SIXTH FRAMEWORK PROGRAMME

MESOR

Management and Exploitation of Solar Resource Knowledge

CA – Contract No. 038665

Publishable final activity report

Carsten Hoyer-Klick, Hans Georg Beyer, Dominique Dumortier, Marion Schroedter-Homscheidt, Lucien Wald, Elena Gaboardi

Date: 26-08-2009

Version History

Version	Date	Authors	Partner	Sent To	Major Changes
0.1	26-08-2009	Carsten Hoyer-Klick	DLR	Consortium	Initial draft version
1.0	27-08-2009	Carsten Hoyer-Klick	DLR	Commission	

Acknowledgement and Disclaimer

The MESOR team acknowledges the financial support of the European Union under contract CA – Contract No. 038665. We would also like to thank all reviewers for their valuable comments.

Table of Contents

1 Contractors involved and contact details

1.1 Contractors involved

Particpant Role	Participant No.	Participant Name	Short name	Country	Date enter project	Date exit project
CO	1	Deutsches Zentrum für Luft und Raumfahrt e.V. (German Aerospace Center)	DLR	DE	1	24
CR	2	Hochschule Magdeburg Stendal	H2M	DE	1	24
CR	3	Ecole Nationale des Travaux Publics de l'Etat (ENTPE), Department of Civil Engineering and Building Physics (DGCB), « Light & Radiation Group »	ENTPE	FR	1	24
CR	4	Armines Association pour la recherche et le développement des méthodes et processus industriels	Armines	FR	1	24
CR	5	Icons	Icons	IT	1	24
CR	6	CIEMAT (Research Centre of Energy, Environmental, and Technology) Department of Energy	CIEMAT	ES	1	24
CR	7	European Commission, Joint Research Centre, Institute for Environment and Sustainability	EC - DG JRC	EU	1	24
CR	8	Universidad Publica de Navarra	UPNA	ES	1	24
CR	9	Oldenburg University, Energy and Semiconductor Research Laboratory	UNIOL	DE	1	24
CR	10	meteocontrol GmbH	meteo-control	DE	1	24
CR	11	Meteotest	Meteotest	CH	1	24
CR	12	CUEPE, University of Geneva	UniGE	CH	1	24
CR	13	Voeikov Main Geophysical Observatory/World Radiation Data Centre	MGO	RU	1	24
CR	14	University of Presov	UniPO	SK	1	24

1.2 Co-ordinator contact details

Carsten Hoyer-Klick
German Aerospace Center (DLR)
Institute of Technical Thermodynamics
Pfaffenwalding 38-40
D-70569 Stuttgart, Germany
Tel. : +49 – 711 – 6862 728
Fax. : +49 – 711 – 6862 747
Email : carsten.hoyer-klick@dlr.de

1.3 Project reference

Website:
http://www.mesor.net

MESoR broker portal:
http://project.mesor.net

2 Overview of general objectives

"Solar resource information" is defined as all data describing site- and time-specific physical parameters of solar radiation at the Earth's surface needed for the proper design and operation of solar energy systems. It covers all time scales: historic, present and future data. Relevant solar energy applications include heating and cooling in the building sector (SHC), photovoltaic (PV), and concentrating solar power (CSP) systems for producing electricity and process heat. **"Knowledge management"** is of critical importance for the reliable flow of information needed for development of these technologies and their integration in distributed energy networks.

In past years there has been substantial funding from the European Commission to develop information systems on solar radiation data, such as the **European Solar Radiation Atlas** (ESRA, JOU2-CT-94-0305), the projects **SoDa** (IST-1999-12245), **Satel-Light** (JOR3-CT95-0041), **PVGIS, PVSAT** (JOR3980230), **PVSAT-2** (ENK5-CT-2002-00631) or **Heliosat-3** (ENK5-CT-2000-00332) and the **Envisolar** project of the European Space Agency (ESA). Additionally, national services were set up (e.g. **Meteonorm** by Meteotest in Switzerland and **SOLEMI** by DLR in Germany). From the regional point of view, the projects focused mainly on Europe or its regions, leading to the situation that several different data bases exist in parallel developed by different approaches, including those exploiting satellite data. The mentioned projects have been focusing on renewable energy applications.

Although a number of institutions have developed approaches for solar energy resource assessments, the individual methods have not been cross-compared and benchmarked. Validation covered mainly the developed methods. For stakeholders the current situation with different solar radiation databases is too complex. According to user statements, as analysed within the ESA market development project Envisolar, the guidance is missing and information on quality of the different products is rare. It has been recognized that a benchmarking of the different solar radiation data is urgently needed together with recommendations and best practices for different applications or geographical regions. The uncertainty of the different sources often prevents their efficient use by these stakeholders.

In addition, access to the data sets, particularly by organizations outside of the countries where these have been developed, is difficult and sometimes impossible. The operational prototype of the MESoR project already demonstrated how different data sets can be accessed through a single user portal.

First approaches for standardisation and more convenient access by stakeholders have been made within the SoDa web-service and the UNEP/GEF project SWERA (Solar & Wind Energy Resources Assessment). The SWERA project showed the value of high resolution resource mapping to rural electrification in the 13 developing countries worldwide. In the course of the project first attempts

have been made to compare results derived by different methodologies and satellite systems. The main conclusion was that a meaningful comparison requires first an exact definition of an acknowledged standard for each data product so that the benchmarking of the approaches can be reasonable and fair. This standard has been created with deliverable D1.1.1 “Methods for Benchmarking” within the MESoR project.

The rationales of the proposed project MESoR are supported by the International Energy Agency’s (IEA) Implementing Agreements for Solar Heating & Cooling (SHC), Solar Power and Chemical Systems (SolarPACES) and for Photovoltaic Power Systems (PVPS) which jointly have recognized the needs for improved and better coordinated information on solar resources. Therefore the IEA task 36 “Solar Resource Knowledge Management” has been formally approved by the SHC Implementing Agreement and has started in July 2005. This project is closely related to this task.

Consequently, the project MESoR aims at removing the uncertainty expressed by stakeholders that face this diversity of solar resource products and assisting them in efficient exploitation of these products by providing clear information and transparent guidance.

The overall objective is to coordinate European research, to develop solar resource management and to improve the position of Europe in international cooperation including industries and research. The European partners currently have a worldwide leading role in the assessment of solar resources and this project aims to maintain and expand this leading role.
The activities as defined in this proposal focus on four main areas: **guiding** the users of the data, **unifying** access to the data for stakeholders from all over Europe and even abroad in Africa and South-West Asia, **connecting** to the relevant communities and the **dissemination** of knowledge on solar resources.

Guiding

The first major objective is to guide stakeholders through efficient exploitation of the existing data sources. All sources have different spatial and temporal coverage and spatial and temporal resolutions, conforming to different stakeholders needs. Stakeholders are investors, banks, companies and consultants planning, designing, developing and operating solar energy systems, governmental bodies deciding strategies and policies as well as the scientific community. To guide the stakeholders in relation to their needs the available data sources were evaluated by benchmarking them to each other. The benchmarking should increase the trust of stakeholders in the solar resource information. A user oriented guide to the available solar energy resources and a handbook of best practices was prepared. Further, a roadmap to the future objectives and priorities was developed, describing requirements for measuring systems, including Earth observation systems, services for effective management and deployment of solar resource knowledge and better fulfillment of the demands of the stakeholders.

Unifying

The second major objective is to ease the access to the existing data sources. For this advanced information web technologies are used. Metadata describing all different sources and a prototype of a web-based broker which guides the user to the different sources based on the metadata were developed. The broker serves as a standard user interface giving standardized data to the user. The unified access will strengthen the position of the consortium in world wide scientific and commercial use of the data. It may also serve as an example to other domains of renewable energy.

Connecting

The third major objective is to connect solar resource knowledge to other relevant activities and communities. The connection to INSPIRE (Infrastructure for Spatial Information in Europe) initiative will ensure the use of standards adopted by geographical information providers in Europe. The project activities relate to the "Power" programme of the NASA, the GMES (Global Monitoring for Environment and Security) contribution of the European Commission to the GEOSS (Global Earth Observing System of Systems), and the Implementing Agreements of the International Energy Agency (IEA), especially the Task 36 on "Solar Resource Management" implemented within the Solar Heating and Cooling Agreement. Improved solar resource knowledge is beneficial to many scientific communities; this project improved the links to the energy, atmospheric, geographical, medical and ecology sciences.

Stakeholder Involvement and Disseminating

Stakeholder involvement is the fourth major objective of this proposal. This has been one by a survey of the stakeholder needs, the development of training material and a broad dissemination of the results of this project and the results of the earlier projects mentioned in the state of the art. Public international workshops addressing stakeholders from the decision making sphere, industry, research and also from other communities were held during the project duration, usually in conjunction with annual project meetings. It is intended to organize these workshops along with major solar conferences. In addition, national workshops can also be organised by participants using the information gathered during workshops and the material produced by the project.

3 Main achievements

WP 1

Work package 1 is about guiding, which consists of benchmarking (WP 1.1), guiding (WP 1.2) and a roadmap (WP 1.3).

To be able to do a coherent benchmarking the “bench” and the “marks” need to be known. The “bench” is set of measures and methods to be able to assess the quality of a data set. The “marks” are a set of high quality ground measurements, which serve as a reference to which the modelled data sets are compared to. Work in WP 1.1 focused on the definition of benchmarking measures and methods as well as to the collections and quality assessment of the reference data. Benchmarking methods and measures for first and second order statistics were defined for time series products. Reference data has been collected from BSRN (Baseline Surface Radation Network), IDMP (International Daylight Measurement Programme) and WRDC (World Radiation Data Center). The data has been subject to a common quality control, converted to a common data format and been stored in the project intranet for common access to all project partners.

WRDC prepared a new access to it’s data base through a cgi-program. WRDC data can therefore be directly accessed via the internet through a URL.

After finishing D1.1.1 “Methods for Benchmarking” and D1.1.2 “Available ground data” the “bench” and the “marks” were known for benchmarking. Based on a comparative analysis of the availability of data from the modelled sources and ground data, three benchmarking exercises were defined by the coordinator of the workpackage (DLR). The first benchmarking exercise covers the years 1996-2000. It defined by the availablitiy of the satel-light data base. The second exercise covers the years 2004 and 2005 and defined by the overlap of Meteosat first and second generation satellites. This case allows the comparison data based on the old and the new Meteosat. The third exercise extend beyond Europe and focuses on sunny regions, it includes stations in Africa and on the Arabian peninsula. DLR also extended the benchmarking script to cover second order measures. Besides the benchmarking script developed by DLR, a respective excel tools is now available.

First benchmarking results were presented by UniGE, JRC, DLR and UNIOL on the 3rd progress meeting in Geneva. It was discussed and decided to use the KSI parameter of the second order statistics as a quality measure for the distribution function. The KSI will only be calculated for single stations and not for an ensemble of stations, as their distribution functions might be very different. All benchmarking exercises report Bias, RMSD and KSI as relative values.

Benchmarking time series data of solar radiation was done by the different organisations, DLR benchmarked the SOLEMI data, UNIOL their data sets, ENTPE satelight data, Meteotest the Meteonorm data. Benchmarking of Helioclim data was done by UniGe. In addition Results were presented at the Seminar ‘Using Solar Resources in Practice’ held May 2009 at the Intersolar Trade fair in Munich. The respective presentations include on one hand a description of the benchmarking process and a general discussion of the benchmarking results (H2M) and, on the other hand a comprehensive test of various radiation products involving some addition ground data (Uni GE).

The results were compiled by DLR. The comparison of results showed no clear ranking of the data sources. The biases were over all small showing that all models were able to determine the average available resource well. EnMetSol data from the University of Oldenburg showed the lowest RMSD. For the KSI each

method was best and worst for different stations. No clear ranking cloud be found. In general it can be noticed that the RMSD and KSI are much higher for direct normal radiation than for global horizontal. For the RMSD is almost a factor of two. Again this was similar for all data sources.

JRC extended the previous work of comparing maps of global horizontal irradiance. Armines, DLR, ENTPE, JRC, Meteotest UNIOL provided maps of the yearly global horizontal irradiance from their data bases to be included to this comparison. JRC also added a comparison of maps of the yearly direct normal irradiation which were provided by DLR, ENTPE, JRC and Meteotest.

The benchmarking of irradiance forecasts was organized by UNIOL. Forecast data were provided by the partners UNIOL, Meteotest, and Meteocontrol. This benchmarking required a set of ground measured irradiance data which was different from the one used for benchmarking time series. The data was chosen to cover a recent period. The evaluation data set comprises data of the German Weather Service DWD and the Swiss Weather service MeteoSwiss. It covers the period 7/2007- 6/2008. This data set is part of the ground measurement data set for evaluation of forecasts collected in the framework of the IEA SHC Task 36 "Solar Resource Knowledge Management". UNIOL performed the comparison of the three forecasting algorithms for Germany, and Meteotest evaluated the forecasts for Switzerland.

Best results are achieved for the ECMWF irradiance forecasts in combination with the post processing procedure of the University of Oldenburg. The *rmse* is around 40% for one day ahead forecasts for Germany and Switzerland. The forecasts provided by meteocontrol show only a slightly higher *rmse* value for Germany (43%), but large *bias* and *rmse* values for stations with high altitudes in Switzerland. The accuracy of the WRF-forecasts by Meteotest is similar to the accuracy of the ECMWF based approaches for stations with a lot of sunny days in Switzerland. Overall, the *rmse* for the first forecasts day amounts to 45% for Switzerland, and to 52% for Germany. All three forecasting approaches perform significantly better than persistence from few hours onwards.

Partners involved in WP 1.1 were DLR (coordinator), H2M, ENTPE, Armines, CIEMAT, EC DG JRC, UPNA, UNIOL, meteocontrol, UniGe and MGO.

ENTPE coordinated work package 1.2. With the other partners, ENTPE contributed to the description of the sources of solar radiation information with at least a European coverage: EnMetSol, ESRA, Helioclim, Meteonorm, NASA SSE, PV-GIS, Satel-light and Solemi. The description, available in the MESOR User Guide (deliverable D1.2.1+D.1.2.2), includes not only information important for the general user: temporal and spatial coverage/resolution, available parameters,but also information important for the technical user: data used to describe the atmosphere, models used to produce the parameters. ENTPE added to the User Guide, a synthesized presentation of the results of the site benchmarking and of the inter-comparison between data sources. An important section of the MESOR User Guide includes 20 case studies describing the use of solar radiation information by stakeholders for 5 different applications: photovoltaic, thermal, concentrators, daylighting/building and bio-treatment. At the beginning of the project, ENTPE presented a format for these case studies, after discussion and

modification, the format was adopted. Each case study was to be two pages with specific sections: context of the study, description, source(s) of solar radiation used, results and links to further information. Each partner involved in the work package was attributed a specific application (ENTPE was in charge of the daylighting/building application). Each partner first contacted stakeholders (link with WP4) asking for contributions, then prepared the case study so that it fits the format. ENTPE gathered all the contributions, 4 to 6 depending on the application, edited all of them to insure perfect consistency with the format and added them to the MESOR User Guide.

Partners involved in WP 1.2 were ENTPE (coordinator), DLR, H2M, CIEMAT, EC DG – JRC, UNIOL, meteocontrol and Meteotest.

In WP 1.3 three road map documents for future research, service and Earth Observation needs were compiled.

Partners involved in WP 1.3 were DLR (coordinator), Armines, UNIOL and Meteocontrol. These documents were reviewed by the MESOR consortium members, the IEA Task 36 ‘Solar Ressource Knowledge Management’ participants outside the MESOR consortium members (e.g. US participants), the GEOSS Energy Community of Practice members, the GEOSS User Interface Committee members responsible for the societal benefit area ‘Energy’, experts who took part in the ‘Symposium on Energy Meteorology’ in Jan 2009 and other interested researchers and industry representatives.

WP 2

The concept of the collaborative information system has been set up in agreement with the current trends at European level in environment.

Metadata are essential to exchange knowledge between applications. A set of metadata (thesaurus) has been defined that is specific to solar resource. It has been presented to conferences and is used to develop the web services and the prototype.

The information system was modelled using the Unified Modelling Language (UML). This model offers different points of view of the information system, ranging from the description of the actors and their roles to the practical implementation of software components of a selected platform.

A set of mature technologies and freely available software was selected to build the information system. Seven Web services were developed by the consortium that populate the information system. A tutorial has been made to help potential providers to develop other Web services. As a whole, documentation was made available to help the community to take up the expertise and knowledge gained in setting up the prototypes.

The first version of the prototype was ready in September 2008 and gauged by the Consortium and selected users. Then, it was revised to create the final version that has been presented to users.

The user interface is instrumental in an information system. After several trials and taking into account on the one hand the users needs and on the other hand the

experience gained in presently running information systems, the user interface was designed.

The benefit of MESoR outcomes to the community is illustrated by the recent discussion between WP 2 (Armines) and the company Transvalor of France, a daughter company of Armines and French banks, in April 2009. Transvalor is presently managing and is building a new version of the SoDa Service by exploiting the publicly available outcomes of WP 2.

Partners involved in WP 2 were Armines (coordinator), EC – D JRC, UniPO and Meteocontrol.

WP 3

The aim of WP 3 was the establishment of links to other initiatives relevant in earth observation, geo data and solar resource management in order to share knowledge and create awareness about the outcomes of MESoR. The activity has been successful and links have been established to the Task 36 of the IEA Solar Heating and Cooling (SHC) implementing agreement (IA), the Task 2 of the IEA Photovoltaic Power Systems (PVPS) IA, the Solar and Wind Energy Resource Assessment programme (SWERA) of UNEP, the European Space Agency (ESA) activities on the exploitation of Earth observation (EO) data, the World Meteorological Organisation (WMO), the EC initiative INSPIRE ((Infrastructure for Spatial Information in Europe)), the Global Earth Observation Systems of Systems (GEOSS), the USA-NASA "Power" initiative, the EC initiative on Global Monitoring for Environment and Security (GMES), the European project PV-Performance, national meteorological offices from Australia, Canada and South Africa, the International Agency for Research on Cancer of the World Health Organisation (WHO) through the European project Eurosun.

Involved partners were Armines (coordinator), DLR and CIEMAT.

WP 4

In the second year, the MESoR secretariat, run by partner iCons, managed and expanded the stakeholders' community and carried out various activities, including: continuous contacts for informing the community about the MESoR progress; the information and dissemination campaign about the MESoR prototype, pushing users to test the prototype; information and dissemination about the MESoR training activities (webinar and training seminar); the organisation and the management of the survey for the evaluation of the prototype; the organisation –in cooperation with UNIOL- of the training seminar and of the follow-up activities; collection and analysis of the feedback to the roadmap. As a final result, the MESoR project can rely on a community of about 150 people from about 140 organisations that have interest in solar radiation knowledge, based in all European countries and overseas. These people actively participated to the various MESoR events (webinar, training seminar) and activities (surveys and consultation) and provided their input and feedback to the MESoR outputs and especially to the prototype. In addition to this "closer" community, MESoR disseminated and raised awareness in the scientific and industrial community at large, both directly and through multipliers. This audience can be estimated in a few thousands people.

A concept and manual for a seminar “Using solar resource knowledge” targeting industrial users was developed by UNIOL with input from several other partners. The half-day seminar consists of a set of six presentations The presentations cover the subjects: user needs, currently available solar resource products, benchmarking, the MESoR portal, example case studies, and an outlook on further developments in solar resource products.These presentations were prepared by the partners DLR, UNIOL, iCons, H2M, UniGe, Armines, ENTPE, and Meteotest according to their responsibilities within MESoR.

The seminar was first held at the Intersolar in Munich, Germany on May 27th 2009. UNIOL organized this event with support of iCons. iCons also prepared a questionnaire for the evaluation of the seminar and was in charge of the evaluation of the seminar.

4 Publishable Results of the Final plan for using and disseminating knowledge

The results of the project are all public and are disseminated through the project reports and publications. They will be available on the project web-site and from the respective project partners.