

SOLAR PROJECT

Solar Data Acquisition

ABSTRACT

An update to the previous Solar Report (25/2/2012) emphasizing on the obstacles faced, the work conducted, and the results of.

1/12/2013

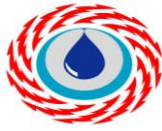


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1. Introduction

The Oman Power and Water Procurement Company SAOC (“OPWP”) is responsible for the procurement of new capacity and output for the Main Interconnected System (MIS) and the Salalah System in the Sultanate of Oman in accordance with the requirements of the law for the regulation and privatization of the electricity and related water sector (“the Sector Law”) promulgated by Royal Decree 78/2004 and the OPWP license.

As one of the leading entities in the Power Sector, the Authority for Electricity Regulation (AER) commissioned a study to assess the availability of renewable sources of energy and the potential utilization of such sources for the generation of sustainable electrical energy to meet future energy demands. The results of this study confirmed the untapped potential of Oman’s renewable sources of energy, and as such, the Public Authority for Electricity and Water (PAEW) conducted a feasibility study on the preparation for the country’s first large scale renewable energy project with net power output ranging from 100 MW to 200 MW.

This study was able to identify twenty three sites in three regions in the Sultanate of Oman to have the characteristics most suitable for the development of a large scale solar plant, the basis of this decision was due to specific criteria including, but not limited to, proximity to the Main Interconnected System (MIS), availability for solar radiation data, environmental issues (including air quality, natural resources, topography & landscape and so on). Further information on the site selection process and results of can be found in the previous Solar Report (25/2/2012).

As a result of the site-selection study, two weather monitoring stations were established with various different instruments to measure and store weather parameters such as wind speed, wind direction, dust, temperature, humidity, and most importantly Direct Normal Irradiance (DNI) and Global Horizontal Irradiance (GHI). The GHI and DNI data, measured in W/m^2 , is what demonstrates the amount of solar radiation that falls upon a square meter and plays a key role in order to determine the not only the ground area requirements for a solar power plant, but also the most suitable technology to be utilized for the solar power plant. Further information on the exact list of instruments available on the site can be found in the previous Solar Report (25/2/2012).

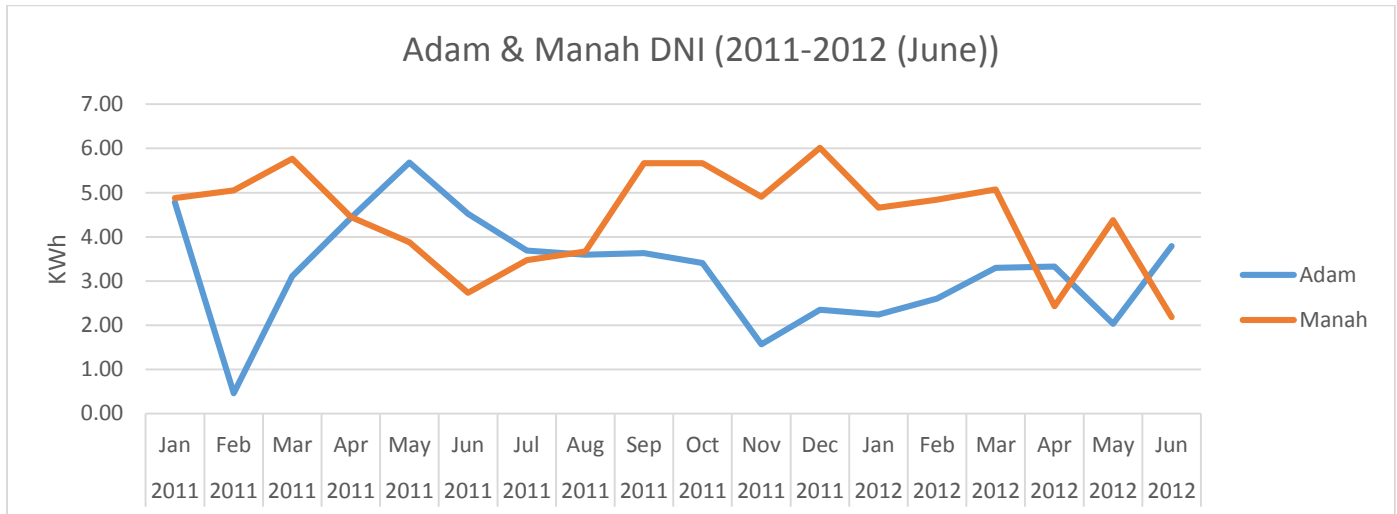
The two weather monitoring stations mentioned above have been operational since 2011, and while most of the parameters measured on site are deemed accurate and reliable, an issue was encountered with the DNI measurement device (Pyrheliometer) that resulted in erratic and inconsistent data measurements between the two sites. And as such, the previous report was uploaded onto the website in order to receive comments from a wider audience, and also, an investigation into the sites and the units were conducted.

The purpose of this report is to update all interested parties, whether be it for investment, development or personal/academic purposes on the current state of the measured data, the initial issues that were discovered with the data, the fixes implemented to resolve those issues, and also to share with all interested parties the solar data that’s currently available.



2. Site Investigation

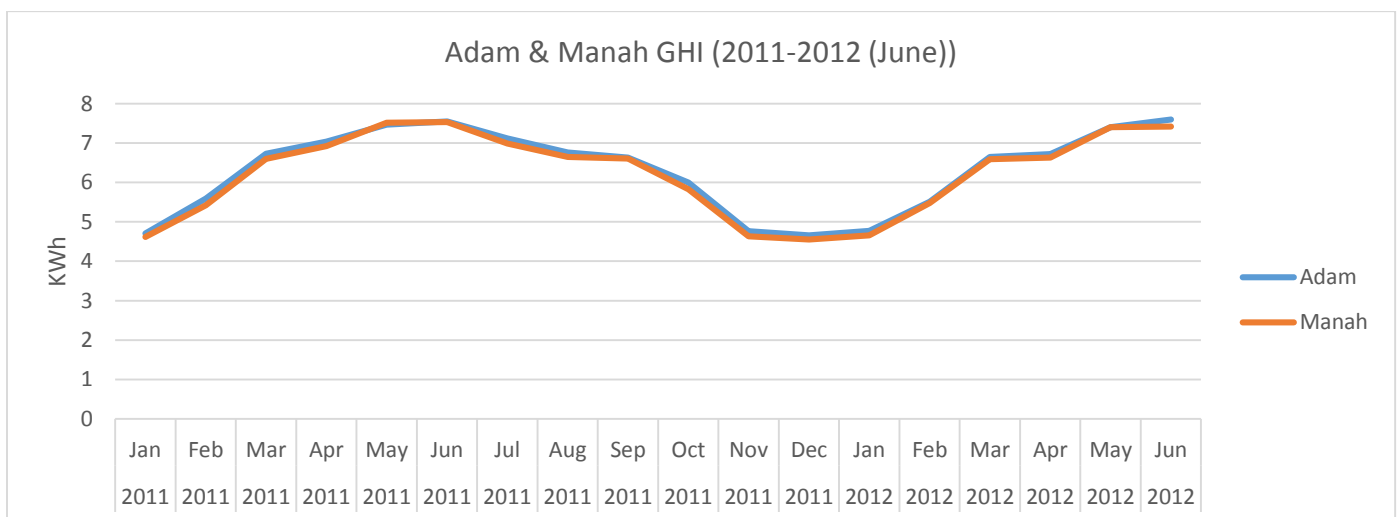
During early 2012, OPWP became involved with the Solar Project, and more specifically with the two weather monitoring sites in Adam & Manah – this is due to the importance of the solar radiation data to OPWP as it is meant to be passed on during the development stage of the solar power plant. However, the DNI data presented to OPWP by the MET Department (who was initially responsible for the operations and maintenance of the sites) raised questions and doubts due to its inconsistent and erratic trend. The graph below represents the data trend during the time period before OPWP took action to resolve the issues that were present on site:



Graph 2.1: Adam & Manah DNI Data 2011-2012 (June)

It's worth to note that this graph is slightly different from the one that was presented in the previous report as this shows the actual data presented from the sites, without eliminating days that did not register DNI readings (previous methodology).

In comparison, the below graph shows the GHI data measured for the same period.



Graph 2.2: Adam & Manah GHI Data 2011-2012 (June)



It was due to the immense difference between the GHI and DNI data that OPWP decided to conduct its own investigation to determine the issues behind the inconsistent and erratic DNI data, and with the collaboration of our consultants provisioned for this part segment of the Solar Project, Worley Parsons, the supplier of the equipment and installers of the sites, Microstep, and the manufacturer of the sun sensors, Kipp & Zonen, it was determined that the issues with the data was not due to improper interpretation methodology of the data, but rather the sites themselves. This was due to the following factors:

1. Re-calibration of the units were neglected.
2. Inconsistency with regards to cleaning the solar panels which may have led to insufficient power for the sites to operate (the weather monitoring sites are completely sustainable and obtain all its energy requirements from solar panels).
3. Improper placement of the Pyrheliometer as it was susceptible to shadows caused by the surrounding elements in the weather station.
4. Manufacturer defect in the Pyrheliometer that caused it to sometimes reset itself during the course of the day.

It was at this point, and upon the discovery of the above factors, that OPWP proposed to take over the operations and maintenance of the sites in order to ensure the correct supervision is maintained and that the data produced by the sites are indeed accurate and reliable. The PAEW reviewed the proposal set forth by OPWP and subsequently approved.

3. Actions Taken

In order to ensure that the issues were rectified, and to avoid its occurrence in the future – the following actions were taken:

1. Re-calibration of the units were neglected:

In order to solve this issue, a representative of the equipment supplier (Microstep) was called down to the Adam & Manah stations to conduct a complete technical assessment of all the units. This assessment produced a list of the calibration requirements of the units, which was put into immediate effect as certain units were sent to their respective manufacturers to conduct the necessary works. Also, to ensure that measurements of the parameters would remain constant throughout the year and not get affected by the re-calibration schedule, spare parts were procured to ensure a rolling spare was available at all times.

2. Inconsistent cleaning of the solar panels and sun sensors:

In order to minimize the probability of neglect, a local entity was contracted to conduct the cleaning. The local person in charge of this duty is also required to report on a daily the time in which the visit was conducted, any observational weather abnormalities, and any observational defects on the site. This set-up ensures that the sites are maintained on a daily basis and if any major issues were to occur, this can be detected almost immediately.



3. Improper placement of the Pyrheliometer:

In order to ensure that the pyrheliometer is not affected by the surrounding instruments, such as the mast that holds up the wind direction and wind speed sensors, a survey of the area was conducted and a new location for the unit was determined. In order to ensure that stability of the unit, a 1.2 meter concrete plinth was constructed and the pyrheliometer unit was installed on the plinth.



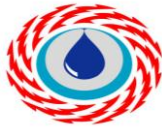
Image 3.1 Initial placement of Pyrheliometer



Image 3.2 New placement of Pyrheliometer

4. Pyrheliometer manufacturer defect:

It was only when OPWP investigated further into the pyrheliometer unit to understand why during certain days the unit would suddenly stop measuring data halfway through the day. This was conducted by reviewing the log files stored by the unit, it was discovered that on the days where the measurements of DNI would drop off to 0 halfway through the day, the log files would report a 'Slip Error' which then causes the unit to reset. This was brought to the manufacturers' attention who then subsequently requested that the units be sent back to them as soon as possible to resolve a defect. Both pyrheliometer units from Adam & Manah went sent to Kipp & Zonen to conduct the necessary repair works, and it's for this reason that while GHI data is available continuously and consistently from 2011 up and until the most recent months, no DNI data is available from July 2012 until February, 2013. As it's during this month when both units were returned to Oman and were re-installed back into the Adam and Manah sites.



Additional actions that were taken were to conduct the following activities:

- a) Upgrade the data logging system on-site in order to accommodate minute-by-minute data logging;
- b) Accommodate remote connectivity and live stream of the weather station parameters to the OPWP offices;
- c) In-house development of an application to sort and manage the raw data files obtained from the data loggers;
- d) Routine maintenance and re-calibration of the units;
- e) Development of a data interpretation methodology and subsequent refinement of such methodology to ensure accurate results.

4. Data Interpretation Methodology

The new data logger that was installed in-site would produce two different sets of data, the initial one would be an automatically calculated hourly average, and the other would be raw minute-by-minute data. For the first few months after the re-installation of the new data loggers on-site, the hourly average data was taken into account and processed. However, it was soon discovered that there were two major flaws with the way the unit would store the hourly average files:

1. The results of an hourly average calculation would be saved with the time stamp of the following hour. This meant that within the report, the hour at the end of the day where the sun had clearly set, the report would have a DNI value stored there.
2. The hourly average would only be calculated if the final minutes of that hour is available. This meant that if maintenance was being conducted on-site and the unit had to be switched off for a few minutes (and so happen to fall at the end of the hour), the data-logger would produce a NULL value for that entire hour.

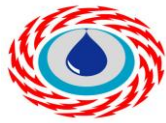
Due to these reasons, the automated hourly average file produced by the unit was no longer deemed reliable, and subsequently, an algorithm was developed in order to quickly and efficiently calculate the hourly average of all the parameters using the minute-by-minute data, and to also conduct error checks and quality assurance logical statements.

It's worth to note that unlike the previous methodology, no days during any of the months starting from February have resulted a DNI of 0 kWh/m²/day – and as such, no days were eliminated from the calculations.

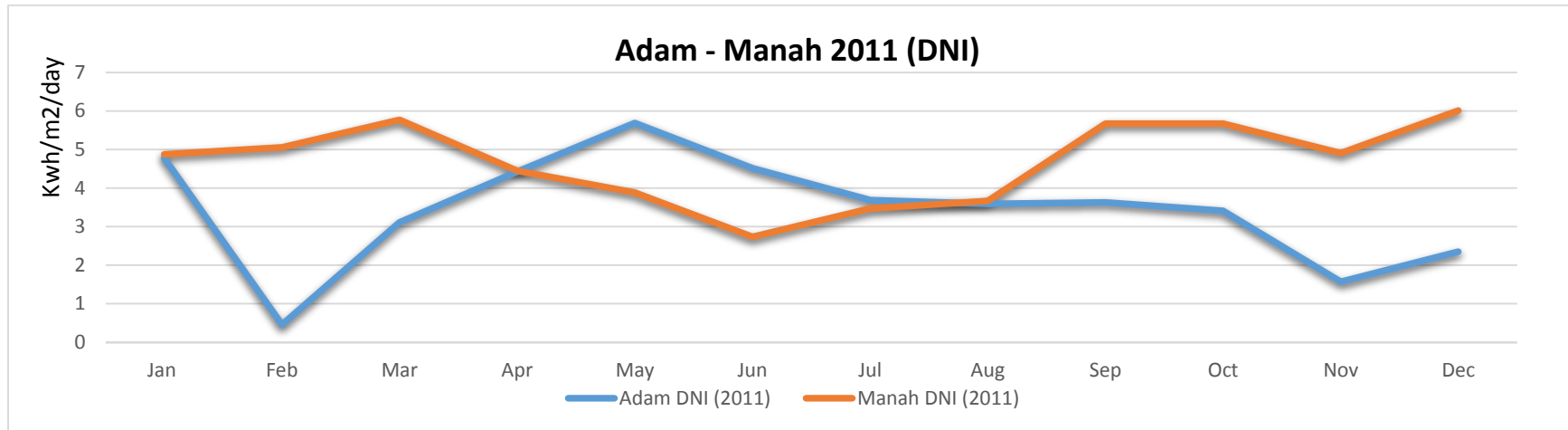
5. Results

The preliminary results of the efforts put in by OPWP show improvements in the data when compared to that previously obtained. Not only is the DNI trend far more stable than it was in the previous years, but it's also showing an increase in measured monthly average DNI data from 0.4 to 2.7 kWh/m²/day when comparing the newly obtained 2013 data to its respective months in both 2011 and 2012.

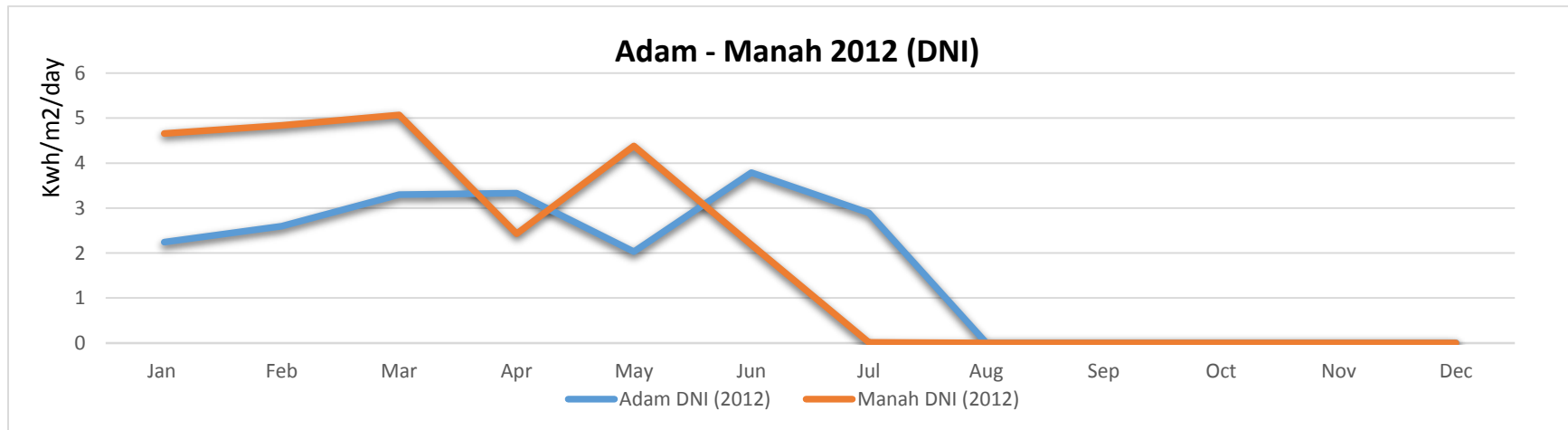
With regards to the GHI data, no real change can be observed. This implies that the available GHI data for the years 2011 & 2012 is indeed accurate and reliable data.



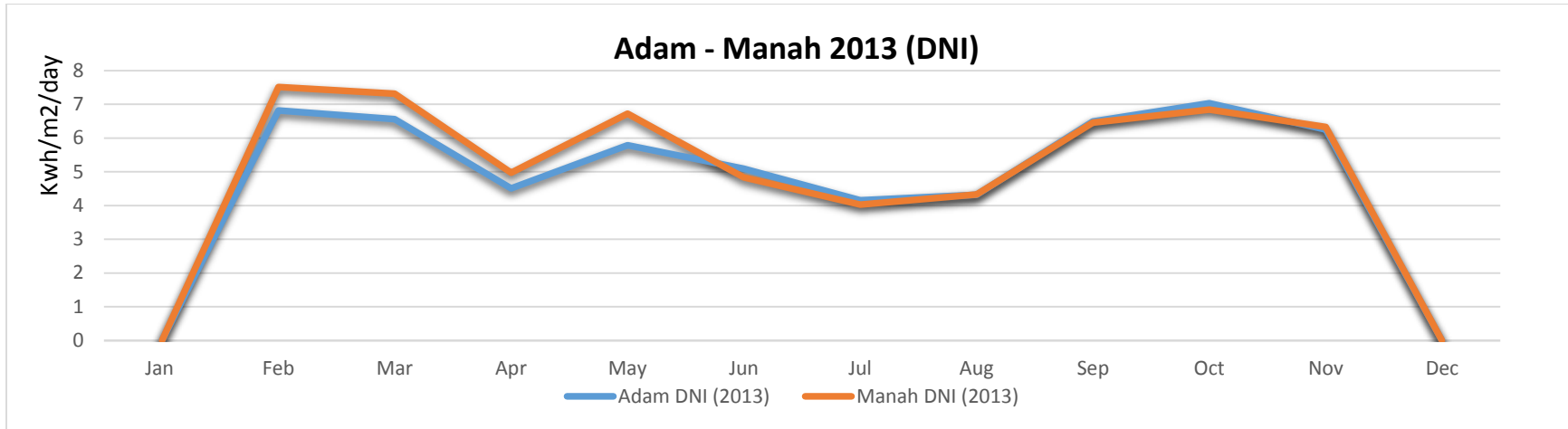
The below graphs shows the improvement in measured DNI when compared to the previous two years:



Graph 5.1 Adam & Manah 2011 (DNI)

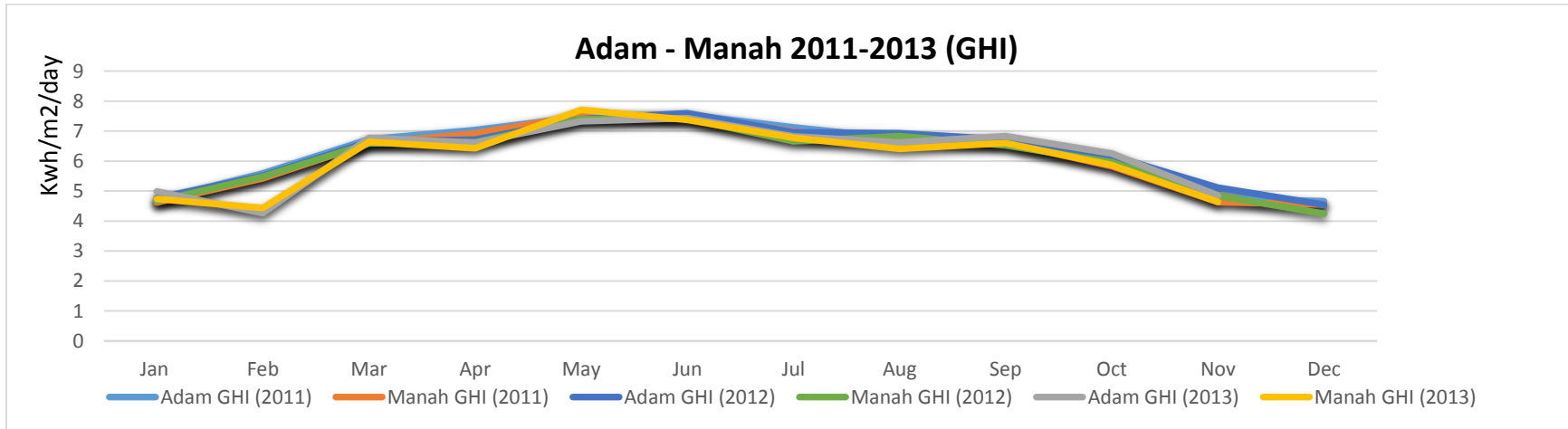


Graph 5.2 Adam & Manah 2012 (DNI)



Graph 5.3 Adam & Manah 2013 (DNI)

The below graphs shows the consistency in the GHI data throughout the years, and thus is deemed to be reliable and accurate data:



Graph 5.4 Adam & Manah 2011-2013 (GHI)



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OMAN POWER AND WATER PROCUREMENT CO. (SAOC)

A follow-up report will be available on the OPWP website that looks at the data obtained during 2013 in further detail and assess the impact of weather (cloud cover and overcast) on the obtained data.

6. Conclusion

The re-commissioning of the weather monitoring sites is deemed to be a success due to the observed improvements in the DNI data. As such, the data shall be publicly available and will be continuously updated on OPWP's website for parties interested in the Solar Project in Oman – be it for development, investment, academic or personal reasons.

All interested parties are welcome to comment and get in touch with OPWP personnel for further information or inquiries.