II. HISTORICAL BACKGROUND

Since 1977 the University of Oregon Solar Monitoring Laboratory has operated a solar radiation monitoring network in the Pacific Northwest. The number of stations participating in the network fluctuated over the years depending on the level of funding. In 1994, a consortium of utilities headed by the Eugene Water and Electric Board initiated the Regional Solar Radiation Monitoring Project (RSRMP) that revitalized the region's solar monitoring efforts. EWEB, Bonneville Power, Idaho Power, PacifiCorp, and PGE are the founding members of the consortium. NREL is also participating in the project since solar radiation data from the UO Solar Monitoring Network have been included in the National Solar Radiation Data Base.

First the history of the original UO Solar Monitoring Network is given followed by a description of the current network and a discussion of the motivation for the RSRMP.

Early History

In 1977, a 5 station global network was established under the auspices of the Pacific Northwest Regional Commission. These five stations were equipped with Schenk pyranometers and integrating chart recorders to facilitate hand analysis of the data. Formation of the network was motivated both by the lack of available solar radiation data around the region and by the large inaccuracies commonly found in older data due to instrumental deficiencies and poor calibration procedures. In preparation for the network, global monitoring was initiated at the Eugene station in 1975. EWEB has been a key backer of the solar monitoring effort from the beginning.

Supplemental assistance for the UO solar radiation monitoring effort was provided from 1977-81 through a contract with the United Stated Department of Energy as part of the Solar Energy Meteorological Research and Training Site Program (in collaboration with Oregon State University). About the same time in 1978, Bonneville funded the UO Solar Monitoring Laboratory to initiate a program of high quality solar radiation data acquisition in the Pacific Northwest. Both global and direct beam radiation were monitored on a continuing basis to characterize the variability of the solar resource. The primary motivation was to provide the requisite resource database for the future development of solar electricity in the region. Initially monitoring stations were set up at three locations:

1. Whitehorse Ranch in southeastern Oregon, which provides coverage of southern Harney and Malheur County east of the Steens Mountains,
2. Burns, which provides coverage of northern Harney and northeastern Lake County areas southwest of Burns, and
3. Hermiston, which provides coverage for northern Morrow County.

Tracking pyrheliometers and Eppley pyranometers were installed at the stations. At the same time, the Eugene station was upgraded to include beam radiation monitoring and an automatic data acquisition system.

During 1980 a fourth Bonneville high quality station was established at Kimberly, Idaho. Another station at Vancouver, Washington was started in October of the same year. The Vancouver station was moved to Portland in 1983. In October 1985 the contract with Bonneville was completed and the stations at Portland and Whitehorse Ranch, Oregon and Kimberly, Idaho were decommissioned.

From September 1982 to August 1986 a global and beam instrumented station was operated at Coeur d'Alene, Idaho, under the auspices of Washington Water Power.

From April 1984 through August 1988, solar radiation data was obtained for a station at Hood River, Oregon under contract with Pacific Power (now part of PacifiCorp). These solar radiation data were used to calculate the energy savings for the Hood River conservation project.

From 1988 to 1994, Burns, Eugene, and (during much of the period) Hermiston were kept operating with funds from EWEB and some supplies from NREL.

Re-Establishment of a Regional Network

In July 1994, a consortium of regional utilities, (Bonneville, EWEB, Idaho Power, PacifiCorp, and PGE) decided that a longer-term solar radiation database was needed to aid decisions on when and where to site solar electric generating facilitates. The UO Solar Monitoring Lab was contracted to gather and archive solar radiation data in the region. Instead of establishing all solar monitoring stations with expensive first class instrumentation, the utility consortium decided that a more comprehensive solar resource assessment could be achieved by maintaining a limited number of high quality reference solar monitoring stations supplemented by a number of less expensive and easier to maintain solar monitoring stations. In this manner, the solar resource could be more thoroughly mapped, and areas with the greatest solar resource could be more quickly identified.

In July, 1994, a consortium of regional utilities, (Bonneville, EWEB, Idaho Power, PacifiCorp, and PGE) decided to re-establish the regional network

Several of the new network stations are part of the US Bureau of Reclamation's AgriMet network. These stations (Christmas Valley, Or., Hermiston, Or., Madras, Or., Parma, Id., Picabo, Id., Twin Falls, Id., and the station in Boise Id.) are equipped with one LiCor pyranometer for global measurements, and a LiCor pyranometer with a shadow band for diffuse measurements. Except for Boise, these stations are referred to as AgriMet station.

Stations at Bend, Or., Boise, Id., Green River, Wy., Hermiston, Or., and Moab, Ut., are equipped with Rotating Shadow Band Pyranometers (RSP). RSPs measure global and diffuse irradiance and calculate beam radiation. These stations are referred to as RSP stations. RSP and AgriMet stations are discussed in more detail in the chapter IV.

In 1997, a multifilter rotating shadowband radiometer (MFRSR) was installed at the Eugene station as part of a program initiated by NASA's Goddard Institute for Space Studies. Spectral measurements from this instrument are used to monitor atmospheric constituents. Eventually, the MFRSR data will be used in satellite evaluation of the region's solar resource.

In September 1997 NREL equipped the Eugene station with an automatic tracker and made the station part of the high quality CONFRRM network. With the automatic tracker, accurate diffuse measurements are made with a shading ball. The ablility to directly measure diffuse irradiance without the need to correct for extra shading by a shadow band greatly assists in characterization and calibration of the network instruments.

Reference stations

By maintaining long-term high quality reference stations, 3 to 5 years of data from AgriMet and RSP stations could be used to estimate the long-term solar potential at these locations. The long-term reference stations establish a yardstick by which the short-term stations can be assessed. By comparing the data taken during the shorter time period with the long-term record at the reference stations, the years under study can be judged as being typical or atypical of the long-term average. If the period is typical at the reference stations then the data from nearby stations give a good indication of the long-term average. If the period under study is sunnier or cloudier than typical, appropriate adjustments can be made. While providing a yardstick to establish the representativeness of the years under study, the high quality reference stations also generate high quality data that can be used in engineering studies of potential solar facilities.

Perspective on Solar Radiation Monitoring

The global solar radiation data are a measure of the total amount of energy incident on a horizontal surface. This information may be sufficient to satisfy the needs of many solar energy users. However, for many applications the accurate direct normal beam data are required. The direct beam component is indicative of the maximum energy that can be collected using concentrating collectors, such as the high temperature collectors needed for electric power generation, or for arrays of photovoltaic devices that track the sun. The beam data can also be used to more accurately calculate the amount of solar radiation incident upon tilted surfaces.

While there are numerous locations in the United States where the global irradiance has been observed, continuous records of the direct beam component are very limited. Prior to 1977 only seven sites in the U. S. had digitized beam data available. Most of these had only one or two years of digitized data, except for Albuquerque, where four years of data were available, and Maynard, Mass., with nine years of data.

*Fig. 1: UO Solar Monitoring Network. Open circles (○) indicate stations containing both global and beam solar instrumentation. AgriMet stations are labeled (**X**). Global and diffuse irradiance are measure at AgriMet stations. Triangles (△) show the location of RSP stations. RSP stations measure global and diffuse radiation and calculate beam radiation. The Boise station has both an RSP and AgriMet instrumentation and is labeled with a square (□).*

The National Oceanic and Atmospheric Administration (NOAA) has operated a network of stations across the country at which both global and beam solar radiation are monitored. Thirty-nine stations were established, but few remain as NOAA reduced the number of operator attended stations to complete its modernization efforts. Three NOAA stations were located in the Pacific Northwest (PNW) at Boise, Idaho, Medford, Oregon, and Seattle, Washington. Solar radiation measurements have been discontinued at the Medford, Oregon station because of its proximity to the Eugene station.

Two difficulties characterized the older solar radiation data. First, it was usually presented only as daily totals. For many solar applications daily data does not provide enough information about short-term variations; hourly or shorter time interval data are essential.

Second, there is a real lack of long-term data. The daily and annual solar radiation at a given station will vary considerably from year to year. For example, the annual beam solar radiation measured in 1981 at Whitehorse Ranch in Southeastern Oregon (by the University of Oregon) was 15% greater than the beam radiation measured for 1982. Across the country at Maynard, Massachusetts, the National Weather Service has measured beam radiation over a nine year period. The difference between the lowest and the highest annual average was 18% of the nine year average and the root-mean-square deviation was 6% of the average. Clearly, information of this type is much needed and will take years to accumulate. Estimates of the amount of data needed to characterize the solar radiation at a particular location have been made using a variety of statistical techniques. These studies all conclude that the minimum period needed is 15 years. Surface temperature records in the United States show periodicities of up to 24 years. Similar time periods are expected to be necessary to characterize the incoming solar radiation.