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ESMAP
Energy Sector Management Assistance Program

Solar Resource Mapping in Tanzania

PHASE 2 IMPLEMENTATION PLAN

AUGUST 2015

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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 Tanzania Solar Atlas, which will be published once the project is completed.

Renewable Energy Resource Mapping. Solar Tanzania.
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Phase 2 Implementation Plan.

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Energio Verda Renewable Energy for Development

GEÓNICA

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1 BACKGROUND

This report forms part of the Solar Resource Mapping Project for Tanzania (WB Selection #1139235). The project comprises three phases. The first phase involves project inception, preliminary modelling and site selection to design a ground measurement network. The key outcome of Phase 1 was an un-validated solar atlas for Tanzania, based on the synergistic combination of satellite and Numerical Weather Prediction Model (NWPM) derived solar data. In Phase 2, ground-based data collection will be undertaken through a measurement campaign at sites selected from areas defined according to the results of Phase 1. Finally, in Phase 3, the validated resource atlas for Tanzania will be generated. Using ground-based solar data collected during the measurement campaign of Phase 2, this validated atlas will have reduced solar resource uncertainty compared with the Phase 1 results will be generated from post-processing satellite and NWPM solar radiation outputs.

It is worth highlighting that the solar resource models used in the Interim Solar Modelling report (February 2015) are not validated with ground-based coincident solar data measured by well-maintained, high accuracy measuring equipment. Therefore, an unknown deviation between the actual solar resource in Tanzania and the modelled data may exist. The solar renewable energy community depends on radiometric measurements to develop and validate solar radiation models (Gueymard & Myers, 2009); the correct planning and execution of a high quality measurement campaign is thus essential for minimizing uncertainties in solar resource assessment.

2 INTRODUCTION

The objective of this report is to draw up an implementation plan to deliver the high quality measurement campaign planned for Phase 2 of the project. This plan will include detailed information about the selected sites and practical considerations for installation, such as subcontracting of local services and required licenses. The Implementation Plan contains all the necessary information to allow making all necessary decisions to implement the project plan. The schedule included in the Plan will be adapted with minor changes once final subcontractors have been selected, and a final schedule for shipping and installation has been determined.

In this report, Section 3 describes the selected sites for ground measurement. Section 4 details considerations for the installation and commissioning of the meteorological stations, including official permits, insurances, transport, installation and maintenance. Section 5 describes the management of measured data, particularly data transmission, administration and monitoring. Section 6 depicts the capacity building and training aspects of the project, focusing on stakeholders, local partners. Section 7 details the schedule of the installation and commissioning of the stations. Finally, Section 8 addresses risk assessment and mitigation. The Annexes at the end of the report provide full site reports from the visits to potential site candidates; a template maintenance sheet to record routine maintenance activity; and the template Memorandum Of Understanding (MOU) document provided to potential site candidates. Reimbursable included costs and Excluded costs will be provided to the World Bank in a separate file.

3 GROUND MEASUREMENT SITES

3.1 Longlist of sites

The Candidate Site Identification Report proposed a longlist of possible site locations in Tanzania for the solar monitoring network, as well as detailing the types of measurement stations to be installed. The longlist was determined by use of a ranking methodology that combined a classification of representative solar characteristic zones with a number of logistical considerations that affect the potential for commercial exploitation of solar resources, as well as taking into consideration different climate and topographical conditions.

In order to maximize the country-wide representativeness of information in the solar monitoring network, it is common to define discrete spatial regions with distance solar irradiance characteristics. The CLARA algorithm was employed to classify the solar irradiance series obtained in the solar modelling report (Interim Solar Modelling Report, February 2015) into groups that represent solar regimes. This analysis produced 7 solar regime clusters (or regions). Within these regions, a methodology for area of potential monitoring station locations selection was applied, taking into account features important in site selection: representativeness, logistical considerations and possible future solar energy facility development. These areas were approximately ~5 x 5 km in size. Finally, for specific site selection within selected areas, several limitations and constraints were taken into consideration. At least one measurement site is required for each region, and in some regions more than 1 measurement sites may be necessary. Accordingly, 14 sites were identified.

Table 1 summarizes the longlist of possible site locations. It is important to note that the list includes sites from Rwanda and Burundi, since the analysis covered these countries within its geographic limits.

Table 1 Longlist of possible site locations. Tz, Rw and Br refer to Tanzania, Rwanda and Burundi respectively.

Region #	Location	Land covered (~km2)	Nearest city
1	Central west; north	37765	Tabora (Tz) Mwanza (Tz)
2	North west; east	7900	Kigali (Rw) Bujumbura (Br)
3	North west	17680	Nyabikere (Br)
4	Central south; east; west	24685	Iringa (Tz) Mbeya (Tz)
5	East; north; south west	41590	Dodoma (Tz) Musoma (Tz) Moshi (Tz)
6	East	3490	Dar es Salaam (Tz) Mtwara (Tz)
7	South	29585	Songea (Tz) Morogoro (Tz)

The final configuration of the network will be determined partly by solar resource variability and distribution, from the solar modelling report, and partly by the need for different types and accuracy levels of stations at each location.

It is important to note that a Tier 1 station was installed in Dar es Salaam during the Phase 1 Workshop. This station is considered as additional to the base requirements of the project.

3.2 Identification of candidate sites for shortlist

Table 1 summarizes the longlist of possible site locations. From this longlist of sites, and the ranking methodology applied described in Candidate Site Identification Report (May 2015), the following shortlist of candidate sites has been produced (Table 2). This list only includes site locations within Tanzania, ignoring at present sites from Rwanda and Burundi (site 3, 4 and 5). These candidate sites have been visited, analyzing possible specific emplacements. The final station site candidates and emplacements have subsequently been selected to take into account technical and logistical considerations. With respect to the type of station to be installed in each site, the following criterion has been applied: for those sites in which annual DNI equals or exceeds 1800 kWh/m^2 Tier 1 stations will be installed, whereas for sites with annual DNI values lower than this threshold, Tier 2 stations will be installed.

After considering technical, logistic and economic aspects the decision is that Tier 1 stations will be supplied by Geonica meanwhile Tier 2 stations will be supplied by Campbell SA.

The principal reason for the DNI Tier1/2 threshold is that the use of DNI is the main resource in determining the potential for Concentrated Solar Power Plants (CSP) and this threshold of annual DNI is commonly used as an indicative measure of a CSP plant's feasibility. According with the Tor requirements, Tier1 stations offer higher accuracy measurement of Direct Normal Irradiance (DNI) than the Tier 2 stations: Tier 1 stations contain a pyrheliometer that directly measures the DNI, whereas Tier 2 stations calculate DNI using Global Horizontal Irradiance (GHI) and Diffuse Horizontal Irradiance (DIF) data measured by mean of a photodiode as inputs. A description of the different types of stations is included in Annex 2. The economic impact of this selection has also been taken into account in the final configuration of the proposal.

The identified potential host institutions were contacted. Some of the host institutions presented potential emplacement locations for nearly all of the sites targeted - the Tanzanian Meteorological Agency (TMA) and the Tanzanian Electric Supply Company (Tanesco). Besides these two institutions, Universities and Technological Institutes in particular were identified and visited as potential hosts.

Table 2 Identification of candidate sites for shortlist.

Ranking classification #	Location	Type of station	Nearest city/town	Potential Host institutions
1	*East*	*Tier 1*	*Dar es Salaam*	*Dar es Salaam University (already installed)*
2	East; north; south wes	Tier 1	Dodoma	University of Ddodoma, Tanesco TMA
3	Central west; north	Tier 1	Tabora	Tanesco, TMA
4	Central south; east; west	Tier 1	Iringa	Mkwawa University, Tanesco, TMA
5	South	Tier 2	Songea	Tanesco, TMA
6	Central west; north	Tier 1	Mwanza	Tanesco, TMA, UDIT, USAUT
7	East; north; south west	Tier 2	Moshi	Tanesco, TMA, NM-AIST
8	Central south; east; west	Tier 2	Mbeya	Mbeya University of Science and Technology, Tanesco

3.3 Site visits. Analysis of potential emplacements.

This section contains a summary of the selected emplacements and their characteristics; the complete site visit reports have been supplied as an Annex of this report. For each potential emplacement, a number of principal criteria have been evaluated. Each criteria has been given a score between 0 and 3; a score of 0 means that installation cannot further be considered, whereas a score of 3 means that conditions are particularly favourable.

The evaluation of the emplacements has been made following WMO site selection criteria and BSRN guidelines. It has also been determined that for all site hosts, routine maintenance activities undertaken by the host staff can be assured.

3.3.1 Dar es Salaam

Dar es Salaam is the largest city in Tanzania, with a municipal population of 4,365,000 (Source: Tanzania National Bureau of Statistics [3]). Located midway down the eastern coast, Tanzania sits on a flat coastal plain. Dar es Salaam is a major transit center, and is the economic capital of the country. The Dar es Salaam Station has already been installed during the Phase 1 Workshop in May 2015, additional to the base requirements of the project. The installation and commissioning of this station were completed prior to the preparation of the present implementation plan. The institution that hosts the station is the University of Dar es Salaam (UDSM).

UDSM

The emplacement identified is sited on the rooftop space above the main of the physics department building (latitude: 39.2037 E, longitude 6.7807 S) and lies 96 m above sea level. The campus is sited in Ubungo district of the Dar es Salaam city. The site visit indicated that the emplacement is a good location for hosting the meteorological station. Fig 1 shows an aerial view of the campus, with the red circle indicating the exact point of the emplacement. The rooftop site is already specifically provisioned by the Physics Department for the installation of meteorological monitoring equipment, so is appropriately set-up.

Fig 1 Aerial view

In the horizon analysis made during the site visit, it was determined that no critical obstacles were present. Directly to the east and west, in the middle distance, there are isolated trees whose crowns reach to an angle of 5˚ above the horizon in both cases. The panoramic picture from the emplacement can be seen in Fig 2

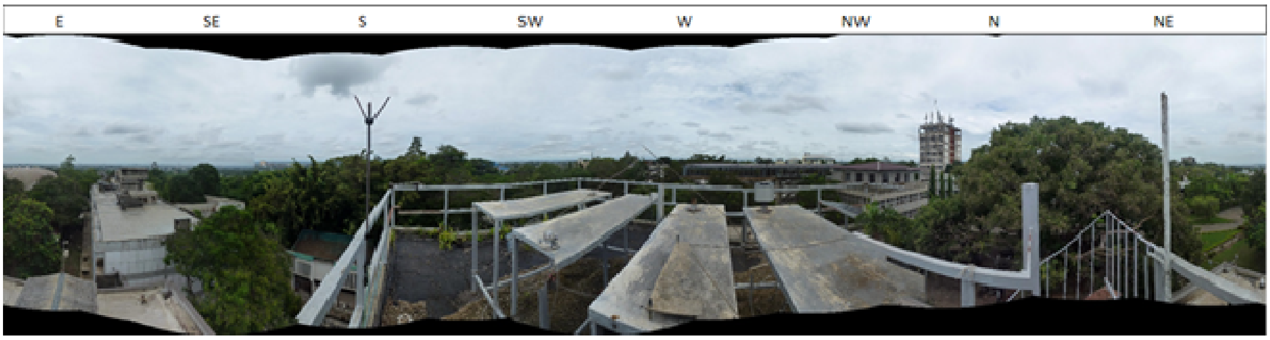

Fig 2 Site Panorama

The other conditions that could affect the suitability of the emplacement were all favorable

Dust: No nearby sources of dust; the campus is vegetated and surrounds the building for kilometers on all sides.

Access for O&M: The roof is easily accessed by spiral staircase, and is wide, flat and fitted with safety rails.

Heat Interference: None likely; the rooftop is isolated from its surroundings by plenty of open space.

Security: The University compound is guarded. The roof is accessible from the main building, and the access door can be locked.

Future Interferences: There are no plans for new building works in the immediate vicinity of the emplacement,

Communications: There is 3G network coverage noted for Vodacom, Airtel, Zantel, Tigo.

3.3.2 Dodoma

Dodoma is the administrative capital of Tanzania and the site of the National Assembly. Located in Dodoma region, it has a municipal population of 411,000 (Source: Tanzania National Bureau of Statistics [3]). Dodoma is roughly in the geographic centre of the country; it sits on an arid upland plateau, at an altitude of 1,200m. The city is a transport hub, with an airport, rail and road links.

Three possible institutions have been identified and visited in Dodoma: The University of Dodoma (UDOM), Tanesco and TMA and 4 potential emplacements have been visited, two from Tanesco and one per each other institution.

The TMA emplacement is sited in the current TMA station within the grounds of Dodoma airport. The first of Tanesco's emplacement sites is on the roof of the Regional Headquarters in town, while the second is within Dodoma's main substation. The UDOM emplacement is sited on the roof of the main administrative building. As can be seen in Fig 3 the UDOM emplacement is outside of the urban environment, to the east of Dodoma's main densely populated areas. The Tanesco headquarters and Dodoma airport are in the urban area of Dodoma while the Tanesco substation is on the west side of the city. The selected emplacement for this site is the **University of Dodoma**; its selection criteria are compiled in the Table 3.

Fig 3 Location of emplacements visited in Dodoma

Table 3 Dodoma decision table.

Site	Shadows	Dust	Heat Interferences	Future Interferences	Access O&M	Civil Works	Security	Communications	Maintenance	Total Score
UDOM	3	3	3	3	3	3	3	3	3	27
Tanesco Headquarters	2	1	3	1	3	3	3	3	3	22
Tanesco Substation	0	2	2	1	3	2	3	3	3	19
TMA	2	3	3	3	3	2	3	3	3	22

University of Dodoma

The emplacement is sited on the roof of the University of Dodoma's Main Administration Building, 8 km East of Dodoma Town (latitude: 35.82489 E, longitude: 6.21493 S) and with a height of 1.288 m above sea level. Fig 4 contains the aerial view of the campus, the red circle indicates the exact location of the emplacement.

Fig 4 Aerial view

In the horizon analysis made during the site visit, it was determined that no critical obstacles are present. To the east there is a hill in the near distance, blocking the horizon at a height under 2˚, rising to 5.7˚ at a bearing of 108 degrees. To the west there are a number of hills in the middle distance, the tallest being at 3.2˚ above the horizon. The panoramic picture from the emplacement can be seen in Fig 5.

Fig 5 Site Panorama

The other conditions that could the suitability of the emplacement are all favorable.

Dust: The site's height above the ground mitigates against potential dust from surrounding scrubland.

Access for O&M: The emplacement is easily accessible on the rooftop by a ladder.

Heat Interference: The emplacement is well ventilated.

Security: The emplacement is on the roof of the main administration building, and the access door can be locked.

Future Interferences: There are no plans for new building works in the immediate vicinity of the emplacement, particularly at a comparable height.

Communications: There is 3G network coverage noted for Vodacom, Airtel, Zantel, Tigo.

3.3.3 Iringa

Iringa town is the administrative capital of the Iringa Region, with a population of 151,000 within the municipal area (Source: Tanzania National Bureau of Statistics [3]). Located 300km south of Dodoma, it is situated within a mountainous region consisting of small, rocky hills at an altitude of 1,600m. Iringa has an airport and strong road links to the rest of the country. Iringa is a centre for manufacturing and food processing.

Three possible institutions were identified and visited in Iringa: The Mkwawa University (MUCE), Tanesco and TMA. 5 potential sites in total were visited, one from Tanesco and two per each other institution.

The first TMA emplacement (TMA1) is in the current TMA station within the grounds of Iringa airport and close to its terminal buildings. The second TMA emplacement (TMA2) is to the immediate north of the current meteorological station, outside of the TMA enclosure fence but still within TMA property. The Tanesco emplacement is located on the outside of Iringa's main substation compound, in its southeastern corner. Both of the MUCE emplacements are located within the campus of the University and on ground sites (as opposed to on building roofs). As can be seen in Fig 6 the TMA emplacements are outside of the urban environment, to the north of Iringa's more densely populated areas. The Tanesco substation is situated to the south of the town, while the Mkwawa campus is in the middle of the town. The selected emplacement for this site is **TMA1/2**; its selection criteria are compiled in Table 4. In this case, both options for TMA can be consider the same, due to their proximity to each other. The horizon visibility is better in TMA 2, but unlike TMA1 it lies outside out of the current TMA enclosure fence.

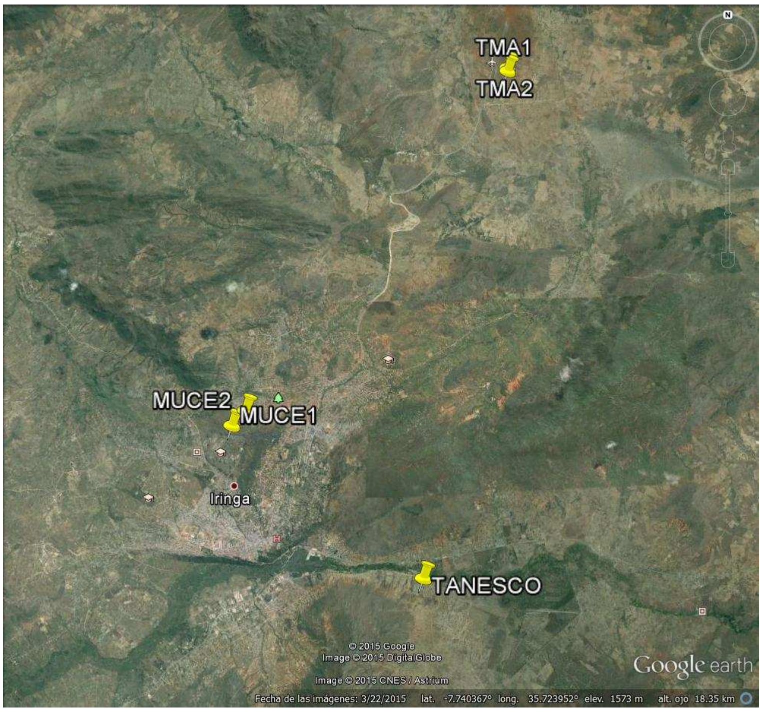

Fig 6   Location of emplacements visited in Iringa

Table 4 Iringa decision table.

Site	Shadows	Dust	Heat Interferences	Future Interferences	Access O&M	Civil Works	Security	Communications	Maintenance	Total score
TMA1	2	2	3	3	3	3	3	3	3	25
TMA2	3	2	3	3	3	2	3	3	3	25
MUCE1	2	3	3	2	2	2	2	3	3	22
MUCE2	1	2	2	2	2	2	2	3	3	19
Tanesco substation	0	2	3	2	3	2	2	3	3	20

TMA airport

The emplacement is sited in the current TMA weather station enclosure at Iringa Airport, 10km north of Iringa town (latitude: 35.75296 E, longitude: 7.67606 S) and with a height of 1.429 m above sea level. Fig 7 contains the aerial view of the airport terminal and the red circles sign the exact location of both options in the emplacement

Fig 7 Aerial view

In the horizon analysis made during the site visit, it was determined that no critical obstacles are present. To the east there are a number of distant hills with peaks at a maximum of 2.3˚ above the horizon. To the west there is a building with its highest point at less than 7º above the horizon, and a hill in the northwest presenting 5º of elevation. The panoramic picture from the first option of the emplacement can be seen in Fig 8.

Fig 8 Site Panorama TMA1

The panoramic view of the second option in the emplacement (north to the current station) can be seen in Fig 9 and it shows how the horizon is clear of significant obstacles.

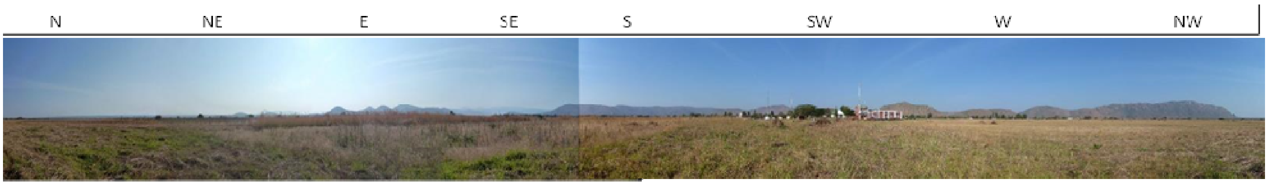

Fig 9 Site Panorama TMA2

The other conditions that could affect the suitability of the emplacement are all favourable

Dust: Seasonal dust likely from surrounding grassland.

Access for O&M: Adjacent to the airport buildings and the TMA office.

Heat Interference: The site is on grassy ground and is well ventilated.

Security: Airport premises are closely guarded, but the TMA enclosure itself has a low wire fence.

Future Interferences: No plans for new building works within the immediate surroundings.

Communications: There is 3G network coverage noted for Vodacom, Airtel, Zantel, Tigo.

3.3.4 Songea

Songea town is the administrative capital of the Ruvuma Region, with a population of 203,000 within the municipal area (Source: Tanzania National Bureau of Statistics [3]) . Located in the far south of the country, 300km south of Iringa, it is situated among relatively open country at an altitude of 1,100m. Songea has an airport and road links to the north. Agriculture is the main economic activity.

Two possible institutions have been identified and visited in Songea: Tanesco and TMA, with one emplacement per institution. The TMA emplacement is sited within the current TMA weather station enclosure at Songea Airport. The Tanesco emplacement is sited within the compound of the TANESCO Songea substation. As can be seen in Fig 10 the TMA emplacement is outside of the urban environment, 6 km west of Songea town. The Tanesco emplacement is sited in the centre of the town. The selected emplacement for this site is **TMA**; its selection criteria are compiled in Table 5.

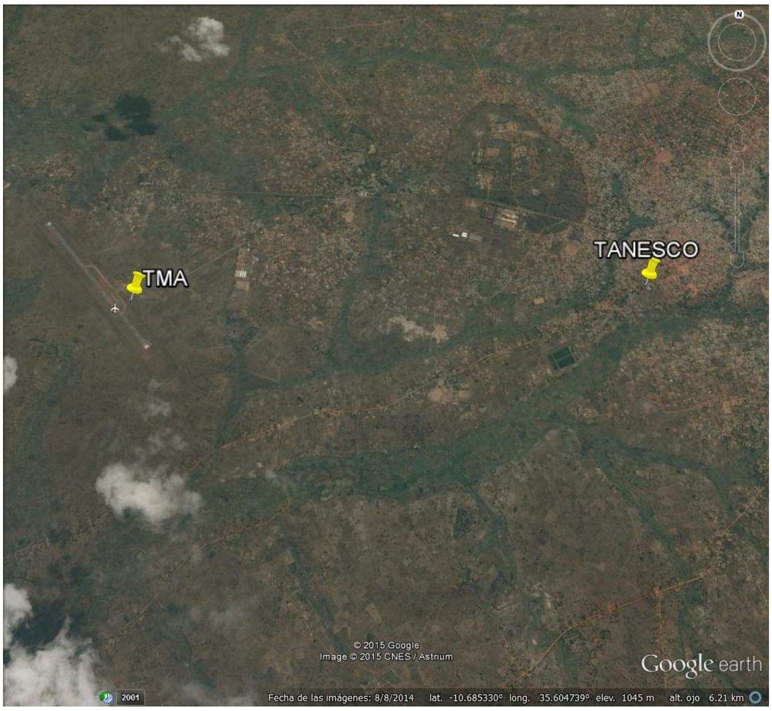

Fig 10 Location of emplacements visited in Songea

Table 5 Songea decision table.

Site	Shadows	Dust	Heat Interferences	Future Interferences	Access O&M	Civil Works	Security	Communications	Maintenance	Total score
TMA Airport	3	2	3	3	3	3	2	2	3	24
Tanesco diesel power station	0	1	2	1	3	2	3	3	3	18

TMA airport

The emplacement is situated in the current TMA weather station enclosure at Songea Airport, 6km west of Songea town (latitude: 35.58438 E, longitude: 10.68253 S) and with a height of 1.060 m above sea level. Fig 11 shows the aerial view of the airport terminal, with the red circle indicating the exact location of the emplacement.

Fig 11 Aerial view

In the horizon analysis made during the site visit, it was determined that no critical obstacles are present. To the west is a hill with a peak elevation of 2.3˚ above the horizon and a small lattice tower in the same direction. The panoramic picture from the emplacement can be seen in Fig 12.

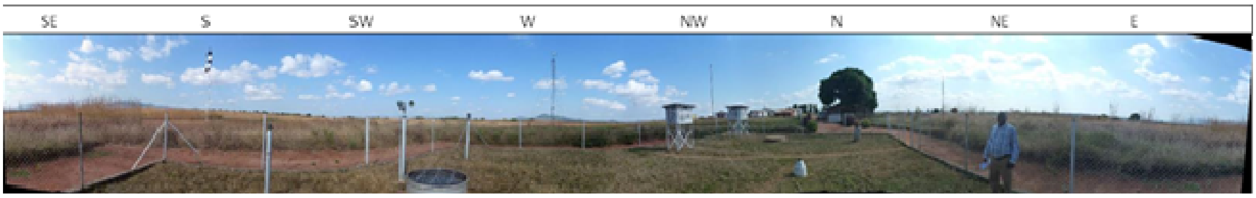

Fig 12 Site Panorama

The other conditions that could affect the suitability of the emplacement are all favourable

Dust: Seasonal dust likely from surrounding grassland.

Access for O&M: Immediately adjacent to the airfield buildings and TMA office

Heat Interference: The site is on grassy ground in a small clearing, and is well ventilated.

Security: The airfield is guarded but has no perimeter fence, and the TMA enclosure itself has only a low wire fence.

Future Interferences: The airfield is not particularly busy and there are no current plans for expansion.

Communications: There is 3G network coverage noted for Vodacom, Airtel, Zantel, Tigo.

3.3.5 Tabora

Tabora town is the administrative capital of Tabora Region, with a population of 227,000 within the municipal area (Source: Tanzania National Bureau of Statistics [3]). Located in the central western part of Tanzania, 300km south of Mwanza, Tabora sits among gentle hills at an altitude of 1,200m. Tabora has a small airfield and road links to the north and east. Agriculture is the main economic activity.

Two possible institutions has been identified and visited in Tabora: Tanesco and TMA and with one emplacement per institution. The TMA emplacement is sited in the current TMA weather station enclosure at the Tabora Airport. The Tanesco emplacement is sited within the substation compound of TANESCO's Tabora substation. As can be seen in Fig 13 the TMA emplacement is outside of the urban environment, 5 km southeast of Tabora town. The Tanesco emplacement is sited at the northern edge of Tabora town. The selected emplacement for this site is **TMA**; its selection criteria are compiled in Table 6**.**

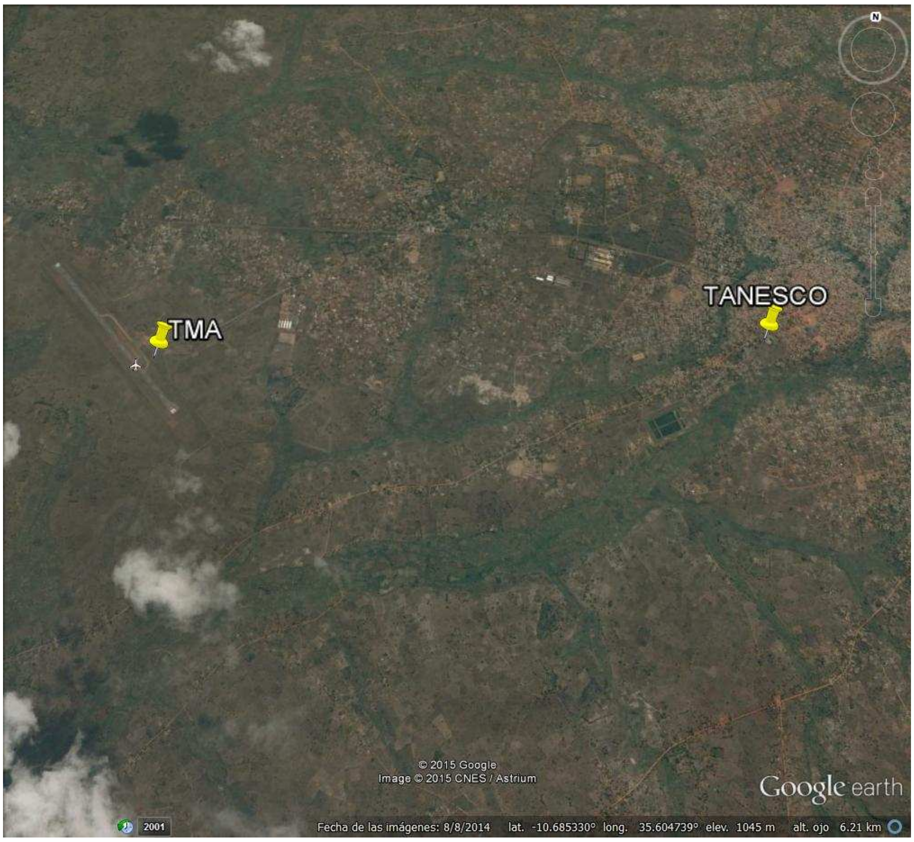

Fig 13 Location of emplacements visited in Tabora

Table 6 Tabora decision table.

Site	Shadows	Dust	Heat Interferences	Future Interferences	Access O&M	Civil Works	Security	Communications	Maintenance	Total score
TMA	2	2	3	2	3	3	2	2	3	24
Tanesco substation	0	1	2	3	3	2	3	3	3	18

TMA airport

The emplacement is sited within current TMA weather station enclosure at Tabora Airport, 5km southeast of Tabora town (latitude: 32.83352 E, longitude: 5.07432 S) and with a height of 1.177 m above sea level. Fig 14 shows the aerial view of the airport, with the red circle indicating the exact location of the emplacement.

Fig 14 Aerial view

In the horizon analysis made during the site visit, it was determined that no critical obstacles are present. The principal potential shadowing objects are sited between the north and northeast directions. In the east direction there is a building that present shadow at an angle of 4.9º. The panoramic picture from the emplacement can be seen in Fig 15.

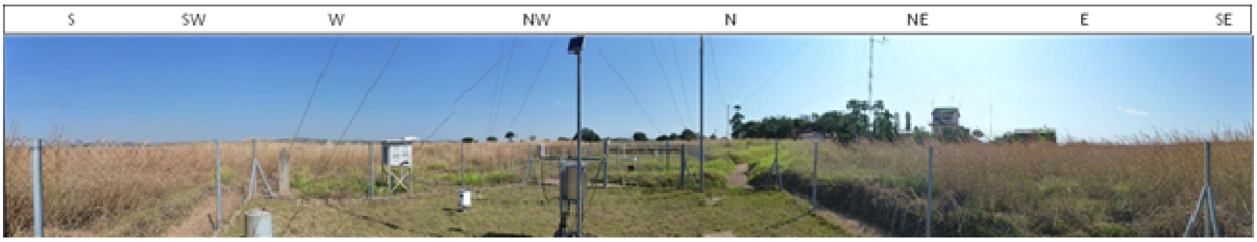

Fig 15 Site Panorama

The other conditions that could affect the suitability of the emplacement are all favourable

Dust: The site is surrounded by grassland, with some susceptibility to dust.

Access for O&M: Site is within the TMA enclosure, so easily accessed by technicians

Heat Interference: The enclosure is covered in short grass, and there are no reflective surfaces nearby.

Security: The airfield is guarded but has no perimeter fence, and the TMA enclosure itself has only a low wire fence.

Future Interferences: The runway is due to be extended, which will not disrupt the TMA station but will create dust.

Communications: There is 3G network coverage noted for Vodacom, Airtel, Zantel, Tigo.

3.3.6 Mwanza

Mwanza city is the administrative capital of Mwanza Region, and is Tanzania's second largest city with a municipal population of 706,000 (Source: Tanzania National Bureau of Statistics [3]). Located in the northwest of Tanzania on the shore of lake Victoria, Mwanza is surrounded by tall, steep hills at an altitude of 1,200m. Mwanza has a large airport and strong road links. The city is an industrial centre, particularly in processing fish from Lake Victoria.

Four possible institutions have been identified and visited in Mwanza: Saint Augustine University (SAUT), The Dar es Salaam Institute of Technology campus in Mwanza (DIT-M), Tanesco and TMA. A total of 5 potential emplacements were visited in the first trip, two from Tanesco and one per each other institution. The SAUT emplacement is located on the rooftop of the main Academic building at the centre of the campus, in the west of Mwanza. The DIT-M emplacement is on the rooftop of an accommodation building at the western of the campus in the northern part of Mwanza. The first Tanesco option is sited in the Mwanza substation compound on the eastern edge of Mwanza city while the second one is located in Mwabuki substation 50 km southeast of Mwanza city. A second visit has been made to the Mabuki substation of Tanesco with the goal of analyzing the rooftop of its administrative buildibg as an option. Finally, the TMA emplacement is sited in the north of the city in its weather radar compound. As can be seen in Fig 16 one of the Tanesco options is sited relatively open countryside, the rest of the emplacement options are distributed across the Mwanza city. The selected emplacement for this site is **SAUT** but we reserve the Mabuki substation (rooftop) as backup emplacement. The selection criteria are compiled in Table 7.

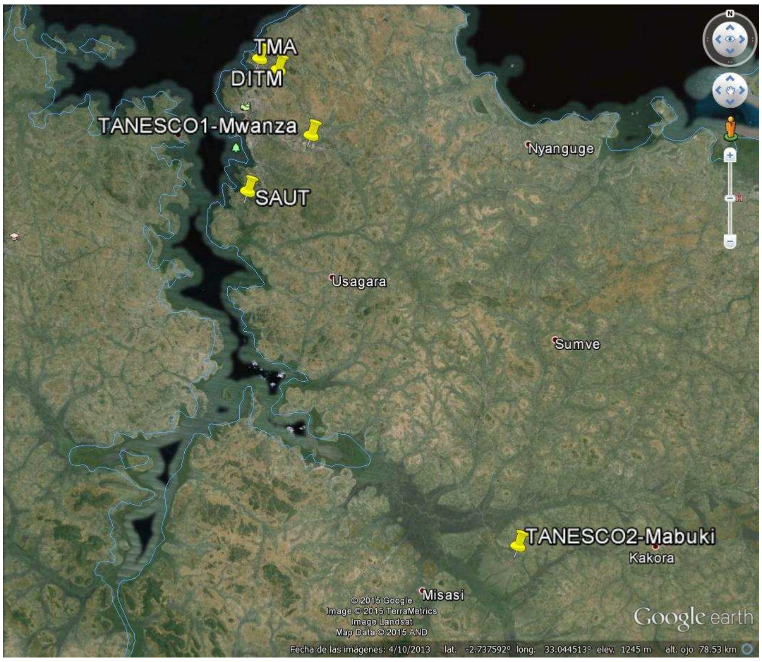

Fig 16 Location of emplacements visited in Mwanza

Table 7 Mwanza decision table.

Site	Shadows	Dust	Heat Interferences	Future Interferences	Access O&M	Civil Works	Security	Communications	Maintenance	Total score
SAUT	3	3	3	3	3	3	3	3	3	27
TMA	2	2	3	0	3	2	3	2	3	21
Tanesco Mwanza	0	2	2	3	3	2	3	3	3	21
Tanesco Mabuki	0	2	2	3	3	2	3	3	3	21
Tanesco Mabuki rooftop	3	2	2	3	2	3	3	3	2	23
DIT-M	3	3	3	3	0	3	3	3	3	24

Saint Augustine University

The emplacement is sited on the roof of the main academic building at the centre of the SAUT campus, in the western edge of Mwanza city (latitude: 32.89803 E, longitude: 2.60344S) and at a height of 1.192 m above sea level. Fig 17 shows the aerial view of the campus, with the red circle indicating the exact location of the emplacement.

Fig 17 Aerial view

In the horizon analysis made during the site visit, it was determined that no critical obstacles are present. To the east there is a line of tall hills approximately 2km away, forming obstacles to the horizon at 4.6˚. The highest elevations are bearing at 98º, so will not cast problematic shadows. To the west the horizon is clear with a number of individual hills peaking at 4.6˚. The panoramic view can be seen in Fig 18.

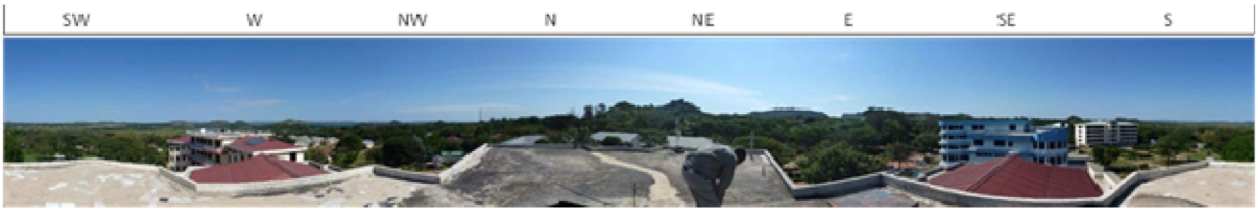

Fig 18 Site Panorama

The other conditions that could affect the suitability of the emplacement are all favourable

Dust: The rooftop is highly elevated and surrounded by vegetated area.

Access for O&M: Site is on the rooftop, accessible by ladder through a trapdoor to the roof.

Heat Interference: The rooftop is well ventilated.

Security: The rooftop is not accessible to students or the public.

Future Interferences: No new developments are planned on the roof or nearby.

Communications: There is 3G network coverage noted for Vodacom, Airtel, Zantel, Tigo.

3.3.7 Arusha-Moshi

Arusha town is the administrative capital of Arusha Region, with a population of 323,000 within the municipal area (Source: Tanzania National Bureau of Statistics [3]). Located in the north of Tanzania, Arusha sits on relatively flat land punctuated by isolated large mountains, at an altitude of 1,500m. Arusha has an airport in the town and is 50km west of Kilimanjaro International Airport, as well as strong road links. Arusha is a centre of international tourism.

Moshi town, 100km east of Arusha, is the administrative capital of Kilimanjaro Region, with a population of 184,000. (Source: Tanzania National Bureau of Statistics [3]) within the municipal area. Moshi has strong road links, and its main economic activity is agriculture.

Three possible institutions have been identified and visited in Arusha: The Nelson Mandela African Institute of Science and Technology (NM-AIST), Tanesco and TMA. Of the 5 potential emplacement sites have visited, two are from TMA and NM-AIST respectively, and one from Tanesco. One of the potential NM-AIST emplacement sites is on the rooftop of the main building, while the other one is on open ground within the campus near the sports area. The first TMA option is in the Arusha Airport weather station enclosure to the west of the Arusha town and the other option is in the TMA Kilimanjaro International Airport enclosure. The Tanesco site is in the compound of the Kilimanjaro International Airport substation. The distribution of the different options can be seen in Fig 19. The final emplacement selected for this site is **NM-AIST**; selection criteria are compiled in Table 8.

Fig 19 Location of emplacements visited in Arusha

Table 8 Arusha decision table.

Site	Shadows	Dust	Heat Interferences	Future Interferences	Access O&M	Civil Works	Security	Communications	Maintenance	Total score
NM-AIST sports area	3	2	3	3	2	2	2	2	3	22
NM-AIST building	0	3	2	3	3	3	3	3	3	23
TMA Kilimanjaro	2	2	2	0	3	2	3	3	3	20
TMA Arusha	3	2	2	0	3	2	2	3	3	20
Tanesco	0	2	2	3	3	2	3	2	3	20

Nelson Mandela African Institute of Science and Technology

The site is adjacent to NM-AIST's running track, a 5 minute walk from the institute's main building (latitude: 36.79840 E, longitude: 3.40270 S) and with at a height of 1.197 m above sea level. Fig 20 shows the aerial view of the NM-AIST enclosure, with the red circle indicating the exact location of the emplacement. It is important note that the possibility of install the station on the rooftop of the main building of the Institute will also be considered; the roof was surveyed during the site visit and initially discarded due to shadowing problems, but it is nonetheless possible that the installation could occur on this building.

Fig 20 Aerial view

In the horizon analysis made during the site visit, it was determined that no critical obstacles are present. The panoramic view of the horizon can be seen in Fig 21.

Fig 21 Site Panorama

The other conditions that affect the suitability of the emplacement are all of them favourable

Dust: The site is surrounded by grassland.

Access for O&M: Site is within a five-minute walk from the institute's main buildings.

Heat Interference: The site is surrounded by flat grassland.

Security: The entire campus is walled, but the site not within direct visibility of the main buildings. A fence will be installed.

Future Interferences: There are no current building plans in the immediate area.

Communications: There is 3G network coverage noted for Vodacom, Airtel, Zantel, Tigo.

3.3.8 Mbeya

Mbeya city is the administrative capital of Mbeya Region, with a population of 385,000 within the city area (Source: Tanzania National Bureau of Statistics [3]). Located in south-western Tanzania, 300km southwest of Iringa, Mbeya sits between mountain ranges at an altitude of 1,800m. Mbeya has an airport and strong road links west to Zambia and Malawi, and east towards Iringa. Mbeya is a centre for agricultural trade.

The installation of a ground station in Mbeya is proposed as an optional addition to the network. In case of its installation, a Tier2 station would be used. The inclusion of Mbeya in the network would be helpful in not only ensuring a more detailed coverage of Tanzania's solar regimes, but also in providing a more extensive high-quality solar radiation dataset across Tanzania for future usage. Note that this site is not included in the economic proposal but it will be the next station to be installed in case of network extension.

The visit to potential Mbeya emplacement sites was made in an earlier site visit, coinciding with other activities of EVA in this city. Two different hosts were identified, Tanesco and the Mbeya University of Science and Technology (MUST). After the visits it was concluded that only the MUST option presented a suitable emplacement.

Mbeya University of Science and Technology

The site is on the rooftop of the main university administration building, situated in the south of Mbeya city (Latitude: 33.4162 E, longitude: 8.9418 S) and located at a height of 1.662m above sea level. Fig 22 shows the aerial view of the MUST campus enclosure, with the red circle indicating the exact location of the emplacement.

Fig 22 Aerial view

In the horizon analysis made during the site visit, it was determined that no critical obstacles are present. The panoramic view of the horizon can be seen in Fig 23.

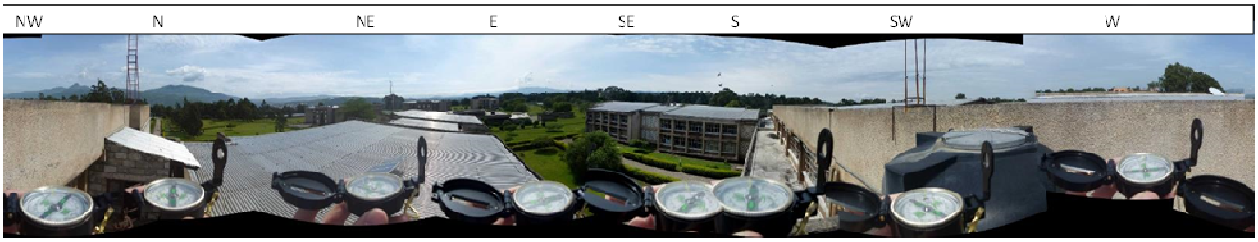

Fig 23 Site Panorama

The other conditions that could affect the suitability of the emplacement are all favourable

Dust: The surrounding area is well vegetated, and the site is well ventilated.

Access for O&M: Site is on the roof of the main university building, so easily accessed by technicians. A ladder would have to be installed

Heat Interference: The site is well ventilated.

Security: The campus is well guarded and access to the rooftop is via locked doors.

Future Interferences: There are no planned building works near the site.

Communications: There is 3G network coverage noted for Vodacom, Airtel, Zantel, Tigo.

3.4 Selected emplacements

Table 9 summarizes the final emplacement decisions and network configuration: the selected site hosts, the type of station and the host institution. The spatial distribution of the network along the geography of Tanzania can be seen in Fig 24; red marks correspond to Tier 1 stations and green marks correspond to Tier 2 stations.

Table 9 Network summary

Site	Type of station	Host Institution
Dar es Salaam	*Tier 1*	*UDSM (already installed)*
Dodoma	Tier 1	UDOM
Tabora	Tier 1	TMA
Iringa	Tier 1	TMA
Songea	Tier 2	TMA
Mwanza	Tier 1	SAUT
Arusha	Tier 2	TMA

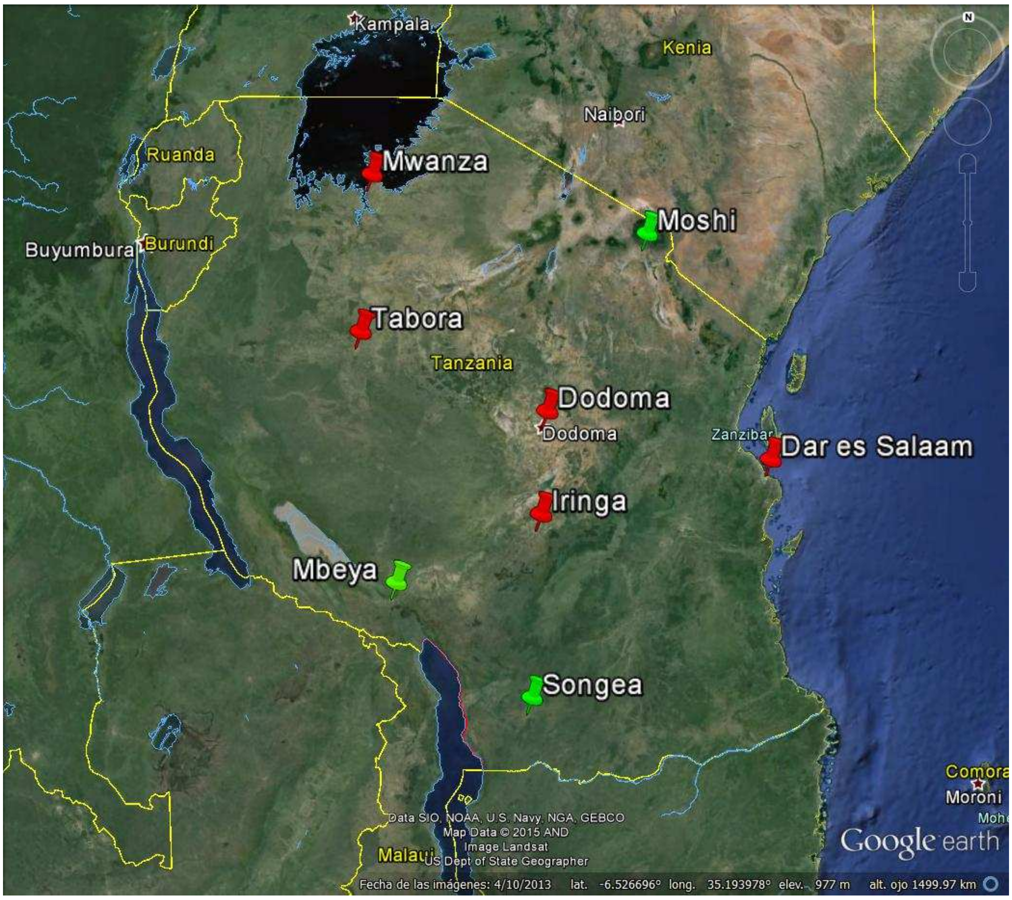

Fig 24 Spatial distribution of the stations

4 IMPLEMENTATION OF THE MEASUREMENT NETWORK

This section describes of all the activities related to the implementation of the measurement network's ground stations, from their transportation, installation and commissioning, to periodic maintenance and monitoring. The company in charge of each activity is also identified as well as the method of cover outlining of whether each task will be covered by mean of subcontracting or by partners work.

It is important remark that there are different suppliers for Tier 1 stations and Tier 2. It principal affects to the installation and commissioning activities besides the international transportation.

4.1 Permissions and agreements

For the three separate types of institution selected as candidates for hosting the stations, a different approach for obtaining permission has been taken.

Tanesco

The Managing Director was first contacted to introduce the ESMAP project. Once TANESCO's interest in the project was affirmed, introduction letters were sent to the Regional Offices within the areas targeted for installation of the stations. These Regional Offices were then visited and the project and specific requirements of the monitoring stations discussed. Following this potential installation sites were visited and surveyed. The MOU is the only agreement needed to install the monitoring stations and govern their operations, maintenance and handover. The standard MOU has been presented to TANESCO at the Managing Director level, and will be signed at this level. The selected sites will be added into the MOU, with one agreement covering all selected sites.

TMA

The Managing Director was first contacted to introduce the ESMAP project. Once TMA's interest in the project was affirmed, introduction letters were sent to the TMA offices within the areas targeted for installation of the stations. These offices and their attached weather stations were then visited. At each of these locations the project and specific requirements of the monitoring stations were discussed, followed by surveying of the weather stations.

The MOU is the only agreement needed to install the monitoring stations and govern their operations, maintenance and handover. The standard MOU has been presented to TMA at the Managing Director level, and will be signed at this level. The selected sites will be added into the MOU, with one agreement covering all selected sites.

Universities

Candidate universities were identified within the regions targeted for installation of the stations. Universities were selected based on their location and their likely interest in the project – whether they have scientific departments which the stations would prove useful to. Introduction letters were sent to each university, which were then visited and surveyed for appropriate sites.

Each selected university will sign an MOU; this is the only agreement needed to install the monitoring stations and govern their operations, maintenance and handover. The standard MOU has been presented to the appropriate representative of each university visited – usually the Vice Chancellor.

MOU

The MOU, attached as Annex 1, outlines the different roles expected by the project team and by the host institution. It also emphasizes that inheritance of the equipment at the end of the project period is conditional on a track record of good servicing by the host.

4.2 Transport

4.2.1 International transport

Automatic Weather Stations (AWS) in CIP conditions according to incoterms 2010®. The following actions are included: packaging and verification of goods at the factory, loading of goods at the factory, inland transport from the factory to the airport of departure, fulfilment of customs requirements for export, transport by airplane to destination airport and Insurance of the goods during international transit.

GEONICA uses an international freight forwarder company (TRANSTACT CARGO, S.A.), that picks up the goods at GEONICA's facilities, prepares all documents and arranges the transport of the goods. This company has more than 30 year of experience in worldwide Export-Import by land, air or sea. For this project, the consortium has decided to ship the goods by air - the size of the Weather stations allow them to easily fit inside a commercial aircraft's cargo hold. The main benefit of air transport compared to transport by sea is a reduction of transport time of near 20 days. In the same line, the case of Tier 2 stations will be shipped by Campbel SA by air to Dar es Salaam airport.

4.2.2 In-country storage and domestic transport

Once the equipment for all stations has been imported by air freight into Tanzania, they will be stored at a warehouse location in Dar es Salaam until a week before installation is due. This is so as to minimize any risks associated with storing the equipment at the site host locations.

Logistical possibilities for transportation of the equipment to each site host are currently being determined to minimize cost: a certain combination of single trips (one truck carrying one station to one location) and multi-stop trips (one truck carrying several stations to different locations), given the geographic spread of site hosts. Though some site hosts are located more than a day's travel from Dar es Salaam, small-aircraft air transport has been ruled out as a possible alternative due to high cost and lack of reliable service providers.

EVA will manage the transportation phase of the project. Domestic transport service providers have been contacted and have quoted for the transportation of the stations from the Dar es Salaam warehouse to the site host locations. The main contacts at the site host institutions will be instructed to anticipate the delivery of the equipment, and will be required to provide photographic evidence that the equipment has been received and stored at a suitable on-site location. A delivery receipt will also be required from the transportation provider. This process was followed for the already-commissioned station at the University of Dar es Salaam. After clearing customs the equipment was taken to a contracted warehousing facility, and stored until the morning of installation, when it was transported to site and installed.

4.3 Customs clearance

The importation of equipment for the stations has already been completed once for the Dar es Salaam station. The importation process is facilitated through use of a customs agent.

Within the week leading up to embarkation of the equipment from the country of supply, the following documents are supplied to the Tanzanian customs agent:

- Commercial invoice for the goods
- Packing list
- Airway Bill advance copy

The customs agent takes the above documents – along with authorization letters from the importing company – to the Tanzania Revenue Authority (TRA) who manages the customs process. Simultaneously the documents are also taken to

Swissport, the company managing goods importation at Dar es Salaam airport. Clearance of goods through customs takes between one and two weeks.

4.4 Insurance and third party liability

The following insurance cover will be taken out for the measurement stations:

1. International transportation: Automatic Weather Stations (AWS) will be shipped in CIP conditions according to incoterms 2010®.to the nearest international airport with customs clearance to the final locations of the AWS. This means that includes; packaging and verification of the goods at the factory, loading of goods at the factory, inland transport from the factory to the airport of departure, customs formalities for export of goods, Transport by airplane to destination airport and Insurance of the goods

   In-country transportation: The equipment insurance policy will cover domestic goods transport. However a separate domestic insurance policy can also be taken out.

2. Erection All Risk (EAR): The all risk insurance to the installation of the solar measurement stations cover the permanent and temporary works including all materials to be incorporated. It covers any one contract, third party liability, of-site storage and inland transit.
3. Equipment insurance: coverage to the value of the equipment in case of damage, theft, vandalism and natural disasters such as lightning strikes. The coverage also applies to goods in transit.
4. Public liability: coverage upon accidental death, injury or illness of any person, or physical damage to any tangible property occurring in connection with the equipment. The coverage is extended to defective workmanship, legal defense costs, and wrongful arrest and defamation.

4.5 Ownership

Ownership of the equipment during measurement campaign will be undertaken by the solar Vendor (represented by EVA). It is envisaged that ownership for the station will transfer from Solar Mapping Vendor to the host of the station and that the station stays in place..

4.6 Equipment installation and commissioning

4.6.1 Site preparation

The selected sites for installation are a variety of open-ground and flat-roof locations. For open-ground locations the procedure for preparing the site for installation is as follows:

- Site demarcation and planning: using GIS software, the exact coordinates of the site are determined and communicated to the site host and the local civil works contractor. The site host and civil works contractor then visit the site and confirm the exact location of the site and its layout. Photographs demonstrating this are sent back to EVA. This occurs 4 weeks before commissioning.

- When necessary, the site location will then be cleared of vegetation and surface rocks. The site will also be regraded so that any dips or rises in the earth that may complicate installation are levelled out. This occurs 2 weeks before commissioning.
- The fencing will be erected 2 weeks before commissioning – allowing plenty of time for unforeseen delays.
- The foundations slabs can be poured off-site, with anchor points embedded in them. Their final resting places will be excavated simultaneously. This occurs 1 week before commissioning.
- EVA and the installation contractors will arrive on-site one day before commissioning. On this day the foundations will be placed in the excavated holes and buried, with checks made to ensure that they are in the exactly correct location. On the day of commissioning the equipment will be assembled, calibrated and commissioned.
- The backup power cable for using mains electricity in the case of failure of the solar panel or battery will be left with technicians to use if a problem. If the cable can be installed without any risk of disturbance over the lifetime of the project, this will be done on the same day as the commissioning of the station.

For rooftop locations, there is no need for buried foundations or security fencing. The procedure for site preparation is the same as for open-ground locations without the steps for fencing installation or foundation excavation. In some cases an access ladder or security door may need to be installed to access or protect the rooftop location. Where this is the case, the specifications will be decided during the site host/civil works contractor meeting 4 weeks before commissioning, and installation will occur 2 weeks before commissioning.

Since the civil works can be completed using local resources and contractors, the exact contractor to undertake the site preparations work at each site will be identified following submission of the Phase 2 Report. The candidate site hosts will be asked to recommend local contractors, some of whom will be in-house to the host institution. 2 quotes for each site will be sought, with the cheaper quote selected (assuming high quality can be assured).

4.6.2 Communications for data transmission

All monitoring station locations have been determined to have good 3G cellular network signal. As a result the stations can reliably transmit data over GSM networks using cheap and easily obtained SIM cards. In the case of a temporary loss of service, the dataloggers used can store data and transmit it in bulk once service is restored.

EVA have determined that the most cost effective and reliable means of ensuring the SIM cards installed in the dataloggers remain in operation over the lifetime of the project is to manually check and re-charge the data allowances of each SIM once per month and this can be done remotely.

As well as transmitting sensor data, it is possible to receive diagnostic information from the station which can ensure that timely maintenance interventions are undertaken if required.

4.6.3 Installation and commissioning

The installation and commissioning of the stations will be made by Geonica in case of Tier 1 stations and subcontracted to the company Geosun in case of Tier 2 ones. EVA as local partner of the consortium is the responsible of the supervision of these activities.

4.7 Maintenance

There are different levels of maintenance observed in the measurement campaign.

4.7.1 Routine maintenance

Even when the meteorological stations have been designed for working in outdoors and in remote unattended areas, it is necessary to carry out a regular maintenance to assure a good quality of all meteorological parameters measured by the weather stations. The regular maintenance of the meteorological stations at the sites necessarily will be provided by the host institution and its own personnel or staff, due to bug fixing (if necessary) and frequent sensor cleaning. Besides, operators will verify all connectors and interconnecting cables in order to confirm that there are not broken parts or damages that could be affected due to dust and moist. Pipelining must be sealed to avoid the effects of water and/or small animals such as rodents.

A detailed guideline for the maintenance of Solar Radiation Measurement Stations will be delivered to each host institution after the installation. A session of training on the job will be made during the commissioning to show the routine maintenance activities. These tasks are very simple and it is not necessary a high qualification of the staff; but the frequency of them is critical to ensure a good quality of measurements.

The activities realized over the stations will be recorded in a log sheet principally to help in determining the quality of the data. Whatever form is used must be determined in concert with the observer so that the information required by the scientist analyzing the data can be easily discovered. Log sheets are essential in the rapid and accurate quality assurance of solar radiation data and each of them covers weekly periods of maintenance. The log sheet format will be delivered to the host institutions to easy and uniform the maintenance activities

The routine maintenance activities are summarized as follow.

Daily maintenance

Good maintenance of the station requires daily maintenance visits. This period will be mandatory in case of Tier 1 stations and recommended for Tier 2 stations. It is however acceptable for Tier 2 stations to receive even only once-weekly maintenance.

Cleaning

The exterior of the sensor domes (pyranometer) or optical surfaces (pyrheliometer window or lens) of each instrument should be cleaned once per day. It is preferable that this cleaning is done before dawn.

Condensation

The radiometer should be checked for any condensation on the inside surface of the outer dome. If this occurs, the outer dome must be removed in a clean, dry location, cleaned and the cause for the leak determined.

Sensor condition

The color and the condition of the thermopile should be checked. If the color is fading or changing; or the thermopile surface appears rough, cracked or weathered; the instrument should be removed from service and replaced with a spare. This rarely occurs on relatively new equipment.

Sensor level

The level of each horizontally mounted instrument (pyranometers) should be checked and corrected as necessary. The bubble of the spirit level should be completely within the inner indicator circle. For most instruments, this indicates that the instrument is level to within ±0.1°. In some ca ses that the radiation shield can make it difficult to perform this check, and it must be removed each time. If this is the case, it is acceptable for this check to be made on a weekly basis.

Alignment

The alignment of any instruments should be checked and, if necessary, corrected. Direct sunlight is required to detect spot alignment for direct beam instruments (pyrheliometers); this is checked by ensuring that the solar spot is aligned over the target.

Shaded instruments

Each shaded instrument (Diffuse pyranometer) must be checked to ensure that the shading device completely covers the outer dome of the sensor.

Other equipment

The solar tracker level must be checked, following the procedure for other horizontally mounted instruments. It is also necessary to check if there is a tracking mismatch, or if any power, mechanical malfunction or software failure has occurred. In such cases operator should refer to the tracker operating manual.

Weekly maintenance

Desiccant

Check the desiccant in each sensor. Desiccant should normally last several months, but is dependent upon atmospheric and specific local conditions. If the desiccant has lost its properties, it should be changed following manufacturer´s instructions.

Cabling

The cabling and connectors leading from the instrument to the data acquisition system or junction box should be inspected for wear. Unless the cable is to be replaced, or must be untangled, the instrument should not be disconnected. All work on the cable should be appropriately documented.

4.7.2 Predictive Maintenance

Yearly in situ calibration

Once a year the pyranometers and pyrheliometers of all the stations will be recalibrated on site using reference sensors (referenced to the World Radiometric Reference established in Davos, Switzerland). The correct behavior of the radiation sensors and related calibration parameters will be checked by simultaneous data recorded in clear sky conditions on central hours of day. This activity will be made by CENER in case of Tier 1 stations and will be subcontracted to the company Geosun in case of Tier 2 ones. In all cases a whole test of all components will be made including communications and power supply

4.7.3 Corrective Maintenance

There are two different ways to detect problems in the station. Firstly daily data monitoring and analysis of the data's quality will detect any malfunctions in the data and communications. Secondly, routine maintenance is also useful to identify problems with the station. It is important to note that it is usual for a problem to be detected by both of these means.

In cases where a problem has been detected, the below protocol will be followed.

Problem detected trough data monitoring

CENER will carry out daily remote monitoring and data quality analysis. This procedure, detailed in section 5.3, allows for the identification of any malfunctions that impact data quality. The causes of problems can be classified into three causes: communication, power supply and sensors. Fast diagnosis of the cause of the problem allows for timely correction. The next steps summarize the actions that will be made to correct a problem:

1. Analysis of the problem and evaluation of possible causes.
2. Communication of the analysis to the local partner EVA, and the station manufacturer.
    a. CENER will address the problem remotely, or will alert the host staff and instruct them to address the problem with remote assistance from the manufacturer.
    b. Where this is not possible, EVA will analyze the situation with the host staff and, if necessary, EVA will visit station site to correct the problem.
    c. If the problem cannot be solved by the local partner, the international staff will travel to the station to undertake the corrective works. An example of when this could be necessary would be when a key part of the station must be replaced.

Problem detected trough routine maintenance

As previously explained, the host institution will be responsible for routine maintenance. Once a week, they will send a maintenance actions sheet to EVA. As soon as a possible problem is detected by the host, it will be communicated to the local partner EVA; the following protocol is thus triggered. It is important remark that usually a problem detected by the host will also have a detectable impact on the data, which remote monitoring will also pick up.

1. EVA communicates a description of the problem to CENER.
2. CENER will evaluate this description and compare with information from the data monitoring. An evaluation of possible causes is made.
3. Communication of the analysis to the local partner EVA, and the station manufacturer.
    a. CENER will address the problem remotely, or will alert the host staff and instruct them to address the problem with remote assistance from the manufacturer.
    b. Where this is not possible, EVA will analyze the situation with the host staff and, if necessary, EVA will visit station site to correct the problem.
    c. If the problem cannot be solved by the local partner, the international staff will travel to the station to undertake the corrective works. An example of when this could be necessary would be when a key part of the station must be replaced.

5 MEASURED DATA MANAGEMENT

5.1 Data transmission

Transmission of data over GSM networks allows for the use of readily available commercial SIM cards. For simplicity, the network of measurement stations will as much as possible use SIM cards from the same network operators. The Tanzanian network operators Vodacom and Airtel are considered to be the most reliable and to have the broadest network coverage.

The SIM cards will be set up with Pay-As-You-Go (PAYG) payment plans, requiring each SIM card to be manually credited with data bundles once per month. This can be done remotely via any other SIM card from the same network, and requires minimal work. Whilst it is possible to obtain long-term data contracts, this is a potentially unreliable and not-easily remedied arrangement, hence manually crediting each SIM once per month gives a greater level of control over the arrangement. EVA will ensure that the SIM cards have sufficient credit over the course of the project.

5.2 Data administration

Data will be downloaded from each site will be done daily and checked to ensure against data loss, corrupted data, calibration drift, possible instrument failure and other interferences

All data will be transmitted electronically from each sensor, and collected by data logging equipment (METEDATA-3008CM for Tier1 and CR1000 for Tier2) with three way-communications capabilities.

1. GPRS communications using a built-in GPRS cellular modem with IP interfaces circuits (Internet, Intranet, VPN) using an antenna and interconnection cable between the GPRS modem and data logger
2. Direct ports.

a. Using Serial port communications via RS-232 cable

b. Using Ethernet link (Tier 1)

c. Using memory card (Tier 2)

The data logger contains an internal backup capable of storing close to one year of data in case of Tier1 and one month of data in case of Tier2. This ensures that any possible communication problems will not cause data loss.

All collected data and quality-assessed data will be monthly uploaded to a data repository provided by the World Bank.

5.3 Data monitoring

A successful quality-control process requires elements of quality assessment and feedback. Fig 25 depicts the procedure that will be carried out in this project, a quality-assurance cycle that couples data acquisition with quality assessment and feedback.

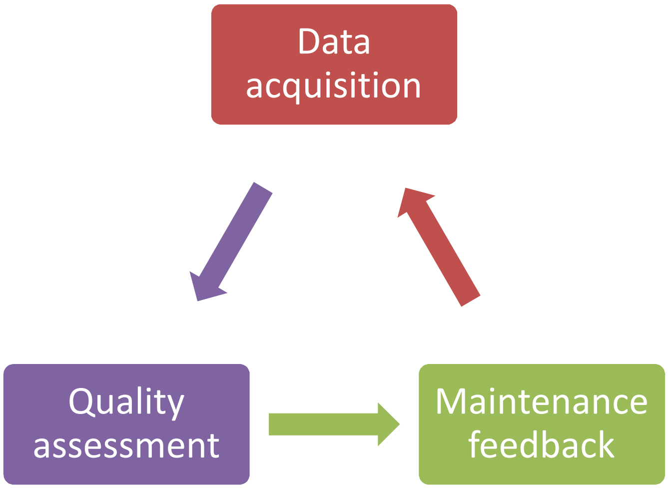

Fig 25 Information flow of a quality-assurance cycle.

In order to ensure high quality measurements from the weather stations in all meteorological parameters, a comprehensive monitoring process will be carried out. This process in detailed in following subsections.

5.3.1 Data recording time and visual inspection

Before a comprehensive numerical check, the recorded values are displayed day by day to classify them as valid or invalid by CENER experts. It includes the analysis of the correct timestamp corresponding to the measured data. This checking makes it possible to detect potential problems that would not be detected by numerical methods automatic quality tests.

In order to evaluate the quality of solar irradiation data collected at the stations, data will be checked by CENER experts in accordance with the recommendations of the BSRN (McArthur, 2005).

- "Physically Possible" test, intended to detect extremely large errors in the measurements and the large random errors introduced during data handling.
- "Extremely Rare" test, used to evaluate whether the measurements are within the limits known as extremely rare.
- "Across Quantities" test, based on empirical relations of the different quantities measured.

To carry out these monitoring services, a tool developed by CENER will be used. This tool, ATDR (Adquisición y Tratamiento de Datos de Radiación), uses an internal database with data management and visualization capabilities. Fig 26 shows examples of the different tool screens[1].

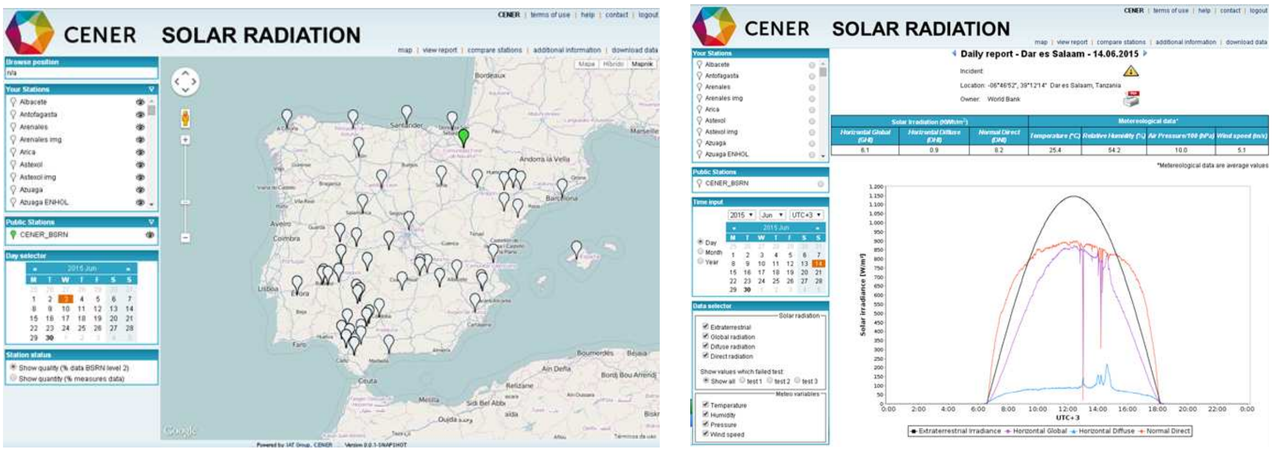

Fig 26 Example of data acquisition system user interface

The monitoring service includes client access to a Web application, in which the measurements are in a geo referenced database. Main features of this application are:

- Full access to the data recorded by the station, from the starting date of service.
- Comparison of hourly, monthly and / or yearly values between stations from the same client and public sources, if there are any available.
- Generation of daily graphics of the recorded variables.
- Results of the application of BSRN filters to the station data, and quality summaries.

Besides the remote data monitoring made by CENER the data logger Meteodata-3000 incorporated in the Tier1 stations includes the firmware program ADAS-3000 that automatically determines the "coherence" of the three measured parameters - DNI, GHI and DHI and generates an alarm event when any inconsistency is detected.

[1] Access to public information CENER BSRN station for real time monitoring: http://it.cener.com/solar

6 METEOROLOGICAL STATIONS REPORTING.

6.1 Preparation of site installation reports

The installation report will include all information related to the process of carrying out the civil works, the installation and the commissioning of the stations. The report will contain the following:

- Exact location details, including coordinate system and datum info. GPS loggings at each station within an accuracy of 1-meter.
- Details of access to the station indicating the optimal route. A map of the area and relevant photographs of the access will be included.
- Description of the undertaking of the civil works, detailing the features and including photographs of the process and final result.
- Configuration drawing of the station layout, including location of each sensor regarding elevation and orientation.
- Complete description of the whole process of assembly and installation of the station, including photographs and a list of instruments detailing brand, model and serial numbers
- Photographs of mounting details of each instrument
- Photographs of data logger and logger cabinet
- Directional photographs of the area taken from the station position in 30° angles, starting from stra ight North (0°) and moving clockwise. This photographs will be taken after station installation

6.2 Preparation of site resource reports

The site resource reports will collect information related to quality data, statistical analysis, and incidences of the ground station and sensors maintenance. They will include:

1. **Description of the meteorological stations**. A detailed description of the sensors installed the sensor calibration reports and results of the on-site calibration after one year of measurement. The location of the emplacement and a description of the local environment and conditions will also be detailed.
2. **Data quality analysis**. All information related to the data availability, disturbance incidents, failures, etc. and an explanation of lost or biased data which were excluded from the analysis. A summary will also be provided of the results obtained from data quality tests applied to the recorded data.
3. **Data analysis results:** Detailed statistical analysis of the available data. It will include monthly and annual analysis of GHI, DNI and the rest of meteorological variables monitored in the station, together with the analysis of the seasonal and diurnal features of GHI and DNI. The frequency of occurrence of GHI and DNI 1-min ramps will also be included in this analysis. These data will be compared with the nearest point of the grid from modelled generated in Phase 1 will be prepared,. Additionally an estimation of the air turbidity parameters as Linke turbidity and aerosol parameters and related descriptions of them will be included.

Data recorded from the station - solar radiation, GHI, DNI and DHI, and the rest of available meteorological variables will be added to the report as an electronic annex. They will be presented with 1 minute of time resolution.

7 CAPACITY BUILDING AND TRAINING

It is worth noting that in the proposed program of capacity building described below, it is intended that it shall be continuously adapted and improved based on stakeholder and client suggestions, as well as additional capacity building needs identified during the course of the project.

7.1 Stakeholders

There are two different types of stakeholders in relation to the project, and the capacity building actions employed will be different for the different stakeholders. The Station Host stakeholders are the staff of the institutions that will host a meteorological station, and so are responsible for routine maintenance. The Project Stakeholders are all those that have interest in the project results and its potential impact.

7.1.1 Station hosts

Routine maintenance will be undertaken by staff from the host institutions. Capacity building for these staff will provide them with knowledge about the sensors, their characteristics and maintenance requirements.

On the job training will be provided during the installation and commissioning of each station and will be delivered by the installation team responsible (Geonica, Geosun) and by the local partner. This training will cover the following elements:

- Description of the different elements of the station.
    - Solar radiation sensors.
    - Meteorological sensors.
    - Power supply elements.
    - Data acquisition devices.
- Data acquisition software.
- Maintenance requirements and methods.
- Periodic sheet recording requirements.
- Protocol to solve problems.

This capacity building will be proven completed by provision of the respective documentation - the learning materials written in English and the record log sheet. It has been confirmed that all selected host institutions' likely maintenance personnel are literate in English.

7.1.2 Project Stakeholders

The principal capacity building activity during Phase 1 aimed at the project stakeholders occurred during the Workshop 1 held in Dar es Salaam on May 2015. In Phase 2, following the suggestion of WB, it is proposed that an additional Capacity Building activity be held to coincide with the first yearly on-site calibration of the grounds stations. This will consist of a training course covering technical aspects of solar radiation and the available technologies to utilize it as an energy source. A tentative index of the topics to be covered is detailed below. It is estimated that the course will have duration of two days.

1. General introduction to Tanzania's climatology.
2. Overview of solar radiation resource concepts.
3. Measuring solar radiation.
4. Criteria for identifying and selecting measurement sites.
5. Modelling solar radiation.
6. PV potential in Tanzania.
7. Solar Thermal electricity potential in Tanzania.
8. Simulation tools.
9. Science, technology and industrial trends.

The cost estimation of this additional course is not included in the budget proposal for the Phase 2 implementation plan.

7.2 Local partner

The local partner EVA will primarily receive capacity building related to the tasks where they will be directly involved. There is an important practical value in achieving strong capacity building in the local partner company, since they play a role in the good development of the project. Hence capacity building of the local partner covers theoretical and practical aspects of solar radiation, meteorological devices and operative maintenance, and remote actions. Close collaboration between international staff and local partner is the principal means of training and building capacity. Already, important face to face training activities have occurred in Phase 1, covering:

- Introduction to solar resource.
- Solar radiation measurements.
- Evaluation of sites to install solar measurement devices.
- Installation and maintenance of meteorological stations.
    - Meteorological sensors.
    - Solar radiation measurement devices.
    - Data communications and software.

8 TIME SCHEDULE

Table 10 shows the schedule for the implementation of Phase 2 according to current planning and execution progress. It is based on previous experience from the implementation of the Dar es Salaam station, and from previously conducted site visit activities.

Table 10 Phase 2 time schedule.

Activity	Deadline
Permissions	
Approved Implementation Plan	*1/09/2015*
Site permission secured (MOU signed)	*15/09/2015*
Equipment ordering and transportation	
Equipment manufactured	*28/09/2015*
Equipment shipped	*29/09/2015*
Equipment cleared through customs	*14/10/2015*
Equipment arrives at site	*19/10/2016*
Site preparation and installation	
Civil works contractor appointment	*15/09/2015*
Fencing installed, foundation pieces completed	*19/10/2015*
Installation and commissioning	*19/10/2015 – 13/11/2015*

9 RISK ASSESSMENT AND MITIGATION

The Environmental, Health, and Safety (EHS) Guidelines are technical reference documents with general and industry-specific examples of Good International Industry Practice[2]. In this section, a risk assessment analysis according to the EHS Guidelines is detailed and risk mitigation measures and strategies are developed and presented.

9.1 Environmental

Air Emissions and Ambient Air Quality

This does not apply in our project: meteorological stations are not sources of air emissions, and their potential for significant impacts to ambient air quality is null.

[2] http://www.ifc.org/wps/wcm/connect/corp_ext_content/ifc_external_corporate_site/home

Energy Conservation

Does not apply. meteorological stations are grid-independent with a solar photovoltaic panel power supply; in limited cases a back-up power supply may be drawn on, but power consumption by the stations is small enough for any energy conservation considerations to be discounted.

Wastewater and Ambient Water Quality

This does not apply in our project: meteorological stations do not generate wastewater, and their potential for significant impacts to ambient water quality is null.

Water Conservation

Small amounts of water are required to clean the sensors of the meteorological stations, but water consumption is small enough for any water conservation considerations to be discounted.

Hazardous Materials Management

Does not apply: hazardous materials (according to the definition in the EHC guidelines) are not used in the project.

Waste Management

This section applies to projects that generate, store, or handle any quantity of waste. The waste generated during the implementation of the measurement network will be solid and non-toxic, the main source being from packing materials: wood, carton and plastic. The quantity of waste from packing materials will be kept to the absolute minimum that is necessary for providing a safe shipment of the measurement equipment.

Due to the small quantities and the nature of one-time occurrence of waste, no special waste disposal, recycling and reuse strategies will be developed. All waste occurring at unpacking, assembling and commissioning will be collected by the installation team and disposed of at a waste disposal facility. The waste will be transported in the same vehicles used for the transportation of the meteorological stations after their commissioning.

Noise

Does not apply: meteorological stations do not generate significant noise.

Contaminated Land

Does not apply: the installation and operation of meteorological stations does not contaminate land.

9.2 Occupational Health and Safety

General Facility Design and Operation

The 10 meter tower needed for wind sensor installation (Tier 1) is the most critical structure from a health and safety perspective. It has a triangular base and is made up of standard sections of 3 m each. Each section consists of:

- 3 tubular legs made of steel.
- Solid steel bracing rods, horizontal and inclined.

The horizontal section of the tower defines an equilateral triangle with side of 18 cm, which is the distance between legs.

Horizontal bracing rods are spaced at 40 cm intervals. The lower section of the tower is pivoted on the base. The tower (in case of a 10m height) is guy wired with anchoring supports at 120 °.

The mounting is done using a "section by section" method. This involves fixing the lower section to the base and placing it in the upright position, ensuring that it is levelled. Next the remaining intermediate sections are mounted, their corresponding guy wires having already been fastened. The mounting process is carried out by climbing up the sections that have already been erected and then lifting the next section that is to be fixed using adequate lifting equipment.

The climb up the trestle-tower should be carried out using the adequate safety measures (safety belt, anchorages, etc.) and no more than two consecutive sections should be erected without being secured by guy wires. When two sections without guy wires have to be erected consecutively, auxiliary guy wires should be used to secure the sections while they are being mounted.

The tower should be continuously levelled via adjustment of the guy wire tension and the use of the appropriate levelling equipment.

In order to preserve the characteristics of the tower at a given site, periodic inspection of the tension of the guy wires and the tightness of bolts will be required; It is also recommended to check the whole structure after strong winds, ice storms or other extreme conditions.

We also recommend regular checking of the structure in areas of high concentration of salinity (shoreline areas) and areas with corrosive environments. Sections that have suffered deformations during transportation, assembly, dismantling or general operating life of the tower will be discarded and replaced. An annual maintenance survey is required, involving checks, repairs, and the reporting of any incidents. The survey involves:

- Check for misalignments and deformations.
- Check welds.
- Check painting.
- Check cable joints.
- Check cables.

Table 11 General facility design and operation hazards

Category	Description	Hazard	Mitigation measures
Integrity of Workplace Structures	Emplacement of the meteorological station, ground or rooftop	Risk of drops.	*Security instructions regarding maximum weight and number of persons on the platform will be attached visibly at the steps in written and pictogram form*
Severe Weather and Facility Shutdown	-	Not applicable in this project	-
Workspace and Exit	Space and work conditions	Risk of drops	*The platform has sufficient space for the staff to perform their tasks safely and conveniently.*
Fire Precautions	-	Not applicable in this project	-
Lavatories and Showers	-	Not applicable in this project	-
Potable Water Supply	-	Not applicable in this project	-
Clean Eating Area	-	Not applicable in this project	-
Lighting	Storms	Lighting	Lightning rods
Safe Access	Accessibility to the station	Risk of drops	*Free and safe access to the perimeter is provided by locating the stations either on the ground or on safely accessible flat roofs* *The safe accessibility of roofs (by staircases or secured ladders with handhold) has been checked during the site evaluation visit.* *In case of need a edge protection or safety fence will be installed on f the roofs .*
First Aid	-	Not applicable in this project	-
Air Supply	-	Not applicable in this project	-
Work Environment Temperature	-	Not applicable in this project	-

Communication and Training

A Capacity Building program is being developed, and includes a set of training and collaborative actions between the Consortium and local stakeholders. Among more technical topics, the Capacity Building program will also contain knowledge transfer related to security topics (i.e., site-specific hazards, basic site rules of work, safe work practices and personal protection).

Physical Hazards

In Table 12, physical hazards are detailed.

Table 12 Physical hazards

Category	Description	Hazard	Mitigation measures
Rotating and moving equipment	Suntracker and rotating shadow bands present automatic movements	Minor risk due to the movements are very slow and shorts	The mobility of these parts are announced.
Electrical	Automatic weather stations allows to operate with 3 different energy sources simultaneously 1. External battery12 VDC 2. Solar panel (12VDC) 3. Main power supply (110/220 VAC) 50/60Hz	There is only risk of electric shock if the AWS is connected to the main power supply (110/220VAC)	Automatic weather stations include Integral overvoltage protection by mains filters, gas dischargers, transzorbs, coils and varistors for all input/output lines According to: DIN 050020; VDE 0170 / 0171; VDE 0165 and TR BF 100
Noise	-	Not occurring in conjunction with the operation of the station	-
Vibration	-	Not occurring in conjunction with the operation of the station	-
Eye Hazards	-	Not applicable in this project	-
Welding / Hot Work	-	Not applicable in this project	-
Industrial Vehicle Driving and Site Traffic	-	Not applicable in this project	-
Working Environment Temperature	Meteorological stations are installed outdoors, and installation and maintenance procedures could occur during hot ambient temperatures as well as intense sunlight	Exhaustion, sun burn or heat shock	Limitation of exposure time to sun and heat, taking breaks as needed in a cool environment Protective clothing and cap Provision of drinking water.
Ergonomics, Repetitive Motion, Manual Handling	-	Not applicable in this project	-
Working at Heights	Only AWS with met. Tower higher of 3 meters present some risk of working at heights. For this project is considered 2 options; 3 meter Met tower 9 meters Met. Tower Only 9 meters configuration present risk when wind sensor and wind directions sensor need to be mounted on the top of the tower. The rest of the sensors and equipment, will be installed in the first 3 meters of height. -	Falls from a height t	Use of Personal Protective Equipment (safety harness, helmet, gloves and boots)-
Illumination	-	Not applicable in this project	-

Table 13 Analysis of physical hazards

	Rotating and moving equipment	Electrical	Working environment temperature
Likelihood	*Unlikely*	*Unlikely*	*Unlikely*
Consequences of occurrence	*Insignificant due to the short movement that present the moving parts of the AWS*	There is only risk of electric shock if the AWS is connected to the main power supply (110/220VAC)	*Insignificant. Insignificant. It doesn't expect hazards to operate on high temperature environment. AWS are designed to operate in ambient temperature higher than expected in the locations of the project.*
Routine avoidance procedure	*Do not touch internal clutch of the solar tracker while it is activated. If it is necessary to check these parts, it is necessary Switch off the AWS via the SW2 switch located on the printed circuit board*	*Operators of AWS have to follow user Manuals of Automatic Weather Station to avoid any risk while they are operating the AWS*	*Avoid touch metallic parts*

Chemical Hazards

This does not apply in our project: materials used in the project do not represent a chemical hazard.

Biological Hazards

This does not apply in our project: biological agents are not used in the project.

Radiological Hazards

This does not apply in our project: no hazardous radiation is emitted from the meteorological stations.

Personal Protective Equipment (PPE)

All staff involved in performing any tasks within the project will be equipped with the proper PPE:

- Installation of measurement stations: safety harness, helmet, gloves and boots.
- Maintenance tasks: safety harness, helmet, gloves and boots
- All tasks performed in the consultant's offices: according to the applicable national regulations of Tanzania

Special Hazard Environments

This does not apply in our project: the previously described hazards will not exist under unique or especially hazardous circumstances.

Monitoring

Occupational health and safety monitoring programs should verify the effectiveness of prevention and control strategies. Therefore, the occupational health and safety monitoring program will include:

Table 14 Occupational health and safety monitoring program

Indicators	Prevention and control strategies
Safety inspection, testing and calibration	*All hardware equipment and its safety features will be thoroughly tested upon installation of the stations and upon regular maintenance visits*
Surveillance of the working environment	*Any changes in the working environment that could impose possible hazards will be documented and analyzed.*
Surveillance of workers health	*Not applicable in this project, as no*
Training	*Training activities for workers will be adequately monitored and documented*

9.3 Community Health and Safety

Water Quality and Availability

The project activities will not involve wastewater discharges, water extraction, diversion or impoundment that can produce adverse impacts to the quality and availability of groundwater and surface water resources.

Structural Safety of Project Infrastructure

No hazards will be posed to the public while accessing project facilities

Life and Fire Safety (L&FS)

This does not apply in our project: no risk described in this section of EHS Guidelines applies to meteorological stations.

Traffic Safety

Traffic safety will be promoted to all personnel involved in the project during transportation, transportation to and from the workplace, on private or public roads.

Transport of Hazardous Materials

This does not apply in our project: no hazardous materials will be used in the project.

Disease Prevention

Disease prevention will be promoted to all personnel involved in the project which travels to Tanzania, according to recommendations of the Ministry of Foreign Affairs and Cooperation[3].

Emergency Preparedness and Response

Emergency situations will be effectively taken care of with proper timely action. The consortium has gathered wide experience through years of technical assistance assignments and is ready to address such problems without jeopardizing the project.

[3] http://www.exteriores.gob.es/Portal/es/ServiciosAlCiudadano/SiViajasAlExtranjero/Paginas/DetalleRecomendacion.aspx?IdP=178

9.4 Construction and Decommissioning

Environment

The sites selected on which the meteorological stations are to be installed can be divided into field soils and existing building rooftops. Their impact in environment is analyzed below:

- Field soil stations. The meteorological stations will be installed on small concrete foundations within a fenced area of perimeter 11x11 m (see Fig 27). The following stations will be constructed on level ground: Iringa, Songea, and, Tabora. The construction of these foundations and the fence will usually be finished within one working day, or in as little as 4 hours. During the construction, a certain limited impact is expected in the form of noise and vibration (excavations for foundations), soil erosion at the excavation place and solid waste (excess concrete and fence material). Other environmental aspects, such as sediment mobilization and transport or structural (slope) stability, are expected to be impacted minimally during the project. The subcontractor performing the civil works will be contractually obliged to comply with all environmental protection regulations applicable in Tanzania.

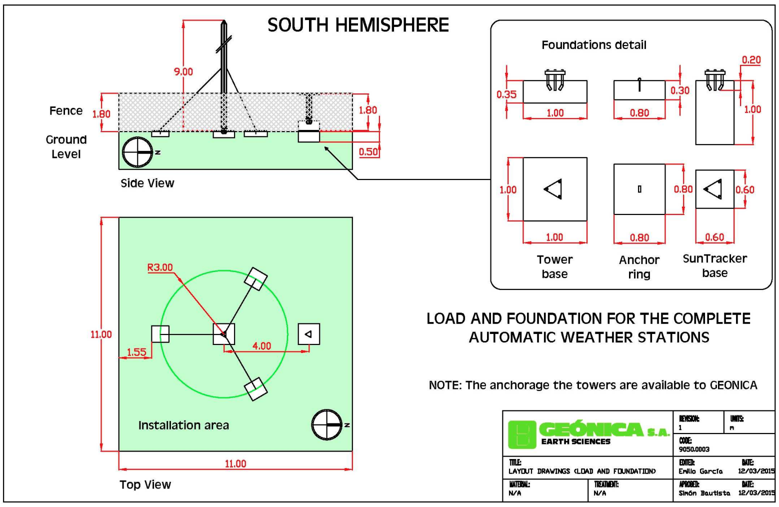

Fig 27 Scheme of the station

- Roof stations. The following stations will be erected on roofs of existing buildings: Dodoma (UDOM), Mwanza (SAUT), Arusha (NM-AIST) and Dar es Salaam (UDSM). The foundations will be cast on the roof surface and will therefore not be influential to the environment.

Others environmental aspects, related to clean runoff management, road design aspects, disturbance to water bodies, air quality, wastewater discharges, contaminated land and hazardous materials are not applicable in this project.

Decommissioning of the stations and the respective civil works is not envisaged, as the meteorological stations will be transferred into the ownership of the local stakeholders who will continue to operate them.

Occupational Health and Safety

The subcontractor performing the civil works will be contractually obliged to comply with all health and safety regulations applicable in Tanzania.

Community health and safety

The project has no effect on community health and safety regarding physical, chemical, or other hazards by any reasonable standard. Risks that may arise from inadvertent trespassing will be prevented by the installation of fences and signs warning against trespassing in field soil stations. The stations to be installed in roof of existing buildings will be protected by the security measures of building (the selected rooftop sites having been assessed favorably in terms of restrictions to access).

The incidence of road accidents involving project vehicles during the transportation of meteorological stations should be minimized through a combination of education and awareness-raising.

ANNEX 1. MOU TEMPLATE

THIS AGREEMENT is made the day of 2015

BETWEEN

Energio Verda Africa Ltd on behalf of the **Consortium** constituted by GEONICA, S.A., IRSOLAV S.L., CENTRO DE INVESTIGACIONES ENERGÉTICAS MEDIOAMBIENTALES Y TECNOLÓGICAS,, ENERGIO VERDA AFRICA Ltd. and FUNDACIÓN CENER-CIEMAT leader of this group of partners (hereinafter referred to as "**EVA**").

EVA is a limited liability company organised and existing under the laws of Tanzania, whose registered office is at 14th Floor, PPF Tower, Ohio Street, Dar es Salaam, PO Box 10560.

AND

Site host, a [institution] organised and existing under the laws of Tanzania, whose registered office is at [location] (hereinafter referred to as "**SiteHost**")

EVA and [**SiteHost**] are hereinafter referred to individually as a "Party" and collectively as the "Parties".

WHEREAS the Consortium has a framework contract with the World Bank for the implementation of a solar resource assessment and mapping project in Tanzania, as part of a global initiative supported and funded by the Energy Sector Management Assistance Program (ESMAP).

WHEREAS ENERGIO VERDA AFRICA Ltd is duly authorized by the consortium for the signature of this agreement.

WHEREAS the solar resource assessment and mapping project in Tanzania includes a ground-based measurement campaign consisting of a network of solar monitoring stations, of which the one to be stationed at the [**Site host, location**] is the subject of this agreement.

WHEREAS the Parties are interested in the implementation of the project by installing equipment in the facilities of [**Site host, location**] in order to collaborate in the undertaking of the measurement campaign under the project.

NOW THEREFORE, in consideration of these premises the Parties agree as follows:

1. DEFINITIONS

"Agreement" means this Memorandum of Understanding and its schedules

"Site" means the location of the Solar Monitoring Station on the [**SiteHost's**] premises, as detailed in Schedule 1.

"Solar Monitoring Station" means the equipment and all ancillary items that are listed in Schedule 2

2. PURPOSE

2.1 The purpose of this Agreement is to provide for collaboration between **EVA** and [**SiteHost**] for the installation, operation, inspection, repair and maintenance of solar monitoring equipment on [**SiteHost's**] premises located at the Site.

3. SEQUENCE OF EVENTS

3.1 The sequence of events entailed in the collaboration of the Parties are as follows:

Pre-study

- **EVA** undertakes a site visit of [**SiteHost**]**'s** facilities, to identify potentially suitable locations
- If **EVA** determines that there is a suitable location on your property, **EVA** will present [**SiteHost**] with a report on the site and guidance on the installation timings and process
- **EVA** will undertake the installation of the Solar Monitoring Station, including equipment set-up and calibration, and security fencing if required.
- [**SiteHost**]will recommend a cleaning personnel to whom **EVA** will provide training

During study

- For the duration of the study **EVA** will be responsible for the Solar Monitoring Station
- [**SiteHost's**] cleaning personnel will undertake regular (once per day) cleaning and checking of the Solar Monitoring Station
- **EVA** will undertake regular (six-monthly or more) checks of the Solar Monitoring Station, and will inspect the monitoring station in cases of fault with the equipment. We will also remotely undertake checks of the equipment twice per week

After study

- At the end of the study period, and contingent on satisfactory care and cleaning of the solar monitoring station, **EVA** will hand over the Solar Monitoring Station to [**SiteHost**]; **EVA** will no longer have any involvement or responsibilities with regards to the Solar Monitoring Station.
- At the end of the study **EVA** will provide a one-day training session to [**SiteHost**]for ongoing data collection and maintenance
- [**SiteHost**] will continue to provide data collected by the Solar Monitoring Station to **EVA** free of charge while the equipment is still operational.
- The objective of transfer of ownership from **EVA** to [**SiteHost**] is to allow for continued solar measurement for research and other purposes, for the benefit of Tanzania, and to facilitate capacity building and learning within [**SiteHost**].
- After the study EVA shall not be responsible for the maintenance of the Solar Monitoring Station and shall not be responsible for any damage, loss, or claim related or in connection with the Solar Monitoring Station.

4. RESPONSIBILITIES AND WARRANTIES

4.1 For the duration of this Agreement **EVA** shall be responsible for:

4.1.1 Undertaking a site visit to assess the suitability of potential sites

4.1.2 Arranging and executing the installation of the Solar Monitoring Station at **EVA's** cost

4.1.3 Training the cleaning personnel to operate and maintain the Solar Monitoring Station

4.1.4 Visiting the site on a regular basis to undertake recalibration or repair work

4.1.5 Providing [staff and students/employees] of [**SiteHost**] access to download the collected data

4.1.6 Handing over the Solar Monitoring Station to [**SiteHost**], including training in ongoing data collection and maintenance, contingent on satisfactory care and cleaning of the Solar Monitoring Station.

4.2 For the duration of this Agreement **EVA** warrants:

4.2.1 Not to object to or block uses of the Site that do not interfere with the operation of the Solar Monitoring Station

4.2.2 To provide adequate insurance for the Solar Monitoring Station to secure loss or damage to the Parties attributable to EVA or its employees, agents or other authorized persons .After the study, EVA will not maintain any insurance for the Solar Monitoring Station.

4.3 For the duration of this Agreement [**SiteHost**]are responsible for:

4.3.1 Ensuring **EVA**, its employees, agents or other authorized persons access to the Site given reasonable advanced notice

- Proposing reliable personnel for regular cleaning of the Solar Monitoring Station. Regarding its employees, **[SiteHost]** shall comply with all the statutory obligations in Tanzania, and shall take out or ensure that there is already in place statutory health insurance for its employees.
- **[SiteHost]** shall take out or ensure that there is already in place a general liability insurance towards any third party, providing coverage of the **[SiteHost]** itself, its staff, employees, agents and any person for which the **[SiteHost]** is answerable, in case of an accident during the cleaning of the Solar Monitoring Station.

4.3.2

4.3.3 Undertaking regular cleaning of the Solar Monitoring Station under the instructions and provisions made by **EVA**,

4.3.4 Preventing and avoiding any other kind of use or modification of the Solar Monitoring Station.

4.3.5 Controlling and avoiding the entrance of any third party to the site in which the Solar Monitoring Station will be installed.

4.3.6 Agreeing not to interfere with the site or to erect any structures near the site that may cause a shadowing effect on the Solar Monitoring Station without written approval of **EVA**; **EVA** shall not withhold permission unreasonably.

4.3.7 Granting **EVA** permission to trim vegetation that will grow to cause a shadowing effect on the Solar Monitoring Station

4.3.8 Providing to **EVA** any data collected by the Solar Monitoring Station once [**SiteHost**]takes it over after the end of the study period

4.4 For the duration of this Agreement [**SiteHost**] warrants that:

4.4.1 It is the true and lawful owner of the premises on which the Site is located

4.4.2 In the case of the sale or disposal of the premises on which the Site is located, this Agreement shall be transferrable to the subsequent holder of the land. [**SiteHost**] shall obtain confirmation from the subsequent holder of the land that this is understood.

5. COSTS AND EXPENSES

5.1 **EVA** will supply and install the Solar Monitoring Station at its expense.

5.2 At the end of the study period [**SiteHost**] will be given the Solar Monitoring Station at no cost.

5.3 Each Party will pay for their own expenses in fulfilling their responsibilities as outlined in Section 3 (Responsibilities). Hence **EVA** will pay the costs of undertaking site visits, installation, visits during the study period and equipment replacement or maintenance. [**SiteHost**] will pay the costs of remedying and breaches to [**SiteHost's**] responsibilities, such as removing shadowing objects that have been placed near the monitoring station.

5.4 [**SiteHost**]will undertake the routine clean and checking the station once a day at its own cost.

5.5 No Party is liable to the other for any costs after the end of the study period, unless those costs are outstanding from before the end of the study period.

6. RELATIONSHIP OF THE PARTIES

6.1 This Agreement does not create any partnership, joint venture or any relationship of principal and agent between the Parties.

7. FORCE MAJEURE

7.1 Neither Party shall be considered in default in the performance of its obligations under this Agreement to the extent that the performance of such obligations is prevented or delayed by any cause beyond the reasonable control of the affected Party.

8. LIMITATION OF LIABILITY

8.1 Each Party shall be responsible only for the implementation of their respective obligations as set out herein.

8.2 **EVA** shall not be responsible towards [**SiteHost**]for any indirect or consequential loss or similar damage such as, but not limited to, loss of profit, loss of revenue or loss of contracts.

8.3 To the fullest extent permissible by applicable law, **EVA's** maximum aggregate liability towards [**SiteHost**] and/or any other person or entities, for all damages and losses arising out of or in connection with this Agreement, and regardless of the legal nature of the liability (contract, tort, negligence or otherwise), shall be limited to the price of the Solar Monitoring Station installed, provided such damage was not caused by a wilful act.

9. DURATION AND TERMINATION OF THE AGREEMENT

9.1 This Agreement shall be for the period of two years from the commencement date; **EVA** may extend the agreement by a further year if data requirements dictate

9.2 This Agreement may be terminated:

9.2.1 By mutual consent between the Parties

9.2.2 By either Party where the other Party has materially breached this Agreement and has failed to remedy that breach within a reasonable period of at least 15 calendar days from the date of service of notice from the first Party specifying the breach and requiring that it be remedied;

9.2.3 The other Party has been declared bankrupt or when its application for suspension of payments has been admitted for consideration.

10. COORDINATION AND MANAGEMENT

10.1 Negotiation, implementation and reporting related to the cooperation will be communicated through the Parties through their respective officials as follows:

[SiteHost]	***EVA***
Contact name	Tomo Sandeman
Contact title	Project Manager, Energio Verda Africa Ltd
Tel. number	+255 222 136 348
Email address	Tomo.sandeman@energioverda.com
Website	www.energioverda.com

11. GOVERNING LAW AND ARBITRATION.

11.1 Any dispute arising out of or in connection with this contract, including any question regarding its existence, validity or termination, shall be referred to and finally resolved by arbitration under the Arbitration Act, Cap 15 of Laws of Tanzania.

11.2 The number of arbitrators shall be one. The seat, or legal place, of arbitration shall be Dar es Salaam, Tanzania. The language to be used in the arbitral proceedings shall be English. The governing law of the contract shall be the Laws of the United Republic of Tanzania.

12. COMMENCEMENT DATE

12.1 This Agreement shall become effective on the date of signature by the Parties.

Signed for EVA on behalf of the **Consortium**

Signature: Name:

Date:

Signed for and on behalf of _________

Signature: Name:

Date:

ANNEX 2. DESCRIPTION OF STATIONS TYPE

Tier1 stations

Tier1 stations use thermopile radiometers to measure all three components (GHI, DNI and DIF). A Tier 1 station consists of a pyrheliometer mounted on an automatic tracker for the DNI measurements and a tracker with a shading ball shading a pyranometer from the direct beam for the diffuse measurements. These stations also include a weather station with temperature, humidity, barometric pressure sensors at 1 to 2m above ground level, and wind speed and direction data mounted on a meteorological tower 3-m high. GEONICA is the supplier of these type of stations for the Tanzania Project.

The principal components of the stations are listed below. The Tier1 stations are equipped with solar panels and batteries that allow them operate without external electricity supply and with data loggers and communication systems that allow for remote operation and data monitoring. Table 15 contains a summary of the principal components of the Tier1 stations and Fig 28 shows an example of sun tracker device with the equipment to measure DNI and DIF.

Related to the spare parts, it is estimated that, for the two years of measurement campaign it is needed disposing of one extra sensor for everyone that are included in the station (radiation and meteorological sensors). Besides it is included an unit of data logger, sun tracker and solar panel.

Table 15 Tier 1 components summary.

Component	Model	Characteristics
Pyranometers	*GEO-SR20)*	Thermoelectric Pyranometer Secondary Standard
Pyrheliometer	GEO-DR01	Thermoelectric Pyrheliometer First Class
Solar tracker	SunTracker-2000	Two Axis Automatic lightweight solar Tracker
Humidity and temperature sensor	STH-S331	Relative Humidity and air Temperature sensor.
Barometric	61302V	Barometric Pressure Sensor
Wind speed	03002 Wind Sentry	Anemometer and Vane, with crossarm.
Rain Gauge	52203-20	Rain gauge sensor
Data logger	METEODATA–3008CM	Remote Automatic Data Acquisition and Transmission Uni

Fig 28 Tier 1 station: Suntracker and meteo tower.

Tier 2 stations.

The Tier2 stations provide the three components of solar radiation (GHI, DNI, and DIF) by means of a Rotating Shadowband Radiometer (RSR). They also include a secondary standard pyranometer and meteorological sensors that measure temperature, humidity, pressure, rainfall and wind speed and direction. The Tier2 stations are capable of operating autonomously and are equipped with data loggers and communication systems that allow for remote operation and data monitoring.

CAMPBELL SA is the supplier of this type of station in this project. The summary of the principal components can be seen in Table 16 and a picture of the rotating shadow band in Fig 29.

As in the case of Tier 1 stations, the spare parts estimated for the Tier 2 configuration includes an extra unit for each one of the key components of the station.

Table 16 Tier 2 components summary.

Component	Model	Characteristics
Rotating shadowband radiometer	*RSR2 Irradiance*	Device capable of provide the three components of solar radiation
Piranometer	CMP10	Pyranometer secondary standard
Humidity and temperature sensor	CS215-L	Relative Humidity and air Temperature sensor.
Rain Gage	TE525-L	Rain gage sensor
Barometric	PTB110	Barometric Pressure Sensor
Wind speed	03002 Wind Sentry	Anemometer and Vane, with crossarm.
Data logger	**CR1000**	Remote Automatic Data Acquisition and Transmission Uni

Fig 29 Rotating Shadow Band Radiometer.

ANNEX 3. SITE VISITS SUMMARY

IRINGA						
Name	**Lat**	**Lon**	**Alt**	**Host and site**	**Shadows**	**Comments. Overall assessment**
MUCE1	35.68834E	7.75943S	1.554 m	Mkwawa University (Pitches)	E - 8º W – 4º (hills)	Suitable site. No significant obstacles on the far and near horizon. Favorable conditions: • Dust: Good • Maintenance: Good • Heat interference: Good • Future interferences: Nearest trees may be regular trimming • Communications: Good • Access: 10 minute walk. • Security: Good, fencing required.
MUCE2	35.69151E	7.75600S	1.578m	Mkwawa University. (Golf course)	E - 7º W - 4º (hills)	Suitable site. No significant obstacles on the far and near horizon. Favorable conditions • Dust: Good • Maintenance: Good • Heat interference: Good • Future interferences: Intermediate. Plans to develop a Golf course. • Communications: Good • Access: 20 minute walk. • Security: Regular, fencing required and remote part of the campus.
TMA1	35.75296E	7.67606S	1.492m	TMA. Iringa Airport near terminal	E- 2.3º (hills) W- 7º (terminal building)	Suitable site. No significant obstacles on the far and near horizon. Favorable conditions • Dust: Intermediate • Maintenance: Good • Heat interference: Good • Future interferences: Good, no plans for near buildings. • Communications: Good • Access: Adjacent to the airport and TMA buildings. • Security: Good, possible higher fence required.

					IRINGA	
TMA2	35.75295E	7.67528S	1.427m	TMA. Iringa Airport away from terminal	E- 2.3º (hills) W- 4.1º (hills)	Suitable site. No significant obstacles on the far and near horizon. Favorable conditions • Dust: Intermediate • Maintenance: Good • Heat interference: Good • Future interferences: Good no plans for near buildings. • Communications: Good • Access: 100 m away from the north of current TMA station. • Security: Good, fencing required.
TANESCO	35.73234E	7.79372S	1.573m	TANESCO. Iringa adjacent to substation	E-2.2º (trees and hills) W-3.8º to 13.2º (mountain)	Unsuitable site. Unacceptable condition for the horizon in the west, southwest direction. Favorable conditions: • Dust: Intermediate • Maintenance: Good • Heat interference: Good • Future interferences: Regular, there are significant expansion plans for the substation • Communications: Good • Access: Good, adjacent to the substation. • Security: Intermediate, Out of the compound, fencing required.

SONGEA						
Name	**Lat**	**Lon**	**Alt**	**Host and site**	**Shadows**	**Comments. Overall assessment**
TMA	35.58438 E	10.68253S	1.060m	TMA. Enclosure at the Songea Airfield.	E- 3º (hills) W- 2.3º (hills)	Suitable site. No significant obstacles on the far and near horizon. Favorable conditions • Dust: Intermediate • Maintenance: Good • Heat interference: Good • Future interferences: No plans for airport extension. • Communications: Good • Access: Immediately adjacent to the airfield buildings and TMA office. • Security: Intermediate. Airfield guarded but not fenced. Higher fence could be required.
TANESCO	35.62460 E	10.67815S	1.077m	TANESCO. Diesel generation station.	E-7º to 11º (trees and buildings) W- 23º (trees)	Unsuitable site. Unacceptable condition for the shadows in the horizon. Unfavorable conditions: • Dust: Bad, near to diesel plant. • Maintenance: Good • Heat interference: Regular, due to influence of generators. • Future interferences: Regular, there are significant expansion plans for the plant. • Communications: Good • Access: Good, adjacent to the substation. • Security: Intermediate, Out of the compound, fencing required.

DODOMA						
Name	**Lat**	**Lon**	**Alt**	**Host and site**	**Shadows**	**Comments. Overall assessment**
TMA	35.75057E	6.16952S	1.126m	TMA. Enclosure adjacent to the Dodoma airport.	E- 2.1º (hills) W- 1.8º (hills)	Suitable site. No significant obstacles on the far and near horizon. Favorable conditions • Dust: Good • Maintenance: Good • Heat interference: Good • Future interferences: No plans for airport extension. • Communications: Good • Access: In the current TMA enclosure. • Security: Good, higher fence could be required.
TANESCO1	35.74895E	6.18129S	1.148m	TANESCO. Regional headquarters.	E-2º, and elements in the roof) W- 3.5º (hills)	Suitable site under actions in the roof. Unacceptable condition for the shadows because lot of near elements on the roof. Favorable conditions: • Dust: Regular, near to rail station. • Maintenance: Good • Heat interference: Good. • Future interferences: Regular, possibilities of new buildings construction.. • Communications: Good • Access: Good, on the rooftop of the building. • Security: Good.

				DODOMA		
TANESCO2	35.69362E	6.18387S	1148m	Tanesco. Dodoma substation.	E- 4.6º (hills) W-2.2º hill and substation structure.	Un suitable site. Unacceptable condition for the shadows because shadows caused by the substation elements. Unfavorable conditions: • Dust: Regular. • Maintenance: Good • Heat interference: Regular. • Future interferences: Regular, future action on the substation. • Communications: Good • Access: Good, in the compound. • Security: Good
UDOM	35.82489E	6.21493S	1288m	University of Dodoma. Main administration building	E-5.7º (mountain) W-3.2º	Suitable site No significant obstacles on the far and near horizon. Favorable conditions: • Dust: Good. • Maintenance: Good • Heat interference: Good. • Future interferences: Good, no plans for new buildings. • Communications: Good • Access: Good, on the rooftop of the building easily accessible • Security: Good

TABORA						
Name	**Lat**	**Lon**	**Alt**	**Host and site**	**Shadows**	**Comments. Overall assessment**
TMA	32.83352E	5.07432S	1.177m	TMA. Enclosure Adjacent to the Tabora airport.	E- 4.9º (building) W- 1.5º (hills)	Suitable site. No significant obstacles on the far and near horizon. Favorable conditions • Dust: Good • Maintenance: Good • Heat interference: Good • Future interferences: Regular. The runway is due to be extended, which will not disrupt the TMA station but will create dust. • Communications: Good • Access: Enclosure in the TMA station. • Security: Intermediate. Airfield guarded but not fenced. Higher fence could be required.
TANESCO	32.80966E	4.99842S	1.195m	TANESCO. Primary grid substation.	E-3º (hills). The structure of the station can create shadows W- 23º (trees)	Unsuitable site. Unacceptable condition for the shadows due to high trees in the west and the influence of the station structure. Favorable conditions: • Dust: Good. • Maintenance: Good • Heat interference: Regular, gravel on the floor. • Future interferences: Good, there are no works planned. • Communications: Good • Access: Good, within the station compound. • Security: Good.

ARUSHA-MOSHI						
Name	**Lat**	**Lon**	**Alt**	**Host and site**	**Shadows**	**Comments. Overall assessment**
TMA1	36.62574E	3.36763S	1.344m	TMA. Arusha airport enclosure..	E- 3.6º (hill) W- 5.6 (building)	Suitable site. No significant obstacles on the far and near horizon. Favorable conditions • Dust: Regular, due to adjacent road. • Maintenance: Good • Heat interference: Good • Future interferences: Regular. The terminal building is planed to be changed. • Communications: Good • Access: Enclosure in the TMA station. • Security: Intermediate. Near of the border of the airport.
TMA2	37.05816E	3.42718S	904m	TMA, Kilimanjaro airport enclosure.	E-4.5º (building)	Suitable site. No significant obstacles on the far and near horizon. Favorable conditions • Dust: Good • Maintenance: Good • Heat interference: Good • Future interferences: Regular. There are plans to extend the taxiing runway. • Communications: Good • Access: Enclosure in the TMA station. • Security: Good.

				ARUSHA-MOSHI		
NM-AIST1	36.79660E	3.39964S	1.209m	Nelson Mandela African Institute. Rooftop of the main building	E-Critical shadow by a dome.	Unsuitable site Significant obstruction from the dome sited to the west. Favorable conditions • Dust: Good • Maintenance: Good • Heat interference: Good • Future interferences: Good • Communications: Good • Access: Good • Security: Good.
NM-AIST2	36.79840E	3.40270S	1.197m	Nelson Mandela African Institute. Near to sports area.	E-2.6º (mountain) W-3.6º (hill)	Suitable site. No significant obstacles on the far and near horizon. Favorable conditions • Dust: Good • Maintenance: Good • Heat interference: Good • Future interferences: Good, no plans for near buildings. • Communications: Good • Access: 5-minute walk. • Security: Regular, sited in the most remote part of the campus. Fencing required.
TANESCO	37.06618E	3.37656S	942m	TANESCO. Kilimanjaro substation	Critical shadows due to the substation structure in the east	Unsuitable site. Unacceptable condition for the shadows due to the station structure. Favorable conditions: • Dust: Regular. • Maintenance: Good • Heat interference: Regular, gravel on the floor. • Future interferences: Good, there are no works planned. • Communications: Good • Access: Good, within the station compound. • Security: Good.

MWANZA						
Name	**Lat**	**Lon**	**Alt**	**Host and site**	**Shadows**	**Comments. Overall assessment**
TMA	32.93024E	2.4747S	1.260m	TMA. Mwanza weather radar compound.	E- 5.3º (building)	Unsuitable site. Insignificant obstacles on the far and near horizon but critical interferences planned. Unfavorable conditions. • Dust: Regular, due to adjacent terrain. • Maintenance: Good • Heat interference: Good • Future interferences: Bad. There are buildings planned near the compound. • Communications: Good • Access: Enclosure in the TMA station. • Security: Good.
TMA2	37.05816E	3.42718S	904m	TMA, Kilimanjaro airport enclosure.	E-4.5º (building)	Suitable site. No significant obstacles on the far and near horizon. Favorable conditions • Dust: Good • Maintenance: Good • Heat interference: Good • Future interferences: Regular. There are plans to extend the taxiing runway. • Communications: Good • Access: Enclosure in the TMA station. • Security: Good.

MWANZA						
DIT	32.91058E	2.46285S	1.152m	Dar es Salaam institute of technology. Rooftop of accommodation building	E-4.1(hill) W-4.1(hill)	Unsuitable site. No significant obstacles on the far and near horizon. Unfavorable conditions due to the access • Dust: Good • Maintenance: Good • Heat interference: Good • Future interferences: Good • Communications: Good • Access: Bad, difficult access by hand lander. • Security: Regular, rooftop of accommodation building.
SAUT	32.89803E	2.60344S	1.192m	Saint Augustine University of Tanzania. Rooftop of academic building	E-4.6º (trees) W-3.9º (hill)	Suitable site. No significant obstacles on the far and near horizon. Favorable conditions • Dust: Good • Maintenance: Good • Heat interference: Good • Future interferences: Good, no plans for near buildings. • Communications: Good • Access: Good. • Security: Good
TANESCO1	32.96534 E	2.54452S	1.249m	TANESCO. Mwanza substation compound	Critical shadows due to the substation structure in the east	Unsuitable site. Unacceptable condition for the shadows due to the station structure. Favorable conditions: • Dust: Regular. • Maintenance: Good • Heat interference: Regular, gravel on the floor. • Future interferences: Good, there are no works planned. • Communications: Good • Access: Good, within the station compound. • Security: Good.

MWANZA						
TANESCO2	33.18445E	2.97842S	1.172m	TANESCO. Mabuki substation. Rooftop of the building	No obstacles to the east or west presenting a shadowing risk above 5˚ above the horizon..	Suitable site.. Favorable conditions: • Dust: Intermediate. • Maintenance: Good • Heat interference: Regular, The rooftop is surfaced with tar, so some heat reflection is expected. • Future interferences: Good, there are no works planned. • Communications: Good • Access: Good, within the station compound. • Security: Good.

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