THE WORLD BANK
IBRD • IDA | WORLD BANK GROUP

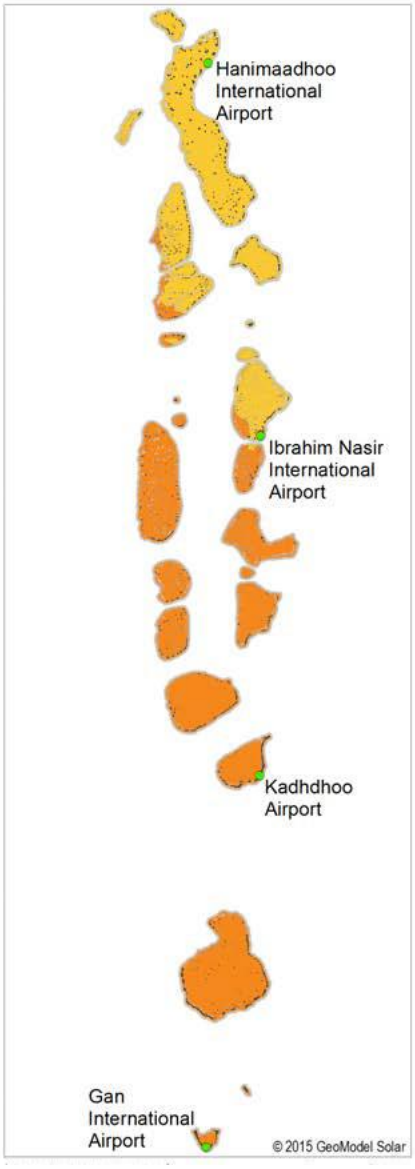
ASTAE
Asia Sustainable and Alternative Energy Program

ESMAP
Energy Sector Management Assistance Program

Solar Resource Mapping in the Maldives

PHASE 2 IMPLEMENTATION PLAN

OCTOBER 2015



This report was prepared by GeoModel Solar, 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 – Maldives" [Project ID: P146018]. 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 Maldives Solar Atlas, which will be published once the project is completed.

Renewable Energy Resource Mapping and Geospatial Planning – Maldives P146018

Solar Resource

Phase 2 Implementation Plan

World Bank Group, ASTAE/ESMAP Renewable Energy Mapping Initiative

October 28, 2015

Lead contractor: GeoModel Solar, Slovakia

Subcontractors: Suntrace, Germany

Renewable Energy Maldives, Maldives

Reference No. (GeoModel Solar): 129-04/2015

TABLE OF CONTENTS

1 INTRODUCTION

1.1 Background

This report is prepared within Phase 1 of the project *Renewable Energy Resource Mapping for the Republic of the Maldives*. This part of the project focuses on solar resource mapping and measurement services as part of a technical assistance in the renewable energy development implemented by the World Bank in Maldives. It is being undertaken in close coordination with the Ministry of Environment and Energy (MEE) of Maldives, the World Bank's primary country counterpart for this project.

Phase 2 of the has to deliver high quality solar resource measured data that are needed for **validation of solar resource and meteorological models**. Central in this effort is a focus on reducing uncertainty of the models and thus reducing financial and technical risk during implementation of photovoltaic solar power plants in Maldives.

Second objective is to **build a network of solar measuring stations** and to implement a **longterm and sustainable solar resource monitoring program** as one of support mechanisms for development and operation of solar power infrastructure in Maldives.

This project is funded by the *Energy Sector Management Assistance Program* (ESMAP) and *Asia Sustainable and Alternative Energy Program* (ASTAE), both administered by the World Bank and supported by bilateral donors.

1.2 Objectives and approach

In Maldives, **four Tier 2 solar measuring stations** will be installed on sites that are selected in the Site Selection Report, elaborated by Consultants and approved by the Government of Maldives and by the World Bank.

This report provides information on implementation of two-year solar measurement campaign including:

- Role of local partner (Chapter 2),
- Details of the solar measuring stations, such as position, equipment, layout, etc. (Chapter 3),
- Applied approaches to ensure sustainable quality of the measured data (Chapter 4),
- Proposed capacity building and training targeted to MMS staff and selected stakeholders (Chapter 5),
- Time table of Phase 2 (Chapter 6),
- Assessment of risks and appropriate mitigation measures (Chapter 7),
- Procedure for obtaining permits and local permission (Chapter 8).

We expect to complete the installation and commissioning of all the 4 stations by December 2015. The first annual site resource report shall be delivered by December 2016, whereas the second annual site resource report will be delivered by December 2017. Recalibration and take over of the equipment by the host or other dedicated organisation is planned also for December 2017.

1.3 Technical consultations

This Plan is a result of consultation based on the delivered *Site Selection Report* in February 2015, where we identified the most suitable host and sites for installing and long-term operation of four TIER 2 Solar Measuring Stations. The choice of Maldives Meteorological Service (MMS, http://www.meteorology.gov.mv/) as a host of all four stations gives a good perspectives for ensuring longterm run of the monitoring program.

During and following the workshop held in Male on 1 to 4 March 2015, where representatives of all stakeholders were present, the decision about location of four meteo stations and hosts was made.

Minutes of the post-workshop meetings held on **4 March 2015** are below.

1. Meeting at the Ministry of Environment and Energy (MEE):

- Meeting was held from 10 to 11 A.M., and was managed by the State Minister Mr. Matheen.
- Besides representatives of MEE Department of Energy, also representatives of the Maldives Meteorological Service participated
- Outcomes of the discussion on solar resource mapping:
  - State Minister, Mr. Matheen, acknowledged the timing of the project and deliverables, which would help in providing the information to developers and to government
  - We presented a proposal for siting of four meteorological stations (summary of *Site Selection Report*). This proposal is delivered as a separate document.
  - The choice of 4 sites, located at the premises of MMS at the airports, has been approved both by representatives of MEE and also MMS: Hanimaadhoo, Hulhulé, Kadhdhoo, Gan
  - In general, the approach of all parties towards the solar component of the Resource Mapping Component was very positive with high expectations, and no obstacles have been identified towards moving to Phase 2.

2. Meeting at the Maldives Meteorological Service (MMS):

- Meeting was held from 2 to 3.30 P.M., and was managed by Mr. Abdulla Wahid, the Director
- We presented proposed sites and equipment relative to Solar Measuring Stations
- Technical and organisational aspects of collaboration were addressed
- We visited the plot with meteorological equipment and identified potential location of the Solar Measuring Station at the Hulhulé airport
- Staff of MMS has shown very positive attitude towards the project

2 LOCAL PARTNER

2.1 Renewable Energy Maldives

GeoModel Solar and Suntrace will cooperate with and subcontract Maldivian company Renewable Energy Maldives (REM) as a local partner to carry out the on-field and other related tasks in Maldives for this project. Renewable Energy Maldives provides a multitude of services that range from energy management/conservation to complete solar off-grid systems. Renewable Energy Maldives has been offering off grid energy solutions to businesses, offices and domestic consumers. REM was formed in 2007 with the mission of reducing Maldives' over reliance on fossil fuel for its energy needs. REM is a well-established and recognized company in Maldives and has formed strategic partnerships with both international and local companies. Compared with other firms REM can provide a highly qualified and multi disciplined team of professionals for station commissioning and operation, as well as provide capabilities for in-county storage and transportation.

The role of the local partner:

- Owner of the meteorological stations including spare parts for the duration of Phase 2
- Site preparation (fencing, foundations)
- Equipment will be cleared in Maldives with the aid of Renewable Energy Maldives and stored at the Renewable Energy Maldives premises
- Field verification after 12 months and recalibration after 24 months (Renewable Energy Maldives and Suntrace)
- Unscheduled site visits on ad hoc or as need basis.
- Installation of stations at the sites together with Suntrace technical expert under supervision of expert from GeoModel Solar
- Trainings will be organised in the premises of MMS, in Hulhulé
    - Training during Phase 2 Kick-off meeting
    - Hands on training before and during the installation of all Tier 2 stations
    - Every 12 months when GeoModel Solar and Suntrace visit Maldives for station maintenance.

2.2 Maldives Meteorological Service

Maldives meteorological Service (MMS) is natural partner and host of solar measuring station in Maldives for this project, as agreed during end of Phase 1 workshop negotiations in Malé. MMS has expressed interest in participating in this project, in Phase 2.

MMS is operating number of meteorological stations in Maldives with trained, skilled and dedicated staff. We have selected airports as the best options for hosting solar measuring stations.

Airports have few obstacles on the horizon. Further, airports with regular airline traffic are usually situated on or near islands with a substantial amount of inhabitants and thus are at solar energy relevant sites. Most of the national and international airports are already equipped with a meteo station of the Maldives Meteorological Service, where well-trained weather experts familiar with meteorological equipment are already available. In some cases parts of airports may be even suitable for PV systems installation, which would be a great advantage as there is not much land available for PV plants on the Maldives and would bring close generation and load centres.

Representatives of MMS and GeoModel Solar have agreed that MMS will support cleaning of solar sensors and control of the equipment at each Tier 2 station by the help of the local staff. At the end of the 2-years project, and after a set of training courses, the technical staff of MMS will be able to handle on its own all the maintenance and service activities.

3 SOLAR MEASUREMENT STATIONS

As a result of discussion with representatives of Government of Maldives (Client) and the World Bank at the end of Phase 1 workshop and during the following weeks, the final decision on measurement stations was taken.

In Maldives, **four Tier 2 solar measuring stations** will be installed on sites that are selected based on the preliminary Site Selection Report, elaborated by the Consultants, preferences of the Client, and strategic goals of the World Bank.

For a successful Phase 2 measuring campaign, the following factors are considered:

- Model validation data must come from high accuracy instruments; where the technical description of the instruments and information on their calibration status must be available.
- The equipment must be diligently maintained, and regular cleaning of sensors must be applied. Data cleaning should be systematic and logged.
- Redundant sensors have to be used for rigorous quality control: in the case of Tier 2 configuration the installation of one secondary standard pyranometer to measure global horizontal irradiance and one Rotating Shadowband Radiometer (RSR) to measure global horizontal and diffuse horizontal irradiance.
- Data should be quality checked on a continuous basis and erroneous values should be flagged to avoid use of data, not passing through QC, in validation and/or calibration of models.
- Regular scheduled visits on the station every six months to prevent common issues such an instrument misalignment, PV power supply, battery failures or issues with data logger.
- Measurement instruments must be protected against damage or destruction. Premises of the MMS on the airports have been selected as an optimum location to ensure high security and safety.

The solar measuring stations will run autonomously with regular cleaning and control by the MMS staff they will have a data capture recovery higher than 95%.

3.1 Position of solar measuring stations

Based on the delivered *Site Selection Report* and the following consultations, it was decided that four sites, suitable for installation of solar measuring stations will be located at the airports within the premises of **Maldives Meteorological Service** (Table 3.1, Figure 3.1).

Besides the good geographical distribution, this choice also fits well to the population centres, where larger solar installations will be deployed. Having a solar measuring station there will be beneficial for financing the power plants nearby:

- Gan airport is a natural choice to represent the very South of the archipelago.
- Hanimaadhoo airport is the natural choice as North of Maldives is slightly affected by regional circulation of aerosols, and thus having a meteo station there is especially useful.
- The location for other two sites is Hulhulé and Kadhdhoo airports in the central part of the archipelago.

In addition the sites fulfil the criteria for the operation and maintenance of the solar measuring stations:

- Availability of free horizon,
- Availability of GSM networks,
- Availability of local work force for maintenance,
- Easy to access and high level of security.

Table 3.1: Location of four solar measuring stations

Site	Type of station	Latitude	Longitude	Elevation (approx.)
Hanimaadhoo airport	Tier 2	6.7482°	73.1696°	2 m
Hulhulé airport	Tier 2	4.1927°	73.5281°	2 m
Kadhdhoo airport	Tier 2	1.8599°	73.5203°	2 m
Gan airport	Tier 2	-0.6911°	73.1599°	2 m

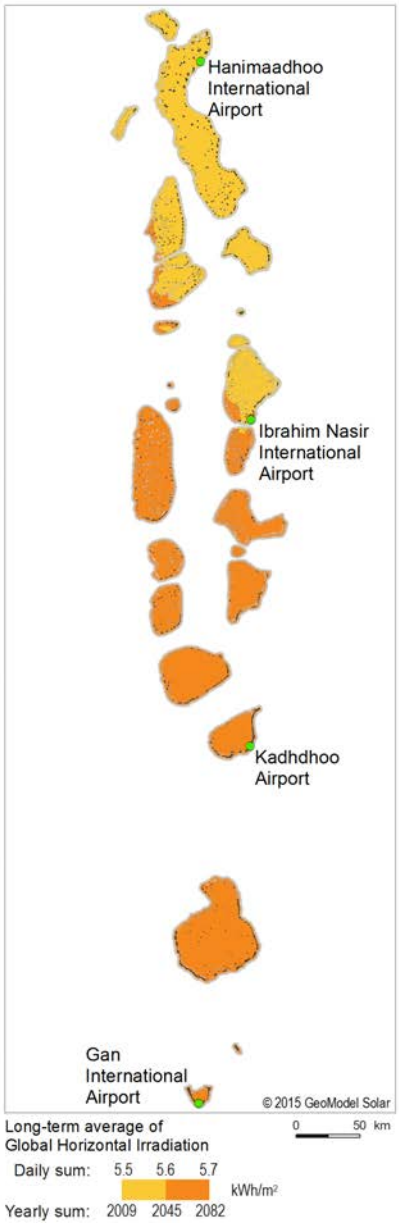


Figure 3.1: Position of four solar measuring stations in Maldives
in the context of Global Horizontal Irradiation (© 2014 GeoModel Solar)

3.2 Solar and meteorological equipment

Suntrace will arrange procurement of the agreed equipment. The following are the planned activities:

- Equipment will be ordered, assembled and tested before shipping by Suntrace.
- All measurement equipment will include factory calibrations. Calibration of radiometers shall be traceable to the World Radiation Reference at WRC/PMOD in Davos. Documentation for each meteo station will be prepared, describing the technical details and the initial calibration protocols.
- Equipment will be packed and shipped to a central storage place in Malé. From there, all equipment will be sent to the sites and installed. Documentation will be prepared for successful custom clearance, which will be responsibility of Suntrace and Renewable Energy Maldives.
- Site preparation (foundations) will be started.
- Installation of stations at the sites and creation of site installation reports

Each station shall be designed in a way to work well under the corrosive tropical maritime climate and to withstand harsh environmental conditions:

- High quality and proven measurement sensors.
- High temperature: pyranometers and RSR equipped are with thermometers at the sensor heads to monitor and allow proper correction of temperature drifts.
- Heating of pyranometers to minimize dew on dome in humid environment
- Use of weather proof electronic casings with high protection class (IP65)
- Good maintenance by local staff: daily cleaning and control of the levelling for the thermopile instruments, and at least once a week cleaning of RSR.
- Lean and elevated installation of equipment on tripod to prevent damage from flooding.
- Shielding from radio frequency interference and protection from lightning strikes by grounding masts and tripods by single point groundings with a copper rod deep in the ground. Low voltage cables are using twisted pair technology and are physically isolated from power cables.

Table 3.2: Equipment to be installed at solar measuring stations

Parameter	Acronym	Instrument
Global Horizontal Irradiance	GHI	Thermopile Pyranometer - Secondary Standard according to ISO 9060
Direct Normal Irradiance	DNI	Calibrated Rotating Shadowband Radiometer
Diffuse Horizontal Irradiance	DIF	Calibrated Rotating Shadowband Radiometer
Global Horizontal Irradiance	GHI	Calibrated Rotating Shadowband Radiometer
Ambient Temperature	TEMP	Ambient Temperature encased in radiation shield
Relative Humidity	RH	Relative Humidity Sensor encased in radiation shield
Atmospheric Pressure	AP	Barometric Pressure Sensor
Wind Speed	WS	Anemometer
Data logger	-	Data logger with 2 GB memory storage for storing up to 3 months data
Communication	-	GPRS Modem
Power Supply	-	PV panel, battery
Accessory	-	Weather proof control cabinet
Accessory	-	Grounding and lightning protection kit
Accessory	-	Mounting material, casing, cabling and other accessories required

Table 3.3: Technical parameters of instruments

Instrument	Parameter	Range	Resolution	Accuracy	Response Time	Calibration
Thermopile Pyranometer (ISO 9060 Sec. Std. with heating)	Global Horizontal Irradiance (GHI)	0.3 - 2.8 µm, -40 to + 80°C	7 to 15 µV/W/m^2	<2% daily uncertainty	≤ 5 s	Yes
Rotating Shadowband Radiometer	GHI, DHI, DNI	0.3 - 1.1 µm, -40 to + 80°C		DNI <2% for annual values with long-term outdoor calibration		Yes
Ambient Temperature and Relative Humidity Sensor encased in radiation shield	Air Temperature	-40 to + 60°C	0.01°C	±0.5°C	<120s	Yes
	Relative Humidity	0 to 100% RH	0.05%	±3%: 10% to 90% RH	<10s	Yes
Pressure Sensor	Atmospheric Pressure	400 to 1100 hPa	-	±1.5 hPa		Yes
Anemometer	Wind Speed	1 to 75 m/s	0.25 m	± 0.3 m/s < 10 m/s	-	Yes
Datalogger with memory for storing up to 3 months data	Datalogger	-	-	-	-	Yes
GPRS Modem	Communication	-	-	-	-	N.A.
PV panel	Power Supply	≥ 60 Wp	-	-	-	N.A.
2 redundant batteries	Power Supply	each ≥15 Ah	-	-	-	N.A.
Weather proof control cabinet	Accessory	-	-	-	-	N.A.
Lightning protection kit	Accessory	-	-	-	-	N.A.
Mounting material, tripod, 3 m wind mast, casing, cabling & other accessories	Accessory	-	-	-	-	N.A.

Sensors should be operated at 1 Hz sampling frequency. The data logger will average these values to 1 min and also log extremes, such as wind gusts, separately. The RSI instruments will be delivered after long-term (>4 weeks) outdoor calibration at DLR's Plataforma Solar de Almería (PSA) facilities in Almería, Spain.

3.3 Site layout at the measurement stations

Following the site visit campaign it was agreed on the final and optimal position for the station and the location of the mast. For proper installation, operation and maintenance of the stations over a longer period it is necessary to have fencing and foundation on which the station would be installed. For foundations we recommend for every foot of the tripod a screw-retained solution of two foundation plates with a size of at least 40 cm x 40 cm. For the installation of Tier 2 stations with wind speed measurement at 3 m height, we recommend to prepare a fencing that is ca. 6 m x 6 m in size. An example of one such fencing is shown in Figure 3.2.

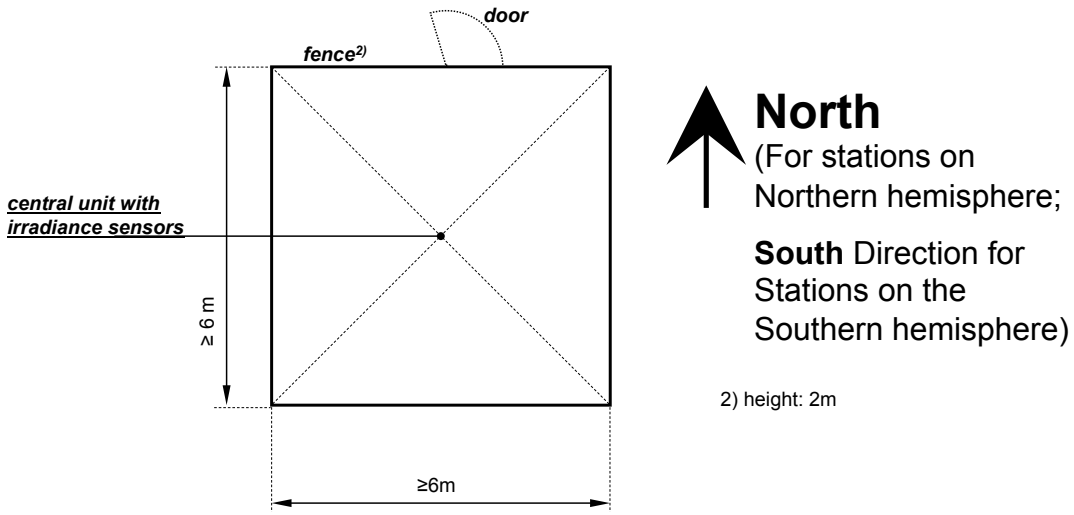


Figure 3.2: Fencing of Tier 2 meteorological stations with wind measurements at 3 m height

Implementation plan considers the actual situation of the existing met station and fit in where the main requirement of a free horizon fits best. If fencing already exists at the suggested locations, the TIER 2 station will be placed within the existing fence.

3.4 Detailed description of solar measurement stations: design and locations

General description of all sites: The sites are located within premises of the airport with restricted movement of unauthorized personnel, which ensures high level of security. The solar measuring stations are positioned at the existing meteorological stations operated by MMS. All meteorological stations have permanent presence of the local MMS staff.

Proposed type of instrumentation at all sites: Tier 2

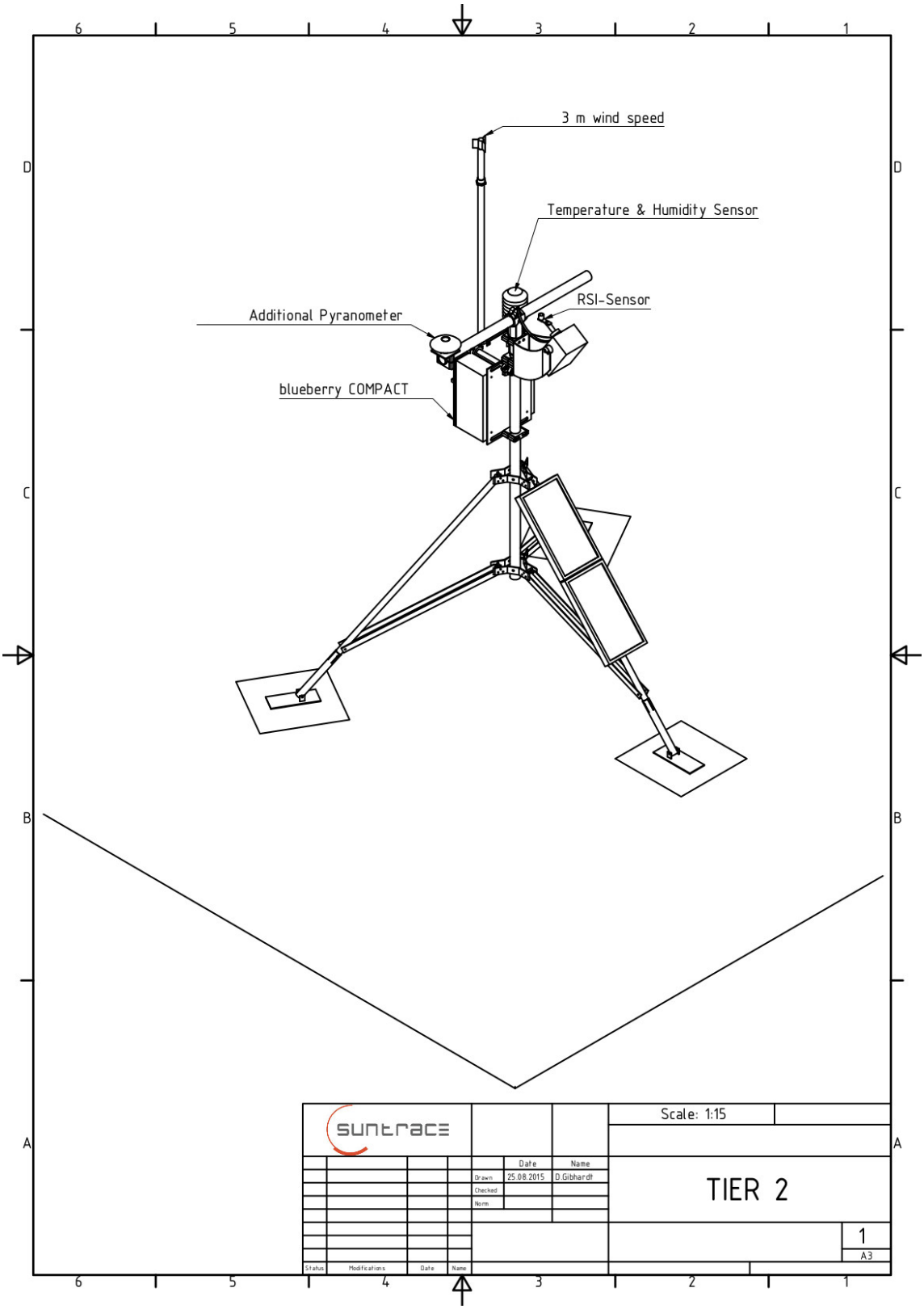


Figure 3.3: 3D view - Technical design of Tier 2 stations

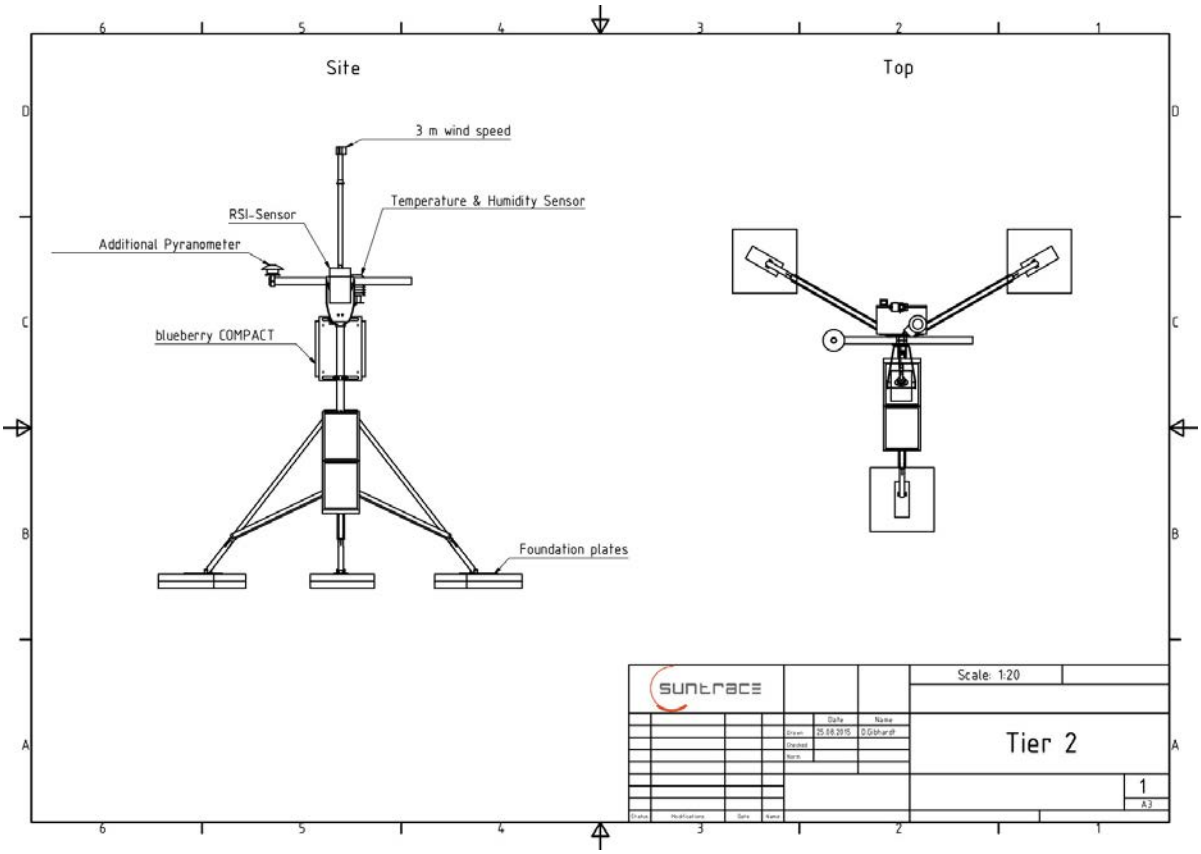


Figure 3.4: Technical design of Tier 2 stations with foundation plates

Hanimaadhoo airport

Short name (Acronym)	Description	Latitude	Longitude	Elevation
Hanimaadhoo (MVHAQ)	International airport at Hanimaadhoo island, Haa Dhaalu Atoll	6.7482°	73.1696°	2 m

SolarGIS iMaps:
http://solargis.info/imaps/#tl=Google:hybrid&bm=satellite&loc=6.7482,73.1696&c=6.749838,73.168098&z=17

Description of site

- The local horizon is free of obstacles with only presence of low-height building and trees in the distance of approx. 25 metres towards West and 150 m towards East.
- The latitude/longitude coordinates show intended position of the solar measuring stations.
- Local pollution is negligible with only small effect of the local air traffic (few flights per day)

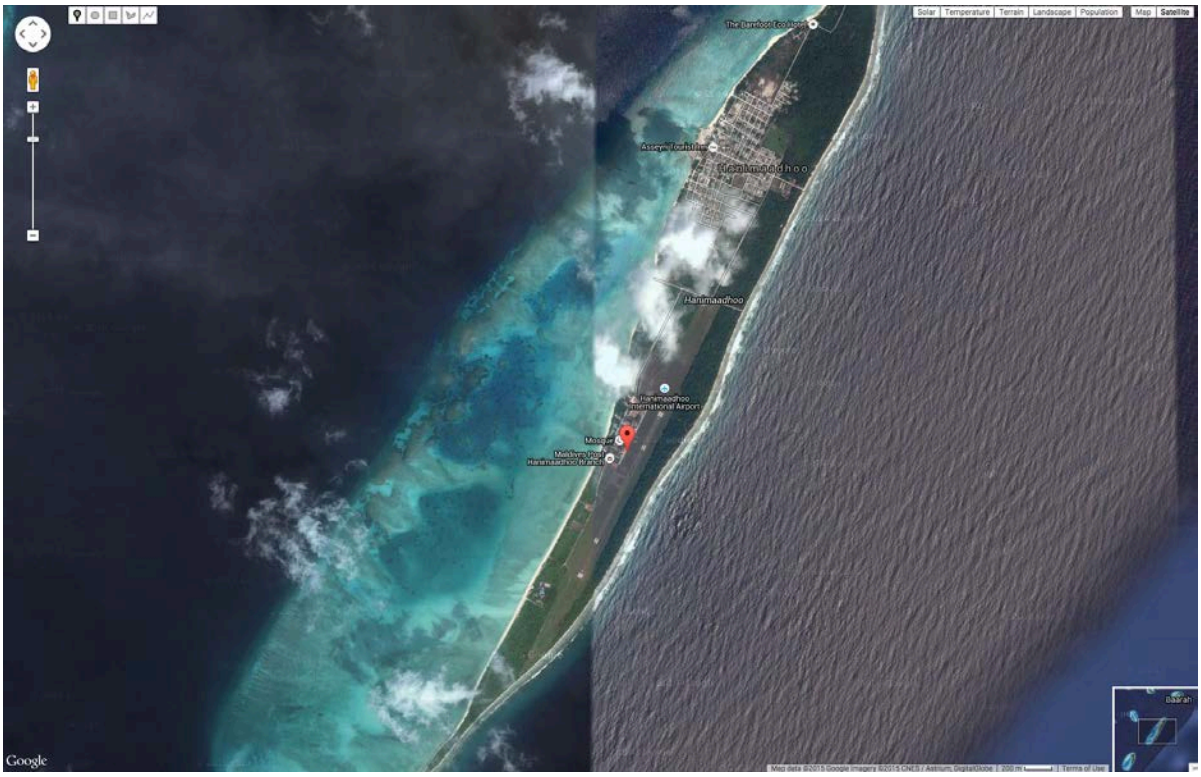


Figure 3.5: Location of MVHAQ site on Hanimaadhoo island
Haa Dhaalu Atoll (Google satellite map)

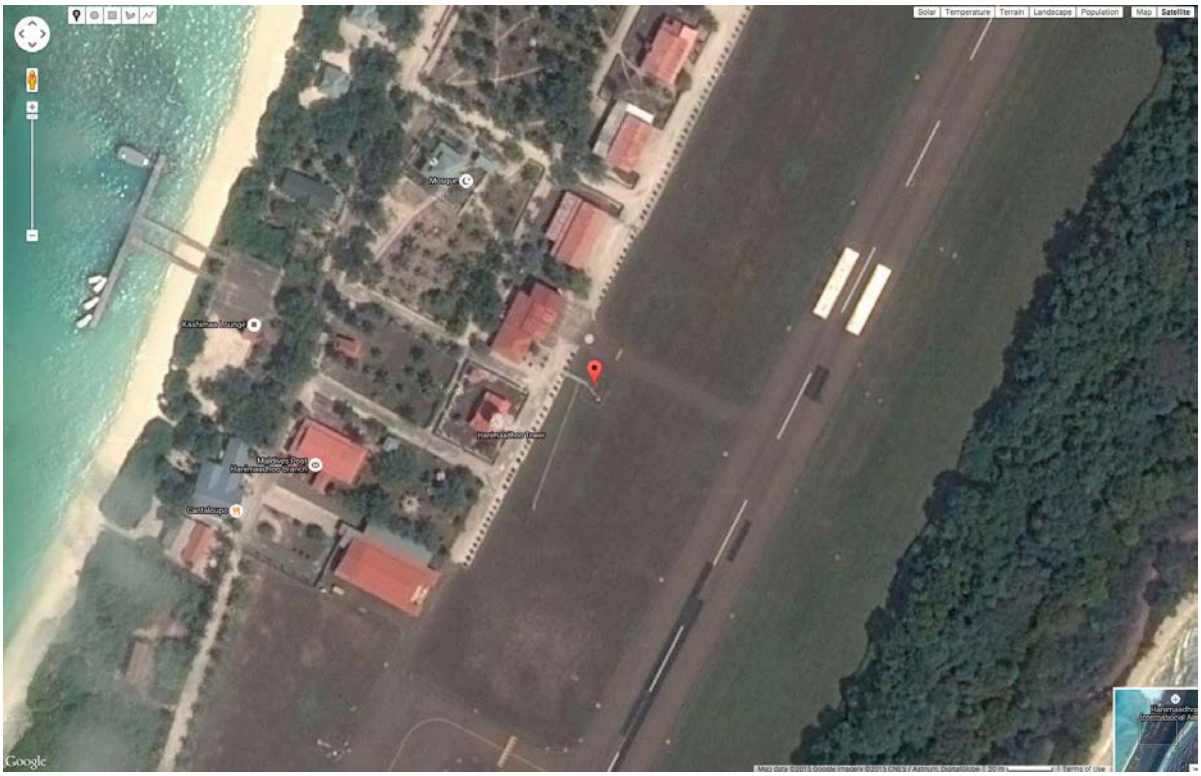
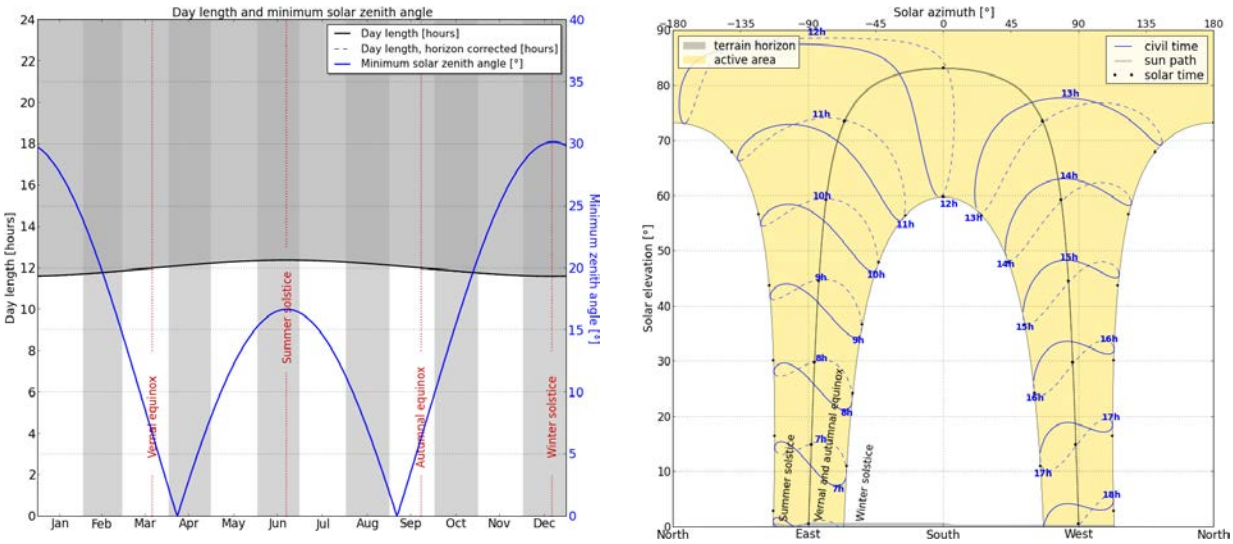


Figure 3.6: Planned position of MVHAQ station at the premises of the airport
(Google satellite map)



(a) Day length and solar zenith angle

(b) Sunpath and terrain horizon

Figure 3.7: Astronomical and geographical situation

Figure 3.8: Photos of the planned position of MVHAQ station

Hulhulé airport

Short name (Acronym)	Description	Latitude	Longitude	Elevation
Hulhulé (MVMLE)	Ibrahim Nasir international airport at Hulhulé Island, North Malé (Kaafu) Atoll	4.1927°	73.5281°	2 m

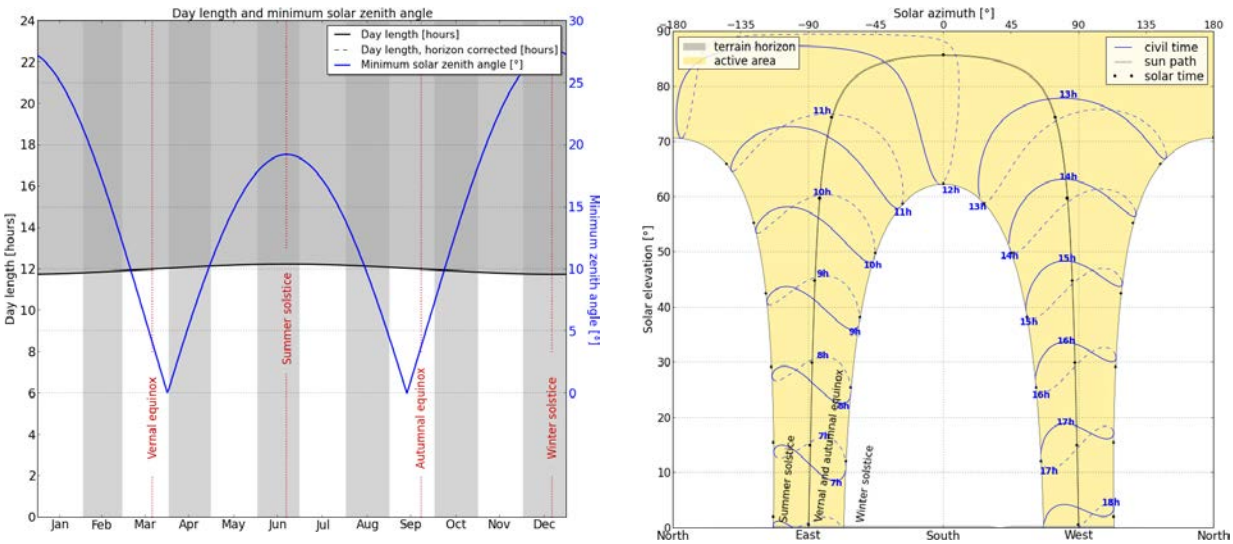
SolarGIS iMaps:
http://solargis.info/imaps/#tl=Google:hybrid&bm=satellite&loc=4.1927,73.5281&c=4.1927,73.5281&z=17

Description of site

- The latitude/longitude coordinates show intended position of the solar measuring stations.
- The local horizon is free of obstacles with only presence of low-height building and trees in the distance of approx. 30 metres towards West, that causes no shading of the instruments
- Local pollution is negligible with only the effect of the air traffic

Figure 3.9: Location of MVMLE site on Hulhulé island
North Malé (Kaafu) Atoll (Google satellite map)

Figure 3.10: Planned position of MVMLE station at the premises of the airport
(Google satellite map)



(a) Day length and solar zenith angle

(b) Sunpath and terrain horizon

Figure 3.11: Astronomical and geographical situation

Figure 3.12: Photos of the planned position at MVMLE station

Kadhdhoo airport

Short name (Acronym)	Description	Latitude	Longitude	Elevation
Kadhdhoo (MVKDO)	Airport at Kadhdhoo Island, Laamu Atoll	1.8599°	73.5203°	2 m

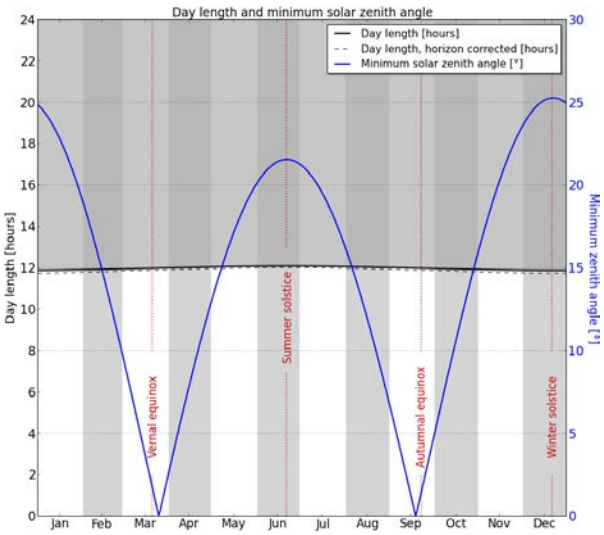
SolarGIS iMaps:
http://solargis.info/imaps/#tl=Google:hybrid&bm=satellite&loc=1.8599,73.5203&c=1.859825,73.520107&z=17

Description of site

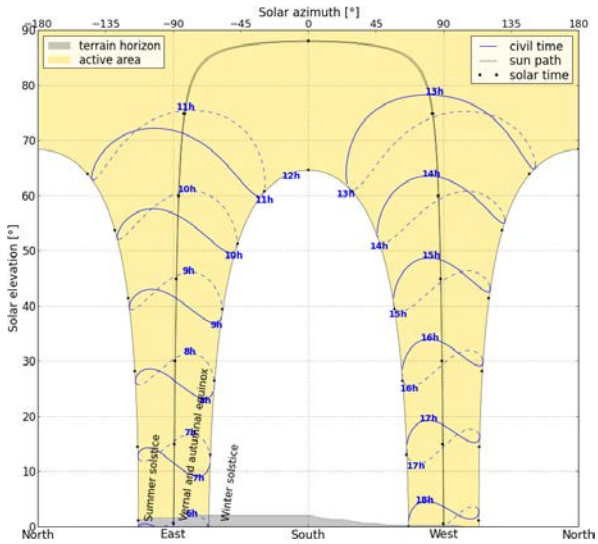
- The latitude/longitude coordinates show intended position of the solar measuring stations.
- The local horizon is free of obstacles with only presence of low-height building and trees in the distance of approx. 20 metres towards West and 160 m towards East.
- Local pollution is negligible with only the effect of the occasional local air traffic
- Exact position will be agreed with personnel from MMS

Figure 3.13: Location of MVKDO site on Kadhdhoo island
Laamu Atoll (Google satellite map)

Figure 3.14: Planned position of MVKDO station at the premises of the airport
(Google satellite map)



(a) Day length and solar zenith angle



(b) Sunpath and terrain horizon

Figure 3.15: Astronomical and geographical situation

Gan International airport

Short name (Acronym)	Description	Latitude	Longitude	Elevation
Gan (MVGAN)	Airport at Gan Island, Addu (Seenu) Atoll	-0.6911°	73.159906°	2 m

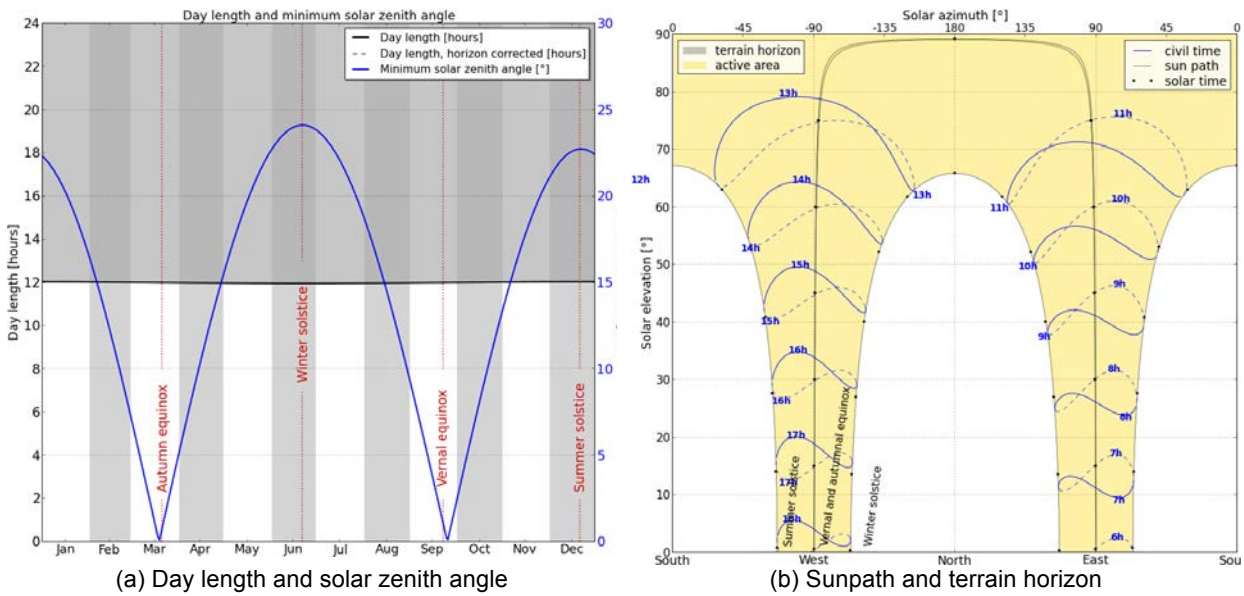
SolarGIS iMaps:
http://solargis.info/imaps/#tl=Google:hybrid&bm=satellite&loc=-0.6911,73.159906&c=-0.6911,73.159906&z=17

Description of site

- The latitude/longitude coordinates show intended position of the solar measuring stations.
- The local horizon is free of obstacles with only presence of low-height building and trees in the distance of approx. 100 metres towards West and 50 m towards East.
- Local pollution is negligible with only the marginal effect of the air traffic
- Exact position will be agreed with personnel from MMS

Figure 3.16: Location of MVGAN site on Gan Island
Addu (Seenu) Atoll (Google satellite map)

Figure 3.17: Planned position of MVGAN station in the premises of the airport
(Google satellite map)



(a) Day length and solar zenith angle (b) Sunpath and terrain horizon

Figure 3.18: Astronomical and geographical situation

4 TASKS AND DELIVERABLES

After approval of this Phase 2 Implementation Plan, the following tasks will be carried out in a sequential order:

- Task 1: Procurement and installation of solar radiation met stations and site installation reports
- Task 2: Operation and maintenance
- Task 3: Data quality control and delivery
- Task 4: Annual data evaluation and Site Resource Report (after 12 and 24 months)
- Task 5: Verification (after 12 months) and calibration (after 24 months) of the instruments

4.1 Procurement, installation and commissioning

Suntrace will manage the local tasks with Renewable Energy Maldives based in Male. GeoModel Solar will provide continuous support in order to facilitate procedures:

- Equipment will be cleared in Maldives with the aid of Renewable Energy Maldives and stored at the Renewable Energy Maldives premises
- Local SIM cards will be procured and tested on the modem of each station before departing from Malé
- One person from Suntrace, one person from Local Partner and (preferably) two members of the local MMS staff will install equipment at each site. During installation the Suntrace staff member will train the local engineers and local staff. Experts form GeoModel Solar will be present at selected installations and representatives from the Client and WB are welcome to attend the installation works.
- Commissioning tests for each meteo stations will be carried out by Suntrace to certify that stations are installed properly following best practices. Using GPS location will be given ±1 m according to WGS84 geodetic date. Azimuth and drawings will refer to true North.
- All data logger and modem settings for each station will be made available with the data logger software and published and archived as requested by WB.
- Site Installation Reports with detailed station descriptions and photos will be prepared for each meteo station, according to specifications by WB.

Maintenance equipment such as tools or cleaning tissues and wear parts such as silica gel will be provided for the first 2 years of operations at each site. One set of spare parts for all instruments will be given through providing a complete spare station.

Suntrace will prepare the **Station Operation and Maintenance Plan**, with guidelines, the aim of which is to guarantee operation at high quality and low failure rates.

Milestones

- Procured, assembled and tested instrumentation and equipment
- Meteo stations tested and documented
- Packing and shipping of the equipment to Maldives
- Equipment cleared at customs and stored in the central storage at Renewable Energy Maldives
- Site permits acquired and fencing and foundations prepared.
- Transportation, installation, testing and commissioning of equipment at each meteo site

Deliverables

D2.3 Documentation for each station, with calibration documents for all sensors, including the RSR instruments and pre-commissioning test protocols.

D2.4 Site Installation Report for each meteo site (including photos, design, and individual documentation of calibration). Sample data recorded from the station.

D2.5 Station Operation and Maintenance Manual with templates for maintenance protocols.

4.2 Operation and maintenance

MMS staff will provide daily control of the equipment. This will include systematic cleaning of thermopile pyranometer and of the RSR instrument.

Renewable Energy Maldives (REM) will be responsible for the in-country verification of the equipment. This will include the following tasks:

- Field verification (optionally re-calibration) every 12 months (Renewable Energy Maldives and Suntrace)
- In addition unscheduled site visits if needed due to results from regular check of data.

Cleaning buttons will be installed at each station, which should be pressed after each cleaning event. The personnel taking care of the meteorological equipment will be trained on cleaning and small maintenance works. Cleaning of the sensors will be monitored remotely from the electronic cleaning logs obtained from the meteo station. In case of no cleaning event, REM will be informed so that measures can be taken.

Maintenance visits will be carried out according to the *Meteo Station Maintenance Manual*. Parts that are either non-functional or need replacement, such as silica gel to prevent condensation in instruments will be replaced during these visits. Small maintenance will be part of routine operations.

In case of failure or malfunction, the fault will be immediately detected through remote monitoring of stations by Suntrace. In such cases, Suntrace will initiate remedial measures and inform REM, who will send their personnel on-site to solve the problem. Suntrace will keep the spare parts and instruments at the office of REM so that the missing or failing components can be replaced in a short time. In case of defective instrument, the instruments would be replaced from the spare kit the defective instrument would be shipped to OEM for replacement. This will ensure high station availability.

After each 12 months a Summary report for each station will be issued including info about all scheduled and unscheduled events and measures taken. For this purpose at each meteo station a Station Logbook will be kept.

Milestones

- Daily cleaning of thermopile pyranometers
- Scheduled site visits and field verification/calibration as set out above
- Unscheduled site visits on as-needed basis

Deliverables

D2.6 Meteo station summary operation report delivered after each 12 months for each meteo station.

D2.8 Report after each unscheduled site visit

4.3 Data quality control and delivery

Data from all the stations will be downloaded and checked on a (work) daily basis by Suntrace. The planned stations for Maldives will be added to the existing data download and quality check system. Automated

value/limit checks that send automatic emails are set up. This system displays data live on large screens (besides automatic controls, visual inspection of data has proved to be very robust method).

In parallel the data will be sent to the server of GeoModel Solar.

The data will be interpreted with the following, but not limited to, typical errors:

- Missing data
- Extreme (minimum and maximum) physical values test
- Clear-sky exceedance test
- Diffuse component exceedance test
- Cleaning frequency test

In quality control Suntrace collaborates with GeoModel Solar using near real time satellite-derived data for cross-validation. Data from meteo stations will be regularly transmitted to the repository established by the Project team.

Monthly reports will be delivered to the World Bank summarizing the situation at all measuring stations, mainly issues encountered and irregularities in data flow. The reports will include the following information:

- Site info
- Summary of technical parameters of the instrumentation and sensor calibration status
- Technical maintenance summary, list of issues and irregularities encountered at the site
- Data coverage summary and quality statistics (following the best practices)
- Validation statistics, soiling control

Milestones

- Continued data download and quality control by Suntrace and GeoModel Solar
- Quality procedures and measurements systematically controlled through monthly reports

Deliverables

D2.9 Data in 1-minute and time aggregations delivered every month, to the World Bank server

D2.10 Monthly reports and Yearly reports (individual delivery for each measurement station)

4.4 Yearly data evaluation and site resource reports

After completion of the first year of the measurement campaign, Site Solar Resource Reports after 12 months will be delivered. After completion of the second year of the measurement campaign, Site Solar Resource Reports after 24 months will be delivered using the same methodology. The reports will be prepared along with quality-controlled measured datasets and site-adapted modelled data.

Separate Report will be delivered for each site and it will include the following **Table of Contents**:

Executive summary

Glossary and abbreviations

Site info

- Position (map) of the site

Instruments

- Summary of technical parameters of the instrumentation and sensor calibration status
- Technical maintenance summary, list of issues and irregularities encountered at to the site

Data Quality Control

- QC following best practices of BSRN and SERI QC
- Note on calibration or field testing
- Data coverage summary and quality statistics
- Validation statistics, soiling control

Correlation with satellite data (SolarGIS 16+ years time series)

- Site adaptation of SolarGIS Time Series
- Uncertainty info

Solar resource and meteo statistics

- Long term summary statistics for each parameter
- Comparison of actual year to long-term average (map and site view)
- Seasonal and diurnal statistics
- 1-minute ramp-rates for ground measured sola resource data
- Comments and suggestions

Interannual variability and uncertainty

- Variability on 1 year and in 20 years
- Uncertainty of estimate
- Combined uncertainty (of estimate and variability)

Conclusions

Time series data will be delivered in SolarGIS CSV data format:

- 12-months data with quality controlled measurements (corrected as applicable) in primary (1-min) and aggregated time resolutions
- Multiyear site-adapted satellite data in hourly and 30-minute data resolution.

TMY data will prepared from the site-adapted time series in SolarGIS CSV, TMY3 and PVSYST data formats.

The data sets will include the following parameters:

- Direct Normal Irradiation, DNI [Wh/m^2]
- Global Horizontal Irradiation, GHI [Wh/m^2]
- Diffuse Horizontal Irradiation, DIF [Wh/m^2]
- Azimuth and solar angle, SA and SE [°]
- Air temperature at 2 metres, TEMP [°C]
- Relative air humidity, RH [%]
- Wet bulb temperature, WBT [°C]
- Wind speed converted to standard height of 10 metres, WS [m/s]
- Wind direction at 10 metres, WD [°]
- Atmospheric pressure, AP [hPa]

Milestones

- Site reports and clean and site-adapted time series data after 12 months
- Site reports and clean and site-adapted time series data after 24 months

Deliverables

D2.13 Site Resource Report on completion of 12 months of the measurement campaign (one for each site) with time series of locally measured and satellite-based data

D2.14 Site Resource Report on completion of 24 months of the measurement campaign (one for each site) with time series of locally measured and satellite-based data

4.5 Verification and calibration of the instruments

The solar sensors are designed in a way that re-calibration is required only every two years. After 12 months, on-site calibration stability will be verified. Verification of solar instruments after one year of operation will be conducted using a *Travelling Standard Equipment*. The travelling standard station, which in parallel is used as source of spare parts, will include equipment as described in Tables 4.1 and 4.2.

Table 4.1: Travelling standard equipment

Instrument	Qty.
Pyranometer (ISO 9060 Secondary Standard) for broadband GHI measurements	1
Rotating Shadowband Radiometer (RSR) for GHI, DHI and DNI measurements	1
Ambient Temperature & Humidity Sensor	1
Pressure Sensor (barometer with accuracy of ± 1.2 hPa)	1
Wind Speed Sensor (WMO First Class)	1

Table 4.2: Additional spare parts

Equipment	Qty.
Wind Mast (3 m) + Accessories	1
GPRS Modem	1
Datalogger	1
Tripod	1

The travelling pyranometer will be used as a reference for verification of installed RSI and pyranometers. In case the on-site comparison reveals a need for an updated calibration, the sensor will be exchanged at the site against the respective device from the Traveling Standard.

At the end of period of 2 years after installation, the sensors need to be recalibrated. The recalibration of the field stations and the existing traveling standard instruments will be carried out using the new set of reference instruments. All existing pyranometers are then calibrated according ISO 9847 (1992[1]).

Suntrace will train REM team for recalibrating the field stations. The traveling standard and one field station will be taken as examples for conducting the training. The REM team then would carry out the field calibrations of the remaining stations during Phase 2.

Calibration will be started 6 months before Phase 2 completion with replacing sensors at MVMLE using spare parts. Sensors will be sent to the manufacturer for accredited calibration including calibration certificate. After arrival back to Maldives (after approx. two months) the sensors, operating in the field for almost 2-years, will be replaced with the re-calibrated sensors. Afterwards, the second set of the calibrated sensors will be shipped to manufacturer for re-calibration and returned back to Maldives. This approach will be followed until all sensors are re-calibrated. Through this recalibration and capacity building it is assumed that measurements can continue for at least another two years.

Milestones

- Calibration verification after 12 months
- Recalibration after 24 months

Deliverables

D2.7 Calibration verification report after 12 months

D2.8 Recalibration report after 24 months

[1] ISO 9847 (1992), Solar energy -- Calibration of field pyranometers by comparison to a reference pyranometer. Standard of the International Organization for Standardization (ISO),

5 CAPACITY BUILDING AND TRAINING

The training and capacity building will be dedicated to the staff members of the Maldives Meteorological Service and will include also our local partner - Renewable Energy Maldives.

Training of the stakeholders

The following stakeholders are expected to participate at the training:

1. For the general part:
    a. Government representatives
    b. Representatives of utilities
    c. Other invited persons
2. For the technical part:
    a. Dedicated technical personnel from Maldives Meteorological Service
    b. Dedicated experts from RE.M
    c. Other invited persons
3. For the daily operation:
    a. Dedicated persons

The content of the training sessions is structured so as to:

- Training 1: Objective is to introduce solar radiation measurements and modelling campaign in a broader context of developing solar photovoltaics strategies as part of general training
- Training 2: MMS technical staff and REM will be trained for design, installation, operation and maintenance of solar measuring stations.
- Training 3: Local MMS staff.

The training 1 and 2 will be organised in the premises of MMS, and will be split into two parts. Training 3 will be organized at the site of solar measuring stations.

In Month 12 and 24 Suntrace and GeoModel Solar will visit Maldives for station operation and maintenance and will deliver further training

Tentative agenda of training for the Phase 2 follows.

5.1 Workshop and training at the beginning of Phase 2

1. General part – summary workshop (3 hours)

- Importance and value of solar monitoring campaign for development of solar energy market in Maldives
- Components of solar monitoring system (model data and measurements)
- Practical examples showing application of solar resource data (planning, monitoring, forecasting)
- Brief summary of solar measuring instruments and approaches
- Selection of sites
- Ownership and responsibilities over the duration of the project and beyond
- Work plan of Phase 2
- Roles of participants: Consultant team, MMS, MEE
- Deliverables and benefits for Phase 3 and beyond of the project

2. Technical part - training

The training is designed to include a mixture of theory and hands on practice. The training focused on MMS technical staff and REM representatives will involve mock tests where the local partner company will have to solve a problem created by at a test meteo station. This entire process would be supervised by experts from Suntrace and GeoModel Solar. The main topics to be covered under these training sessions are as follows:

- Basics of solar radiation
- Overview of measuring technologies and instruments and related uncertainties
- Site selection criteria
- Selection of solar radiation and other meteorological sensors
- Data loggers and modems, data formats, data retrieval
- Installation and operation of meteo stations
- Procedures for daily cleaning and maintenance, safety and security
- Documentation, operation, servicing
- Verification and calibration of solar instruments
- Data analysis and interpretation, data quality checks and reporting
- Troubleshooting, maintaining long term quality
- Decommissioning and translocation of the meteo site
- Hands-on exercise during the installation and demonstration phase
- Review of first measuring results

3. Training of the local MMS staff for daily operation

This training will be held during the installation of the meteo equipment and continued/re-evaluated at the occasion of each yearly visit. The topics include:

- Basics on solar and meteorological monitoring
- Overview of measuring instruments
- Procedures for daily cleaning and maintenance
- Simple servicing and troubleshooting of instruments
- Safety and security policies

5.2 Workshop and training in Month 12 of Phase 2 campaign

1. General part – workshop (2 hours)

- Review of the results achieved at the end of Month 12 of the measuring campaign
- Status of meteo stations, instruments, measurement statistics
- Summary report on site resource assessment delivered on completion of 12 months of the measurement campaign with time series of locally measured and satellite-based data
- Report on reduced modelled data uncertainty and implications for solar energy development
- Lessons learned
- Next steps

2. Technical part (staff of MMS and REM)

- Review of procedures related to equipment and data monitoring
- Status of cleaning and calibration verification
- Typical issues
- Status of data analysis and interpretation, data quality checks and reporting
- Lessons learned

- Organisational issues
- Next steps towards maintaining long term quality
- Hands-on re-confirmation on specific maintenance tasks

5.3 Training in Month 24 of Phase 2 campaign

1. General part (3 hours)

- Review of the results achieved at the end of Phase 2 measuring campaign
- Status of meteo stations, instruments, measurement statistics
- Report on calibration
- Summary report on site resource assessment delivered on completion of 24 months of the measurement campaign with time series of locally measured and satellite-based data
- Transfer of ownership
- Demonstration of preparedness for sustainable continuation of the measurement program
- Lessons learned

2. Technical part (staff of MMS and REM)

- Review of procedures related to equipment and data monitoring
- Status of cleaning and calibration verification
- Typical issues
- Status of data analysis and interpretation, data quality checks and reporting
- Extended maintenance and servicing, calibration
- Lessons learned
- Transfer of ownership and documentation
- Next steps towards maintaining long term quality
- Hands-on re-confirmation on specific tasks

At the end of the measurement campaign and in preparation for the passing on of the equipment to the organization identified by Client, we will provide a 2-day training to continue the measurement activities. We support the idea that meteo stations are kept operational in long-term as part of supporting infrastructure for management of country solar energy program and to further improve the reliability of solar maps for the country. Therefore the decommissioning of stations is not considered in this proposal, but can be provided upon request as additional service. At the end of Phase 2 we will execute transferring the equipment to the legal entity, designated by MEE.

Key messages from the technical training will be communicated within Phase 3 workshop.

Milestones

Three training sessions (each having a general part and technical part)

- At the installation
- In Month 12 to review the results and to confirm the calibration status
- In Month 24 to review the results and to focus on training and capacity building for MMS and REM at the end of measurement campaign to continue measurement by a local organization identified by the Client/WB.

Deliverables

D2.11 Training programme overview for each format

D2.12 Brief reports from each training event

6 TIME TABLE AND DELIVERABLES

Table 6.1 shows time plan and deliverables of Phases 2 of the Project. Table 6.2 shows plan of scheduled visits. Each visit will include also training and capacity building component.

Table 6.1: Time schedule for Phase 2

Task	Activity	07/15	08/15	09/15	10/15	11/15	12/15	01/16	02/16	03/16	04/16	05/16	06/16	07/16	08/16	09/16	10/16	11/16	12/16	01/17	02/17	03/17	04/17	05/17	06/17	07/17	08/17	09/17	10/17	11/17	12/17
2.1	Site selection and Phase 2 Implementation Plan	▨	D2.1																												
2.2	Procurement, installation of meteo stations and site			D2.2 D2.3	▨	D2.4 D2.5																									
2.3	Operation and maintenance of meteo stations																	D2.6	D2.7											D2.6	D2.7
2.4	Data quality control and delivery						D2.9 D2.10	D2.9 D2.10	D2.9 D2.10	D2.9 D2.10	D2.9 D2.10	D2.9 D2.10	D2.9 D2.10	D2.9 D2.10	D2.9 D2.10	D2.9 D2.10	D2.9 D2.10	D2.9 D2.10	D2.9 D2.10	D2.9 D2.10	D2.9 D2.10	D2.9 D2.10	D2.9 D2.10	D2.9 D2.10	D2.9 D2.10	D2.9 D2.10	D2.9 D2.10	D2.9 D2.10	D2.9 D2.10	D2.9 D2.10	D2.10
2.5	Training and capacity building				▨	D2.11	D2.12											D2.12												D2.12	
2.6	Annual Site Resource Reports after 12 months																	▨	D2.13												
2.7	Annual Site Resource Reports after 24 months																													▨	D2.14

Table 6.2: Summary of the work plan and deliverables for Phase 2

Phase	Tasks		Deliverables	
2	2.1	Site selection and Phase 2 Implementation Plan	D2.1	Site Selection Report for final-selection procedure
			D2.2	Updated and approved Phase 2 Implementation Plan
	2.2	Procurement, installation of meteo stations and site installation reports	D2.3	Documentation for each station, with calibration documents for all sensors, including the RSR instruments and pre-commissioning test protocols.
			D2.4	Site Installation Report for each meteo site Sample data recorded from the station.
			D2.5	Station Operation and Maintenance Manual with templates for maintenance protocols
	2.3	Operation and maintenance of meteo stations	D2.6	Meteo station summary operation report delivered after each 12 months for each meteo station
			D2.7	Re-calibration reports if such action required
			D2.8	Report after each unscheduled site visit
	2.4	Data quality control and delivery	D2.9	Data in 1-minute and time aggregations delivered every month, to the dedicated World Bank server
			D2.10	Monthly report (individual delivery for each measurement station), Yearly report for each station
	2.5	Training and capacity building	D2.11	Training programme overview for each format
			D2.12	Brief reports from each training event
	2.6	Annual Site Resource Report after 12 months	D2.13	Site Resource Report on completion of 12 months of the measurement campaign (one for each site) with time series of locally measured and satellite-based data
	2.7	Annual Site Resource Report after 24 months	D2.14	Site Resource Report on completion of 24 months of the measurement campaign (one for each site) with time series of locally measured and satellite-based data

The data and reports from Phase 2 will feed directly into Phase 3 which will focus on delivery of accuracy enhanced Solar Atlas (See details in the Technical proposal).

Table 6.3 Scheduled visit to the sites

Task	Date	GeoModel Solar	Suntrace	REM
Installation and commissioning	Dec 2015	X	X	X
Start of measurement campaign	**Jan 2016**			
Regular visit	May 2016			X
Calibration verification	Nov 2016	X	X	X
Regular visit	May 2017			X
Re-calibration	May-Nov 2017	X	X	X

Table 6.4 Experts participating on the installation campaign:

- Marcel Suri (GeoModel Solar)
- Tomas Cebecauer (GeoModel Solar)
- Marco Schwandt (Suntrace)
- Jana Mueller (Suntrace)
- Hudha Ahmed (R.E.M.)
- Ibrahim Nashid (R.E.M.)
- Technical experts from MMS headquarters
- Local members of the MMS staff at each station

7 ASSESSMENT OF RISKS

The assessment of environmental and social risks was applied within all phases of the project Renewable Energy Resource Mapping for the Republic of the Maldives to minimize and prevent harm during the planning and implementation of the project. Before site selection, the assessment was started with research into existing legislation and guidance relevant to the assessment followed by a screening to identify potential risks. The identification of potential risks can help to answer hypotheses at an early stage in the assessment and was based on data important for the analysis. Results were used to determine which risks should be investigated in greater detail using techniques suitable to the nature of the risk and quality of the evidence base.

Screening procedure was applied to determine whether a proposed project is likely to have significant effects on the environment. Availability of land for installation of solar measuring stations without causing an impact on the environment was identified as a major issue. Areas protected under domestic and international environmental law and regulations were identified at the beginning of the project and excluded as potential sites. The same applies for military exclusion zones, urban areas and land owned by local people. Consisting of 1190 islands, land is a scarce resource in Maldives covering approximately 1% of its surface area. Potential sites for installations should meet requirements such as availability of personnel for maintenance and cleaning, security and sustainability of running the measurement campaign in a long term and acceptance of the present landowner. Measuring stations should be located at least 20 m away from any permanent structure of more than 8 m height. These requirements reduced the potential sites significantly after the first screening. Furthermore, solar measuring stations should be located in a flood-safe area, not close to sources of pollution and close to existing infrastructure being accessible without additional environmental impacts. Finding a synergy between mitigating environmental impacts and quality and reliability of the measurement campaign resulted in a list of twelve potential sites located at international and local airports. Potential sites listed have the advantage that no clearance of trees is required, no location of natural habitats in the region or sector is involved and other safeguards do not apply. No long-term effects on the environment are expected from installation and operation of the solar measurement stations. After the initial assessment of World Bank Groups Safeguards, the likely impact of the project on the environment is expected to be Category C, having minimal or no adverse impacts.

Based on the long list of candidate sites most suitable sites were selected and visited by technical experts of Suntrace and GeoModel Solar of the project. During the visits, both environmental and social acceptability and technical suitability of the sites have been evaluated. Considering that proposed sites should have the support of the wider community while providing safe operation of measuring stations, most promising sites were identified on the property of the Maldives Meteorological Service. Fencing and external power supply is already available at some sites and no further infrastructure is required. After examination of the soil structure, it was decided to install the stations without solid foundations to reduce the impacts of soil sealing and civil and construction works. Furthermore, no significant quantities of emissions or effluents nor hazardous materials or processes are generated during the construction, operation, and decommissioning phase of the project. Adverse impacts are minimized, where possible, in all stages of the project phase. Emissions caused by transport means will comply with national programs of the Maldives and the approach given in the EHS Guideline. The meteorological stations are designed to be efficient in energy at low cost, for example being independent of external power supply. Water quality will not be influenced by any direct or indirect discharge of wastewater.

The solar radiation measurement stations should be set up and operated at the grounds of airfields and thus are located relatively close to runways. As take off and landing are the most critical flight manoeuvres, good viewing conditions without significant visual irritation is essential. The met stations to be set up do not provoke such significant reflections as

a) the instruments are only passive sensors (no light is emitted, as e.g. by the laser of a cloud ceilometer)

b) most of the surfaces such as the white plastic box of the data logger or the tarnished aluminium pipes of the structure do not cause directional reflections, but will cause diffuse light

c) the pyranometer due to its 360° glass dome structure is causing some direct sun reflections in almost all directions of the hemisphere. However, most of the sunlight is absorbed by the instrument itself and the size of the dome is only of about 4 cm in diameter. Thus the intensity of directional reflections should not be more than e.g. the reflections a wristwatch might cause.

Meteo stations with similar equipment are used at many airports. Therefore, it is concluded that the solar radiation stations to be installed in the ESMAP Maldives project are not causing significant reflections, which might be harmful for safe operations at the airports.

Risks related to the installation, operation and maintenance itself could occur from the use, storage or handling of any quantity of hazardous materials, we assessed materials representing a risk to human health, property or the environment. The delivered stations are equipped with data logger batteries (12V with at least 15Ah capacity) that will be transported, stored and handled in order to facilitate the safe handling of battery packs under normal and emergency conditions. To guarantee safe handling during operation, the meteorological stations are equipped with encapsulated batteries, that are resistant to shocks and vibration, as well as against moisture, solvents, and corrosive agents. Encapsulation is also used to aid electrical insulation, flame resistance and heat dissipation. All batteries will be made safe for handling, prior to packing for shipment. The International Air Transport Association (IATA) regulates air transportation. International Maritime Organization (IMO) whose regulations are contained in the International Maritime Dangerous Goods (IMDG) Code regulates the maritime transport. Various weight limits apply to batteries, batteries with equipment, and batteries in an equipment of each passenger and cargo of an aircraft. Pursuant to 49 CFR 173.185, all shipments of hazardous materials must comply with packaging regulations based on recommendations made by the United Nations.

All waste management steps (collection, temporary storage, recycling, disposal, etc.) for spent or waste materials for disposal will be conform to the Universal Waste Management Guideline and the EHS Guidelines of the World Bank Group. In general, all processes in this project are designed and operated to restrict the quantities of generated waste. Where waste generation cannot be avoided, it will be minimized. Delivered Meteorological Stations, for example, are designed to be reliable and long lasting and we support the idea that Meteorological Stations are kept operational after implementation of the project. Therefore decommissioning and waste management for the meteorological stations is not considered in this Implementation Plan.

Preventive and protective measures are carried out to protect the health and safety of all workers during construction, decommissioning and the operational phase of the project. The staff of the Maldives Meteorological Service and Renewable Energy Maldives has high technical capabilities and experience to manage the occupational health and safety issues. In general, the construction, decommissioning and operational activities were designed to fulfil the highest possible standards of safety. All staff contributing to commissioning and operation of the meteorological stations will be trained before and periodically during the maintenance and operation of the stations by authorized personal. The highest possible safety while station operation will be guaranteed by a fence placed around each station. The sites are located within premises of the airport with restricted movement of unauthorized personnel, which ensures a high level of security.

Community health and safety are related to the project operation and some aspects outside of the traditional project boundaries. At the current stage of the project it is not expected that relevant issues concerning community health and safety arise.

8 PERMITS AND IMPORT PROCEDURE

Since the location of solar and meteo stations are finalized, GeoModel Solar, Suntrace and Renewable Energy Maldives will liaise with national authorities to best fulfil the requirements of the project. While making these decisions we will rely on local knowledge of Renewable Energy Maldives, who will arrange for identifying and acquiring the necessary permits and clearances for the selected sites.

The measuring stations will be installed on the premises of the Maldives Meteorological Services (MMS) which is a part of the Ministry of Environment and Energy (MEE). MMS will host the station at their premises. The Ministry of Environment and Energy will assist with gaining any written permission required for the installation and operation of the station (e.g. access to the premises of the airport). Obtaining an Environmental Impact Assessment for the selected sites is not required according to Environmental Impact Assessment Regulations of the Maldives.

Equipment will be tested, prepared for shipping and shipped from Suntrace premises in Hamburg. Shipping from Hamburg to Maldives will be done according to DDU - Delivered Duty Unpaid - means that Suntrace fulfils their obligation to deliver when the goods have been made available at Renewables Energy Maldives premises in Maldives. Once the goods arrive by air freight at Male international airport the goods will be stored at the airport cargo section. Air freight good needs to be cleared within 3 days of arrival. For Air freight demurrage charges occurs after 3 days of the arrival of shipment and for sea freighted cargo the demurrage occurs after 6 days of arrival.

In order to obtain an Import License, the following requirements must be fulfiled and the documentation issued to the Ministry of Economic Development and Male' City Council:

As per Maldives Export/Import Law (No: 31/79) and Taxation Law (No: 3/2013), any party wishing to import goods into Maldives must be registered at Maldives Inland Revenue Authority (MIRA) and should possess a license issued by Ministry of Economic Development/or any party allocated by this ministry to carry out the licensing procedures. For obtaining the import lisence the following documents should be submitted:

1. ORIGINAL BILL OF LADING DOCUMENT:
   - The bill of Ladings should include the Consignee's Company Registration number (as per Ministry of Economic Development) as per new guidelines from the Maldives Ports Authority. Renewable Energy Maldives Pvt Ltd is registered under the code: C-603/2007.
   - AIRWAY BILL - In case of air freight the same applies as Bill of Lading.

2. INVOICE:
   a) Title and Invoice number: The customs require a final commercial invoice document with the title 'Commercial Invoice'
   b) Points to include:
      - The customs require a unit price associated with each of the items listed on the invoice.
      - If additional details are needed, the packing list can be used.
      - Country of origin:
      - Freight: The freight charges should be listed as a separate item.
      - Insurance: The insurance charges should be listed as a separate item in the commercial invoice.

   Separate documents for freight charges, Ex works or any other relevant freight transactions have to be issued if the terms are not CIF.

3. PACKING LIST: All details of items should be listed with numbers of items of the shipment.

For quick clearance the duty exemption permit needs to be submitted to customs before the goods arrive. The duty exemption will be provided to the equipment to be imported for this project. The President Office or Maldives Energy Authority provides the duty exemption letter after Ministry submits all the relevant documents. Suntrace will write to Ministry of Environment to have the duty exemption letter before the goods arrive. With the request letter Suntrace will send the invoice of the goods as soon as the goods are shipped, the airway bill and packing list.

In order to avoid delay in obtaining the duty exemption and customs clearance the above mentioned documents should be addressed to the Ministry of Environment and Energy:

Document that is needed to be submitted to customs are the following:

1. Packing list
2. Invoice
3. Air way bill (for air freighted goods) or bill of lading (for sea freighted goods)
4. Specification detail of the goods (pictures/seizes/material/model/brand)
5. Duty exemption letter

Details that should be included in the invoice (required by Customs):
1. Should be addressed to the Ministry of Environment and Energy.
2. Should include Air freight charges if the cargo is been delivered by air freight.
3. Should include Sea freight charges if the cargo is been delivered by air freight.
4. Should include INCO terms (FOB/CNF/CRF/CIF).
5. If items are insured the policy of insurance.

Ministry will provide all paper works for the clearance of goods.

Once the goods are cleared from customs by REM the goods will be transported to Male' and be kept in storage in Male' by Renewable Energy Maldives. The stations will be transported from Male' to the required islands by REM.

9 ACRONYMS

ASTAE	Asia Sustainable and Alternative Energy Program
ESMAP	Energy Sector Management Assistance Program
MEE	Ministry of Environment and Energy
MMS	Maldives Meteorological Service
REM	Renewable Energy Maldives

10 LIST OF FIGURES

11 LIST OF TABLES

12 SOLAR RESOURCE MALDIVES CONSULTANTS

12.1 Lead contractor: GeoModel Solar

Primary business of GeoModel Solar is in providing support to the site qualification, planning, financing and operation of solar energy systems. We are committed to increase efficiency and reliability of solar technology by expert consultancy and access to our databases and customer-oriented services.

The Company builds on more than 25 years of expertise in geoinformatics and environmental modelling, and more than 15 years in solar energy and photovoltaics. We strive for development and operation of new generation high-resolution quality-assessed global databases with focus on solar resource and energy-related weather parameters. We are developing simulation, management and control tools, map products, and services for fast access to high quality information needed for system planning, performance assessment, forecasting and management of distributed power generation.

Members of the team have long-term experience in R&D and are active in the activities of International Energy Agency, Solar Heating and Cooling Program, Task 46 Solar Resource Assessment and Forecasting.

GeoModel Solar operates a set of online services, integrated within SolarGIS® information system, which includes data, maps, software, and geoinformation services for solar energy.

See more at http://geomodelsolar.eu and http://solargis.info

ISO 9001
LL-C (Certification)

GeoModel Solar is ISO 9001:2008 certified company for quality management since 2011.

12.2 Subcontractor: Suntrace

Suntrace was established in 2009 in Hamburg, Germany, as a company specialized on larg scale solar power plants. It gives expert advice for the growing solar energy activities in emerging solar markets from the Middle East, African countries to Latin America, but also in Asia, especially India.

Our advisory mandates cover measurement of solar radiation, solar resource assessments of project sites, technical concepts, performance analysis, lenders engineering, owners engineering, feasibility studies, financial advisory for project finance of large solar plants, etc. Our services also include strategic market intelligence, knowledge regarding main equipment manufacturers and local capacity building. Suntrace' success in providing its expertise and services in many countries of the world is achieved by associating with local companies, who have the local market experience and knowledge and Suntrace brings its international experience and domain-specific expertise.

For design, manufacturing and distribution of solar energy specific meteorological measurement stations Suntrace has established a collaboration with the Hamburg based company Wilmers Messtechnik GmbH. Since 1991 Wilmers develops and produces data loggers, and turnkey measurement systems for wind site assessment, climate research and meteorological observations. Under the brand HelioScale Wilmers and Suntrace market their solar radiation measurement stations.

See more at http://www.suntrace.de and http://www.helioscale.org

12.3 Subcontractor: Renewable Energy Maldives

Renewable Energy Maldives (REM) was formed in 2007 with the mission of reducing Maldives' over reliance on fossil fuel for its energy needs. REM is a company engaged in the development of renewable energy and energy efficiency projects in the Republic of Maldives.

The focus of REM is on renewable energy, energy efficient equipment particularly cooling technology, designing and building energy efficient electric boats and energy management programs tailored to a client's needs.

REM formed a joint venture company, Wirsol RE Maldives (WREM), with WIRSOL APAC GmbH, Germany, which is a 100% subsidiary of WIRSOL Solar AG, Germany, to strengthen the company's' capacity to deliver viable Solar PV projects. Under this joint venture REM has installed more than 700 kW solar PV projects until 2013. REM continues to undertake small solar PV projects for private and government as well as donor-funded projects in the Maldives.

See more at http://www.renewableenergymaldives.com