VII. SOLAR RADIATION DATA COMPARISONS

In this section some of the solar radiation data gathered by the UO Solar Monitoring Network is presented in tabular and pictorial form and related to similar information from other Western U.S. sites. A comparison of the amount of incident solar radiation is made using Whitehorse Ranch as a reference. Both annual totals and the sums for the winter heating season are presented in Table 8, which also includes data from Seattle, Albuquerque, Phoenix, and Ely (Nevada). The estimated (1961-1990) solar radiation values for these four sites come from the National Solar Radiation Data Base (NSRDB). The same information is presented graphically in Figs. 11 and 12. As would be expected the sites in the Southwest receive more sunshine on an annual basis than do the sites in eastern Oregon.

Table 8. Comparison of global solar radiation at Whitehorse Ranch (WH) with other selected stations.

Station	Year	Annual Totals		Winter Heating Season†	
		kWh/m^2	Station/WH	kWh/m^2	Station/WH
Burns, OR	1979-97	1598	1.00	447	0.96
Coeur d'Alene, ID	1982-86	1246	0.78	278	0.60
Eugene, OR	1975-97	1331	0.84	336	0.72
Hermiston, OR	1979-97	1499	0.94	364	0.79
Hood River, OR	1984-88	1403	0.88	323	0.70
Kimberly, ID	1980-97	1629	1.02	470	1.01
Portland, OR	1980-85	1207	0.76	307	0.66
WH Ranch, OR	**1977-85**	**1592**	**1.00**	**463**	**1.00**
Albuquerque, NM	1961-90	2035	1.28	726	1.57
Ely, NV	1961-90	1795	1.13	595	1.29
Phoenix, AZ	1961-90	2096	1.32	744	1.61
Seattle, WA	1961-90	1220	0.77	295	0.64

† *The winter heating season runs from October through March.*

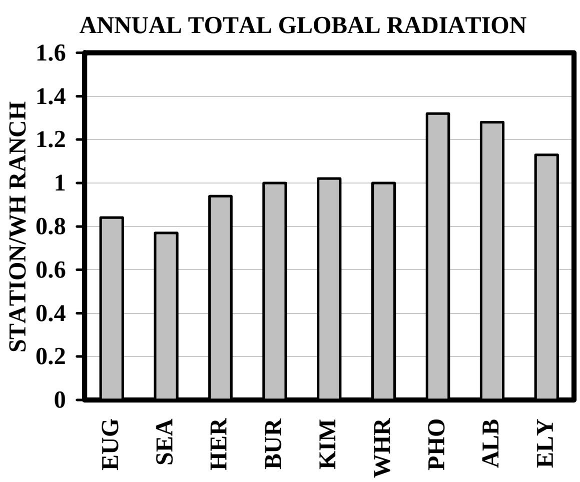

Fig. 11: Comparison of the annual global irradiance at Whitehorse Ranch with that received at other selected stations.

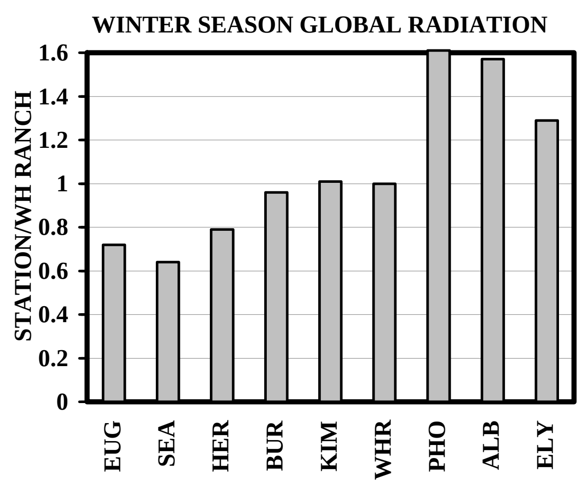

Fig. 12: Comparison of the global irradiance at Whitehorse Ranch over the winter heating season with winter global irradiance received at other selected stations.

A number of important conclusions can be drawn from the above comparisons of global data:

1. The solar radiation patterns for Whitehorse Ranch, Burns, and Kimberly are quite similar over the entire year.
2. While the solar energy received in Seattle, Eugene, and Portland during the winter heating season is less than that incident upon sites east of the Cascades, the amount of backup heating for a passive solar building is about the same in the two regions. This is because the average temperature east of the mountains is considerably cooler in the winter.
3. Solar water heating is about as economical in the PNW as in any other region in the country. For this application it is the annual solar radiation that matters. A solar domestic water heating system in the Northwest can easily provide the same proportion of the annual hot water needs as in the Southwest by utilizing a slightly larger collector area. Since the cost of a typical solar water heating system does not vary much with the collector area (in sharp contrast to active solar space heating systems), the cost of the solar water heating systems remains about the same.

Beam Radiation

Next let us compare the amount of direct beam solar radiation incident at the UO solar monitoring stations with that received at Medford, Ely, Phoenix, Daggett, and Albuquerque. Data from Daggett, California allows us to compare the beam solar intensity from our eastern sites with that received by the 10 MWe solar tower facility at Barstow. The solar radiation information for all 9 locations is tabulated in Table 9. Both the annual totals and the results for the 6 summer months are listed and compared with the results from Whitehorse Ranch. It should be noted that over 90% of the values in the NSRDB are estimated from cloud cover observations. Small systematic errors have been found in the NSRDB data base [1].

Table 9. Comparison of beam radiation at Whitehorse Ranch with other selected stations.

Station	Year	Annual Totals		Summer Totals†	
		kWhr/m^2	Station/WH	kWhr/m^2	Station/WH
Burns, OR	1979-97	1958	1.02	1334	1.02
Coeur d'Alene	1982-86	1265	0.66	1001	0.77
Eugene, OR	1978-97	1318	0.68	972	0.74
Hermiston, OR	1979-97	1725	0.90	1285	0.98
Hood River, OR	1984-88	1534	0.80	1192	0.91
Kimberly, ID	1980-85	1845	0.96	1277	0.98
Portland, OR	1980-85	1106	0.57	815	0.62
WH Ranch, OR	**1979-85**	**1924**	**1.00**	**1308**	**1.00**
Albuquerque, NM	1961-90	2445	1.27	1378	1.05
Daggett, CA	1961-90	2726	1.42	1605	1.23
Ely, NV	1961-90	2181	1.13	1309	1.00
Medford, OR	1961-90	1715	0.89	1277	0.98
Phoenix, AZ	1961-90	2481	1.29	1445	1.10

†*Summer totals include the months of April through September*

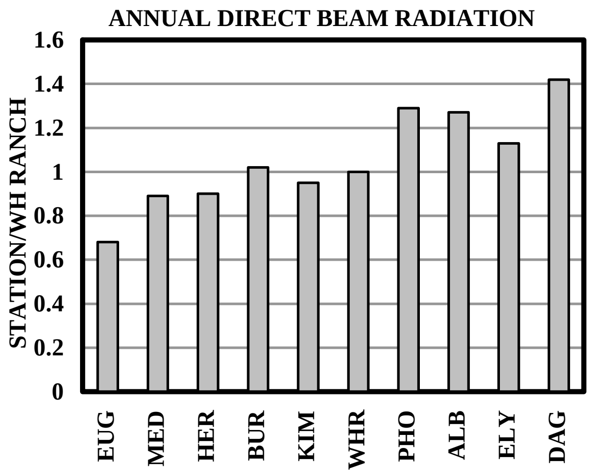

Fig. 13: Comparison of annual beam irradiance at Whitehorse Ranch with that received at other selected stations.

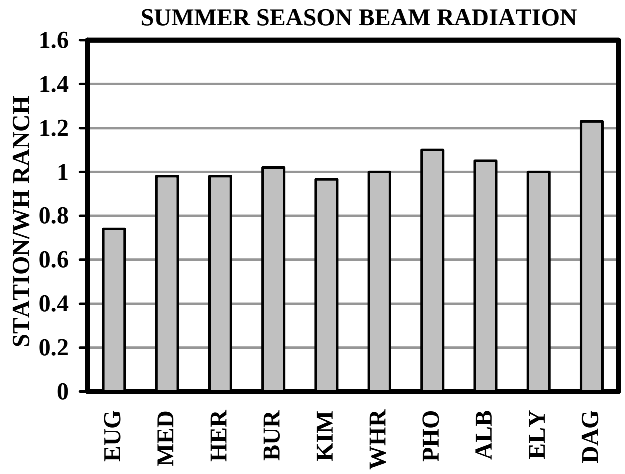

Fig. 14: Comparison of beam irradiance at Whitehorse Ranch over the 6 summer months with that received at other selected stations.

The beam comparison is presented graphically in Figs. 13 and 14. In these figures the ratio of the solar radiation received at a given site is plotted against the same quantity at Whitehorse Ranch. The sunnier sites are represented by the taller bar graphs.

From Table 9, the two associated figures, and the annual averaged data several important conclusions can be drawn:

1. The annual beam solar radiation intensities received at Burns, Whitehorse Ranch, and Kimberly are about the same.
2. A similar statement can be made about the beam solar radiation received at these three sites during the summer. This points out the similarities in their beam solar radiation patterns.
3. The annual direct beam solar radiation fluctuations from year to year are about the same as those observed over the summer months. However, the size of the fluctuation points out the need for many years of data gathering.
4. The annual amount of beam solar radiation incident upon southeastern Oregon is between 70% to 85% of that incident upon the California-Arizona desert region, where the 10 MWe Barstow central tower demonstration plant is operating.
5. The solar radiation incident at Whitehorse Ranch during the 6 summer months is 80% to 90% of that striking the Southwest.

The frequency distribution of the beam solar radiation indicates the type of fluctuations that would be encountered by a solar electric plant. We have made a first step in this direction by evaluating the percentage of time that the solar intensity lies within a small energy interval.

The distribution of hourly values of the direct beam solar radiation at Whitehorse Ranch is shown in Fig. 15. Because of the large amount of data (7122 effective daylight hours), the curve is very smooth with a strong peak at the clear day point corresponding to the standard solar constant of 950 watts/m^2. It is satisfying to note that just over 60% of all effective daylight hours at Whitehorse Ranch have solar radiation values over 1600 KJ/m^{2}hr (or 450 W/m^2). Considering that there are many poor days in the winter at Whitehorse Ranch – essentially 9% of all winter days have extremely low values of solar radiation – this number of 60% is even more impressive.

It tends to indicate that the variations in solar radiation during the better days are not too extreme. Naturally, this question needs further study. Another interesting fact determined from this figure is that 90% of all energy incident at Whitehorse Ranch is greater than 450 W/m^2.

Potential solar sites in eastern Oregon and southern Idaho are sufficient to provide the electrical generating equivalent of more than 100,000 average Megawatts

The Pacific Northwest is fortunate in having a considerable area east of the Cascades that has a large annual flux of solar radiation, and which is not suitable for other uses. Potential solar sites in eastern Oregon and southern Idaho are sufficient to provide the electrical generating equivalent of more than 100,000 average Megawatts. This is about 10 times the amount of electricity output by the Bonneville system.

The solar radiation data now being taken by the UO Solar Monitoring Network will provide the database needed to establish solar electric generating plants in the future. Previous to our data, it was estimated that the annual direct normal beam radiation incident in southeastern Oregon was about 2/3^{rds} (or less) than the solar radiation in the southwestern portion of the United States. This low estimate was used in one study to conclude that the best approach for the Pacific Northwest would be to import solar electricity from the desert areas of California or Arizona where the average solar radiation is higher. Now we see that these early estimates were too low. An important goal of the solar radiation monitoring program is to obtain a more precise measurement of the annual beam radiation east of the Cascades. This information, coupled with statistical analysis of the short and long term fluctuations in intensity, will provide the data needed to design solar electric facilities for the area.

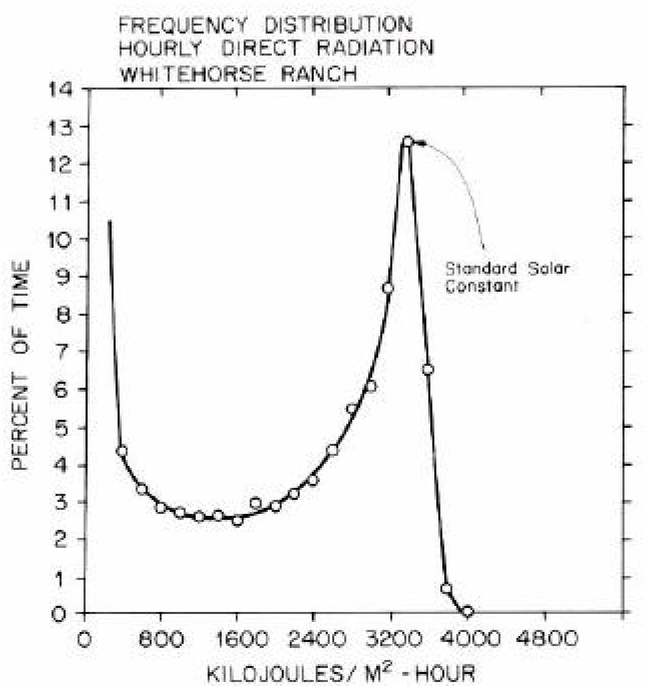

Fig. 15: Distribution of hourly direct beam solar radiation at Whitehorse Ranch. Each point is plotted at the top of a 200 KJ/m^{2}hr interval. The data covers a consecutive period of two years from November 1, 1979 to October 31, 1981.

Reference

1. F. Vignola, Testing of the METSTAT Model. **Proceedings of the 1997 Annual Conference of the American Solar Energy Society, Inc**., Washington D.C., 287-292 (1997).