III. VALUE OF LONG-TERM SOLAR RADIATION DATA

Long-term solar radiation data sets are scarce due to the considerable effort and expense of data gathering. Long-term (30-year) solar radiation data sets, as with other meteorological databases, are desired to comprehensively describe the trends and variability of the solar resource. The required minimum length of a solar data set depends upon the questions one needs answered.

The utilizability of 5, 15, and 30-year solar radiation data sets is summarized as follows.

- 5-year data sets determine the long-term average solar radiation with a fair degree of accuracy, but do not contain enough information to accurately represent the variations from year to year.
- 15-year data sets start to show patterns and trends in solar radiation. Statistically these variations are complex and do not follow a simple bell shaped curve of a random distribution.
- 30-year data sets are needed to describe the relationship between solar and other renewable resources with a high degree of statistical confidence.

In this section, examples are taken from the UO Solar Monitoring Network's solar radiation data base to illustrate the capabilities and limitations of a 5-year data set, show why a 15 year data set is required, and explain why a 30 year data set is desirable to accurately describe the variability of the solar resource.

Monthly averaged direct normal beam radiation data are used because beam radiation is a very good indicator of the amount of useful energy that a solar energy system can collect. The variations of monthly average beam radiation in July and December are analyzed.

Utility and Limitations of 5 Years of Data

The example in Fig. 2 plots 20 years of average December beam data from Eugene, Oregon. This figure demonstrates the limitations of a 5-year data set in describing the average monthly solar radiation. Groups are separated into 3 groups of 5 years and 1 group of 4 years. Each "block" represents a given year's monthly average beam irradiance. For example, over the 20-year period plotted in Fig.2, four Decembers had an average beam intensity of about 0.5 kWhr/m^2 per day. Calculating the 5-year average within each group produces 5-year averages that are within 15% to 20% of the 20-year December average. This is fair agreement considering average beam intensity for a given December can differ by a factor of two from the long-term average.

While a 5-year data set approximates the

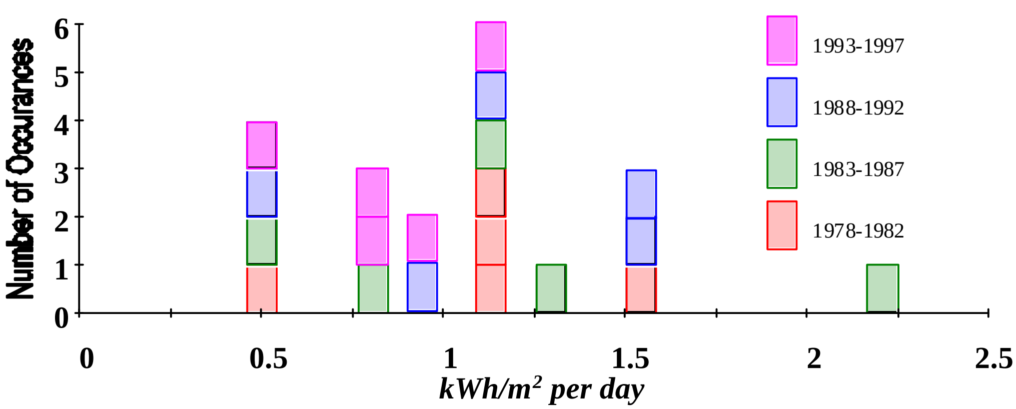

Fig. 2: Monthly Average December Beam Insolation for Eugene, Oregon. Each block represents the monthly average data for one given year. Cross hatching seperates the data into 5 year periods

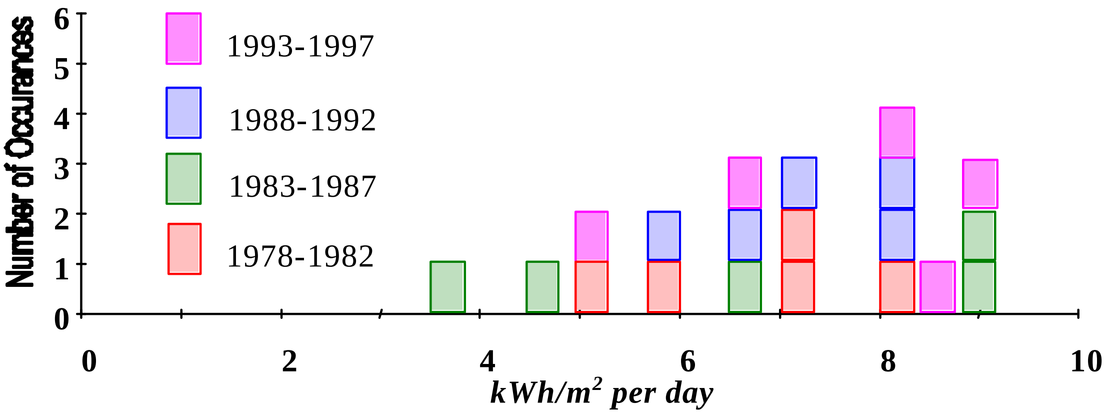

Fig. 3: Average July Beam Insolation for Eugene, Oregon

long-term average with a useful degree of accuracy, it does not characterize the observed year to year variations. The frequency distribution of monthly average July and December beam data are shown in Figs. 2 and 3 for 20 years of beam data from Eugene, Oregon.

Table 1: Variation of Burns Beam Data Values in $kWhr/m^2$ per hr

Period/ Month	1979-1983	1984-1988	1989-1991	1993-1997	Ave.
July	8.38	9.12	9.11	9.32	8.98
Oct	4.37	5.67	5.31	5.44	5.20
Dec.	1.80	2.52	2.94	2.25	2.38

None of the 5-year data sets reflect the frequency of occurrences observed in the 20-year data sets.

Another site with long-term data is Burns, Oregon. Table 1 shows the variation of selected periods with the 18-year average. Five-year averages are within 5 to 7% of the 18-year average. That means that if solar radiation was measured for 5 years in an area similar to Burns, the available incident beam solar radiation could be estimated to within 5-7% in July. In October, 5 years of measurements enables an estimate of the average beam irradiance to within 10 to 15%. In December the uncertainty is up to 20%.

Utility and Advantages of 15 Years of Data

Fifteen-year data sets accurately estimate the long-term average beam irradiance. With three times the amount of data, the uncertainty of the monthly average should drop by nearly

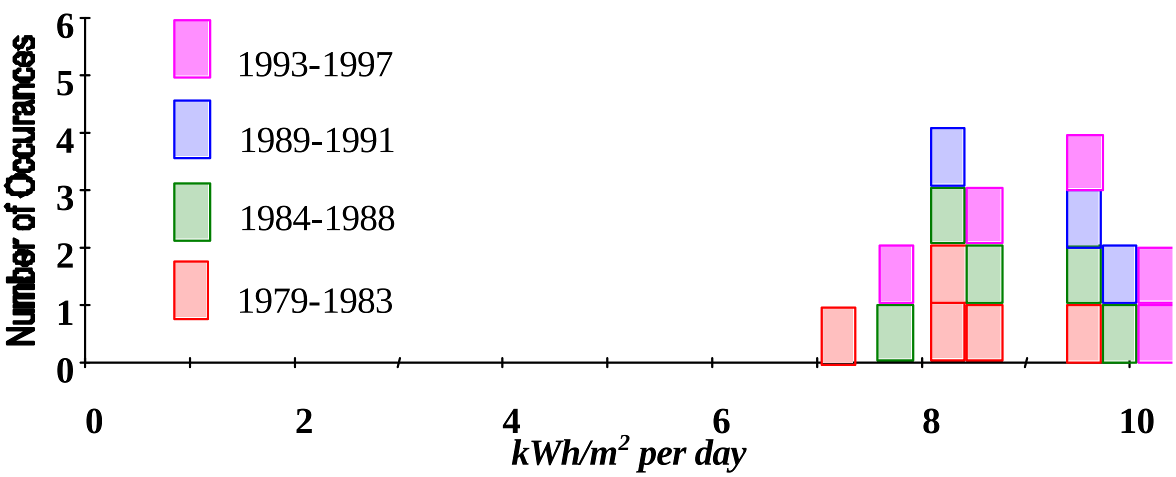

Fig. 4: Average July Beam Insolation for Burns, Oregon

a factor of two. A 30-year data set would reduce the uncertainty by another 40%.

Figs. 4 and 5 plot 18 years of monthly average July and October beam data for Burns, Oregon. The year to year variability of the solar resource is clearly shown in these figures. While it is possible to get monthly average solar radiation values outside the range indicated by the figures, such extremes would not occur frequently and would be expected to have values close to extreme values plotted in the figures.

Most meteorological variable such as temperature are averaged over 30 year to obtain reliable averages. The long-term averages are necessary because there is a need to average over a number of cyclic events such as El Niños that occur every 3 or 4 years.

Rainfall records in Oregon suggest that there may even be a 40-year cycle for rainfall, twenty years of plentiful rainfall, and twenty year of relative drought. Since rainfall and solar radiation are inversely related, it may take a 40-year record to cover one complete weather cycle.

Other Considerations

Just as stream flow data are important for operating the hydroelectric system in the region, solar data is important in operating solar electric facilities. When assessing the value of a long-term solar radiation database, one can compare it to the value of stream flow data.

As solar energy starts to contribute to the region's energy mix, the inverse correlation between rainfall and solar radiation needs to be thoroughly characterized. It will be important to coordinate the operation of all electrical generating facilities in order to optimize the region's electricity production. Proper planning and the appropriate mix of renewable resources require knowledge of dependability of the resource and how the resources can augment one another. This requires a long-term solar radiation database.

It is unrealistic to say that every solar facility will need 15 to 30 years of data before it is built. Selected reference sites with long-term databases will enhance the ability of nearby sites with short-term (3 to 5 years) data sets to adequately characterize the solar resource at potential facility locations.

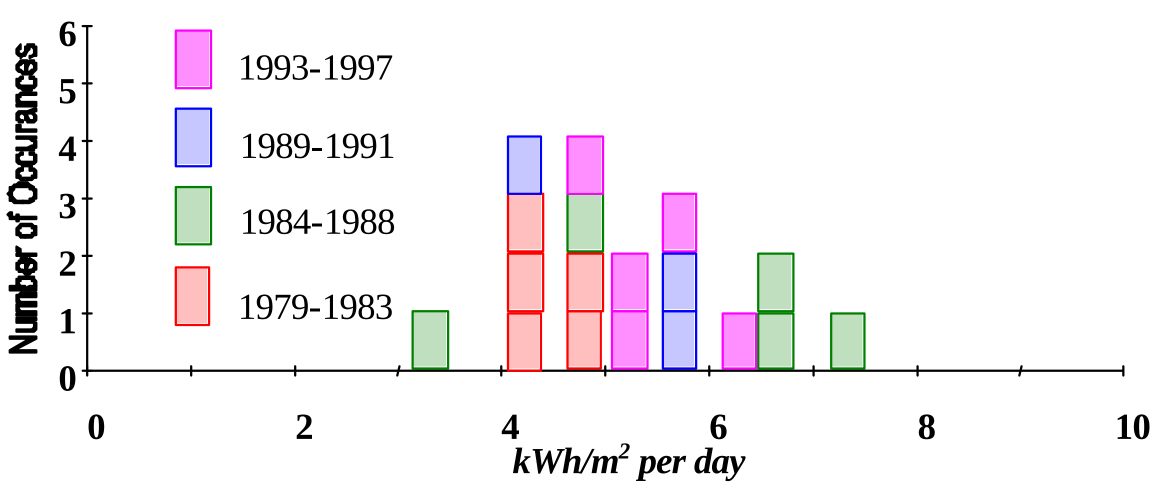

Fig. 5: Average October Beam Insolation for Burns, Oregon.
A different view of the same data is shown on page 38.