(b) The direct component of radiation using short interval integration or continuous sampling at no greater than 5 second intervals; or 20 level event recording.

(c) Global radiation using short interval integration or continuous sampling at no greater than 5 second intervals; or 20 level event recording.

In this case it would be valuable to measure global radiation on both a horizontal surface and an inclined plane as is often done at present.

The reasons for these requirements are simply that for (a) and (b) the mirror collectors do not collect the diffuse component and for (b) and (c) the solar cells respond instantaneously to changes in radiation intensity. In the latter case for each level of intensity there is an optimum matching load resistance. Therefore the design of an installation employing solar cells involves the selection of an optimum configuration for the interconnection of the cells and the load. This may involve switching between configurations as the intensity of radiation changes. In either case the optimum configurations cannot be determined from average radiation alone as would be determined by long interval integration recording.

URGENCY. Since solar radiation is apt to vary in pattern from year to year, it is necessary to refer to measurements over a period of about ten years in order to make reasonably accurate assessments of solar power generating proposals. Therefore measurements begun now will enable good assessments to be made in a decade from now. Delays in commencing appropriate measurements will result in further delaying the time before which it will be virtually impossible to make an unambiguous assessment of any proposal for solar power generation.

RECOMMENDATIONS. The Bureau should be appropriately financed to enable, as soon as possible, the extension of the existing solar radiation measuring network in several (for example, 10) selected stations to include in each the following instruments:

(a) Tracking pyrheliometer for measuring the direct component of radiation;

(b) Recorder(s) to enable recording of the data from the tracking pyrheliometer and the existing global radiation pyranometers (horizontal and inclined) using either:

short interval (5 second) integration;
continuous sampling (5 second interval);
event recording (20 levels).

A rough estimate of the cost of this equipment would be $5,000 per station.

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