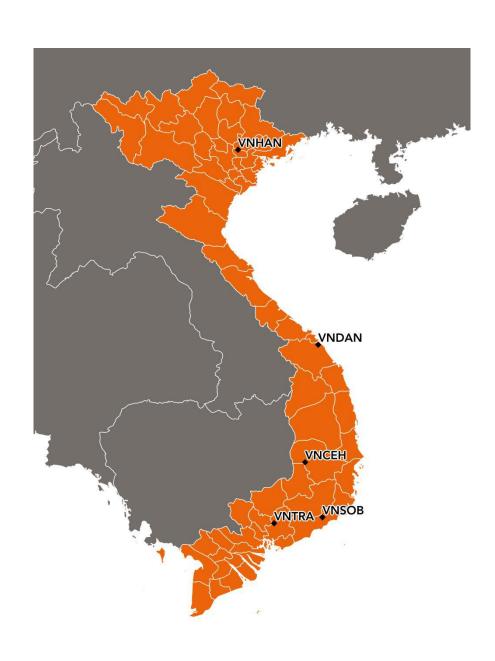




# Solar Resource Mapping in Vietnam

# SITE INSTALLATION REPORT

SEPTEMBER 2017



This report was prepared by <u>Suntrace</u>, under contract to <u>The World Bank</u>.

It is one of several outputs from the solar resource mapping component of the activity "Renewable Energy Resource Mapping and Geospatial Planning – Vietnam" [Project ID: P145513]. This activity is funded and supported by the Energy Sector Management Assistance Program (ESMAP), a multi-donor trust fund administered by The World Bank, under a global initiative on Renewable Energy Resource Mapping. Further details on the initiative can be obtained from the <u>ESMAP website</u>.

This document is an interim output from the above-mentioned project, and the content is the sole responsibility of the consultant authors. Users are strongly advised to exercise caution when utilizing the information and data contained, as this may include preliminary data and/or findings, and the document has not been subject to full peer review. Final outputs from this project will be marked as such, and any improved or validated solar resource data will be incorporated into the <u>Global Solar Atlas.</u>

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- 2. Site Installation Report: Da Nang
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- 4. Site Installation Report: Song Binh
- 5. Site Installation Report: Tri An



# SOLAR MEASUREMENT CAMPAIGN IN VIETNAM

**SELECTION #: 1231900** 

# Installation Report: Central Highlands (VNCEH)

Suntrace Technical Documentation 21 September 2017

World Bank Group
ESMAP Renewable Energy Mapping Initiative

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#### 1. INTRODUCTION

The principal task of this installation project was the installation of six meteorological measurement stations at the selected sites including the training of the local staff from EVN (Vietnam Electricity, state-owned utility) on principle maintenance works of the meteorological measurement stations of Type HelioScale ω (Tier 1) and Type HelioScale  $\varphi$  (Tier 2). The selected sites are listed in Table 1, see also Implementation Plan for more details.

The first installation mission took place from 22<sup>nd</sup> of August to 1<sup>st</sup> of September 2017. During the first installation mission, the Tier 1 stations were installed at the sites VNCEH (Central Highlands), VNTRA (Tri An) and VNHAN (Bac Ninh near Hanoi). All Tier 2 stations (2x Tier 2 stations for sites VNDAN (Da Nang) and VNSOB (Song Binh) plus 1x Tier 2 spare station) were additionally installed at VNCEH for calibration of the RSP sensors for 2 ½ weeks until the second installation mission started. The second installation mission was undertaken from 12th to 19th of September 2017 and the Tier 2 stations at VNDAN and VNSOB were installed. The spare station will be stored at the Head office of VATEC in Nha Trang. The inauguration with the local government, EVN and World Bank representatives was held on 20th of September in Song Binh (VNSOB).

The International Experts Joana Zerbin and Marko Schwandt from Suntrace GmbH traveled from Germany / Spain to the sites in Vietnam. Vietnam Applied Technical Co. Ltd (VATEC) as local partner company in this project supported Suntrace during the installation.

### Overview of Station Sites



Figure 1. Country map showing sites for solar measurement stations considered for the Vietnam ESMAP project.



Site name and description	Туре	Site code	Elevation	Latitude	Longitude
Hanoi region: Bac Ninh on rooftop of new EVN bldg.	Tier1	VNHAN	60 m	21.2013°N	106.0629°E
Da Nang on rooftop of EVN/CPC bldg. within the city	Tier2	VNDAN	24 m	16.0125°N	108.1865°E
Central Highlands region on ground before EVN bldg. near hydro spillway	Tier1	VNCEH	290 m	12.7535°N	107.8761°E
Song Binh station location on private house's rooftop	Tier2	VNSOB	62 m	11.2641°N	108.3452°E
Tri An region near HCMC on top of EVN bldg. near water spillway	Tier1	VNTRA	57 m	11.1024°N	107.0378°E

Table 1. Selected sites for solar measurement stations in Vietnam within the WB ESMAP program

This report gives an overview of the on-site installation of the Tier 1 station close to the guardhouse at the water spillway of the Tan Hoa dam, in Dak Lak, Central Highlands region, which took place between 24th and 27th of August 2017. The site code for this site is VNCEH.

Tier 1 stations are equipped with a robust and highly reliable pyrheliometer, a shaded pyranometer (which measures DHI), a non-shaded pyranometer (which measures GHI), and a 2-axis sun tracker with a shadow-ball assembly. Besides, a barometer measures atmospheric pressure and a thermo-hygro sensor measures air temperature and relative humidity. Additionally, a wind mast with a cup anemometer and a wind vane assembly ensures measuring accurate wind speed and direction. Furthermore, a plug-and-play blueberry COMPACT datalogging system controls, stores and transmits the measured data of the stations. For power supply of the Tier 1 stations, a solar panel, batteries and charge controllers are installed. At this site, a soiling measurement system is also installed.



#### 2. LOCATION CENTRAL HIGHLANDS – VNCEH



Figure 2. Country map showing the site VNCEH for solar measurements considered for the Vietnam ESMAP project.



Figure 3. Location of VNCEH relative to the extent of the region



#### 3. **DESCRIPTION OF STATION**

Installation details	
Location	Central Highlands region on ground in front of EVN bldg. near hydro spillway.
Site ID	VNCEH
Station ID	1162
Longitude/Latitude	12.7535°N / 107.8761°E
Elevation	290 m
Date of commence- ment	26 <sup>th</sup> of August 2017

Table 2. Overview of site parameters VNCEH

## Solar Measurement Station Tier 1

## Recorded meteorological parameters:

- global horizontal irradiance (GHI) in W/m<sup>2</sup>
- direct normal irradiance (DNI) in W/m<sup>2</sup>
- diffuse horizontal irradiance (DHI) in W/m<sup>2</sup>
- ambient temperature in °C
- relative humidity in %
- wind speed in m/s 10 m above ground
- wind direction at 10 m above ground
- barometric pressure in hPa
- soiling measurement via 3 reference cells measuring global tilted (10°) irradiance (GTI) in W/m²

## Additional information:

For Tier 1 stations, a 250 Wp photovoltaic panel, batteries and a charge controller are installed.

## List of installed instruments and measurement sensors

No.	Instrument	Manufacturer	Model No.	Serial No.
1	Pyrheliometer	Hukseflux	DR02	9299
2	Pyranometer 1 (DHI)	Hukseflux	SR30-01	2118
3	Pyranometer 2 (GHI)	Hukseflux	SR30-01	2121
4	Reference Cell 1	IKS	ISET Cell	03081
5	Reference Cell 2	IKS	ISET Cell	03085
6	Reference Cell 3	IKS	ISET Cell	03087
7	Data logger Blueberry COMPACT	Wilmers Messtechnik	0141	1162
8	Thermo-hygro sensor	E+E	EE071	1711050002481361
9	Anemometer	Wilmers Messtechnik	0293	1289
10	Wind vane	Wilmers Messtechnik	0218	20003588
11	Sun tracker including shading assembly	EKO	STR-22G	\$15136.06

Table 3. List of installed instruments and measurement sensors at VNCEH





Figure 4. Photo of Tier 1 Station of type HelioScale  $\boldsymbol{\omega}$  installed at VNCEH



#### 4. **HORIZON**



Figure 5. Horizon at VNCEH

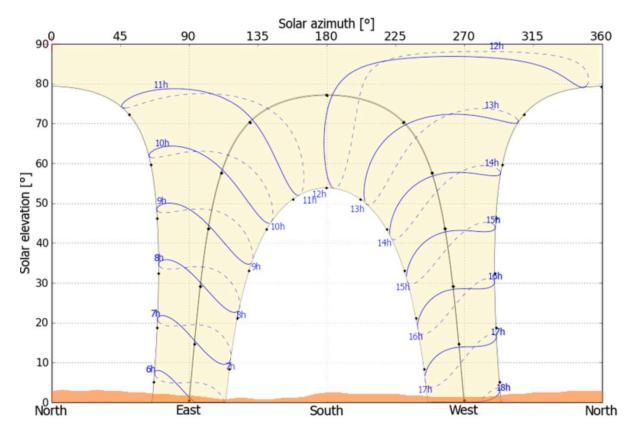


Figure 6. Sun path for VNCEH



#### 5. STATION COMMISSIONING

## Responsible staff for monitoring of the stations

## Standby Station Keeper

Name: Duc Nguyen

Address: Srepok 3 HPP, Tan Hoa ward, Bum Don district, Dak Lak province, Vietnam

Mobile: +84 966009899 Mail: duc.ngd@gmail.com

## Station Supervisor

Name: Tan Tien Nguyen

Address: 60A Cau Be, xa Vinh Thanh, Thanh pho Nha Trang, tinh Khanh Hoa

Mobile: +84 905707760 Mail: tiennt.vatec@gmail.com

## Station Supplier

Suntrace GmbH

Address: Grosse Elbstrasse 145c, 22767 Hamburg, Germany

Phone: +4940-76796380 Fax: +4940-767963820 Mail: meteo@suntrace.de

	Applied test	Details	Approved Yes/No	Comments
1	RSI	-	-	No part of station
2	pyranometers	Check for any damage, condensation, check the glass surface for scratches/other damages, check ventilation motors (if any) are functioning properly. If any condensation and/or scratches on glass is/are found, replace or repair the instrument. Check the desiccant, replace if dehydrated.	Yes	
3	pyrheliometer	Check for any damage, condensation, check the glass surface for scratches/other damages, check ventilation motors (if any) are functioning properly. If any condensation and/or scratches on glass is/are found, replace or repair the instrument. Check the desiccant, replace if dehydrated.	Yes	



	Applied test	Details	Approved	Comments
			Yes/No	
4	reference cells	Check for any damage, condensation, check	Yes	
		the glass surface for scratches/other damages,		
		check ventilation motors (if any) are function-		
		ing properly. If any condensation and/or		
		scratches on glass is/are found, replace or		
		repair the instrument. Check the desiccant,		
		replace if dehydrated.		
5	leve-	Check water levels for proper leveling, if in-	Yes	
	ve-	strument (cable) is aligned to GEOGRAPHIC		
	ling/positioning	North (Northern Hemisphere) or GEOGRAPH-		
	of horizontal	IC South (Southern Hemisphere). Correct if		
	pyranometer	necessary. Check if any parts are misplaced or		
		loose.		
6	sun tracker	Check if tracker is well fixed at the foundation.	Yes	
		Check for proper alignment of sun tracker		
		(GEOGRAPHIC North/South) by checking the		
		spot created and/or the leveling of the tracker		
		assembly. Spot should be created within a		
		specific range. Check for proper mechanical		
		functioning of the tracker.		
7	thermohygro	Check for correct installation, functionality and	Yes	
		discernible external damage.		
8	anemometer	Check for correct installation, functionality and	Yes	
		discernible external damage.		
9	wind direction	Check for correct installation, functionality and	Yes	
	vane	discernible external damage.		
10	further sensors	-	-	No further sensors
11	weather housing	Weather housing of all sensors is proper and	Yes	
		fixed, check the piping for visible damages.		
		Replace if worn.		
12	PV-panel	Properly fixed to tripod, facing south at north-	Yes	
		ern hemisphere and vice versa, no visible		
		damages (cracks, scratches).		
13	loose parts	Check if any parts are misplaced or loose	Yes	
		(sensors, antenna, PV panel, wind mas wires,		
		etc.).		
14	cabling of all	Check if the cabling of all sensors is done	Yes	
	sensors	properly and fixed. Check the sensor cables		
		for discernable damages.		
15	check power	Check if the battery and the PV panel are	Yes	
	supply system	correctly working and if the charge controller		
		charges the battery.		
L	I.	1	<u> </u>	<u>.                                    </u>



	Applied test	Details	Approved Yes/No	Comments
16	sensor connec-	Check if the sensors are properly connected to	Yes	
	tions to data	the data logger (fixing cables to the corre-		
	logger	sponding port). Compare with connection		
		plan.		
17	data logger con-	Check the measurement values and correct	Yes	Internet provider:
	figuration	configuration of the sensors in the data logger		Viettel Mobile
		(type, unit, slope, offset, etc.). Correct if nec-		APN: e-connect
		essary. Update communication configuration		
		(e.g. e-mail address) if necessary.		
18	modem	Check if SIMcard is inserted and modem regis-	Yes	
		ters to GSM network. It should be possible to		
		communicate with a remote server/computer		
		properly.		
19	real time meas-	Check real time measurements using the data	Yes	
	urements	logger web interface, compare them with your		
		observation and document them.		
20	tracker table,	Check if is steady and well fixed on the	Yes	
	tripod & wind	ground. Check bolts on the foundations.		
	mast			
21	fence, door, lock	Check the fence and door including its lock.	Yes	
22	horizon pictures	360° panorama picture from the view point of	Yes	
		radiation sensors should be taken.		
23	station pictures	Take photos of all sensors and instruments	Yes	
		and also of the whole station. The serial num-		
		bers should be seen.		
24	general view	Anything unusual? If NO write "Yes" for ap-	Yes	
		proved		
25	station keeper	Training of Station Keeper. Check the station	Yes	
	training and doc-	documentation such as: analogy of serial		
	umentation	numbers, station logbook, etc.		

Table 4. List of applied tests for commissioning of VNCEH



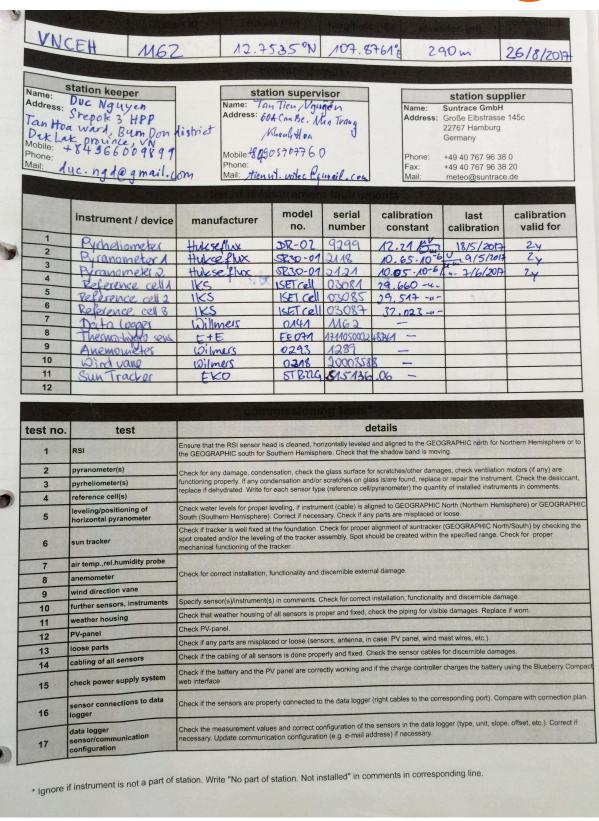


Figure 7. Commissioning Protocol page 1/3 VNCEH.



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20	tripod, wind mast		Check if the ma	ast(s) is/are steady and we	e data logger web interface, com ell fixed on the ground. Check b	olts on the foundations of	mast(s).	
21	fence, door, lock		Check the fend	e and door including its los	ck.	1	3	
22	station pictures		360° panorama	picture from the view point	nt of radiation sensors should b	e taken.	uld be seen.	
23	general view		Take photos of	all sensors and instrumen	nt of radiation sensors should be its and also of the whole station	. The serial florid	*	
25	station keeper trai	ning and	Anything unusu	ion Keeper. Check the sta	ation documentation such as: an	nalogy of serial numbers,	station logbook, etc.	
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Figure 8. Commissioning Protocol page 2/3 VNCEH.



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Figure 9. Commissioning Protocol page 3/3 VNCEH.



#### SUMMARY OF COMPLETED TASK 6.

- The installed station and spare parts have been tested prior to delivery for the project.
- The World Bank ESMAP Tier 1 solar measurement station at the location VNCEH is installed and commissioned successfully at the 26<sup>th</sup> of August 2017.
- For cross-calibration of the RSP-instruments of the 3x Tier 2 stations including the spare station were set up provisionally and pre-commissioned at the VNCEH site. The pre-commissioning protocols are attached as Annex to this report.
- Recorded data will be downloaded daily via GPRS. Data will be provided on a monthly basis including a summary of the last recorded month. Data transfer works properly. A daily automatic quality control procedure is applied to the unprocessed raw data, this additionally to the by contract committed monthly delivery of post processed data including a monthly summary report.
- FTP servers will be set up for data sharing with EVN companies at all sites of this measurement campaign.



#### 7. PHOTO DOCUMENTATION



Figure 10. Sun tracker with shadow ball assembly and PV panel in the front at VNCEH. Soiling measurement on the right.



Figure 11. Sun tracker with shadow ball assembly, and Pyranometer 1 in the front closer to the shadow ball measuring DHI and Pyranometer 2 in the back



Figure 12. Calibration station (left), sun tracker with PV panel (middle), soiling measurement (right), wind mast (back)





Figure 13. Tier 1 station at VNCEH

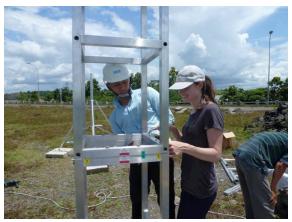


Figure 14. Mounting sun tracker table



Figure 15. Complete Tier 1 station with Tier 2 calibration station at VNCEH





Figure 16. Complete Tier 1 station with calibration station at VNCEH



Figure 17. Calibration station at VNCEH



Figure 18. Commissioning and station keeper training at VNCEH



Figure 19. Calibration station with rotating shadow bands



Figure 20. Commissioning and station keeper training at VNCEH





Figure 21. After commissioning with EVN staff at VNCEH



Figure 22. Special training on solar resources and HelioScale Stations for EVN staff at VNCEH



Figure 23. Special training on solar resources and HelioScale Stations for EVN staff at VNCEH



Figure 24. Station with fence at VNCEH



Figure 25. Figure 26. Station with fence at VNCEH





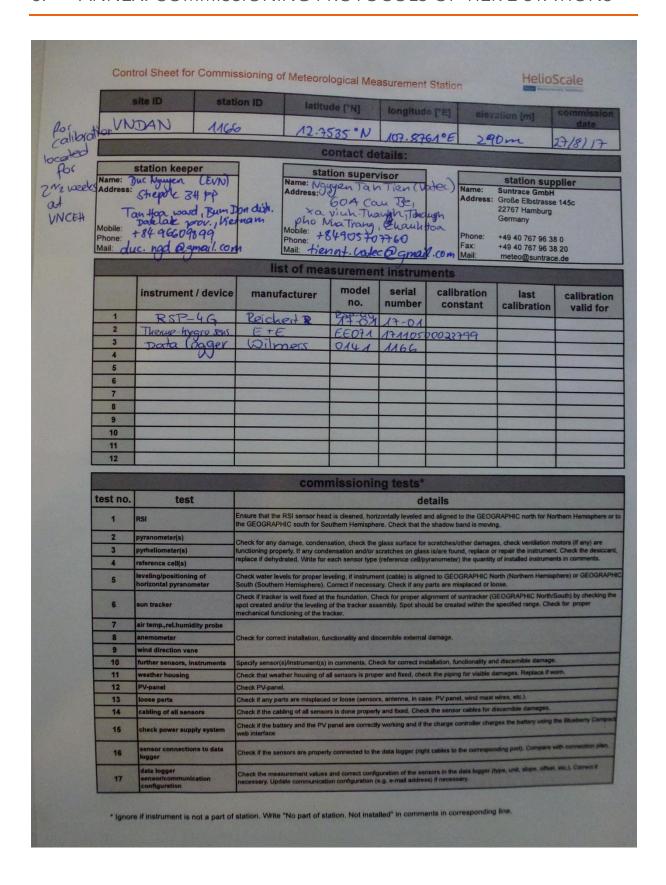
Figure 27. Tier 1 station with calibration station in VNCEH



Figure 28. Tier 1 station at VNCEH



#### ANNEX: COMMISSIONING PROTOCOLS OF TIER 2 STATIONS 8.



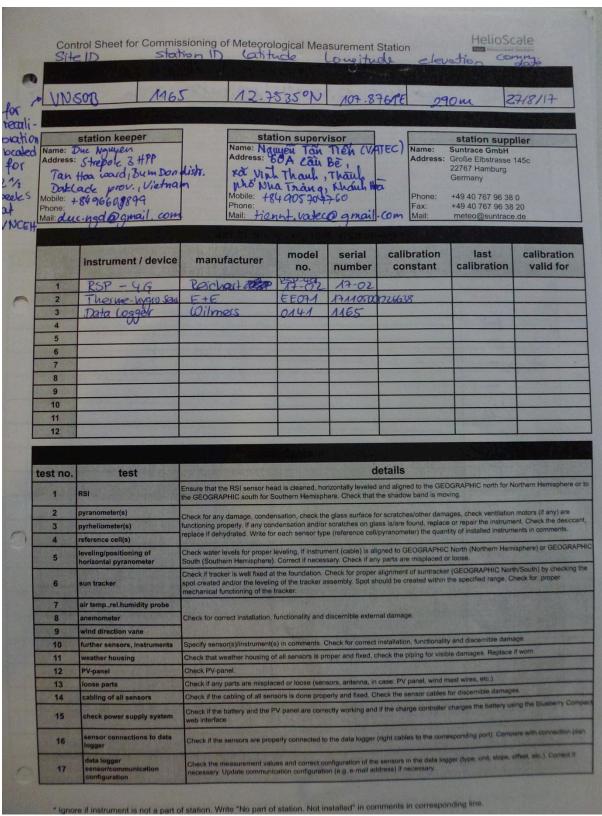


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2	Thesme-hygres	W. EHE GEO			733					
3	data logger	Wilmers	blusery	116A	NO STATE OF THE ST		Residence of the second			
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2	pyranometer(s)	Check for any damage, cond		a alasa sudasa k	or scretches/other dame	nes check ventilation	n motors (if any) are			
3	pyrheliometer(s)	the most realized managements of many or	andonestion and/or	coratches on als	ee je/are found replace	or repair the instrum	ient, Check the desi			
4	reference cell(s)	replace if dehydrated. Write	for each sensor typ	e (reference cell	pyranometer) the quant	uty of installed instrui	nems in continuits.			
	leveling/positioning of	Check water levels for prope	k water levels for proper leveling, if instrument (cable) is aligned to GEOGRAPHIC North (Northern Hemisphere) or GEOGRA ( Southern Hemisphere). Correct if necessary. Check if any parts are misplaced or loose.							
5	horizontal pyranometer	South (Southern Hernisphere	e). Correct if neces	Sary. Check if an	alignment of suntracket	(GEOGRAPHIC No	rth/South) by check			
6	sun tracker	spot created and/or the level mechanical functioning of the	ing of the tracker a	ssembly, Spot sh	ould be created within	the specified range. C	Check for proper			
7	air temp.,rel.humidity probe	是								
8	anemometer	Check for correct installation	, functionality and	discernible extern	nal damage.					
9	wind direction vane					THE RESIDENCE OF THE PARTY OF T	ACTUAL DISTRIBUTION			
10	further sensors, instruments	Specify sensor(s)/instrumen	t(s) in comments. (	Check for correct	installation, functionality	y and discernible dan	if wore			
11	weather housing	Check that weather housing	of all sensors is pr	oper and fixed, c	heck the piping for visib	se damages. Replace				
12	PV-panel	Check PV-panel.	(C) VIVING	SALES AND		nest select				
13	loose parts	Check if any parts are mispl	aced or loose (sen	sors, antenna, in	case. PV paner, wind in	for discernible damas	20%			
14	cabling of all sensors	Check if the cabling of all se	nsors is done prop	erly and fixed, Cl	the sensor capies	charges the battery of	ising the Blueberry I			
15	check power supply system	Check if the battery and the web interface					CHARLEST STATE OF THE PARTY OF			
16	sensor connections to data logger	Check if the sensors are pro	operly connected to	the data logger	right cables to the corre	esponding port). Com	pare with connection			
STEWNS .	data logger	Check the measurement values and correct configuration of the sensors in the data logger (type, unit, slope, offest, etc.). Correct necessary, Update communication configuration (e.g. e-mail address) if necessary.								



	site ID		ion ID	latitude [°N]	longitude [°E]	elevation [m]	commission				
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18	check commu (modem)	nication		ssible to communicate with a rem							
19	real time meas		Check real time	e measurements using the data lo ast(s) is/are steady and well fixed	ogger web interface, compare to	nem with your observations a	and document them.				
21	fence, door, los			e and door including its lock.	on are ground, or con both on	the foundations of mast(s).					
22	horizon pictures	ALCOHOLD BY A STREET		picture from the view point of ra- all sensors and instruments and							
24	general view		Anything unusu			ocina numbers stidulo de sei	en.				
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# SOLAR MEASUREMENT CAMPAIGN IN VIETNAM

**SELECTION #: 1231900** 

## Installation Report: Da Nang (VNDAN)

Suntrace Technical Documentation 21 September 2017

World Bank Group
ESMAP Renewable Energy Mapping Initiative

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5.	Station Commissioning	7
6.	Summary of completed task	13
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#### 1. INTRODUCTION

The principal task of this installation project was the installation of six meteorological measurement stations at the selected sites including the training of the local staff from EVN (Vietnam Electricity, state-owned utility) on principle maintenance works of the meteorological measurement stations of Type HelioScale ω (Tier 1) and Type HelioScale  $\varphi$  (Tier 2). The selected sites are listed in Table 1, see also Implementation Plan for more details.

The first installation mission took place from 22<sup>nd</sup> of August to 1<sup>st</sup> of September 2017. During the first installation mission, the Tier 1 stations were installed at the sites VNCEH (Central Highlands), VNTRA (Tri An) and VNHAN (Bac Ninh near Hanoi). All Tier 2 stations (2x Tier 2 stations for sites VNDAN (Da Nang) and VNSOB (Song Binh) plus 1x Tier 2 spare station) were additionally installed at VNCEH for calibration of the RSP sensors for 2 ½ weeks until the second installation mission started. The second installation mission was undertaken from 12th to 19th of September 2017 and the Tier 2 stations at VNDAN and VNSOB were installed. The spare station will be stored at the Head office of VATEC in Nha Trang. The inauguration with the local government, EVN and World Bank representatives was held on 20th of September in Song Binh (VNSOB).

The International Experts Joana Zerbin and Marko Schwandt from Suntrace GmbH traveled from Germany / Spain to the sites in Vietnam. Vietnam Applied Technical Co. Ltd (VATEC) as local partner company in this project supported Suntrace during the installation.

### Overview of Station Sites



Figure 1. Country map showing sites for solar measurement stations considered for the Vietnam ESMAP project.



Site name and description	Туре	Site code	Elevation	Latitude	Longitude
Hanoi region: Bac Ninh on rooftop of new EVN bldg.	Tier1	VNHAN	60 m	21.2013°N	106.0629°E
Da Nang on rooftop of EVN/CPC bldg. within the city	Tier2	VNDAN	24 m	16.0125°N	108.1865°E
Central Highlands region on ground before EVN bldg. near hydro spillway	Tier1	VNCEH	290 m	12.7535°N	107.8761°E
Song Binh station location on private house's rooftop	Tier2	VNSOB	62 m	11.2641°N	108.3452°E
Tri An region near HCMC on top of EVN bldg. near water spillway	Tier1	VNTRA	57 m	11.1024°N	107.0378°E

Table 1. Selected sites for solar measurement stations in Vietnam within the WB ESMAP program

This report gives an overview of the ground installation of the Tier 2 station in Da Nang on top of the EVN CPC company building. The installation took place between 13th and 15th of September 2017. The site code for this site is VNDAN.

Tier 2 stations are designed to be very robust and less sensitive to cleaning, as a Rotating Shadowband Irradiometer (RSI) measures GHI, DHI and DNI. In order to reach high quality data, the Tier 2 stations are equipped with a thermopile pyranometer, which complies with Secondary Standard requirements - highest quality Level of ISO 9060 (1990). Besides, a barometer measures atmospheric pressure and a thermo-hygro sensor measures air temperature and relative humidity. Furthermore, a plug-and-play blueberry COMPACT data-logging system controls, stores and transmits the measured data of the stations. For power supply of the Tier 2 stations, a solar panel, batteries and charge controllers are installed. Additionally, a wind mast with a cup anemometer assembly ensures measuring accurate wind speed. A soiling measurement system and a corrosion measurement kit were installed as additional equipment.



#### 2. LOCATION DA NANG - VNDAN



Figure 2. Country map showing the site VNDAN for solar measurements for Solar Measurements in Vietnam ESMAP project.

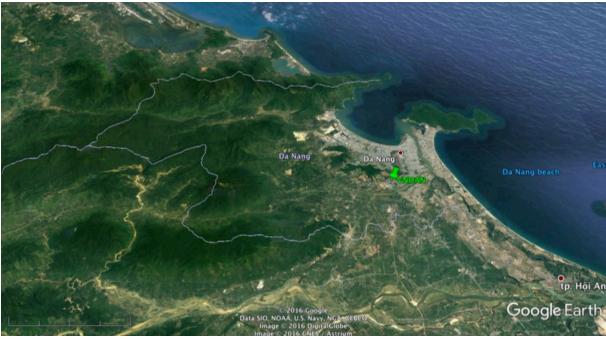


Figure 3. Location of VNDAN relative to the extent of the region



#### **DESCRIPTION OF STATION** 3.

Installation details	
Location	Vietnam – Da Nang City, EVN CPC rooftop
Site ID	VNDAN
Station ID	1166
Longitude/Latitude	16.0125°N /108.1865°E
Elevation	24 m
Date of commencement	15 <sup>th</sup> of September 2017

Table 2.Overview of site parameters VNDAN

## Solar Measurement Station Tier 2

# Recorded meteorological parameters:

- global horizontal irradiance (GHI) in W/m<sup>2</sup>
- direct normal irradiance (DNI) in W/m<sup>2</sup>
- diffuse horizontal irradiance (DHI) in W/m<sup>2</sup>
- ambient temperature in °C
- relative humidity in %
- wind speed in m/s 27 m above ground
- barometric pressure in hPa
- soiling measurement via 3 reference cells measuring global tilted (10°) irradiance (GTI) in W/m²

### Additional information:

- The Reichert RSP4G (RSI), which is installed, is known to be a precise and robust instrument. Contrary to pyrheliometers, which are used in Tier 1 stations and require daily cleaning to reach its outstanding accuracy, it is sufficient to clean such RSI on a weekly basis.
- The Hukseflux SR20 is used in the RSI, which is equipped with dome heating system to reduce the influence of dew, but is not ventilated
- For Tier 2 stations, a 60 Wp photovoltaic panel, batteries and a charge controller are installed.
- As the roof of the EVN building in Da Nang is 24 m high, a wind mast measuring wind speed was installed at a height of 3 m.



# List of installed instruments and measurement sensors

No.	Instrument	Manufacturer	Model No.	Serial No.
1	Rotating Shadow-	Reichert	RSP-4G	17-01
	band Irradiometer			
2	Pyranometer 1	Hukseflux	SR20-D2	6998
3	Reference Cell 1	IKS	ISET Cell	03083
4	Reference Cell 2	IKS	ISET Cell	03082
5	Reference Cell 3	IKS	ISET Cell	02665
6	Data logger Blue-	Wilmers Messtech-	0141	1166
	berry COMPACT	nik		
7	Thermo-hygro Sen-	E+E	EE071	17110500023799
	sor			
8	Anemometer	Wilmers Messtech-	0293	1294
		nik		

Table 3.List of installed instruments and measurement sensors at VNDAN



Figure 4. Photo of Tier 2 Station of type HelioScale  $\boldsymbol{\phi}$  installed at VNDAN



#### 4. **HORIZON**



Figure 5. Horizon at VNDAN

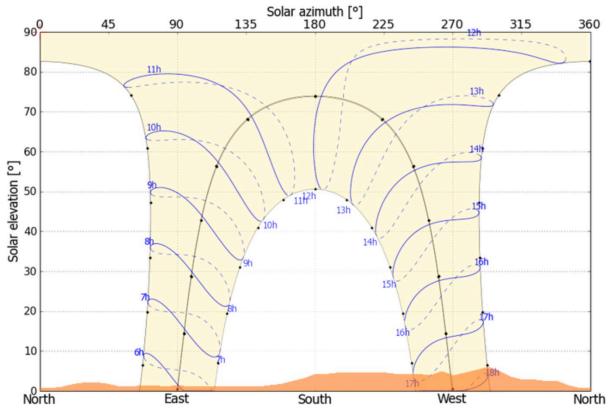


Figure 6. Sun path for VNDAN



#### 5. STATION COMMISSIONING

# Responsible staff for monitoring of the stations

# Standby Station Keeper

Name: Dang Don Thach

Address: To 26 Phuong Hoa tho Tay, quan Cam Le, thanh pho Da Nang

Mobile: +84 979444093 Phone: +84 906560698

Mail: dangdonthach@gmail.com

# Station Supervisor

Name: Tan Tien Nguyen

Address: 60A Cau Be, xa Vinh Thanh, Thanh pho Nha Trang, tinh Khanh Hoa

Mobile: +84 905707760 Mail: tiennt.vatec@gmail.com

# Station Supplier

Suntrace GmbH

Address: Grosse Elbstrasse 145c, 22767 Hamburg, Germany

Phone: +49 40 767 96 38 0 Fax: +49 40 767 96 38 20 Mail: meteo@suntrace.de

	Applied test	Details	Approved Yes/No	Comments
1	RSI	Ensure that the RSI sensor head is cleaned, horizontally leveled and aligned to the GEO-GRAPHIC north for Northern Hemisphere or to the GEOGRAPHIC south of Southern Hemisphere. Check that the shadow band is moving.	Yes	
2	pyranometer(s)	Check for any damage, condensation, check the glass surface for scratches/other damages, check ventilation motors (if any) are functioning properly. If any condensation and/or scratches on glass is/are found, replace or repair the instrument. Check the desiccant, replace if dehydrated.	Yes	



	Applied test	Details	Approved Yes/No	Comments
3	Pyrheliometer(s)	Check for any damage, condensation, check the glass surface for scratches/other damages, check ventilation motors (if any) are functioning properly. If any condensation and/or scratches on glass is/are found, replace or repair the instrument. Check the desiccant, replace if dehydrated.		No part of this station. Not installed.
4	reference cell(s)	Check for any damage, condensation, check the glass surface for scratches/other damages, check ventilation motors (if any) are functioning properly. If any condensation and/or scratches on glass is/are found, replace or repair the instrument. Check the desiccant, replace if dehydrated.	Yes	
5	leve- ve- ling/positioning of horizontal pyranometer	Check water levels for proper leveling, if instrument (cable) is aligned to GEOGRAPHIC North (Northern Hemisphere) or GEOGRAPHIC South (Southern Hemisphere). Correct if necessary. Check if any parts are misplaced or loose.	Yes	
6	sun tracker	Check if tracker is well fixed at the foundation. Check for proper alignment of sun tracker (GEOGRAPHIC North/South) by checking the spot created and/or the leveling of the tracker assembly. Spot should be created within a specific range. Check for proper mechanical functioning of the tracker.		No part of this station. Not installed.
7	air temperature, rel. humidity probe (ther- mohygro)	Check for correct installation, functionality and discernible external damage.	Yes	
8	anemometer	Check for correct installation, functionality and discernible external damage.	Yes	
9	wind direction vane	Check for correct installation, functionality and discernible external damage.		No part of this station. Not installed.
10	further sensors, instruments	Specify sensor(s)/instrument(s) in comments.  Check for correct installation, functionality and discemible damage	-	No further sensors installed.
11	weather housing	Weather housing of all sensors is proper and fixed, check the piping for visible damages. Replace if worn.	Yes	



	Applied test	Details	Approved Yes/No	Comments
12	PV-panel	Properly fixed to tripod, facing south at northern hemisphere and vice versa, no visible damages (cracks, scratches).	Yes	
13	loose parts	Check if any parts are misplaced or loose (sensors, antenna, PV panel, wind mas wires, etc.).	Yes	
14	cabling of all sensors	Check if the cabling of all sensors is done properly and fixed. Check the sensor cables for discernable damages.	Yes	
15	check power supply system	Check if the battery and the PV panel are correctly working and if the charge controller charges the battery.	Yes	
16	sensor connections to data logger	Check if the sensors are properly connected to the data logger (fixing cables to the corresponding port). Compare with connection plan.	Yes	
17	data logger sen- sor/communicati on configuration	Check the measurement values and correct configuration of the sensors in the data logger (type, unit, slope, offset, etc.). Correct if necessary. Update communication configuration (e.g. e-mail address) if necessary.	Yes	Internet provider: Viettel Mobile APN: e-connect
18	modem	Check if SIMcard is inserted and modem registers to GSM network. It should be possible to communicate with a remote server/computer properly.	Yes	
19	real time meas- urements	Check real time measurements using the data logger web interface, compare them with your observation and document them.	Yes	
20	tracker table, tripod & wind mast	Check if is steady and well fixed on the ground. Check bolts on the foundations.	Yes	Tracker table not part of the station
21	fence, door, lock	Check the fence and door including its lock.	Yes	Station on roof top, building well locked
22	horizon pictures	360° panorama picture from the view point of radiation sensors should be taken.	Yes	
23	station pictures	Take photos of all sensors and instruments and also of the whole station. The serial numbers should be seen.	Yes	
24	general view	Anything unusual? If NO write "Yes" for approved	Yes	
25	station keeper training and doc- umentation	Training of Station Keeper. Check the station documentation such as: analogy of serial numbers, station logbook, etc.	Yes	

Table 4. List of applied tests for commissioning at VNDAN



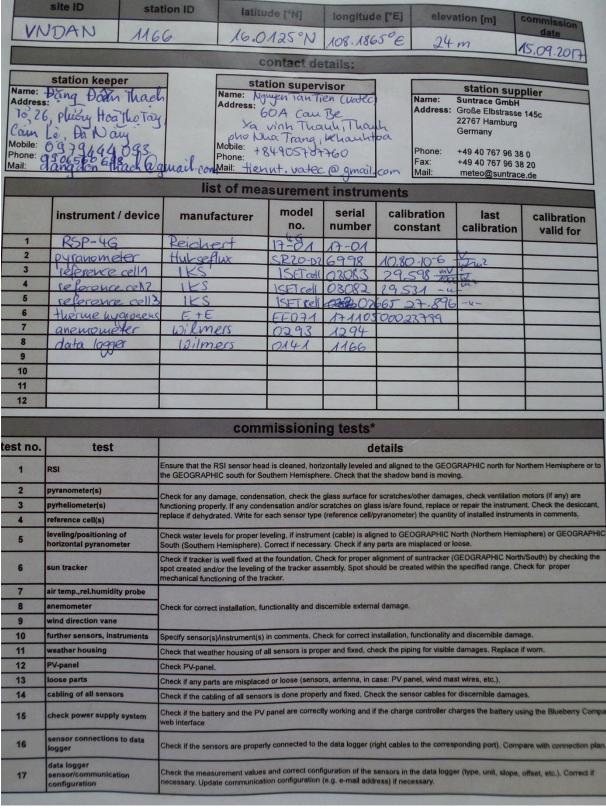


Figure 7. Commissioning Protocol page 1/3 VNDAN



SIL	e ID	station ID	latitude [°N]	longitude [°E]	elevation [m]	commission
VNDA	IN	MG6 MO 01250N) 100 101 500 01				date
18	check communic (modem)	ation It should	be possible to communicate with a re			15.09,2017
19	real time measure		al time measurements using the data		nem with your share	
	tripod, wind mast	STATE OF THE PARTY	The steady and well fixe	ed on the ground. Check bolts on	the foundations of mast(s)	d document them.
	fence, door, lock	Check th	e fence and door including its lock.		A DECISION NOT THE REAL PROPERTY.	
22	station pictures	Take pho	orama picture from the view point of	radiation sensors should be taken		
24	general view	Anything	tos of all sensors and instruments an unusual?	id also of the whole station. The s	erial numbers should be seen.	
25	station keeper tra documentation	ining and Training	of Station Keeper. Check the station of	documentation such as: analogy of	f serial numbers, station logbo	ook, etc.
da	ate:	15.09.20			13:45	
7			test res			
test no.	approved ? Yes/No			comments*		
1	Yes					
2	Yes	1 SR20	of station.	lobal thoise	tal Irrodiance	)
3	-	No part	of station.	Not installed		
4	Yes	3 tekee	ince cells (Soin	ling measurem	rent)	
5	Yes			V		
6	-	No par	t of station.	Not installed.		
7	Yes					
8	Yes					
10		No pa	rt of station.	Not installed.		
11	1/2	~	0 -			
12	Yes Yes					
13	Yes		The second second			
14	yes					
15	yes					
16	Yes					
18	yes Yes				MA TOLIC	
19						
21	yes					

Figure 8. Commissioning Protocol page 2/3 VNDAN



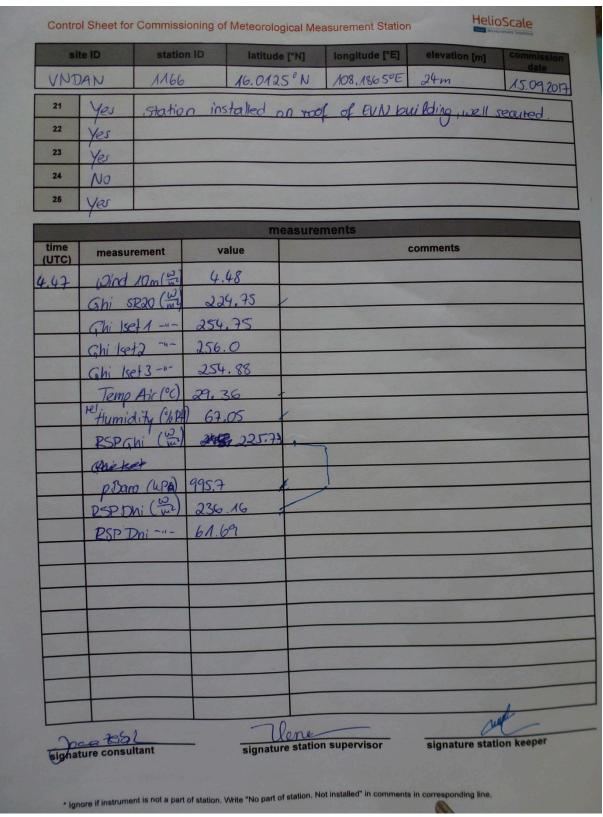


Figure 9. Commissioning Protocol page 3/3 VNDAN



#### SUMMARY OF COMPLETED TASK 6.

- The installed equipment has been tested prior to delivery for the project.
- The World Bank ESMAP Tier 2 solar measurement station at the location VNDAN is installed and commissioned successfully at the 15th of September 2017
- Recorded data will be downloaded daily via GPRS. Data will be provided on a monthly basis including a summary of the last recorded month. Data transfer works properly. A daily automatic quality control procedure is applied to the unprocessed raw data, this additionally to the by contract committed monthly delivery of post processed data including a monthly summary report.
- FTP servers will be set up for data sharing with EVN companies at all sites of this measurement campaign.



#### 7. PHOTO DOCUMENTATION



Figure 10. Tier 2 station with soiling measurement at VNDAN



Figure 12. Tier 2 station with soiling measurement at VNDAN



Figure 11. Tier 2 station with soiling measurement at VNDAN



Figure 13. Wind mast measuring wind speed at VNDAN





Figure 14. Sensors of Tier 2 station (RSP, SR20, Thermohygro & soiling sensor) at VNDAN



Figure 15. Commissioning & station keeper training with EVN staff at VNDAN



Figure 16. Commissioning & station keeper training with EVN staff at VNDAN



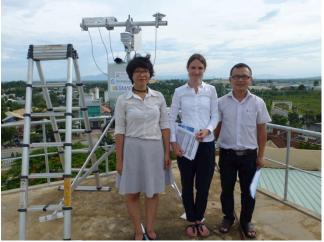


Figure 17. After commissioning with EVN staff at VNDAN



Figure 18. Tier 2 station at VNDAN



Figure 19. Tier 2 station with wind mast (left) and lightning protection (middle) on rooftop at VNDAN





Figure 20. Tier 2 station with wind mast on rooftop at VNDAN





Figure 21. After commissioning with EVN staff at VNHAN



Figure 22. After commissioning with EVN staff at VNHAN



# SOLAR MEASUREMENT CAMPAIGN IN VIETNAM

**SELECTION #: 1231900** 

# Installation Report: Bac Ninh (VNHAN)

Suntrace Technical Documentation 21 September 2017

World Bank Group
ESMAP Renewable Energy Mapping Initiative

Authors:

Joana Zerbin, Marko Schwandt

Reviewed by:

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	Horizon	
	Station Commissioning	
6.	Summary of completed task	13
7.	Photo documentation	14



#### 1. INTRODUCTION

The principal task of this installation project was the installation of six meteorological measurement stations at the selected sites including the training of the local staff from EVN (Vietnam Electricity, state-owned utility) on principle maintenance works of the meteorological measurement stations of Type HelioScale ω (Tier 1) and Type HelioScale  $\varphi$  (Tier 2). The selected sites are listed in Table 1, see also Implementation Plan for more details.

The first installation mission took place from 22<sup>nd</sup> of August to 1<sup>st</sup> of September 2017. During the first installation mission, the Tier 1 stations were installed at the sites VNCEH (Central Highlands), VNTRA (Tri An) and VNHAN (Bac Ninh near Hanoi). All Tier 2 stations (2x Tier 2 stations for sites VNDAN (Da Nang) and VNSOB (Song Binh) plus 1x Tier 2 spare station) were additionally installed at VNCEH for calibration of the RSP sensors for 2 ½ weeks until the second installation mission started. The second installation mission was undertaken from 12th to 19th of September 2017 and the Tier 2 stations at VNDAN and VNSOB were installed. The spare station will be stored at the Head office of VATEC in Nha Trang. The inauguration with the local government, EVN and World Bank representatives was held on 20th of September in Song Binh (VNSOB).

The International Experts Joana Zerbin and Marko Schwandt from Suntrace GmbH traveled from Germany / Spain to the sites in Vietnam. Vietnam Applied Technical Co. Ltd (VATEC) as local partner company in this project supported Suntrace during the installation.

# Overview of Station Sites



Figure 1. Country map showing sites for solar measurement stations considered for the Vietnam ESMAP project.



Site name and description	Туре	Site code	Elevation	Latitude	Longitude
Hanoi region: Bac Ninh on rooftop of new EVN bldg.	Tier1	VNHAN	60 m	21.2013°N	106.0629°E
Da Nang on rooftop of EVN/CPC bldg. within the city	Tier2	VNDAN	24 m	16.0125°N	108.1865°E
Central Highlands region on ground before EVN bldg. near hydro spillway	Tier1	VNCEH	290 m	12.7535°N	107.8761°E
Song Binh station location on private house's rooftop	Tier2	VNSOB	62 m	11.2641°N	108.3452°E
Tri An region near HCMC on top of EVN bldg. near water spillway	Tier1	VNTRA	57 m	11.1024°N	107.0378°E

Table 1. Selected sites for solar measurement stations in Vietnam within the WB ESMAP program

This report gives an overview of the ground installation of the Tier 1 station in Bac Ninh near Hanoi on top of the local head office of EVN in Bac Ninh province. The installation took place between 30th of August and 1st of September 2017. The site code for this site is VNHAN.

Tier 1 stations are equipped with a robust and highly reliable pyrheliometer, a shaded pyranometer (which measures DHI), a non-shaded pyranometer (which measures GHI), and a 2-axis sun tracker with a shadow-ball assembly. Besides, a barometer measures atmospheric pressure and a thermo-hygro sensor measures air temperature and relative humidity. Additionally, a wind mast with a cup anemometer and a wind vane assembly ensures measuring accurate wind speed and direction. Furthermore, a plug-and-play blueberry COMPACT datalogging system controls, stores and transmits the measured data of the stations. For power supply of the Tier 1 stations, a solar panel, batteries and charge controllers are installed. At this site, a soiling measurement system is also installed.



#### 2. LOCATION BAC NINH NEAR HANOI – VNHAN



Figure 2. Country map showing the site VNHAN for solar measurements considered for the Vietnam ESMAP project.





#### 3. **DESCRIPTION OF STATION**

Installation details	
Location	Vietnam – Hanoi region: Bac Ninh on rooftop of
	new EVN building
Site ID	VNHAN
Station ID	1163
Longitude/Latitude	21.2013°N /106.0629°E
Elevation	60 m
Date of commencement	1st of September 2017

Table 2. Overview of site parameters VNTRA

# Solar Measurement Station Tier 1

## Recorded meteorological parameters:

- global horizontal irradiance (GHI) in W/m<sup>2</sup>
- direct normal irradiance (DNI) in W/m<sup>2</sup>
- diffuse horizontal irradiance (DHI) in W/m<sup>2</sup>
- ambient temperature in °C
- relative humidity in %
- wind speed in m/s ca. 63 m above ground
- wind direction at ca. 63 m above ground
- barometric pressure in hPa
- soiling measurement via 3 reference cells measuring global tilted (10°) irradiance (GTI) in W/m²

# Additional information:

- As the roof is 60 m high, the wind mast was installed at a height of 3 m above the rooftop.
- For Tier 1 stations, a 250 Wp photovoltaic panel, batteries and a charge controller are installed.

## List of installed instruments and measurement sensors

No.	Instrument	Manufacturer	Model No.	Serial No.
1	Pyrheliometer	Hukseflux	DR-02	9298
2	Pyranometer 1 (DHI)	Hukseflux	SR30-01	2123
3	Pyranometer 2 (GHI)	Hukseflux	SR30-01	2125
4	Reference Cell 1	IKS	ISET Cell	03110
5	Reference Cell 2	IKS	ISET Cell	03091
6	Reference Cell 3	IKS	ISET Cell	02672
7	Data logger Blue-	Wilmers Messtech-	0141	1163
	berry COMPACT	nik		
8	Thermo-hygro Sen-	E+E	EE071	171105000265DA
	sor			
9	Anemometer	Wilmers Messtech-	0293	1291
		nik		
10	Wind vane	Wilmers Messtech-	0318	20003589
		nik		



No.	Instrument	Manufacturer	Model No.	Serial No.
11	Sun tracker includ-	EKO	STR-22G	S1513605
	ing shading assem-			
	bly			

Table 3.List of installed instruments and measurement sensors at VNHAN



Figure 4. Photo of Tier 1 Station of type HelioScale  $\omega$  installed at VNHAN



#### **HORIZON** 4.



Figure 5. Horizon at VNHAN

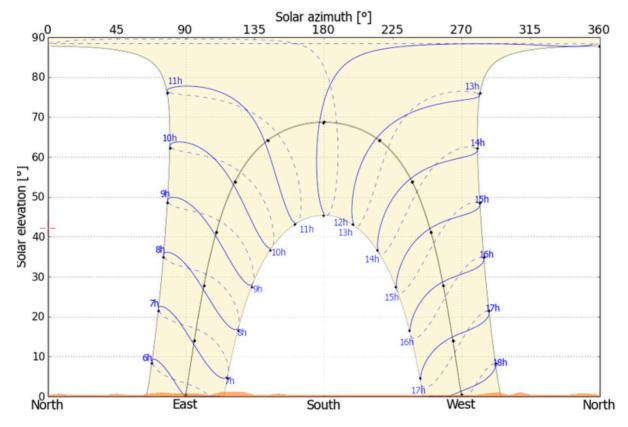


Figure 6. Sun path for VNHAN



#### 5. STATION COMMISSIONING

# Responsible staff for monitoring of the stations

# Standby Station Keeper

Name: Ta Thauh Tuan

Address: Cong ty Dien luc tinh Bac Ninh, xa Hoa Long, thanh pho Bac Ninh, tinh Bac Ninh

Mobile: +84 963154985

Mail: tuanhan150485@gmail.com

# Station Supervisor

Name: Tan Tien Nguyen

Address: 60A Cau Be, xa Vinh Thanh, Thanh pho Nha Trang, tinh Khanh Hoa

Mobile: +84 905707760 Mail: tiennt.vatec@gmail.com

# Station Supplier

Suntrace GmbH

Address: Grosse Elbstrasse 145c, 22767 Hamburg, Germany

Phone: +49 40 767 96 38 0 Fax: +49 40 767 96 38 20 Mail: meteo@suntrace.de

	Applied test	Details	Approved Yes/No	Comments
1	RSI	-	-	No part of station – not installed
2	pyranometer(s)	Check for any damage, condensation, check the glass surface for scratches/other damages, check ventilation motors (if any) are functioning properly. If any condensation and/or scratches on glass is/are found, replace or repair the instrument. Check the desiccant, replace if dehydrated.	Yes	
3	Pyrheliometer(s)	Check for any damage, condensation, check the glass surface for scratches/other damages, check ventilation motors (if any) are functioning properly. If any condensation and/or scratches on glass is/are found, replace or repair the instrument. Check the desiccant, replace if dehydrated.	Yes	
4	reference cell(s)	Check for any damage, condensation, check the glass surface for scratches/other damages, check ventilation motors (if any) are functioning properly. If any condensation and/or	Yes	



	Applied test	Details	Approved	Comments	
			Yes/No		
		scratches on glass is/are found, replace or			
		repair the instrument. Check the desiccant,			
		replace if dehydrated.			
		-	V/		
5	leve-	Check water levels for proper leveling, if in-	Yes		
	ve-	strument (cable) is aligned to GEOGRAPHIC			
	ling/positioning	North (Northern Hemisphere) or GEOGRAPH-			
	of horizontal	IC South (Southern Hemisphere). Correct if			
	pyranometer	necessary. Check if any parts are misplaced or			
		loose.			
6	sun tracker	Check if tracker is well fixed at the foundation.	Yes		
		Check for proper alignment of sun tracker			
		(GEOGRAPHIC North/South) by checking the			
		spot created and/or the leveling of the tracker			
		assembly. Spot should be created within a			
		specific range. Check for proper mechanical			
		functioning of the tracker.			
7	air temperature,	Check for correct installation, functionality and	Yes		
	rel. humidity	discernible external damage.			
	probe (ther-				
	mohygro)				
8	anemometer	Check for correct installation, functionality and	Yes		
O	ancinometer	discernible external damage.	103		
9	wind direction	Check for correct installation, functionality and	Yes		
7	vane	discernible external damage.	163		
10		Specify sensor(s)/instrument(s) in comments.	_	No additional sen-	
10	further sensors,		-		
	instruments	Check for correct installation, functionality and		sors were installed.	
4.4		discemible damage			
11	weather housing	Weather housing of all sensors is proper and	Yes		
		fixed, check the piping for visible damages.			
		Replace if worn.			
12	PV-panel	Properly fixed to tripod, facing south at north-	Yes		
		ern hemisphere and vice versa, no visible			
		damages (cracks, scratches).			
13	loose parts	Check if any parts are misplaced or loose	Yes		
		(sensors, antenna, PV panel, wind mas wires,			
		etc.).			
14	cabling of all	Check if the cabling of all sensors is done	Yes		
	sensors	properly and fixed. Check the sensor cables			
		for discernable damages.			
15	check power	Check if the battery and the PV panel are	Yes		
	supply system	correctly working and if the charge controller			
		charges the battery.			
16	sensor connec-	Check if the sensors are properly connected to	Yes		
	tions to data	the data logger (fixing cables to the corre-			
	10 data	and data legger (many capies to the conte-	<u> </u>		



	Applied test	Details	Approved Yes/No	Comments
	logger	sponding port). Compare with connection		
		plan.		
17	data logger sen-	Check the measurement values and correct	Yes	Internet provider:
	sor/communicati	configuration of the sensors in the data logger		Viettel Mobile
	on configuration	(type, unit, slope, offset, etc.). Correct if nec-		APN: e-connect
		essary. Update communication configuration		
		(e.g. e-mail address) if necessary.		
18	modem	Check if SIMcard is inserted and modem regis-	Yes	
		ters to GSM network. It should be possible to		
		communicate with a remote server/computer		
		properly.		
19	real time meas-	Check real time measurements using the data	Yes	
	urements	logger web interface, compare them with your		
		observation and document them.		
20	tracker table,	Check if is steady and well fixed on the	Yes	
	tripod & wind	ground. Check bolts on the foundations.		
	mast			
21	fence, door, lock	Check the fence and door including its lock.	Yes	Station on roof top,
				building well locked
22	horizon pictures	360° panorama picture from the view point of	Yes	
		radiation sensors should be taken.		
23	station pictures	Take photos of all sensors and instruments	Yes	
		and also of the whole station. The serial num-		
		bers should be seen.		
24	general view	Anything unusual? If NO write "Yes" for ap-	No	
		proved		
25	station keeper	Training of Station Keeper. Check the station	Yes	
	training and doc-	documentation such as: analogy of serial		
	umentation	numbers, station logbook, etc.		
		l		

Table 4. List of applied tests for commissioning at VNTRA



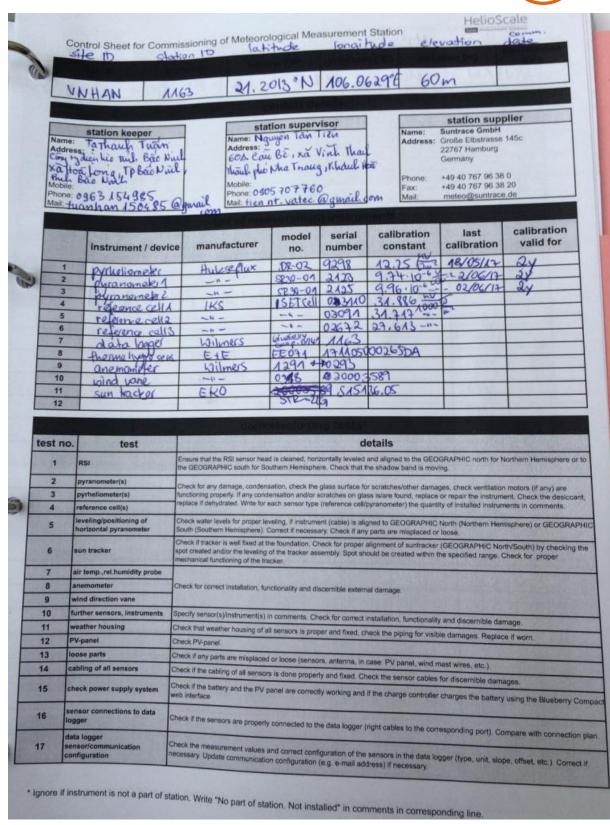


Figure 7. Commissioning Protocol page 1/3 VNHAN



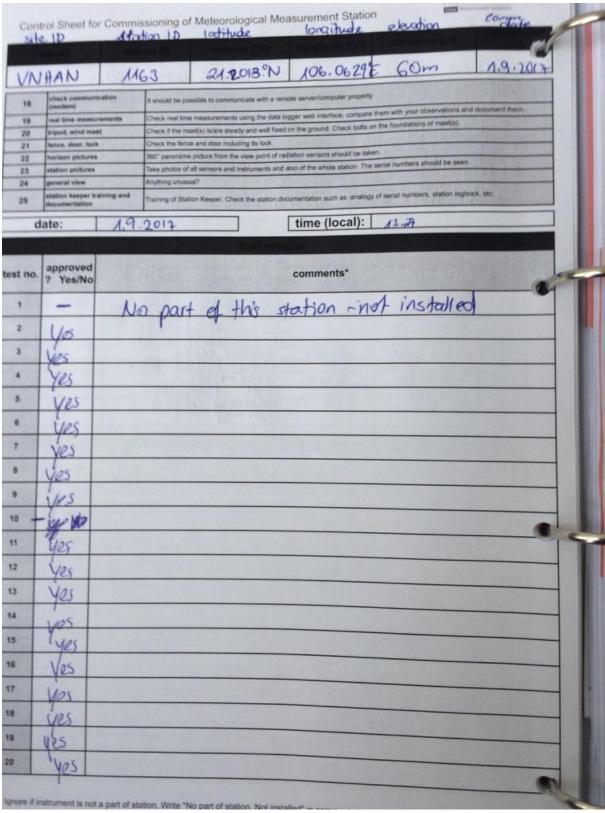


Figure 8. Commissioning Protocol page 2/3 VNHAN



-	Control s	Sheet for C	Commission Station	oning of	Meteorolo	gical Mea	surement Stat	ion e el	Helic	Scale
	VNHAN		1163		21.2013°N		106.06399	E GO		4 04012
	21	Yes					, building			1.9.2017
	22	Yes								
1	24	Ves No								
	25	Ves	State of the last							
H		l				cosucen	ents ( )			
	time (UTC)	measur	200000000000000000000000000000000000000	V	alue			commen	ts	
2	6.27	Did A		1.32			DV			
	~ -	Wind	direction	149.	87					
	-4-		12) JE 01	District Control				237		
			1 SP30							
			- SR30		997					
		Ghi Is			647					
			Isets	122	and the same of th	1 -12 - 3				
	-4-		Iset 1	37.	5°C					
		Temp	Iset 3		3°C					
	-n-	Town	p Air		5°C					
10		rel-W	umidity	79	1%					
	-									
	-									
		-							100000	
	-	+				1				
9	signat	ure consult	tant			e station s	upervisor	signat s in correspon	lure station k	eeper buil

Figure 9. Commissioning Protocol page 3/3 VNHAN



#### SUMMARY OF COMPLETED TASK 6.

- The installed station and spare parts have been tested prior to delivery for the project.
- The World Bank ESMAP Tier 1 solar measurement station at the location VNHAN is installed and commissioned successfully at the 1st of September 2017
- Recorded data will be downloaded daily via GPRS. Data will be provided on a monthly basis including a summary of the last recorded month. Data transfer works properly. A daily automatic quality control procedure is applied to the unprocessed raw data, this additionally to the by contract committed monthly delivery of post processed data including a monthly summary report.
- FTP servers will be set up for data sharing with EVN companies at all sites of this measurement campaign.



#### 7. PHOTO DOCUMENTATION



Figure 10. Tier 1 station at VNHAN at VNHAN



Figure 12. Wind mast measuring wind speed and direction at VNHAN



Figure 11. Tier 1 station with wind mast and soiling measurement at VNHAN



Figure 13. Soiling measurement system at sunset at VNHAN





Figure 14. EVN NPC building with Tier 1 station on roof top at VNHAN



Figure 15. Commissioning and station keeper training with EVN staff at VNHAN  $\,$ 





Figure 16. After commissioning with EVN staff at VNHAN

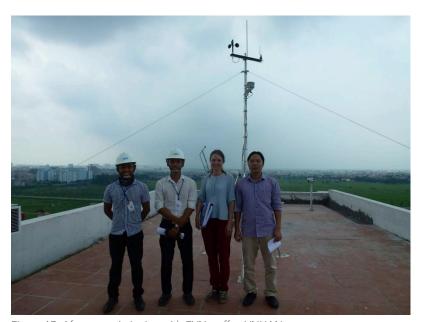


Figure 17. After commissioning with EVN staff at VNHAN



# SOLAR MEASUREMENT CAMPAIGN IN VIETNAM

**SELECTION #: 1231900** 

# Installation Report: Song Binh (VNSOB)

Suntrace Technical Documentation 21 September 2017

World Bank Group
ESMAP Renewable Energy Mapping Initiative

Authors:

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2.	Location Song Binh – VNSOB	3
	Description of station	
4.	Horizon	6
5.	Station Commissioning	7
	Summary of completed task	
	Photo documentation	



#### 1. INTRODUCTION

The principal task of this installation project was the installation of six meteorological measurement stations at the selected sites including the training of the local staff from EVN (Vietnam Electricity, state-owned utility) on principle maintenance works of the meteorological measurement stations of Type HelioScale ω (Tier 1) and Type HelioScale  $\varphi$  (Tier 2). The selected sites are listed in Table 1, see also Implementation Plan for more details.

The first installation mission took place from 22<sup>nd</sup> of August to 1<sup>st</sup> of September 2017. During the first installation mission, the Tier 1 stations were installed at the sites VNCEH (Central Highlands), VNTRA (Tri An) and VNHAN (Bac Ninh near Hanoi). All Tier 2 stations (2x Tier 2 stations for sites VNDAN (Da Nang) and VNSOB (Song Binh) plus 1x Tier 2 spare station) were additionally installed at VNCEH for calibration of the RSP sensors for 2 ½ weeks until the second installation mission started. The second installation mission was undertaken from 12th to 19th of September 2017 and the Tier 2 stations at VNDAN and VNSOB were installed. The spare station will be stored at the Head office of VATEC in Nha Trang. The inauguration with the local government, EVN and World Bank representatives was held on 20th of September in Song Binh (VNSOB).

The International Experts Joana Zerbin and Marko Schwandt from Suntrace GmbH traveled from Germany / Spain to the sites in Vietnam. Vietnam Applied Technical Co. Ltd (VATEC) as local partner company in this project supported Suntrace during the installation.

# Overview of Station Sites



Figure 1. Country map showing sites for solar measurement stations considered for the Vietnam ESMAP project.



Site name and description	Туре	Site code	Elevation	Latitude	Longitude
Hanoi region: Bac Ninh on rooftop of new EVN bldg.	Tier1	VNHAN	60 m	21.2013°N	106.0629°E
Da Nang on rooftop of EVN/CPC bldg. within the city	Tier2	VNDAN	24 m	16.0125°N	108.1865°E
Central Highlands region on ground before EVN bldg. near hydro spillway	Tier1	VNCEH	290 m	12.7535°N	107.8761°E
Song Binh station location on private house's rooftop	Tier2	VNSOB	62 m	11.2641°N	108.3452°E
Tri An region near HCMC on top of EVN bldg. near water spillway	Tier1	VNTRA	57 m	11.1024°N	107.0378°E

Table 1. Selected sites for solar measurement stations in Vietnam within the WB ESMAP program

This report gives an overview of the on-site installation of the Tier 2 station near Song Binh, on a private house rooftop. The installation took place between 17th and 19th of September 2017. The site code for this site is VNSOB.

Tier 2 stations are designed to be very robust and less sensitive to cleaning, as a Rotating Shadowband Irradiometer (RSI) measures GHI, DHI and DNI. In order to reach high quality data, the Tier 2 stations are equipped with a thermopile pyranometer, which complies with Secondary Standard requirements - highest quality Level of ISO 9060 (1990). Besides, a pluviometer measures rain precipitation, a barometer measures atmospheric pressure and a thermo-hygro sensor measures air temperature and relative humidity. Furthermore, a plug-and-play blueberry COMPACT data-logging system controls, stores and transmits the measured data of the stations. For power supply of the Tier 2 stations, a solar panel, batteries and charge controllers are installed. Additionally, a wind mast with a cup anemometer and a wind vane assembly ensures measuring accurate wind speed and direction. A soiling measurement system and a corrosion measurement kit were installed as additional equipment.



#### 2. LOCATION SONG BINH - VNSOB



Figure 2. Country map showing the site VNSOB for solar measurements for Solar Measurements in Vietnam ESMAP project.



Figure 3. Location of VNSOB relative to the extent of the region



#### **DESCRIPTION OF STATION** 3.

Installation details	Installation details					
Location	Vietnam – Song Binh station location on private					
	house's rooftop					
Site ID	VNSOB					
Station ID	1166					
Longitude/Latitude	16.0125°N /108.1865°E					
Elevation	24 m					
Date of commencement	19 <sup>th</sup> of September 2017					

Table 2.Overview of site parameters VNSOB

# Solar Measurement Station Tier 2

# Recorded meteorological parameters:

- global horizontal irradiance (GHI) in W/m<sup>2</sup>
- direct normal irradiance (DNI) in W/m<sup>2</sup>
- diffuse horizontal irradiance (DHI) in W/m<sup>2</sup>
- ambient temperature in °C
- relative humidity in %
- wind speed in m/s 10 m above ground
- wind direction 10 m above ground
- barometric pressure in hPa
- soiling measurement via 3 reference cells measuring global tilted (10°) irradiance (GTI) in W/m²
- corrosion measurement kit measuring the corrosivity of metals i.e. oxidation of metal. 4 different samples are used\_aluminum (Al), copper (Cu), steel (Fe) and zinc (Zn).
- rain gauge (pluviometer) measuring rain precipitation in mm.

### Additional information:

- The Reichert RSP4G (RSI), which is installed, is known to be a precise and robust instrument. Contrary to pyrheliometers, which are used in Tier 1 stations and require daily cleaning to reach its outstanding accuracy, it is sufficient to clean such RSI on a weekly basis.
- The Hukseflux SR20 is used in the RSI, which is equipped with dome heating system to reduce the influence of dew, but is not ventilated
- For Tier 2 stations, a 60 Wp photovoltaic panel, batteries and a charge controller are installed.
- As the roof of the private house near Song Binh is 4 m high, the wind mast was installed at a height of 6 m above rooftop.
- Signal deviations of the RSP sensor of the Tier 2 station for VNSOB were noticed during calibration. It was decided to replace it and re-checked.



# List of installed instruments and measurement sensors

No.	Instrument	Manufacturer	Model No.	Serial No.
1	Rotating Shadow-	Reichert	RSP-4G	17-03
	band Irradiometer			
2	Pyranometer 1	Hukseflux	SR20-D2	6997
3	Reference Cell 1	IKS	ISET Cell	02623
4	Reference Cell 2	IKS	ISET Cell	03089
5	Reference Cell 3	IKS	ISET Cell	02759
6	Data logger Blue-	Wilmers Messtech-	0141	1167
	berry COMPACT	nik		
7	Thermo-hygro Sen-	E+E	EE071	17110500025733
	sor			
8	Anemometer	Wilmers Messtech-	0293	1290
		nik		
9	Wind vane	Wilmers Messtech-	0318	20002437
		nik		
10	Corrosion meas-	Fraunhofer ISE	Samples: S155-15	7, Z155-157, A155-157,
	urement kit		C155-157	
11	Rain Gauge	Young	52203	TB13883

Table 3.List of installed instruments and measurement sensors at VNSOB



Figure 4. Photo of Tier 2 Station of type HelioScale  $\phi$  installed at VNSOB



#### 4. **HORIZON**



Figure 5. Horizon at VNSOB

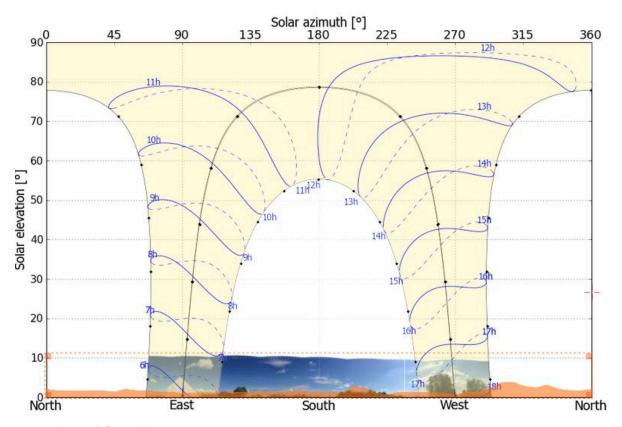


Figure 6. Sun path for VNSOB



#### 5. STATION COMMISSIONING

# Responsible staff for monitoring of the stations

# Standby Station Keeper

Name: Le Sy Phu

Address: Ban quan ly du an thuy dien 5, khu pho 3, Phuong My Binh, thanh pho Phan Rang, Thuy Chau, Ninh

Thuan

Mobile: +84 935612666 Mail: syphuqltd5@gmail.com

# Station Supervisor

Name: Tan Tien Nguyen

Address: 60A Cau Be, xa Vinh Thanh, Thanh pho Nha Trang, tinh Khanh Hoa

Mobile: +84 905707760 Mail: tiennt.vatec@gmail.com

# Station Supplier

Suntrace GmbH

Address: Grosse Elbstrasse 145c, 22767 Hamburg, Germany

Phone: +49 40 767 96 38 0 Fax: +49 40 767 96 38 20 Mail: meteo@suntrace.de

	Applied test	Details	Approved Yes/No	Comments
1	RSI	Ensure that the RSI sensor head is cleaned, horizontally leveled and aligned to the GEO-GRAPHIC north for Northern Hemisphere or to the GEOGRAPHIC south of Southern Hemisphere. Check that the shadow band is moving.	Yes	
2	pyranometer(s)	Check for any damage, condensation, check the glass surface for scratches/other damages, check ventilation motors (if any) are functioning properly. If any condensation and/or scratches on glass is/are found, replace or repair the instrument. Check the desiccant, replace if dehydrated.	Yes	



	Applied test	Details	Approved	Comments
			Yes/No	
3	pyrheliometer(s)	Check for any damage, condensation, check		No part of this
		the glass surface for scratches/other damages,		station. Not in-
		check ventilation motors (if any) are function-		stalled.
		ing properly. If any condensation and/or		
		scratches on glass is/are found, replace or		
		repair the instrument. Check the desiccant,		
		replace if dehydrated.		
4	reference cell(s)	Check for any damage, condensation, check	Yes	
		the glass surface for scratches/other damages,		
		check ventilation motors (if any) are function-		
		ing properly. If any condensation and/or		
		scratches on glass is/are found, replace or		
		repair the instrument. Check the desiccant,		
		replace if dehydrated.		
5	leve-	Check water levels for proper leveling, if in-	Yes	
	ve-	strument (cable) is aligned to GEOGRAPHIC		
	ling/positioning	North (Northern Hemisphere) or GEOGRAPH-		
	of horizontal	IC South (Southern Hemisphere). Correct if		
	pyranometer	necessary. Check if any parts are misplaced or		
		loose.		
6	sun tracker	Check if tracker is well fixed at the foundation.		No part of this
		Check for proper alignment of sun tracker		station. Not in-
		(GEOGRAPHIC North/South) by checking the		stalled.
		spot created and/or the leveling of the tracker		
		assembly. Spot should be created within a		
		specific range. Check for proper mechanical		
		functioning of the tracker.		
7	air temperature,	Check for correct installation, functionality and	Yes	
	rel. humidity	discernible external damage.		
	probe (ther-			
	mohygro)			
8	anemometer	Check for correct installation, functionality and	Yes	
		discernible external damage.		
9	wind direction	Check for correct installation, functionality and	Yes	
	vane	discernible external damage.		
10	further sensors,	Specify sensor(s)/instrument(s) in comments.	Yes	Rain gauge.
	instruments	Check for correct installation, functionality and		Corrosion Meas-
		discemible damage		urement kit, this will
				be exposed after 1
				year
11	weather housing	Weather housing of all sensors is proper and	Yes	
		fixed, check the piping for visible damages.		
		Replace if worn.		



	Applied test	Details	Approved Yes/No	Comments
12	PV-panel	Properly fixed to tripod, facing south at northern hemisphere and vice versa, no visible damages (cracks, scratches).	Yes	
13	loose parts	Check if any parts are misplaced or loose (sensors, antenna, PV panel, wind mas wires, etc.).	Yes	
14	cabling of all sensors	Check if the cabling of all sensors is done properly and fixed. Check the sensor cables for discernable damages.	Yes	
15	check power supply system	Check if the battery and the PV panel are correctly working and if the charge controller charges the battery.	Yes	
16	sensor connections to data logger	Check if the sensors are properly connected to the data logger (fixing cables to the corresponding port). Compare with connection plan.	Yes	
17	data logger sen- sor/communicati on configuration	Check the measurement values and correct configuration of the sensors in the data logger (type, unit, slope, offset, etc.). Correct if necessary. Update communication configuration (e.g. e-mail address) if necessary.	Yes	Internet provider: Viettel Mobile APN: e-connect
18	modem	Check if SIMcard is inserted and modem registers to GSM network. It should be possible to communicate with a remote server/computer properly.	Yes	
19	real time meas- urements	Check real time measurements using the data logger web interface, compare them with your observation and document them.	Yes	
20	tracker table, tripod & wind mast	Check if is steady and well fixed on the ground. Check bolts on the foundations.	Yes	Tracker table not part of the station.
21	fence, door, lock	Check the fence and door including its lock.	Yes	Station on roof top, ladder locked
22	horizon pictures	360° panorama picture from the view point of radiation sensors should be taken.	Yes	
23	station pictures	Take photos of all sensors and instruments and also of the whole station. The serial numbers should be seen.	Yes	
24	general view	Anything unusual? If NO write "Yes" for approved	Yes	
25	station keeper training and doc- umentation	Training of Station Keeper. Check the station documentation such as: analogy of serial numbers, station logbook, etc.	Yes	

Table 4. List of applied tests for commissioning at VNSOB



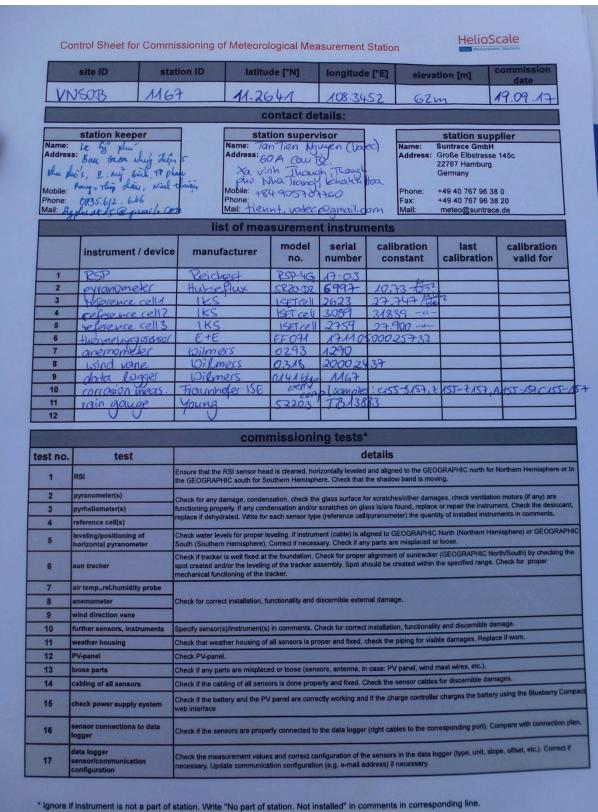


Figure 7. Commissioning Protocol page 1/3 VNSOB



To the same	site ID	etat	ion ID	latitude [°N]	longitude [°E]	elevation [m]	commission
							19.09.17
LVK	150B	M69		11.7641	108.3452	62m	171.0671
18	(modem)	nication	The second second second		mote server/computer property.	The second secon	
19	real time meas		Check real time r	neasurements using the data	logger web interface, compare	them with your observations an	d document them.
20	fence, door, loc			t(s) is/are steady and well fixe and door including its lock.	ed on the ground. Check bolts o	I the foundations of managers	
21	horizon picture		360° panorama p	icture from the view point of r	adiation sensors should be take	en.	
23	station pictures				d also of the whole station. The	serial numbers should be seen	
24	general view station keeper to	raining and	Anything unusual		ttation such as analog	y of serial numbers, station logi	book, etc.
25	documentation		Training of Station	n Keeper. Check the station of	locumentation such as, analog	y or serial numbers, statements	
d	ate:	Atei.	19.09.	17	time (local):	14:15	
T.				test res	ults		
	approved						
est no.	? Yes/No				comments*		
1	Vas						
2	Yes					The Land State of the Land Sta	
3	100	No	met	of Huis	station.	Vot insta	led.
4	yes	100	The state of the s				
5	1/25						
6	- T	No	part	of station	n. Wot in	stalled	
7	Ver	100	1	VF SIGNO	T. NO. III		
8	yes						
9	Yes						
0	Ves	Pair	Gare	go , Co	ecosion to	Darre Men	t. sustem
1	Ves	100	- Cone	5 , 0		A A A A A A A A A A A A A A A A A A A	1
2	Yes			(Fa) = 1 (Fa)			
3	Yes						
	yes						
	Ves						
1	yes						
	yes						
1	les						E I I I I
	les						
1	bs		STATE OF				

Figure 8. Commissioning Protocol page 2/3 VNSOB



	site ID	stat	ion ID lat	itude [°N]	longitude [°E]	elevation [m]	commission
UNS	50B	1/67		2641	108.3452	62m	19.09.17
21	I yes	10	idder of	oof top	locked		
22	Ves						
23	yes						
24	yes						
25	Yes						
				measure	ments		A SHARE
time (UTC)	measure	ement	value			comments	
6:56	wind	10m	3.15 m/s	N ATTA			
	wind o		161.670				
	Ghi SR	20	293.17	2			
	ali Ise	+1	299 -11-				
	_ 11 -	THE RESERVE TO SHARE	343				
	-n-		299				
	Temp 1		32°C				
	rel. bu	midity	63 % R	+			
	Pain		Omus				
	Ghi R		402.34				
	Dhi -		432,59-	All the second second			
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			A STATE OF THE STA				
Marie Contract			2031/21A	No.			
	1500 C. E.		MANAGER				
	SUE					4	
m	= 70bi		-7	lone-	supervisor	signature stat	lan bacman

Figure 9. Commissioning Protocol page 3/3 VNSOB



#### SUMMARY OF COMPLETED TASK 6.

- The installed equipment has been tested prior delivery for the project.
- The World Bank ESMAP Tier 2 solar measurement station at the location VNSOB is installed and commissioned successfully at the 19<sup>th</sup> of September 2017
- Recorded data will be downloaded daily via GPRS. Data will be provided on a monthly basis including a summary of the last recorded month. Data transfer works properly. A daily automatic quality control procedure is applied to the unprocessed raw data, this additionally to the by contract committed monthly delivery of post processed data including a monthly summary report.
- FTP servers will be set up for data sharing with EVN companies at all sites of this measurement campaign.



#### 7. PHOTO DOCUMENTATION



Figure 10. Tier 2 station in VNSOB (northern view)



Figure 12. Tier 2 station in VNSOB (western view)



Figure 11. Tier 2 station in VNSOB (northwestern view)



Figure 13. Tier 2 station in VNSOB during installation





Figure 14. Rain gauge (pluviometer)



Figure 15. Rain gauge (pluviometer) from top



Figure 16. Corrosion measurement kit



Figure 17. Foto group 1 after commissioning of VNSOB  $\,$ 

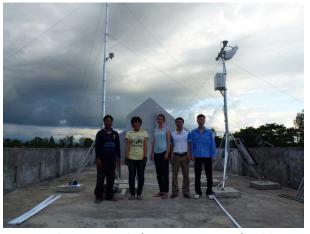


Figure 18. Foto group 2 after commissioning of VNSOB





Figure 19. General view of VNSOB station: wind mast (far left), Tier 2 station and soiling system (far right), rain gauge (center) and corrosion kit (near right).



# SOLAR MEASUREMENT CAMPAIGN IN VIETNAM

**SELECTION #: 1231900** 

# Installation Report: Tri An (VNTRA)

Suntrace Technical Documentation 21 September 2017

World Bank Group
ESMAP Renewable Energy Mapping Initiative

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#### 1. INTRODUCTION

The principal task of this installation project was the installation of six meteorological measurement stations at the selected sites including the training of the local staff from EVN (Vietnam Electricity, state-owned utility) on principle maintenance works of the meteorological measurement stations of Type HelioScale ω (Tier 1) and Type HelioScale  $\varphi$  (Tier 2). The selected sites are listed in Table 1, see also Implementation Plan for more details.

The first installation mission took place from 22<sup>nd</sup> of August to 1<sup>st</sup> of September 2017. During the first installation mission, the Tier 1 stations were installed at the sites VNCEH (Central Highlands), VNTRA (Tri An) and VNHAN (Bac Ninh near Hanoi). All Tier 2 stations (2x Tier 2 stations for sites VNDAN (Da Nang) and VNSOB (Song Binh) plus 1x Tier 2 spare station) were additionally installed at VNCEH for calibration of the RSP sensors for 2 ½ weeks until the second installation mission started. The second installation mission was undertaken from 12th to 19th of September 2017 and the Tier 2 stations at VNDAN and VNSOB were installed. The spare station will be stored at the Head office of VATEC in Nha Trang. The inauguration with the local government, EVN and World Bank representatives was held on 20th of September in Song Binh (VNSOB).

The International Experts Joana Zerbin and Marko Schwandt from Suntrace GmbH traveled from Germany / Spain to the sites in Vietnam. Vietnam Applied Technical Co. Ltd (VATEC) as local partner company in this project supported Suntrace during the installation.

# Overview of Station Sites



Figure 1. Country map showing sites for solar measurement stations considered for the Vietnam ESMAP project.



Site name and description	Туре	Site code	Elevation	Latitude	Longitude
Hanoi region: Bac Ninh on rooftop of new EVN bldg.	Tier1	VNHAN	60 m	21.2013°N	106.0629°E
Da Nang on rooftop of EVN/CPC bldg. within the city	Tier2	VNDAN	24 m	16.0125°N	108.1865°E
Central Highlands region on ground before EVN bldg. near hydro spillway	Tier1	VNCEH	290 m	12.7535°N	107.8761°E
Song Binh station location on private house's rooftop	Tier2	VNSOB	62 m	11.2641°N	108.3452°E
Tri An region near HCMC on top of EVN bldg. near water spillway	Tier1	VNTRA	57 m	11.1024°N	107.0378°E

Table 1. Selected sites for solar measurement stations in Vietnam within the WB ESMAP program

This report gives an overview of the on-site installation of the Tier 1 station in Tri An region, near Ho Chi Minh City, on top of an EVN building close to the Tri An dam near the water spillway. The installation took place between 28th and 29th of August 2017. The site code for this site is VNTRA.

Tier 1 stations are equipped with a robust and highly reliable pyrheliometer, a shaded pyranometer (which measures DHI), a non-shaded pyranometer (which measures GHI), and a 2-axis sun tracker with a shadow-ball assembly. Besides, a barometer measures atmospheric pressure and a thermo-hygro sensor measures air temperature and relative humidity. Additionally, a wind mast with a cup anemometer and a wind vane assembly ensures measuring accurate wind speed and direction. Furthermore, a plug-and-play blueberry COMPACT datalogging system controls, stores and transmits the measured data of the stations. For power supply of the Tier 1 stations, a solar panel, batteries and charge controllers are installed. At this site, a soiling measurement system and a corrosion measurement kit are also installed.



#### 2. LOCATION TRI AN – VNTRA



Figure 2. Country map showing the site VNTRA for solar measurements considered for the Vietnam ESMAP project.

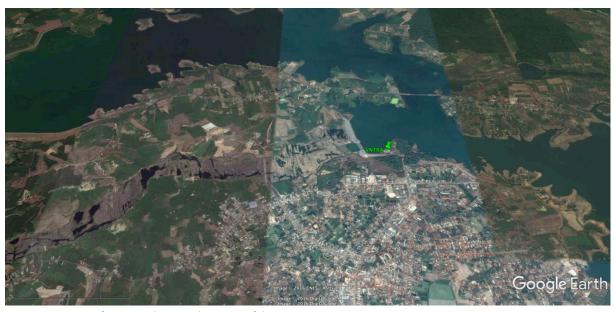


Figure 3. Location of VNTRA relative to the extent of the region



#### **DESCRIPTION OF STATION** 3.

Installation details					
Location	Vietnam – Tri An region near HCMC on top of EVN				
bldg. near water spillway, Tri An dam					
Site ID	VNTRA				
Station ID	1164				
Longitude/Latitude	11.1024°N/107.0378°E				
Elevation	57 m				
Date of commencement	29 <sup>th</sup> of August 2017				

Table 2.Overview of site parameters VNTRA

# Solar Measurement Station Tier 1

# Recorded meteorological parameters:

- global horizontal irradiance (GHI) in W/m<sup>2</sup>
- direct normal irradiance (DNI) in W/m<sup>2</sup>
- diffuse horizontal irradiance (DHI) in W/m<sup>2</sup>
- ambient temperature in °C
- relative humidity in %
- wind speed in m/s ca. 13 m above ground
- wind direction at ca. 13 m above ground
- barometric pressure in hPa
- corrosion measurement kit measuring the corrosivity of metals i.e. oxidation of metal. 4 different samples are used\_ aluminum (Al), copper (Cu), steel (Fe) and zinc (Zn).
- soiling measurement via 3 reference cells measuring global tilted (10°) irradiance (GTI) in W/m²

# Additional observations:

- As the EVN building's roof is ca.10 m high, a 3 m high wind mast was installed above the rooftop.
- For Tier 1 stations, a 250 Wp photovoltaic panel, batteries and a charge controller are installed.

# List of installed instruments and measurement sensors

No.	Instrument	Manufacturer	Model No.	Serial No.
1	Pyrheliometer	Hukseflux	DR-02	9312
2	Pyranometer 1 (DHI)	Hukseflux	SR30-01	2120
3	Pyranometer 2 (GHI)	Hukseflux	SR30-01	2124
4	Reference Cell 1	IKS	ISET Cell	02687
5	Reference Cell 2	IKS	ISET Cell	02691
6	Reference Cell 3	IKS	ISET Cell	02683
7	Data logger Blue-	Wilmers Messtech-	0141	1164
	berry COMPACT	nik		
8	Thermo-hygro Sen-	E+E	EE071	171105000249E8
	sor			



No.	Instrument	Manufacturer	Model No.	Serial No.
9	Anemometer	Wilmers Messtech-	0293	1292
		nik		
10	Wind vane	Wilmers Messtech-	0318	20003590
		nik		
11	Sun tracker includ-	EKO	STR-22G	S1510788
	ing shading assem-			
	bly			
12	Corrosion meas-	Fraunhofer ISE		Samples: S152-154,
	urement			Z152-154, A152-
				154, C152-154

Table 3.List of installed instruments and measurement sensors VNTRA



Figure 4. Photo of Tier 1 Station of type HelioScale  $\omega$  installed at VNTRA



#### 4. **HORIZON**



Figure 5. Horizon at VNTRA

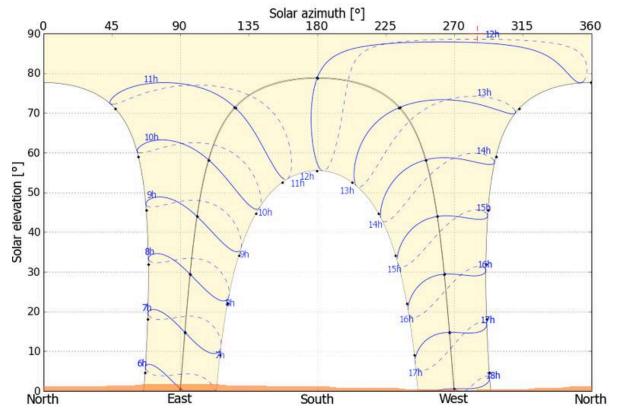


Figure 6. Sun path for VNTRA



#### 5. STATION COMMISSIONING

# Responsible staff for monitoring of the stations

# Standby Station Keeper

Name: Huynh Ngoc Cuong

Address: Thi tran Vinh An, huyen Vinh Cuu, tinh Dong Nai

Mobile: +89 974426699

Mail: huynhngoccuong@yahoo.com

# Station Supervisor

Name: Tan Tien Nguyen

Address: 60A Cau Be, xa Vinh Thanh, thanh pho Nha Trang, tinh Khanh Hoa

Mobile: +84 905707760 Mail: tiennt.vatec@gmail.com

# Station Supplier

Suntrace GmbH

Address: Grosse Elbstrasse 145c, 22767 Hamburg, Germany

Phone: +49 40 767 96 38 0 Fax: +49 40 767 96 38 20 Mail: meteo@suntrace.de

	Applied test	Details	Approved Yes/No	Comments
1	RSI	-	-	No part of station – not installed
2	pyranometer(s)	Check for any damage, condensation, check the glass surface for scratches/other damages, check ventilation motors (if any) are functioning properly. If any condensation and/or scratches on glass is/are found, replace or repair the instrument. Check the desiccant, replace if dehydrated.	Yes	
3	pyrheliometer(s)	Check for any damage, condensation, check the glass surface for scratches/other damages, check ventilation motors (if any) are functioning properly. If any condensation and/or scratches on glass is/are found, replace or repair the instrument. Check the desiccant, replace if dehydrated.	Yes	



	Applied test	Details	Approved	Comments		
	Applied test	Details	Yes/No	Comments		
			res/INO			
4	reference cell(s)	Check for any damage, condensation, check	Yes			
		the glass surface for scratches/other damages,				
		check ventilation motors (if any) are function-				
		ing properly. If any condensation and/or				
		scratches on glass is/are found, replace or				
		repair the instrument. Check the desiccant,				
		replace if dehydrated.				
5	leve-	Check water levels for proper leveling, if in-	Yes			
	ve-	strument (cable) is aligned to GEOGRAPHIC				
	ling/positioning	North (Northern Hemisphere) or GEOGRAPH-				
	of horizontal	IC South (Southern Hemisphere). Correct if				
	pyranometer	necessary. Check if any parts are misplaced or				
		loose.				
6	sun tracker	Check if tracker is well fixed at the foundation.	Yes			
O	Juli tracker	Check for proper alignment of sun tracker	103			
		(GEOGRAPHIC North/South) by checking the				
		spot created and/or the leveling of the tracker				
		•				
		assembly. Spot should be created within a				
		specific range. Check for proper mechanical				
		functioning of the tracker.				
7	air temperature,	Check for correct installation, functionality and	Yes			
	rel. humidity	discernible external damage.				
	probe (ther-					
	mohygro)					
8	anemometer	Check for correct installation, functionality and	Yes			
		discernible external damage.				
9	wind direction	Check for correct installation, functionality and	Yes			
	vane	discernible external damage.				
10	further sensors,	Specify sensor(s)/instrument(s) in comments.	-	Corrosion Meas-		
	instruments	Check for correct installation, functionality and		urement kit, this will		
		discemible damage		be exposed after 1		
				year		
11	weather housing	Weather housing of all sensors is proper and	Yes			
		fixed, check the piping for visible damages.				
		Replace if worn.				
12	PV-panel	Properly fixed to tripod, facing south at north-	Yes			
		ern hemisphere and vice versa, no visible				
		damages (cracks, scratches).				
13	loose parts	Check if any parts are misplaced or loose	Yes			
10	1003c parts	(sensors, antenna, PV panel, wind mas wires,	103			
		etc.).				
14	cabling of all	Check if the cabling of all sensors is done	Yes			
17	sensors	properly and fixed. Check the sensor cables	103			
	3C113U13	for discernable damages.				
		TOT CISCETTIANTE CATTIAGES.				



	Applied test	Details	Approved Yes/No	Comments
15	check power supply system	Check if the battery and the PV panel are correctly working and if the charge controller charges the battery.	Yes	
16	sensor connections to data logger	Check if the sensors are properly connected to the data logger (fixing cables to the corre- sponding port). Compare with connection plan.	Yes	
17	data logger sen- sor/communicati on configuration	Check the measurement values and correct configuration of the sensors in the data logger (type, unit, slope, offset, etc.). Correct if necessary. Update communication configuration (e.g. e-mail address) if necessary.	Yes	Internet provider: Viettel Mobile APN: e-connect
18	modem	Check if SIMcard is inserted and modem registers to GSM network. It should be possible to communicate with a remote server/computer properly.	Yes	
19	real time meas- urements	Check real time measurements using the data logger web interface, compare them with your observation and document them.	Yes	
20	tracker table, tripod & wind mast	Check if is steady and well fixed on the ground. Check bolts on the foundations.	Yes	
21	fence, door, lock	Check the fence and door including its lock.	Yes	Station on roof top, building well locked
22	horizon pictures	360° panorama picture from the view point of radiation sensors should be taken.	Yes	
23	station pictures	Take photos of all sensors and instruments and also of the whole station. The serial numbers should be seen.	Yes	
24	general view	Anything unusual? If NO write "Yes" for approved	No	
25	station keeper training and doc- umentation	Training of Station Keeper. Check the station documentation such as: analogy of serial numbers, station logbook, etc.	Yes	

Table 4. List of applied tests for commissioning at VNTRA



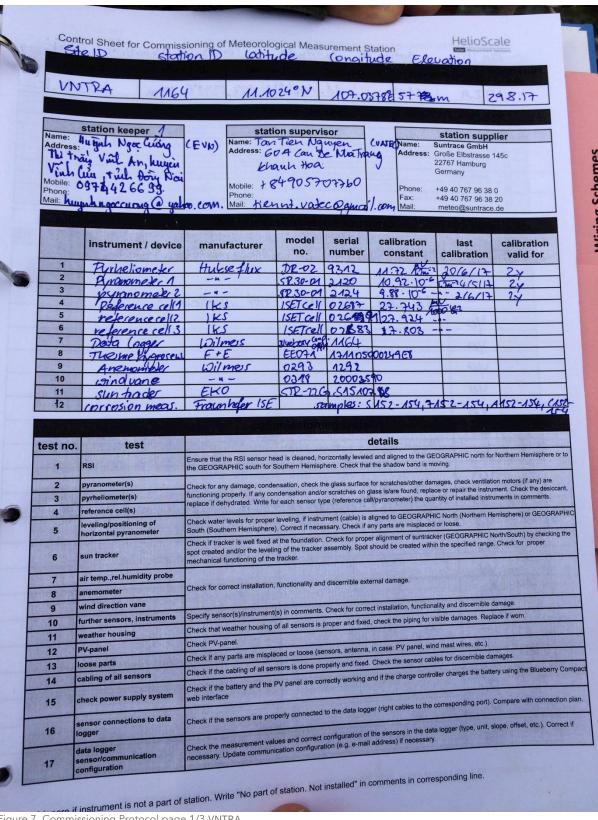


Figure 7. Commissioning Protocol page 1/3 VNTRA



VIV	ILA	Me	,4			easurement (ong		57 M	49	29.8.1	3
18	check communi (modem)	ication	II REMEMBER	possible to comm	nunicate with a re	mote server/comput	er property	T IV	983988	Market !	
20	real time measu tripod, wind ma	st	Check real ti	me measuremen	nts using the date	to a second		m with your obse	ervations and	document then	n.
22	fence, door, loci horizon pictures		Check the le	ince and door inc	cluding its lock	ed on the ground. Ch	NAME OF TAXABLE PARTY.		masus).		
23	station pictures general view station keeper training and documentation		solotos	180° panorama picture from the view point of radiation sensors should be taken. Take photos of all sensors and instruments and also of the whole station. The serial numbers should be seen. Anything unusual?  Training of Station Keeper, Check the station documentation such as: analogy of serial numbers, station logbook, etc.							
25			Anything uni								
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7	yes										
8	yes										
9	yes								1000		
10	yes	Corr	osion	Measu	emen	1 System	-will	be exa	posed	after 1	Yes
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12	yes										
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16		NE TELE									
17	yes										
	Yes										
18	Yes										
19	Yes										
20	Yas										

Figure 8. Commissioning Protocol page 2/3 VNTRA



Control Sheet for Commissioning of Meteorological Measurement Station Site ID Station ID (atitude Congitude elevation commission ID)  VMTRA 1164 11.1024°N 107.0378E 57 m 29.8.17  21 Yes Stationon 1001 top 15 wilding well locked  23 Yes  24 No  25 Yes	
(UTC) measurement value comments  09:07	
* Ignore if instrument is not a part of station. Write "No part of station. Not installed" in comments in corresponding line.	

Figure 9. Commissioning Protocol page 3/3 VNTRA



#### SUMMARY OF COMPLETED TASK 6.

- The installed station and spare parts have been tested prior to delivery for the project.
- The World Bank ESMAP Tier 1 solar measurement station at the location VNTRA is installed and commissioned successfully at the 29<sup>h</sup> of August 2017
- Recorded data will be downloaded daily via GPRS. Data will be provided on a monthly basis including a summary of the last recorded month. Data transfer works properly. A daily automatic quality control procedure is applied to the unprocessed raw data, this additionally to the by contract committed monthly delivery of post processed data including a monthly summary report.
- FTP servers will be set up for data sharing with EVN companies at all sites of this measurement campaign.



#### 7. PHOTO DOCUMENTATION



Figure 10. Tier 1 station at VNTRA



Figure 11. Wind mast measuring wind speed & direction and thermo-hygro sensor at VNTRA



Figure 12. Tier 1 station with wind mast and soiling measurement at VNTRA



Figure 13. Tier 1 station at VNTRA









Figure 15. Tier 1 station with data logger in the front at VNTRA



Figure 16. Corrosion measurement kit (left), soiling measurement system (front), wind mast (back) at VNTRA





Figure 17. Tier 1 station on the rooftop at VNTRA



Figure 18. Commissioning and station keeper training with EVN staff at VNTRA

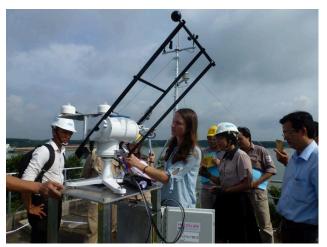


Figure 19. Commissioning and station keeper training with EVN staff at VNTRA



Figure 20. Commissioning and station keeper training with EVN staff at VNTRA



Figure 21. After commissioning with EVN staff at VNTRA