

### How Much Incoming Solar Energy (Insolation) Is Received at Different Locations?

For purposes of designing heating/cooling systems and other uses, average insolation data are available for many sources. One is the US Department of Energy's National Renewable Energy Laboratory (<http://www.nrel.gov/>). Their data are available through:

<http://rredc.nrel.gov/solar/pubs/redbook/#maps>

The first step is to select a location and become familiar with the format in which the data are presented. To begin, you might wish to find a location relatively near you by choosing from the alphabetical list. At the top, you're given the **city, state**, identification (WBAN) number, **latitude, longitude, elevation** (feet), and other information. Of most importance are the items indicated in bold-face above.

Next come three sets of data providing information averaged over a thirty-year period by collectors at different angles. For your purposes, just look at the first set labeled "SOLAR RADIATION FOR FLAT-PLATE COLLECTORS FACING SOUTH AT A FIXED-TILT (kWh/m<sup>2</sup>/day)." Within these, just use the top three lines showing the "Average," "Minimum," and "Maximum" values for each month and the year.

**Select four or five of the available locations.** Try to choose sites with approximately the same latitudes or longitudes. For each, follow the on-line instructions to:

1) **obtain name, latitude, and longitude, and average, minimum, and maximum insolation for each month and for the year.**

*[Necessary information:*

The amount of "incoming solar energy" ("**insolation**") can be measured with a "radiometer."

Average monthly and annual values are reported in units of "kilowatt hours/square meter/day" (kWh/m<sup>2</sup>/day).]

2) **Present the data in a table or spreadsheet.**

3) **Select appropriate portions** of the table and **make graphs showing patterns in insolation.** (Examples: You can use line graphs to show variations in average monthly solar energy values at different locations, or you could use a bar graph to compare average annual values.)

4) **Provide brief interpretations of what you have learned.** You should be able to write at least one or two paragraphs about each part of this project.

**[Extension/extra credit:** The web site also provides climate data. **Design an investigation comparing solar radiation and climate conditions.]**

1. What factors may affect the amount of solar energy received at a location?
  
2. What would be three things to consider in deciding where to locate a radiometer site? (Consider what should be done to avoid obtaining misleading data.)
  
3. If skies over a location become more polluted from natural (ex., volcanic eruptions) or human (ex., vehicle or factory exhaust) sources, what changes might occur in the amount of solar energy reaching the surface?
  
4. Patterns used so far represent monthly averages. Search the NREL or other data bases for year-to-year variation, and analyze what you find.
  
5. How might changes in solar radiation from year-to-year or long-term trends impact the vegetation and fauna of the region. Explain your reasons.

Extra credit: Based on what you have learned, create one or two scientific research questions you could investigate. What might be your hypotheses?

Example of how to organize the data  
(<http://rredc.nrel.gov/solar/pubs/redbook/#maps>)

The station data presented below provides an example of what can be done using the data available on the web site. The data have been entered into an Excel spreadsheet. Then the Excel graphing capabilities have been used.

City: BOSTON \* State: MA (WBAN No: 14739)  
Lat(N): 42.37 Long(W): 71.03 \* Elev(m): 5 \* Pres(mb): 1015 \*

Solar Radiation, kWh/m<sup>2</sup>/day

Variable	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Average	3.6	4.3	4.6	4.7	4.7	4.8	4.9	5	4.9	4.4	3.3	3.1	4.4
Minimum	2.6	3	3.7	3.8	4.1	4.1	4.3	4.4	4.3	3.7	2.4	2	4
Maximum	4.6	5.8	5.8	5.5	5.5	5.5	5.3	5.7	5.5	5.2	4.2	3.9	4.7

