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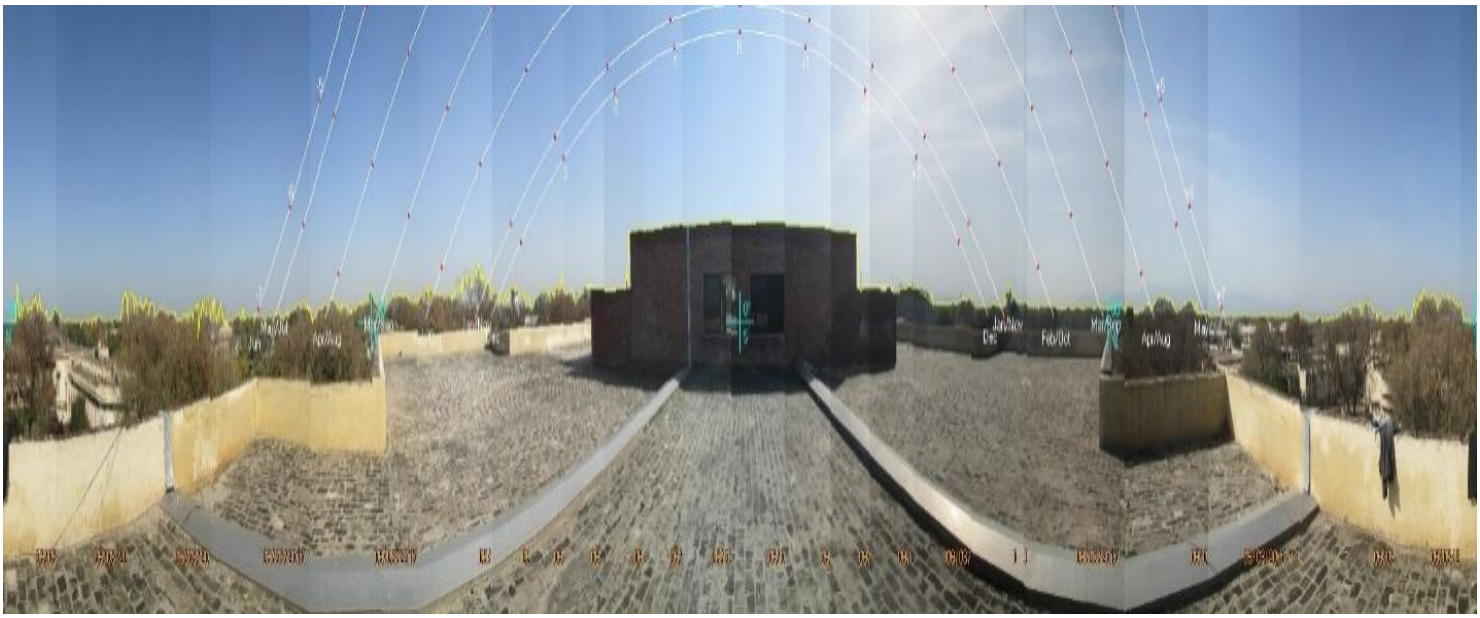
ESMAP
Energy Sector Management Assistance Program

Solar Resource Mapping in Pakistan

SITE EVALUATION REPORT: PESHAWAR UET

July 2015



This report was prepared by the consultants listed on the following pages, under contract to The World Bank.

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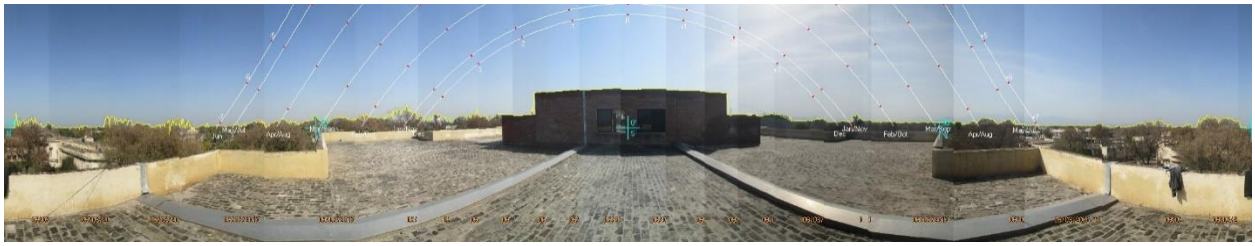
This document is an **interim output** from the above-mentioned project. Users are strongly advised to exercise caution when utilizing the information and data contained, as this has not been subject to full peer review. The final, validated, peer reviewed output from this project will be the Pakistan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

ESMAP – Renewable Energy Resource Mapping Initiative

- Solar Resource Mapping for Pakistan –

Site evaluation report: University of Engineering and Technology Peshawar



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Contents

1 Executive Summary

A member of the solar vendor consortium for the ESMAP Pakistan Solar Resource Mapping Project visited the University of Engineering and Technology in Peshawar on March 09, 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 one of the campus buildings 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 the Pakistan Meteorological Department in Peshawar, 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

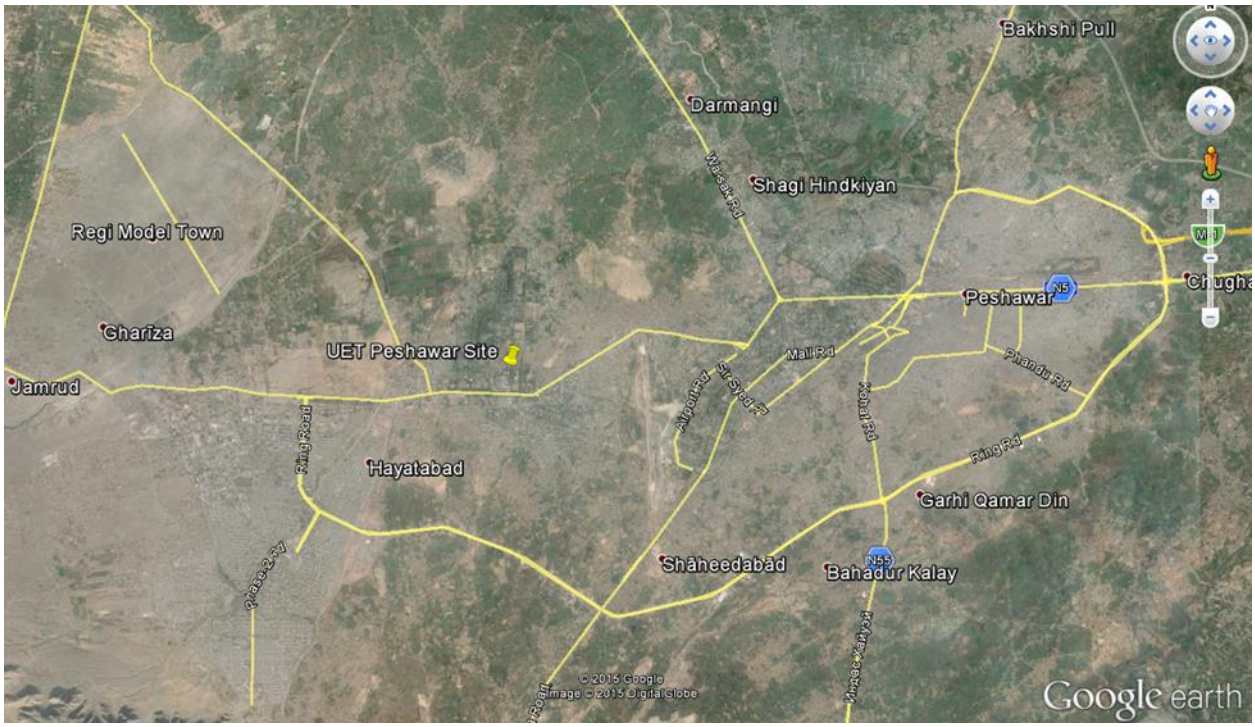

Figure 1: Location overview (Google Earth View)

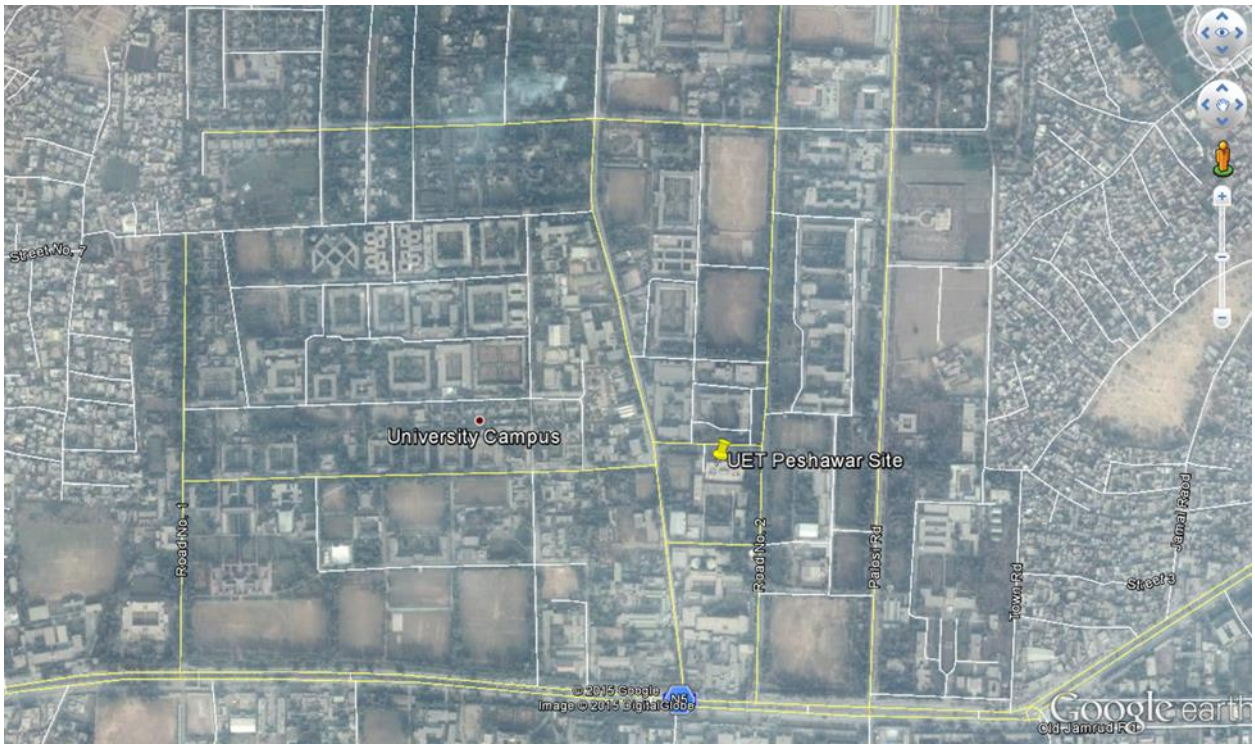

Figure 2: Aerial View (Google Earth View)

Peshawar, the capital of Khyber Pakhtunkhwa province, is located on the eastern exit of the Chaiber pass over the Spin Ghar mountain range and is crossed by the Kabul river and several small tributaries, one of which is located about 2 km to the North of the site. The Swat river is coming from the mountains north of the city and joins the Kabul river 15 km northeast of Peshawar. The mountains are sheltering the city to the west, north (30 km distance) and south (25 km distance). To the east there is mostly flat terrain for about 100 km until the Tarbela dam and lake on the Indus river. The two large rivers unite about 55 km east of the city.

The UET campus is situated about 8 km west of Peshawar city and about 2.5 km west of the airport. In the immediate surroundings, there are housing areas with dense population. To the west, the Narai Khwar river is passing from north to south, a small river that divides into two arms directly after passing the campus. To the south, there is the National Highway 5, passing the campus in east-west-direction. The campus itself is consisting of a number of buildings with up to 5 storeys. Between the buildings, there are streets and lanes with gardens and trees.

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 the University has dedicated engineers and technicians available for the task.

Contact Information

The local contact for the site is

Dr Najeeb Khan

Cell No. +92 300 9359 398

3.3 Site evaluation

3.3.1 Coordinates

N 34.0017° E 71.4854°, altitude 370 m above mean sea level

The site is located on the roof of the mechanical engineering department building of the university complex.

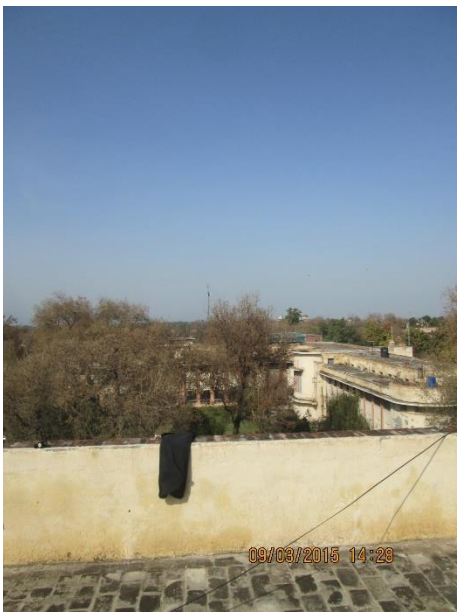

Figure 3: View from Site to the North

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[i]	Minimum area 10 × 10 m²	Yes	Rooftop
Surface	Firm natural ground[ii]	No	
	Ground type[iii]	Concrete	
	Horizontally levelled[iv]	Yes	
	Excavation for foundations possible[v]	Yes	Casting Blocks are preferred
	Fencing of the site possible[vi]	Yes	
	No drifting sand/snow[vii]	No	Slight Dust Storms

	No flooding possible[viii]	No	
Surroundings	Obstructions If yes, note direction, distance and approx. height[ix]	No	See Panoramic Pictures
	Reflections or light sources[x]	-	
	Industrial areas or power plants[xi]	No	Hayatabad Industrial Estate around 7 km from the site
	Sources of smoke or vapor[xii]	No	
	Quarry or mine[xiii]	No	
	Main road, dirt road, track[xiv]		Paved Roads
	Airports[xv]	-	Around 3 km from the site
	Settlements, towns, city[xvi]	Yes	Urban Area
	Agricultural area[xvii]	No	
	Swamp, lake, river, ocean[xviii]	No	
	Sand dunes[xix]	No	
	Animal populations[xx]	No	
	Occurrence of snowfall[xxi]	No	
	Temperatures below freezing point[xxii]	No	
	Other[xxiii]	-	
Accessibility	Accessible by car[xxiv]	Yes	
GSM coverage	2G network available[xxv]	Yes	All 5 providers
Land use rights	Permit available[xxvi]	Yes	Internal Decision
Operation permit	Permit available[xxvii]	Yes	Internal Decision
Security	No underground or overhead electrical lines, pipelines or similar [xxviii]	No	
	Measures against theft or vandalism required?[xxix]	No	

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 (distance is at least several kilometres) thus no negative impacts on irradiation and measurement conditions is anticipated. 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 and has been assured.

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.

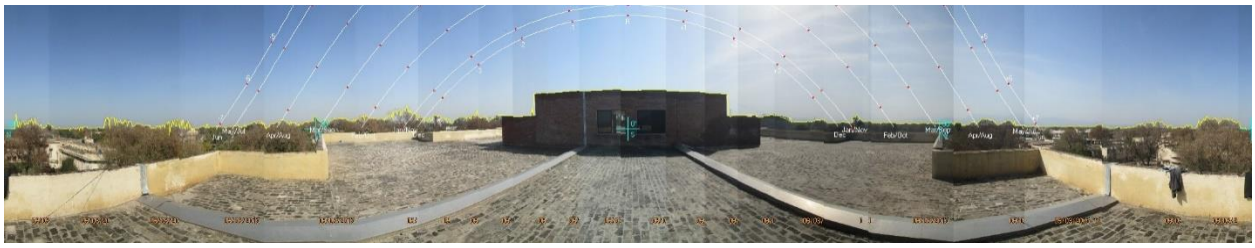

Figure 5: Panoramic View with North, South, horizon line and monthly sun paths with the corresponding position at full hours marked

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

Shading Table for Sun Elevations >0°

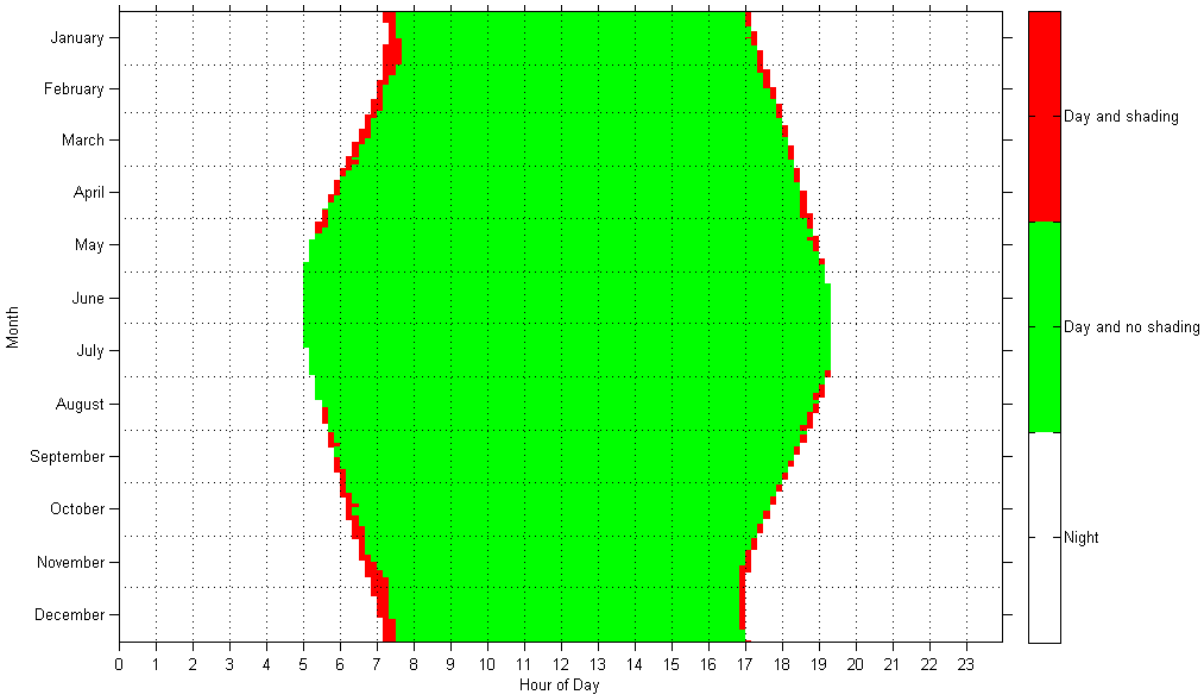

Figure 6: Shading Table for Sun Elevations >0°

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 and evening in the months from August to April, but with a short duration of only about 10-20 minutes.

Shading Table for Sun Elevations >5°

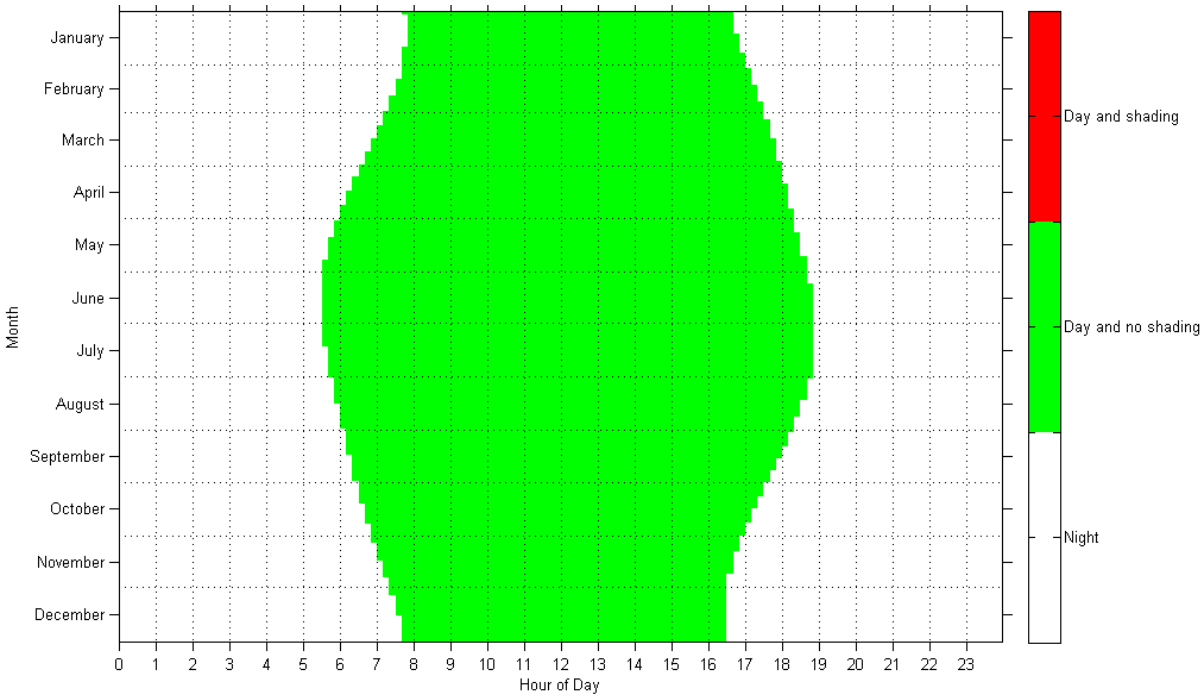

Figure 7: Shading Table for Sun Elevations >5°

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.

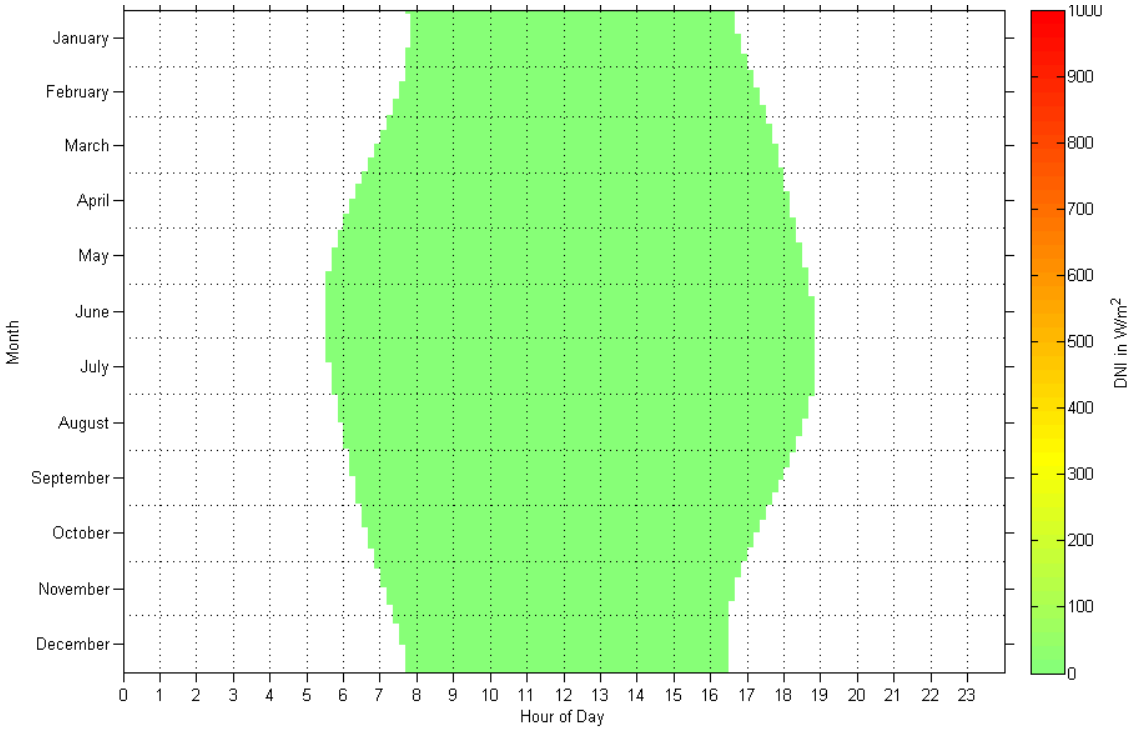

Figure 8: Shading Impact on BirdDNI for Sun Elevations >5°

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. The small structure on the rooftop to the South has a low-reflective surface and is situated in a position where occurring reflections will not fall on the sensor itself.

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.

Detailed description of checklist criteria:

[i] A site with a minimum extension of 10 × 10 m² is required for the collocation of the meteorological measurement equipment, complying with the characteristics and criteria listed in the following.

[ii] The site suitable for collocation of a meteorological station needs to have a firm ground in order to enable a secure fixation of the equipment on the ground, e.g. by ground anchors and guying ropes.

[iii] Annotate here if the ground consists of firm and naturally grown soil or artificially (by man) filled soil, if it consists of bedrock, firm soil, loose soil or sand.

[iv] Annotate here if the site is approximately horizontally levelled and flat.

[v] Annotate here if it is possible and permitted to lay small foundations (4-5 foundations each approximately 1 × 1 m² and ~0.3 m deep).

[vi] Annotate here if it is possible and permitted to fence the compound.

[vii] Annotate here the terrain consists of drifting sand or snow.

[viii] Annotate here if the terrain may run the risk to be flooded at heavy rain falls.

[ix] Describe any object which exceeds 2 m height in the closer environment of the site and which might shade the measurement equipment on the site from direct sun at any time of the year or which obstructs parts of the sky dome. Describe in detail at least all such objects within 30 m distance as well as bigger objects up to at least 200 m distance from the site. As the sun at sun rise and sun set approaches the horizon in East and West direction (~±30 degrees depending on season), obstructions in these directions are of particular importance. Add sketches of the site environments where possible.
Possible obstructing objects are: mountains, hills, buildings, skyscrapers, houses, industrial or commercial buildings, warehouses, churches/mosques or similar buildings (for religious or cultural activities), walls, bridges, towers, chimneys, wind energy plants, transmission masts, power poles, other poles or rods, cranes, street lights, greenhouses, trees, bushes, shrubberies, any other higher vegetation, or similar.
Moreover, the view from the site towards the horizon should be documented by 360° photographs (see corresponding description) or a short movie taken from the site, starting in direction to the North over East, South, and West to North direction again.

[x] Annotate if any reflecting surfaces like mirrors, glazing, shiny metal surfaces, PV panels, etc., or artificial light sources are in the environments and might cause reflections or radiation on the measurement equipment, influencing irradiation measurements.

[xi] Annotate if any industrial production site or power plant is located in the environments of a few kilometers, which may cause emissions of smoke, vapor, dust or other aerosols.

[xii] Annotate any source of smoke or water vapor columns located in the environments.

[xiii] Annotate quarries or mines in the environments causing pollution by elevated dust.

[xiv] Annotate close by roads as they frequently cause increased sensor soiling by elevated dust settling down on the sensors, or increase the risk for theft or vandalism due to increased visibility.

[xv] Annotate the presence of airports in the environments as exhaust gases of planes may influence the measurements.

[xvi] Annotate the presence and size of settlements in the environments in order to judge potential influences on the measurements (personally or as secondary effects like smoke or dust) by man.

[xvii] Annotate type and frequency (if possible) of agricultural activities in the environments in order to judge potential impacts on the measurements (e.g. elevated dust, etc.).

[xviii] Annotate their potential presence in the environments in order to judge impacts on the measurements due to increased humidity, oxidation of the equipment, instability of the ground, etc.

[xix] Annotate the presence of sand dunes in the proximities of some kilometers in order to judge potential deposition of sand on the equipment.

[xx] Annotate if any animal population frequents the area which might have any impact on the measurements. Also take into account birds, termites, insects (bees, wasps, etc.), etc.

[xxi] Annotate the occurrence and the frequency (if possible, may be estimated) of days with snowfall or remaining snow cover in order to design the power supply and version of the irradiation sensor(s).

[xxii] Annotate the occurrence and the frequency (if possible, may be estimated) of days with temperatures below freezing point temperature (zero degrees Celsius) in order to design the equipment and judge potential impacts on the measurements.

[xxiii] Annotate any other observations, occurrences or presences which you may estimate them causing potential impacts on the measurements. In the case of doubt about an influence, please annotate the observation.

[xxiv] Annotate if the site is easily reachable by car in order to facilitate the transport of the equipment to the site.

[xxv] Verify with your mobile phone or contacting a reliable local mobile phone network provider the availability of 2G network from different providers. If only 3G network (or higher) is available, verify with the network provider if GPRS connection in 2G mode is enabled. Check with your mobile phone by switching it manually to 2G connection only and test data connectivity via GPRS or EDGE.

[xxvi] Verify and annotate if the land use permits are conceded or given from the land owner.

[xxvii] Verify and annotate if the permits to use the compound for operation of a meteorological station are conceded or given by law and local authorities.

[xxviii] Verify and annotate if no high voltage lines (exceeding 20 V) are crossing the compound neither as overhead line nor in the ground. Verify and annotate if no gas, water, remote heat or other pipeline are crossing the compound above or in the ground.

[xxix] Estimate the risk of theft or vandalism on the measurement equipment. Give an estimation of a safety guard or similar is required to watch the equipment.