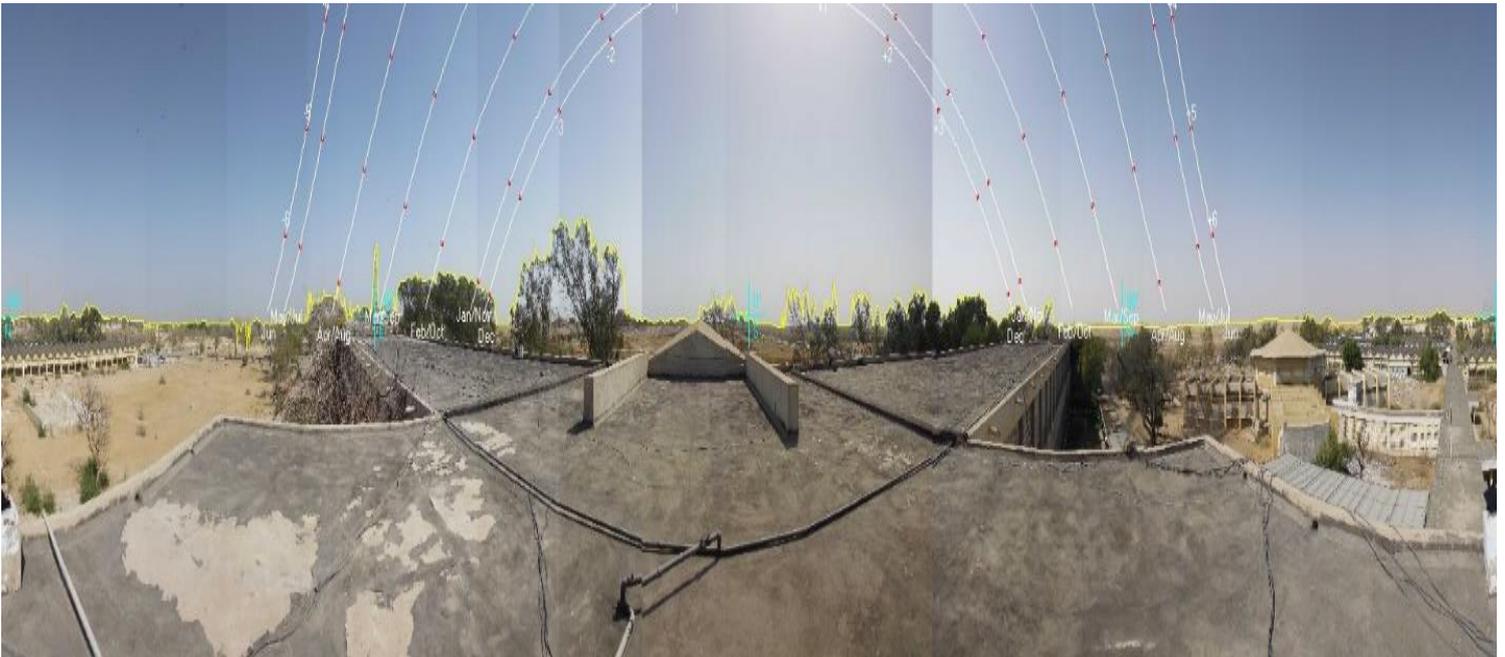


Solar Resource Mapping in Pakistan

SITE EVALUATION REPORT

July 2015



This report was prepared by the consultants listed on the following pages, under contract to [The World Bank](#).

It is one of several outputs from the solar **resource mapping component of the activity “Renewable Energy Resource Mapping and Geospatial Planning – Pakistan”** [Project ID: P146140]. This activity is funded and supported by the Energy Sector Management Assistance Program (ESMAP), a multi-donor trust fund administered by The World Bank, under a global initiative on Renewable Energy Resource Mapping. Further details on the initiative can be obtained from the [ESMAP website](#).

This document is an **interim output** from the above-mentioned project. Users are strongly advised to exercise caution when utilizing the information and data contained, as this has not been subject to full peer review. The final, validated, peer reviewed output from this project will be the Pakistan Solar Atlas, which will be published once the project is completed.

Copyright © 2015 International Bank for Reconstruction and Development / THE WORLD BANK
Washington DC 20433
Telephone: +1-202-473-1000
Internet: www.worldbank.org

This work is a product of the consultants listed, and not of World Bank staff. The findings, interpretations, and conclusions expressed in this work do not necessarily reflect the views of The World Bank, its Board of Executive Directors, or the governments they represent.

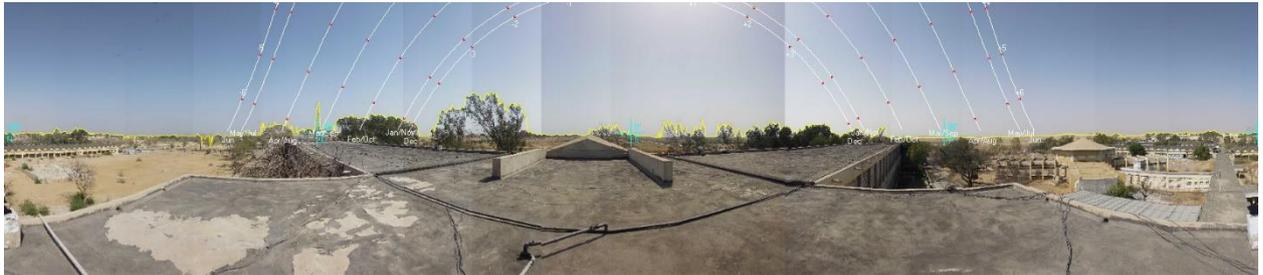
The World Bank does not guarantee the accuracy of the data included in this work and accept no responsibility for any consequence of their use. The boundaries, colors, denominations, and other information shown on any map in this work do not imply any judgment on the part of The World Bank concerning the legal status of any territory or the endorsement or acceptance of such boundaries.

The material in this work is subject to copyright. Because The World Bank encourages dissemination of its knowledge, this work may be reproduced, in whole or in part, for non-commercial purposes as long as full attribution to this work is given. Any queries on rights and licenses, including subsidiary rights, should be addressed to World Bank Publications, The World Bank Group, 1818 H Street NW, Washington, DC 20433, USA; fax: +1-202-522-2625; e-mail: pubrights@worldbank.org. Furthermore, the ESMAP Program Manager would appreciate receiving a copy of the publication that uses this publication for its source sent in care of the address above, or to esmap@worldbank.org.

ESMAP – Renewable Energy Resource Mapping Initiative

- Solar Resource Mapping for Pakistan –

Site evaluation report: Mehran University Jamshoro



Responsible Authors

Birk Kraas (CSP Services)
Christoph Schillings (DLR)
Qazi Sabir (PITCO)

DOC: SiteEvalReport_JamS_2015-02

Author Contact Information:
CSP Services GmbH
Friedrich-Ebert-Ufer 30
51143 Köln/Cologne, Germany
e-mail: b.kraas@cspservices.de

02 March 2015



CSP Services GmbH

Birk Kraas
Friedrich-Ebert-Ufer 30
51143 Cologne, Germany
Phone: +49 2203 959003 6
Mob.: +49 162 9373484
b.kraas@cspservices.de

DLR

Dr. Christoph Schillings
Pfaffenwaldring 38-40
70563 Stuttgart, Germany
Phone: +49 711 6862 784
christoph.schillings@dlr.de

PITCO:

Qazi Sabir, Mohammad Umer Kamal
Phone: +92 (42) 36363751
qazi.sabir@pitcopk.com



Contents

- 1 Executive Summary 4**
- 2 Procedure and tasks of the site visit..... 4**
- 3 Site visit results..... 5**
 - 3.1 Overview, description of the site and surroundings5
 - 3.2 Local support, maintenance staff and future hardware use6
 - 3.3 Site evaluation.....7
 - 3.3.1 Coordinates7
 - 3.3.2 Checklist for evaluation of the situation of and at the site7
 - 3.3.3 Shadings and Reflections9
- 4 Conclusion 13**



1 Executive Summary

A member of the solar vendor consortium for the ESMAP Pakistan Solar Resource Mapping Project visited the Mehran University of Engineering and Technology in Jamshoro on February 19, 2015. The goal was to evaluate if the location is suitable for the installation of a solar ground measurement station in the framework of the project.

A site on the main building of the university has been examined on the campus.

The site is recommended for the installation of a Tier2 meteorological station (CSP Services MDI automatic weather station). It is replacing the formerly selected site of Tando Jam AgriMet Office, where installation of the station proved to be unfeasible.

2 Procedure and tasks of the site visit

The following tasks have been performed for the site visit, following the procedure from the site visit manual:

1. Recording of exact geographic coordinates of the site(s) and orientations
2. Photographic documentation of the site
 - Overview of site and location,
 - panoramic 360 degrees round view from the site for identification of potential obstacles blocking the sun path
3. Check of availability, strength and potential providers of GSM network at the site
4. Audit of local staff to clarify all relevant information (see checklist)
5. Information of local staff at the site about the project, its aim and required tasks for realization and clarification of availability and prospected quality of the required support from their side
6. In-office evaluation of results and compilation of this report



3 Site visit results

The results of the site visit and its evaluation is presented in the following section.

3.1 Overview, description of the site and surroundings



Figure 1: Location overview (Google Earth View)

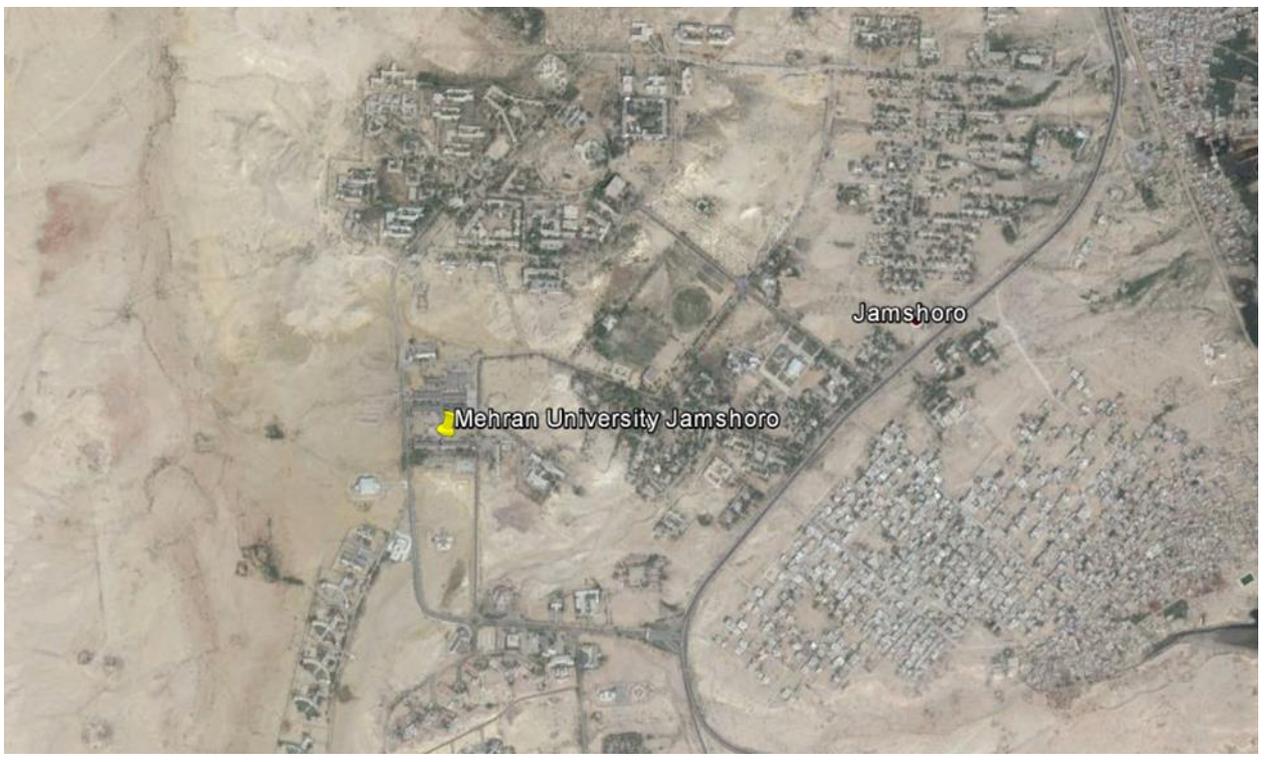


Figure 2: Aerial View (Google Earth View)



Jamshoro is located about 10 km to the west of Hyderabad, on the opposite side of the Indus river. The city borders the irrigated area of the Indus valley to the east. To the west, a dry area sloping westwards toward the Khirtar mountain range. To the east lies the vast Indus valley with its large irrigated agricultural areas.

Mehran University is situated on the western border of Jamshoro town. It consists of a large open campus with little vegetation besides the trees lining the roads and surrounding the buildings. To the south of the campus, the Karachi-Hyderabad motorway is passing the campus in East-West direction. To the east of the campus, the Karachi canal, connecting the Indus to the Keenjar lake and further to the Karachi area, is passing by in a distance of 3 km.

3.2 Local support, maintenance staff and future hardware use

The availability of qualified staff for the regular local maintenance (cleaning of sensors and other parts, visual inspection, surveillance of equipment) and the institutional support of the involved stakeholder are directly relevant for the success of the ESMAP project measurement campaign.

Future use of the equipment after the ESMAP project termination is another issue to be considered in order to provide maximum sustainability of the project.

Local support and maintenance staff

Local staff is available and confirmed to be willing to perform maintenance tasks throughout the 24 months of the measurement campaign. A short briefing about the required tasks and their frequency of occurrence has been given to the University representatives. Qualification of local staff for the task is assumed to be given, since Mehran University has dedicated engineers and technicians available for the task.

Contact Information

The local contact for the site is

- Professor Khanji Harijan
Tel: +92-333-2653820

3.3 Site evaluation

3.3.1 Coordinates

N 25.4134° E 68.2595°, altitude 60 m above mean sea level

The site is located on the roof of the main building of the university complex.

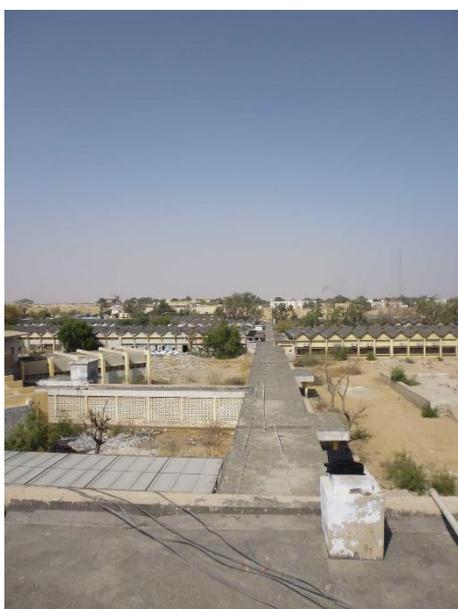


Figure 3: View from Site to the North



Figure 4: View from Site to the South

3.3.2 Checklist for evaluation of the situation of and at the site

The following checklist has been filled at the site visit and is completed by interviewing stakeholders on site.

Table 1: Site checklist

Criteria/Measure		Yes / No	Notes
Dimensions ¹	Minimum area 10 × 10 m ²	Yes	
Surface	Firm natural ground ²	Rooftop	
	Ground type ³	RCC	
	Horizontally levelled ⁴	Yes	
	Excavation for foundations possible ⁵	-	Casting blocks preferred
	Fencing of the site possible ⁶	Yes	
	No drifting sand/snow ⁷	Yes	Slight sandstorms
	No flooding possible ⁸	No	



Surroundings	Obstructions If yes, note direction, distance and approx. height ⁹		See Pictures
	Reflections or light sources ¹⁰	No	
	Industrial areas or power plants ¹¹	No	None nearby
	Sources of smoke or vapor ¹²	No	
	Quarry or mine ¹³	No	
	Main road, dirt road, track ¹⁴	Yes	
	Airports ¹⁵	No	
	Settlements, towns, city ¹⁶	Yes	Urban Area
	Agricultural area ¹⁷	No	More than 10km away
	Swamp, lake, river, ocean ¹⁸	No	Karachi Canal – 3km from site Indus River – 5km from Site
	Sand dunes ¹⁹	No	
	Animal populations ²⁰	No	
	Occurrence of snowfall ²¹	No	
	Temperatures below 0°C ²²	No	
Other ²³	-		
Accessibility	Accessible by car ²⁴	Yes	
GSM coverage	2G network available ²⁵	All Five	
Land use rights	Permit available ²⁶	Yes	
Operation permit	Permit available ²⁷	Yes	
Security	No underground or overhead electrical lines, pipelines or similar ²⁸	Yes	
	Measures against theft or vandalism required? ²⁹	No	
360° photographs	Take 360° photographs or panoramic photo, indicate North direction ³⁰	Yes	The Tripod bag represents the north direction



Regarding the aspects covered by the checklist, the site is well suited for the installation of a ground measurement station. The installation on a roof-top is a good option since it elevates the station above many obstacles. The direct surroundings lack any industrial facility thus no negative impacts on irradiation and measurement conditions is stated. All roads in the surroundings are paved and therefore not heavily dust-emitting; large water bodies are at least several kilometres distant. No special permits are required and permission to use the site can be given by the University.

3.3.3 Shadings and Reflections

Panoramic View

The picture in Figure 5 shows a panoramic view with a centered south view, North is on the left and right edge of the picture. Blue markers show the North, South, East and West direction as well as horizon height. The sun paths throughout the year are displayed in the picture, revealing if any objects on the horizon are imposing an obstruction to the direct solar irradiance.



Figure 5: Panoramic View with North, South, horizon line and monthly sun paths with the corresponding position at full hours marked

From the panoramic view, it is visible that a few obstacles such as trees, on the horizon are blocking the sun especially at sunrise, but these obstacles are not very high. The impact is further analyzed in the following paragraphs.



Shading Table for Sun Elevations >0°

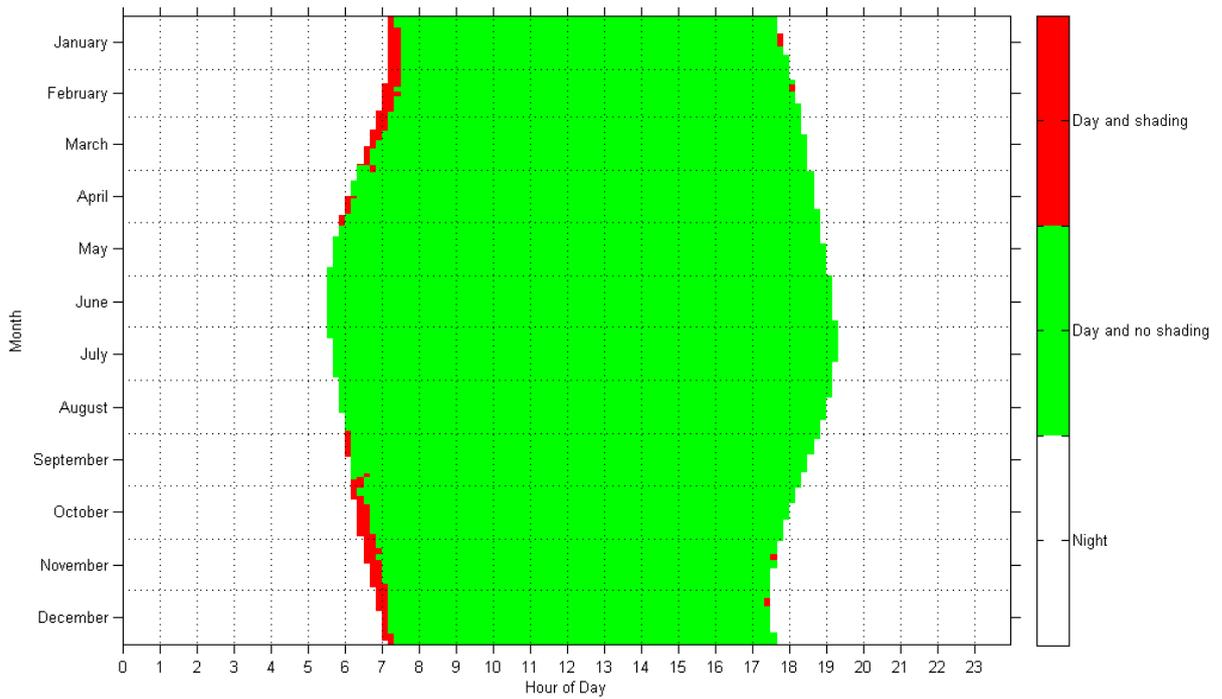


Figure 6: Shading Table for Sun Elevations >0°

Figure 6 shows the shading table throughout the year. It becomes clear that throughout the year, only a few shadings are obstructing the sensor in the morning in the months from September to April, but with a short duration of only about 20 minutes. In the evening, practically no shading is present throughout the year.



Shading Table for Sun Elevations >5°

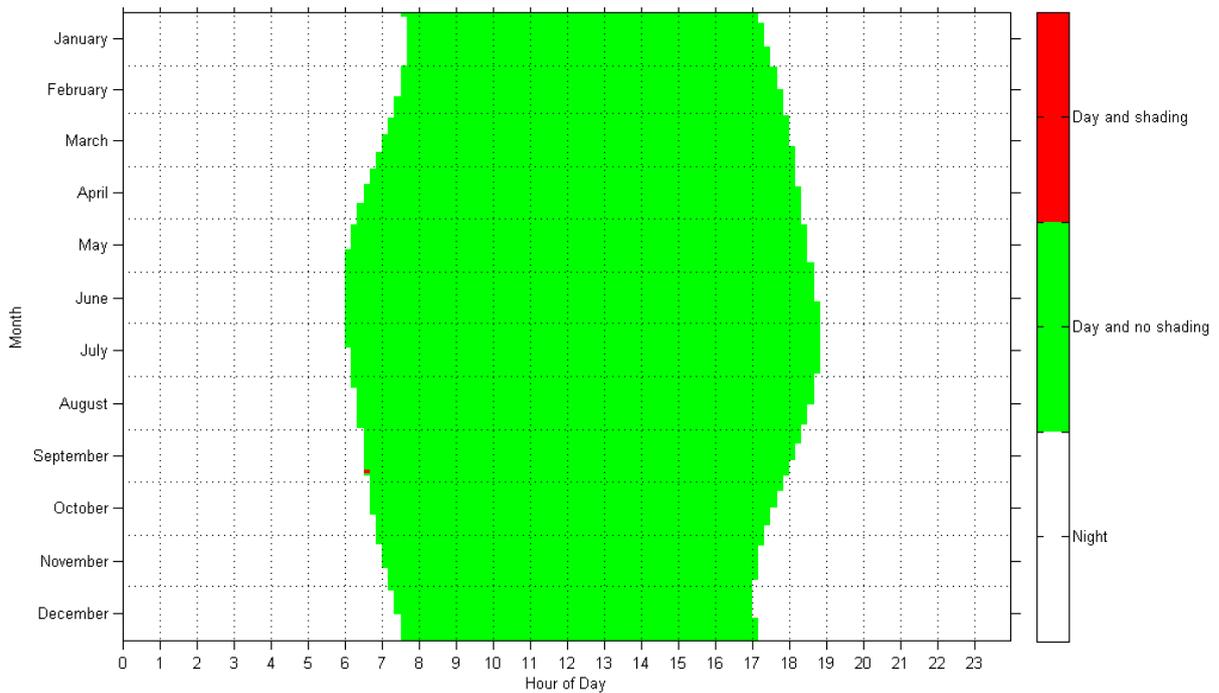


Figure 7: Shading Table for Sun Elevations >5°

Figure 7 shows the shading table after excluding Sun Elevations smaller than 5° above horizon. At these low angles, measurement uncertainty of satellite and ground measurement is elevated due to the large cosine error, and the data from these periods is therefore excluded from the satellite data adjustment and validation. Also from the view of any solar power installation (PV or CSP), sun elevation smaller than 5° is usually not contributing to electricity or heat generation due to shading, unfavorable incidence angles and low irradiance intensity. *Subsequently, all further graphs and evaluations refer to sun elevations larger than 5°, as the main aim of the measurements on ground is the adjustment of the long-term satellite data.*

From the graph, it is visible that shading is no more present after exclusion of sun elevations smaller than 5°.



Direct Shading Impact

Figure 8 shows the impact of shading on direct normal irradiation (DNI). DNI is modeled according to Bird (Bird et al., 1991) as a theoretical clear-sky DNI throughout the year and can be interpreted as the maximum solar resource. The impact of shading on this figure is therefore the maximum quantitative impact shading could have on solar resource.

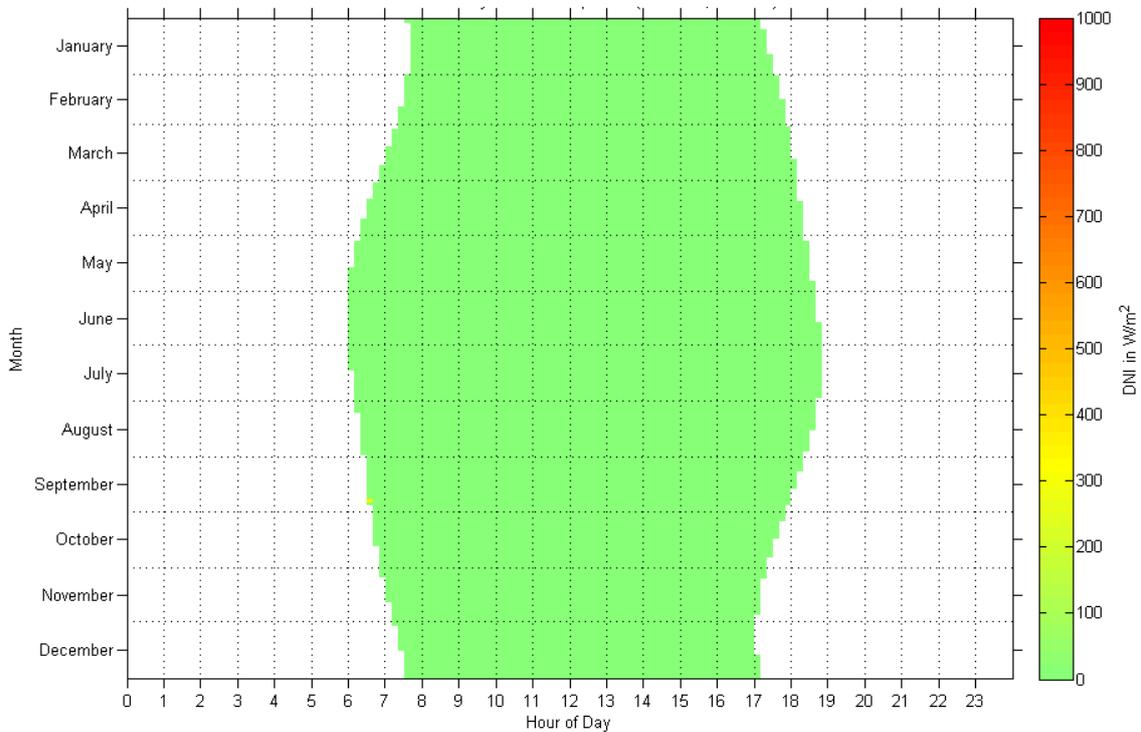


Figure 8: Shading Impact on BirdDNI for Sun Elevations >5°

From the figure, it is obvious that shadings have no impact on the sensor. In total, 0 % of the time is affected by direct shading.

Diffuse Shading and Reflections

Diffuse shading and reflections of any mentionable quantity are not to be expected since no large obstacles close to the site and no highly reflective surface above sensor height can be identified.



4 Conclusion

The surroundings of the location are acceptable for the installation of a ground measurement station. No significant single external influence from surrounding facilities on the overall meteorological and atmospheric conditions could be stated during the site visit. The local stakeholder confirmed his support and smooth operation and proper maintenance of the station is expected with high probability. Future use of the equipment by the local stakeholder after the two years measurement campaign is also probable, since the University representatives expressed a keen interest in collecting solar data.

The site is recommended for the installation of a Tier 2 meteorological station