Ministry of Environment, Climate Change and Technology

Republic of Maldives

ACCELERATING RENEWABLE EENRGY INTEGRATION AND SUSTAINABLE ENERGY (ARISE) PROJECT

CTF Grant Number TF0B4305

Terms of Reference (TOR)

Capacity and Energy Yield Assessment Using Helioscope Software of Solar PV Installation Sites for Installation of Estimated 11MW to 14MW Grid-Tied Solar Photovoltaic Systems under DBFOOT Basis

A. BACKGROUND

The Republic of Maldives is a South Asian island country, located southwest of Sri Lanka and India. It is comprised of 1,192 coral islands grouped into 26 geographical atolls, spreading over an area of 115,300 km^2 and occupying a total land area of 224 km^2. Maldives is recognized as an upper middle-income economy by the World Bank, with a GDP growth rate of 6.99 % in 2019[1].

Out of the total 1,192 islands, 187 are inhabited, 123 are self-contained tourist resorts and 128 are used for other industrial and commercial activities. The total population of Maldives is 530,9532. The dispersed nature of the islands requires each island to have a separate power generation and distribution system. The powerhouses are operated mainly by three utility companies namely, State Electric Company Limited (STELCO), FENAKA Corporation Ltd. (FENAKA) and Male' Water and Sewerage Company Pvt. Ltd. (MWSC). Maldives has achieved universal electricity access with provision of 24 hours electricity service for all inhabited islands including resorts throughout the country in 2008.

By the end of 2018, the total installed generation capacity in Maldives stood as below3:

- Diesel based installed capacity: Diesel based installed capacity in inhabited islands stood at 319 MW, and around 210 MW across resort islands, therefore, making a total of ~530 MW
- Renewable based installed capacity: Total installed capacity of Renewable Energy (RE) Systems stood at 16.5 MW

To ensure energy security, the Government of the Republic of Maldives (GoM) has embarked on a plan to transform the electricity sector and the enabling policies and programs of the GoM makes the country an attractive destination for private sector investments in RE. The National Strategic Action Plan (2019-2023) (SAP) sets targets to increase the share of RE by 20% compared to 2018 levels and also GoM has recently announced its vision to achieve the ambitious goal of carbon neutrality by 2030.

There are several solar PV projects that have already been installed/awarded in the country through various modes under different programs. By the end of 2019, the total installed capacity of RE systems in the Maldives reached 20.5 MW.

[1] Source : https://data.worldbank.org/indicator/NY.GDP.MKTP.KD.ZG?locations=MV

[2] Census 2014. http://statisticsmaldives.gov.mv/nbs/wp-content/uploads/2015/12/census-leaflet-final-Page-1-2.jpg

[3] Source: https://www.environment.gov.mv/v2/en/download/10752

B. PROJECT DESCRIPTION

Maldives is seeking private sector investment pathways to address the financial challenges for renewable energy development in the country. The Accelerating Sustainable Private Investments in Renewable Energy (ASPIRE) project supported by guarantees from the International Development Association (IDA) and grant from the Scaling-up Renewable Energy Program (SREP) of the Climate Investment Funds (CIF) mobilized through the World Bank has made significant contributions in addressing the early stage challenges for developing RE projects in the Maldives, through private investments.

Two successful subprojects which include installation of 1.5 MW rooftop PV and 5MW land-based PV, have been rolled out through the ASPIRE project based on a standardized public-private partnership project framework backed by risk mitigation instruments. The third subproject for an installation of 11 MW land based solar PV is also ongoing.

As the current RE targets of the Maldives require a high penetration of variable renewable energy (VRE) to the island grids, modernizing and upgrading of the existing grid infrastructures and building complementing technology options for energy storage become necessary. In addressing this need, during December 2020, the World Bank has approved the Accelerating Renewable Energy Integration and Sustainable Energy (ARISE) project for further assisting the Maldives in its energy transition process.

The development objective of the ARISE project is to increase the generation capacity from renewable energy sources and facilitate the integration of VRE in the mini grids of Maldives islands. The ARISE project has a target of 36 MW new solar PV installations with an estimated cumulative 50MWh of Battery Energy Storage Systems (BESS), and grid infrastructure upgrades.

In preparation for the first phase of solar PV installations under the ARSIE project, 14 island grids comprising of the below islands have been selected and a total capacity range of 11-14 MW is expected based on currently identified sites. Hybridisation of these grids will result in Solar PV and BESS taking a significant share of the energy mix of the grid specially during day time, and lowering the overall reliance on diesel for power generation. In addition to the island grids listed below, the sites incorporated in this assessment (Annexure 1) includes PV installation sites for Addu city Meedhoo which is a site under the third subproject of ASPIRE.

1. L. Fonadhoo: 2 MW
2. L. Gan: 2.5 MW
3. L. Dhanbidhoo: 0.2 MW
4. L. Isdhoo: 0.4 MW
5. L. Kalaidhoo: 0.4 MW
6. L. Maabaidhoo: 0.5 MW
7. L. Maamendhoo: 0.5 MW
8. L. Kunahandhoo: 0.2 MW
9. L. Hithadhoo: 0.3 MW
10. L. Maavah: 0.5 MW
11. Lh. Naifaru: 1.5 MW
12. Dh. Kudahuvadhoo: 1.5 MW
13. GA. Villingili: 1.5 MW
14. Sh. Funadhoo: 1MW

C. OBJECTIVE OF THIS ASSIGNMENT

The aim of this assessment is to support the Ministry of Environment, Climate Change and Technology (MECT), GoM, to conduct a due diligence exercise for the deployment of identified sites in installing grid connected PV via private investment, and thus discovering the maximum achievable electric capacity for these sites. The outlined tasks will reduce the risks associated with resource estimation at the project level and improve project design and due diligence by private and public stakeholders.

D. SCOPE OF WORKS

The appointed consultant shall provide the following services to the MECT, GoM

1. Conduct an off-site/base-line plant capacity assessment
    - Locate each site using geographical co-ordinates
    - Determine the following for each site using HelioScope software tool
        - ✓Indicative solar PV array layout super imposed on Google image
        - ✓Estimated solar PV plant capacity based on available shadow free roof area/land space
    - Estimated annual energy generation based on local climatic data for year 1
    - Create report for each site
    - Compile site information in a spread sheet
    - Upload site specific reports and compiled list in an online data room which will be shared with bidders by the MECT, GoM
2. Asses site specific shading conditions for each site remotely/online using 3D Drone mappings, building structural drawings, or any other site related information provided by MECT and optimize/ fine-tune the capacity and yield assessments obtained in step 1, in respect to actual site features
    - Produce shading analysis report for each site based on accurate modelling of the site. Data from 3D drone maps shall be used to correctly identify height and position of all shade causing obstacles (adjacent buildings, walls, trees, etc) on or nearby to the site.
    - Fine tuning and verification of the initial capacity/yield assessment reports produced from step 1 to obtain optimum yield for PV plant in consideration:
        - ✓ Optimize and verify PV array layout[4] (orientation and tilt) for each site such that maximum possible area from all secured spaces are utilized and optimal yield is generated for each plant.
        - ✓ For specified sites (canopy-based structures for road sides or airport areas)[5] in the site list detailed in Annexure 1 estimate variation of plant capacity and output with varying angles of tilt and orientations (in increment of X degrees)

[4] Note that due to the issue of space limitations it is advised to eliminate only areas of critical shading (that cannot be addressed through design) and only a bare minimum shall be allocated where space margins are to be given for safety and maintenance of plant

[5] Proximity to airport or road areas raises concerns of glare concerns and thus in addition to yield assessments a separate glare analysis will be conducted (by others) to finalize PV module inclination and orientations. Hence range of tilt and orientations shall be assessed for such sites.

- ✓ Assess the characteristic components such as approximate length of DC/AC cables, PV modules, inverter features/types etc and finalize electrical design inputs
- ✓ Revised estimate of maximum solar capacity for each site based on actual usable area
- ✓ Revised estimated annual energy generation based on shading and other site-specific conditions

- Recommend height levels to be maintained for shade creating objects such as trees
- Recommended minimum heights for the canopy-based structures to avoid shading from adjacent buildings and related structures and height to be maintained for objects such as trees

3. Yield assessment and shading analysis reports for each site to consider two options of PV modules; i.e. a base case with widely used wattage panels (300-400W range) and high-power case with recently available options of high wattage (670Wp) / large-format /bi-facial PV modules in the market.
4. Summary of assessment output for all the sites compiled in an excel sheet. Yield assessment output for all the scenarios covered in the scope of works detailed above shall be presented.
5. Comparative analysis for each site on installation capacity and performance subject to actual shading conditions for the site that from a shade free installation at the site. Update site specific reports and compiled list in the online data room which will be shared with bidders by the MECT.
6. Attending to specific requests from MECT for alternative analysis for any of the site listed in Annexure 1 such as updating the optimal Helioscope reports for minor changes such as consideration of an alternative tilt/orientation to cater for a particular design requirement

Note: In undertaking the above study, the consultant shall ensure coordination with the MECT advisors at all times. Also, to enhance accuracy it is advisable to compare the consultant's choice of weather data set with the weather data set for Maldives published by ESMAP from the solar resource mapping taken at measurement sites of Maldives6. If significant differences it is ideal to base the assessment on ESMAP weather data set.

E. FACILITIES TO BE PROVIDED BY THE CLIENT

The following details related to sites included in this assignment will be shared via a google data drive

- ✓ Site List (Also attached in annex 1)
- ✓ Drone maps of the sites
- ✓ Building layouts and drawings for rooftop sites

F. DELIVERABLES

Based on site assessment and use of HelioScope tool, a web-based data room will be created in google drive which will contain the following information for each site. Separate folders will be created for each project site.

- ✓ Geographical co-ordinates of identified site

[6] https://documents.worldbank.org/en/publication/documents-reports/documentdetail/444811564035369373/solar-resource-and-pv-potential-of-the-maldives-24-month-solar-resource-report

- ✓ AutoCAD diagram of conceptual design (PV array layout, structure height etc)
- ✓ Electrical design generated from software (SLD, BoM)
- ✓ Standard Helioscope generated Annual production report for each site to cases listed below providing details on plant DC/AC name plate capacities, Annual production, performance ration, plant specific yield (kWh/kWp), etc with details of key plant components such as inverters, modules and cable length and sizing
    - Base case PV modules
    - High wattage case PV modules
    - For both options of PV modules each site shall have the optimum helioscope report or helioscope report for range of tilt and orientations in increments of particular degrees as applicable
- ✓ 3D shading analysis report for each site
- ✓ Helioscope project files
- ✓ Summary file in excel

G. TIMELINE

Desktop assessment for preliminary setup for Helioscope assessment (Sites with coordinates)	7 days from day 1
Initial Helioscope report generation	14 days from day 1
Updated annual production reports and shading reports for site specific condition (any revisions to previous versions based on drone footage analysis etc)	28 days from day 1
Creation of data room and uploading final reports for all the sites covering details of aspects under D deliverables	42 days from day 1

H. QUALIFICATION REQUIREMENT

- Experience in successful delivery of at least 3 similar assignments in the last 5 years.
- Consultancy team to comprise the following experts at a minimum:
    - Solar PV engineering expert with minimum 8 years of experience in development of solar PV projects
    - Electrical engineer with minimum 5 years of experience

I. EVALUATION

The technical proposal will be evaluated using the following criteria:

No.	Criteria	Points
1	Adequacy and quality of the proposed methodology, and work plan in responding to the Terms of Reference.	40
2	Key experts	50
3	Bidders experience and competence for the Assignment.	10
	Total Points	**100**
	Pass % for each Technical Score	=> 70%

Contract will be awarded to the substantially responsive bidders with a pass marks and with the lowest evaluated price.

Annexure 1: List of identified sites for PV installation

No	Atoll	Island	PV Type	Site description	Coordinates	Area (m2)	Est kW (based on area)	Min Cumulative PV (MW)	Helioscope for varying tilit & orientations
1	Laamu	Hithadhoo	Canopy structure	Area 1 - Near Harbour	1°48’4.79’’N, 73°23’17.28’’E	450	56	0.3	
			Canopy structure	Area 2 – Near Hithadhoo school	1°47’58.50’’N, 73°23’15.81’’E	325	40		
			Canopy structure	Area 3 – Park Boundary	1°48’0.11"N, 73°23’18.36"E	700	87		
			Canopy structure	Area 4 – Cemetery	1°48’0.67"N, 73°23’26.22"E	200	25		
			Canopy structure	Area 5 – In front of Harbour	1°48’2.05"N, 73°23’18.22"E	900	112		
2	Laamu	Kunahandhoo	Canopy structure	Area 1- Near Kunahandhoo school	1°47'5.67"N, 73°22'7.96"E	1537	192	0.2	
			Canopy structure	Area 2 - Near Hukuru Miskiy	1°47'4.12"N, 73°22'11.59"E	697	87		
			Canopy structure	Area 3 - Near Hukuru Miskiy	1°47'4.59"N, 73°22'10.77"E	499	62		
			Canopy structure	Area 4 - Near island office	1°47'4.27"N, 73°22'7.45"E	334	41		
3	Laamu	Maabaidhoo	Canopy structure	Area 1- Near public water tanks	2° 1'27.99"N, 73°31'54.27"E	2972	371	0.3	
4	Laamu	Maamendhoo	Canopy structure	Area 1 - Near Maamendhoo Council	1°49'8.95"N, 73°23'23.31"E	1186	148	0.5	
			Canopy structure	Area 2- Boundary of Mortuary	1°49'5.65"N, 73°23'21.05"E	795	99		
			Canopy structure	Area 3 - Compound of Maamendhoo council	1°49'8.04"N, 73°23'22.33"E	72	9		
			Canopy structure	Area 4 - Park Near Harbour	1°49'9.90"N, 73°23'20.98"E	390	48		

No	Atoll	Island	PV Type	Site description	Coordinates	Area (m2)	Est kW (based on area)	Min Cumulative PV (MW)	Helioscope for varying tilit & orientations
			Canopy structure	Area 5 - Near harbour (Commercial plots)	1°49'13.63"N, 73°23'19.55"E	680	85		
			Canopy structure	Area 6 - In front FENAKA	1°49'16.98"N, 73°23'18.27"E	460	57.5		
			Canopy structure	Area 7 - Near Maamendhoo School	1°49'12.78"N, 73°23'18.26"E	528	66		
5	Laamu	Maavah	Canopy structure	Area 1- Near Harbour	1°53'8.73"N, 73°14'51.70"E	1012	126	0.5	
			Canopy structure	Area 2 - Volley court	1°53'6.16"N, 73°14'44.99"E	419	52		
			Canopy structure	Area 3 - Futsal ground	1°53'4.10"N, 73°14'46.17"E	280	35		
			Canopy structure	Area 4 - Netball court	1°53'5.62"N, 73°14'46.42"E	160	20		
			Canopy structure	Area 5 - Near cemetery (1)	1°53'6.72"N, 73°14'35.66"E	732	91.5		
			Canopy structure	Area 6 - Near cemetery (2)	1°53'8.30"N, 73°14'35.55"E	323	40		
			Canopy structure	Area 7 - Zuvaanunge Hiya	1°53'5.87"N, 73°14'35.66"E	874	109		
6	Laamu	Isdhoo	Canopy structure	Area 1 - Outdoor gym	2° 7'47.90"N, 73°35'6.74"E	2435		0.4	
			Canopy structure	Area 2 - Plot in Island South side	2° 7'25.78"N, 73°34'35.10"E	2101			
7	Laamu	Kalaidhoo	Canopy structure	Area 1 - Near football ground	2° 6'36.83"N, 73°33'40.90"E	3687	460	0.4	
8	Laamu	Fonadhoo	Canopy structure	Area 2- Dhandhubin plot	1°50'31.90"N, 73°30'30.74"E	1363	170	2	
			Canopy structure	Area 5- Near rowhouse mosque	1°50'30.31"N, 73°30'27.76"E	1282	160		

No	Atoll	Island	PV Type	Site description	Coordinates	Area (m2)	Est kW (based on area)	Min Cumulative PV (MW)	Helioscope for varying tilit & orientations
			Canopy structure	Area 6 - B-143 Dhandu	1°50'19.48"N, 73°30'17.45"E	959	119		
			Canopy structure	Area 7 - B-143 Dhandu	1°50'22.28"N, 73°30'18.00"E	464	58		
			Canopy structure	Area 8 - B-143 Dhandu	1°50'21.52"N, 73°30'22.28"E	1049	131		
			Canopy structure	Area 12 - Infront of school	1°50'1.17"N, 73°30'0.50"E	3148	393		
			Canopy structure	Area 13	1°49'55.86"N, 73°29'57.23"E	152	19		
			Canopy structure	Area 14	1°49'51.56"N, 73°29'52.98"E	678	84		
			Canopy structure	Area 15	1°49'49.83"N, 73°29'54.45"E	486	60		
			Canopy structure	Area 16	1°49'50.88"N, 73°29'57.52"E	222	27		
			Canopy structure	Area 17	1°49'51.34"N, 73°29'58.43"E	111	13		
			Canopy structure	Area 18	1°49'40.26"N, 73°29'42.13"E	989	123		
			Canopy structure	Area 19	1°49'38.21"N, 73°29'41.79"E	176	22		
			Canopy structure	Area 20	1°49'32.96"N, 73°29'31.68"E	152	19		
			Canopy structure	Area 21	1°49'24.06"N, 73°29'20.39"E	1496	187		
			Canopy structure	Area 22 - Harbour Area - I	1°50'7.58"N, 73°30'4.22"E	980	122		
			Canopy structure	Area 22 - Harbour Area - I	1°50'7.58"N, 73°30'4.22"E	859	107		

No	Atoll	Island	PV Type	Site description	Coordinates	Area (m2)	Est kW (based on area)	Min Cumulative PV (MW)	Helioscope for varying tilit & orientations
			Canopy structure	Area 23 - Harbour Area - II	1°50'7.58"N, 73°30'4.22"E	232	29		
			Canopy structure	Area 23 - Harbour Area - II	1°50'7.58"N, 73°30'4.22"E	675	84		
9	Laamu	Gan	Canopy structure	Gan Link Road Median strip (23 sections)	1°55'2.48"N, 73°32'35.14"E	17700	2212	2.5	✓
10	Laamu	Dhanbidhoo	Canopy structure	Area 1- Farm land	2° 5'59.40"N, 73°32'47.31"E	1997	249	0.2	
11	Dhaalu	Kudahuvadho	Canopy structure	Island council approvals of identified sites ongoing		13192		1.5	
12	Lhaviyani	Naifaru	Canopy structure	Licence track	5°26'31.40"N, 73°21'46.83"E	1161	145	1.5	
			Canopy structure	Ifthithaahee Magu 40.27 A	5°26'40.85"N, 73°21'46.95"E	241	30		
			Canopy structure	Ifthithahee magu 40.27 B	5.444725°, 73.362962°	211	26.		
			Canopy structure	North Harbour Pavement I	5°26'38.41"N, 73°22'3.97"E	1110	139		
			Canopy Structure	North Harbour Pavement II	5.445094°, 73.367668°	255	32		
			Rooftop (New)	100 Housing units Block A roof	5.441391°, 73.362984°	881	110		
			Rooftop (New)	100 Housing units Block B roof	5.441693°, 73.363173°	881	110		
			Rooftop (New)	100 Housing units Block C roof	5.441693°, 73.363173°	881	110		
			Rooftop (New)	100 Housing units Block D roof	5.441693°, 73.363173°	881	110		
			Canopy structure	100 Housing units Block A parking I & II	5.441391°, 73.362984°	227	28		

No	Atoll	Island	PV Type	Site description	Coordinates	Area (m2)	Est kW (based on area)	Min Cumulative PV (MW)	Helioscope for varying tilit & orientations
			Canopy structure	100 Housing units Block B parking I & II	5.441391°, 73.362984°	227	28		
			Canopy structure	100 Housing units Block C parking I & II	5.441391°, 73.362984°	227	28		
			Canopy structure	100 Housing units Block D parking I & II	5.441391°, 73.362984°	227	28		
			Rooftop	Madhrasathul Ifthithaah	5°26'38.66"N, 73°21'52.52"E	2690	336		
			Rooftop	Multipurpose building roof	5°26'39.19"N, 73°21'47.94"E	450	56		
			Rooftop	Ekuveni Roof	5°26'42.11"N, 73°21'50.98"E	530	66		
			Rooftop	Near fire building (40.15)	5°26'30.94"N, 73°21'53.98"E	40.15	5		
			Structure mount	40.38 D	5°26'55.49"N, 73°21'54.27"E	198	25		
			Rooftop	Gogreen park	5.448117°, 73.366051°	760	95		
			Rooftop	Dhanaal	5.443451°, 73.363828°	645	81		
			Rooftop	Indoor sports complex	5.444976°, 73.364108°	530	66		
			Rooftop	Community cente	5.444317°, 73.367183°	145	18		
			Rooftop	Atoll council	5.443387°, 73.367550°	110	14		
			Rooftop (New)	Office new building	5.443116°, 73.367792°	250	31		

No	Atoll	Island	PV Type	Site description	Coordinates	Area (m2)	Est kW (based on area)	Min Cumulative PV (MW)	Helioscope for varying tilit & orientations
			Rooftop	Rahvehinge	5.443009°, 73.367299°	125	16		
			Canopy structure	Tiny park	5.441035°, 73.365855°	726	91		
			Canopy structure	40.15	5.441941°, 73.365035°	246	31		
			Canopy Structure	40.38 D	5°26'55.49"N, 73°21'54.27"E	198	24.75		
			Rooftop	Island council Office new building	5°26'35.22"N, 73°22'4.23"E	250	31		
13	GA	Villingili	Canopy structure	Site identification and securing ongoing				1.5	
14	Shaviyani	Funadhoo	Canopy structure	Area 1- Airport side road section 1	6° 9'50.28"N, 73°17'19.42"E	1189	149	1	✓
			Canopy structure	Area 2- Airport side road section 2	6° 9'26.44"N, 73°17'14.90"E	3316	415		✓
			Canopy structure	Area 3- Opposite side of airport	6° 9'37.42"N, 73°17'20.02"E	2787	348		✓
			Canopy structure	Area 4 - Park section 1	6° 9'4.32"N, 73°17'16.56"E	185	23		
			Canopy structure	Area 5- Park section 2	6° 9'1.67"N, 73°17'17.01"E	185	23		
			Canopy structure	Area 6- Park section 3	6° 8'59.46"N, 73°17'17.22"E	185	23		
			Canopy structure	Area 7- Park section 4	6° 8'56.99"N, 73°17'17.64"E	185	23		
NEW SITES UNDER 21 MW BID (Lot 2 - 11 MW Land based solar)									
15	Seenu	Meedhoo	Canopy structure	Near Protected area	0°35'21.12"S, 73°14'8.25"E	10000	1000	1	