Renewable Energy 35 (2010) 2792–2798

Contents lists available at ScienceDirect

Renewable Energy

journal homepage: www.elsevier.com/locate/renene

New methodology of solar radiation evaluation using free access databases in specific locations

Iñigo Pagola [a], Martín Gastón [a,*], Carlos Fernández-Peruchena [b], Sara Moreno [d], Lourdes Ramírez [c]

[a] CENER (National Renewable Energy Centre), Ciudad de la Innovación 7, Sarriguren 31621 (Navarre), Spain
[b] CENER (National Renewable Energy Centre), Pabellón de Italia, Isaac Newton 4 5 SO, 41092 Sevilla, Spain
[c] CENER (National Renewable Energy Centre), Urbanización La Florida, Somera 7-9 1D, 28023 Madrid, Spain
[d] AICIA Pabellón de Italia, Isaac Newton 4 5 SO, Sevilla 41092 Sevilla, Spain

ARTICLE INFO

Article history:
Received 12 January 2009
Accepted 28 April 2010
Available online 1 June 2010

Keywords:
Solar energy
Solar radiation
Databases
Location assessment

ABSTRACT

In this paper, solar radiation obtained from different frequently used databases is compared in some different locations. In the analyzed databases, the data come from ground measurement networks, or from different models and with different resolutions. The proposed methodology assumes the hypothesis that the uncertainty of the databases is approximately the same as the meteorological uncertainty of the location. Therefore the heterogeneity of the observations is due to different observations. A weighted average is proposed taking into account different time and spatial characteristics of each database, and the estimation of standard deviation of weighted observations that derives the meteorological variability expected.

1. Introduction

As a result of the actual electrical market situation, the demand of solar radiation assessment in specific sites is greatly increasing. These types of studies have two different phases:

1. Initial study phase
2. Detail study phase

The second phase, corresponding to detail assessment of solar radiation resource, needs the carrying out of measurement campaign in the interesting place [1]. The cost of investment and maintenance of solar radiation instruments suggests the requirement of these initial studies with the goal of optimizing the selected emplacement bearing in mind the previous available information.

One of the critical points that appear when these initial studies are made is the interpretation of the results offered by the different databases and the justification of important differences between them. The available databases of solar radiation contain different kind of data: measured data and interpolating or satellite estimations.

In general, we must take into account that:

1. In the measurement case, they can come from different quality measuring and from different years.
2. In the interpolation case, they can come from grids of different densities in the input data and from different years.
3. In the estimation case [2] it is needed to take into account the model features (years of data and images used in the development), the characteristics of images (resolution and geometry) and the time periods of the used data.

It is true that beam radiation data are more frequently required each time, but databases rarely offer this information. Furthermore, adding the fact of the difficulty to obtain solar beam radiation measures and nonexistence of databases with an appropriate representability, in this work the estimation of the most probably global radiation in a first step is proposed and, as a second step, the estimation of solar beam radiation by means of the synthetic generation of the hourly global radiation [3,4]. Actually, this procedure of solar beam radiation estimation from the global one is the usual methodology implemented by satellite and spatial interpolating databases.

In this paper it is proposed a set of techniques which allows the inclusion of characteristic information from each database in the most probably value estimation for a concrete place. So, the hypothesis that all the provided values are possible is proposed but they participate with a different weight in the most probable mean value estimation

* Corresponding author.
E-mail addresses: ipagola@cener.com (I. Pagola), mgaston@cener.com (M. Gastón), cfernandez@cener.com (C. Fernández-Peruchena), smoreno@cener.com (S. Moreno), lramirez@cener.com (L. Ramírez).

0960-1481/$ – see front matter © 2010 Elsevier Ltd. All rights reserved.
doi:10.1016/j.renene.2010.04.034

Table 1
Location of emplacements of study.

	Latitude	Longitude
Albacete	39.007N	1.86W
Cáceres	39.472N	6.34W
Madrid	40.45N	3.72W
Murcia	38.002N	1.17W
Sevilla	37.40N	5.98W

and in the standard deviation estimation. This standard deviation will provide information about the expected variability of the solar radiation through different years, assuming that the observed variance is in the same order of magnitude as the meteorological one.

2. Methodology

To make an appropriate analysis of the results provided by different databases, the specific features of each database must be taken into account. It is necessary to pay attention to temporal characteristics, duration and time of data as location features, measurement stations data, interpolation from a set of ground stations or estimation from satellite images.

References [5–9] allow to analyze the uncertainties caused by the different resources of solar radiation. As a result:

1. The uncertainty induced by transforming the information from satellite to radiation is among 12–13% (daily base).
2. The uncertainty of ground measurements is caused by data acquisition systems, sensor gadgets and maintenance procedures and it contributes to the mean squared error in a 7–10% (hourly base).
3. The uncertainty due to the use of meteorological data from stations sited farther away than 15 km from the locations of study is about 15% (hourly base).

Therefore, taking into account all described before, to carry out an appropriate interpretation of the solar radiation data, it is needed to bear in mind some aspects such as:

1. Temporal features: concrete periods referred to the data, if they were measures, if they come from model development or model applications.
2. Databases characteristics: measurements of high, mean or low quality (the same to the models results).
3. Spatial features: distance between stations, spatial distribution implemented in the model development, resolution of the model outputs.

Table 3
Albacete. Initial study data by proposed methodology.

Month	Mean	Standard deviation	89% Probability		
			Range	Min	Max
Jan	72	3	20	62	82
Feb	90	4	21	80	101
Mar	136	4	22	125	148
Apr	168	6	35	151	186
May	199	5	32	183	215
Jun	224	6	34	207	241
Jul	240	9	56	213	268
Aug	210	10	59	181	240
Sep	156	9	54	129	183
Oct	109	5	28	95	123
Nov	76	5	33	59	92
Dec	62	3	19	52	71
Total kWh/m^2	1744	57	343	1572	1915

Referring to time frequency of data, since the goal is an initial assessment of the solar resource, monthly mean value for each database is estimated. After that, and taking into account the uncertainties of the estimations in each database, the hypothesis that the given differences are in the same order of magnitude as the meteorological ones is assumed, being all observations in the location of study possible. Therefore, it is possible to suggest that the most probable value is calculated using the expression

$$G_m = \frac{\sum p_i G_i}{\sum p_i} \tag{1}$$

where G_m is the most probable monthly mean value of global radiation. G_i is the monthly mean radiation proposed by each database and p_i is the proposed weights.

In the estimation of the p_i weights three coefficients are involved, so

$$p_i = \frac{t_i}{c_i d_i} \tag{2}$$

where, t_i introduces the time effect caused by years with data in each database. c_i depends on the origin of the information, its value is 1 when data had contrasted quality, 2 when data were

Table 2
Albacete. Data from different sources and parameters.

Parameters	Measurements		Models				
	MAPA1	MAPA2	SATEL-LIGHT	PVGIS	METEONORM	SODA	SSE-NASA
t	7	7	4	10	10	10	10
c	2	2	3	3	3	3	3
d	2	2	10	10	10	10	20
p	1.75	1.75	0.13	0.33	0.33	0.33	0.17
Jan	76	70	72	71	70	65	68
Feb	94	89	100	85	89	85	87
Mar	138	135	152	137	135	128	134
Apr	168	175	166	158	160	161	159
May	203	200	194	199	187	190	185
Jun	226	227	228	211	222	216	209
Jul	249	242	236	219	235	228	220
Aug	218	209	239	195	208	195	187
Sep	167	153	152	151	148	138	145
Oct	112	109	117	113	103	97	101
Nov	82	74	74	72	65	69	68
Dec	65	60	62	61	56	56	57
Total kWh/m^2	1798	1745	1794	1671	1678	1629	1620