ITTrms

UNDP

2018 -V2

Inception Report

CONDUCTING A NATIONAL PHOTO VOLTAIC RESOURCE ASSESSMENT STUDY/ RESEARCH AND TRAINING IN BANGLADESH FOR SREPGEN PROJECTS OF UNDP BANGLADESH.

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Content

Acronyms:

GoB	Government of Bangladesh
RE	Renewable Energy
SREDA	Sustainable and Renewable Energy Development Authority
PV	Photo Voltaic
GHI	Global Horizontal Irradiance
GHG	Green House Gas
RBIS	River Basin Information System
CSV	Comma Separate Value
SEVIRI	Spinning Enhanced Visible and Infrared Imager

1 INTRODUCTION

1.1 BACKGROUND

Power Division, Ministry of Power Energy and Mineral Resources, Government of Bangladesh (GoB) is implementing GEF-Funded Project "Development of Sustainable Renewable Energy Power generation (SREPGen)". The objective of the Project is to reduce the annual growth rate of Green House Gas (GHG) emissions from the fossil fuel-based power generation by exploiting Bangladesh's renewable energy resources for electricity generation. In this project UNDP is working with GoB as an implementing partners to foster energy access for poor people. The basic approach of the Project will be to promote renewable energy in Bangladesh through the recently established Sustainable and Renewable Energy Development Authority (SREDA).

For Bangladesh to achieve a greater share of renewable energy (RE) in its energy mix, the project has four main components that will:

(i) transform SREDA to evolves into a facilitation center to support private sector RE investment development; enable regulators to determine fair flexible tariff structures, develop RE power plans, and adopt RE power management and incentive regulations; bring confidence to private RE investors; and increase the number of approved RE projects;

(ii) increase capacities of relevant government agencies to generate, process, obtain and disseminate reliable RE resource information for use by GoB and potential project developers and investors;

(iii) increase affordability and access to photovoltaic solar power and associated livelihood benefits for low income households;

(iv) account increased shares of renewable energy into Bangladesh's power generation mix;

According to renewable energy policy 2009, the Government of Bangladesh is committed to facilitate both private and public-sector investments in renewable energy projects to substitute indigenous non-renewable energy supplies and scale up contributions existing renewable energy-based electricity production. The demand for solar energy utilization for thermal and photo voltaic (PV) applications is increasing rapidly in Bangladesh. In this regard, SREPGen Project will support the SREDA to become a strong renewable energy facilitation unit bringing confidence to private investors. Mechanisms to promote broader investment will be developed, including regulations policies, tariffs and incentives. The project will also enable government agencies to measure, obtain, generate and disseminate reliable renewable energy resource information (i.e. investment grade wind, solar and biomass data).

Generally, the design of solar energy systems need to be tailored depending upon the solar energy availability at a specific location. Hence, the knowledge of the availability of solar radiation and its intensity distribution at the place of interest are the primary requirements for the designer of solar energy systems. Usually, solar radiation measurement instrument installed at national meteorological agencies. However, Bangladesh Meteorological Department has no solar radiation measurement instrument installed in any of its existing station. Therefore, availability of this important information is rather restricted or not available at all.

To overcome this situation, the proposed project will install solar irradiance monitoring stations at different locations in Bangladesh. Apart from this National PV resources assessment study will be conducted, which will inform the spatial and temporal patter of solar irradiance in Bangladesh. Subsequently, SREDA officials will be trained also to handle the equipment to be installed under this project and other technical aspects. This project is combined with research and study where data will be fed by the 10 Nos. solar irradiance monitoring station across Bangladesh.

1.2 OBJECTIVES

The project has four key objectives which includes:

1. Installation of 10 Nos. solar radiation station
2. Designing of monitoring design of the solar radiation station
3. Development of a national solar PV resources assessment report
4. Training and capacity building for SREDA officials

2 WORK PROGRAM AND IMPLEMENTATION PLAN

2.1 DETAILED WORK PROGRAM AND METHODS

2.1.1 Project Approach

Through this project ITTrms will install 10 Nos. solar irradiance monitoring station across Bangladesh. Next to this a high quality solar irradiance study will be conducted which will inform the spatial and temporal pattern of solar irradiance in Bangladesh. The detail project approach is described below-

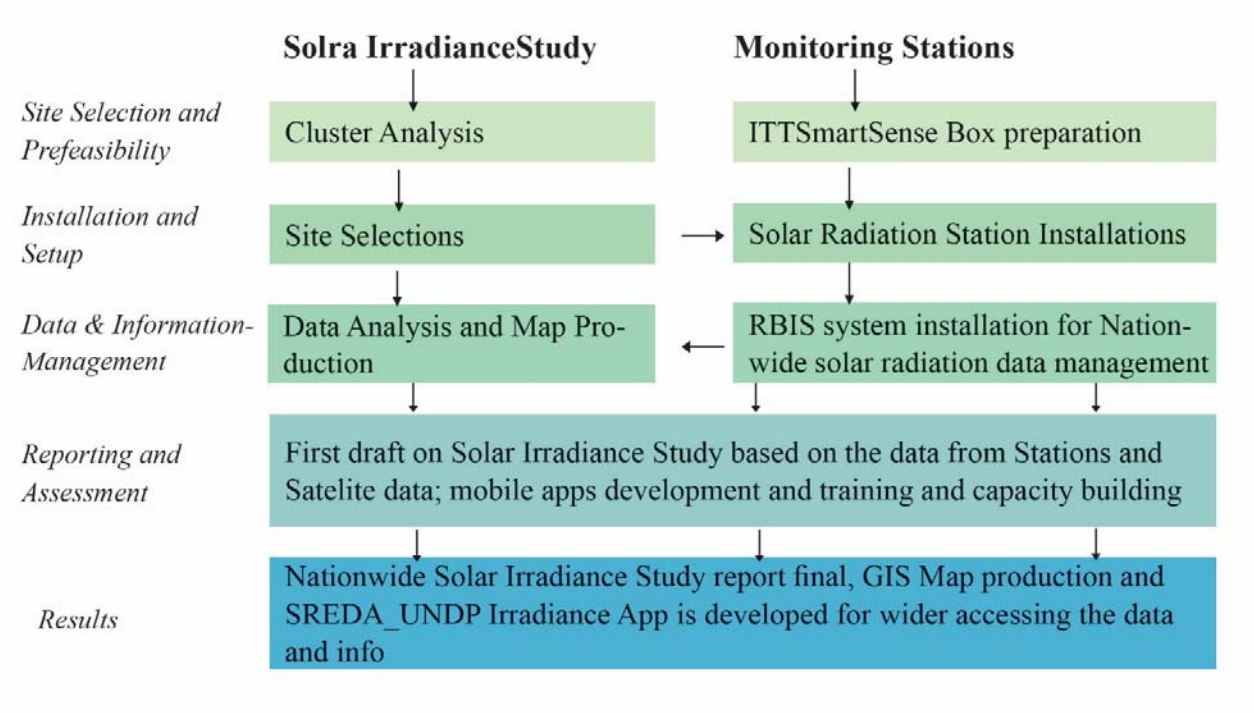

Figure-1: The overall project approach

A. Site Selection and Prefeasibility Study

A prefeasibility study will be conducted to determine sites to measure solar irradiance, based on a cluster analysis and geo-statistics. The Optimal Cluster Selection method is applied, which is a clustering process and validation methodology to select an optimal number of clusters from an initial given set of Global Horizontal Irradiance (GHI) measurements. This method is applied to reveal the number of required ground-based stations and their spatial representativeness for sufficient monitoring of surface solar irradiance in Bangladesh.

There are two main components in the proposed methodology. Firstly, the long term mean monthly GHI data will be evaluated. The mean GHI would provide an approximation about the radiation pattern of the study site and accordingly the distribution of the station can be fixed. However, very often the readily available GHI data is time consuming and involve significant cost. In case the data is not available, satellite-based cloudiness data will be than used for this study. An example of the output of this cluster analysis shown in figure -2

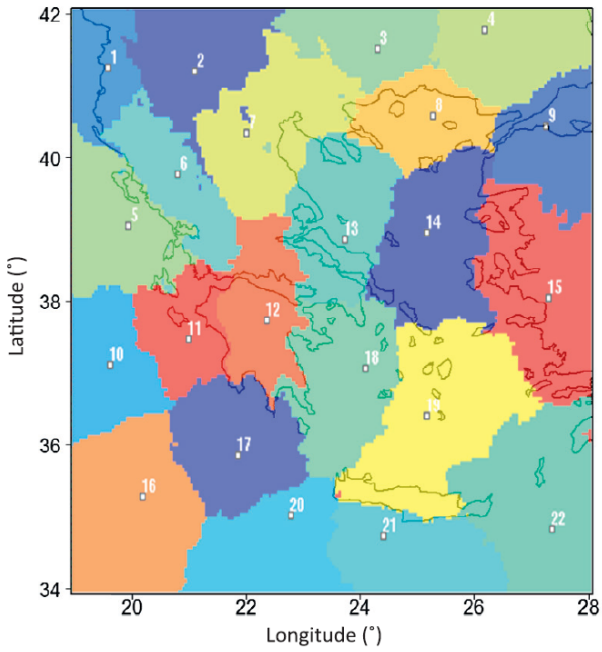

Fig-2: An example of clustering structure of Greece. The figure represents an optimal spatial partition of the area over Greece into 22 clusters as derived from the application of satellite-based method. Some domains are presented in the same color, although they are classified differently

Based on the results from Cluster analysis, at least 15 suitable locations would be selected. Pyranometers require regular maintenance and cleaning in order to maintain consistency and accuracy of the collected data. 3G/ Wifi communication would be used to upload the recorded datasets to webserver. Therefore, all the selected locations should have proper phone reception and a responsible personal who would be taking care for regular maintenance of the stations. These criteria would also be considered during the shortlisting of final sites for installation. While selecting the site selection, personnel from SREDA will be involved to determine the exact location of the station. Based on the mentioned criteria, SREDA will finalize the appropriate site. As one of the goal of this project is to technology transfer, therefore the personnel of SREDA will jointly work with ITTrms to install the devices. In addition to this, the local personnel will be trained how to monitor and manage the devices in case of certain failure.

B. Installation and Setup

ITT has extensive research experience in developing sensor technology. Under this framework, ITTSmartSense technology has been applied to enable research and allow the wider community to monitor the environment in a cost-effective manner. Traditional industrial production is often costly and may not provide the complete solution of a total monitoring system. For example, industrial production often provides equipment, but no data management support or data integration solutions upon which the whole monitoring activities will be implemented. With industrial production, additional support is needed, or other agencies must be commissioned to accomplish the tasks of data acquisition and data management. The ITTSmartSense package provides not only the equipment, but also offers a complete solution of data transmission, data integration in a central server and also helps to transfer data into

appropriate information for stakeholders. For this study, 10 pyranometer will be used to detect solar radiation at different locations across Bangladesh. To cover the state-of-art way of collecting solar radiation across Bangladesh, two different approaches have been selected for solar radiation monitoring station. Out of 10 pyranometers, 7 sites will monitor GHI and three locations will monitor Diffuse Irradiance along with GHI together. Which means, 4 sites will monitor only GHI and 3 sites will monitor GHI and Diffuse irradiance. Therefore, altogether 10 stations will be implemented at 7 sites. Additional parameters, e.g., temperature, pressure, humidity and wind speed will be monitored at each site.

Additionally, access to monitor the solar irradiance data through the central server at ITTSmartSense webportal will be provided. A mobile app will be developed for directly accessing the solar irradiance data from the stations. This will ensure real-time data access, thus providing nationwide information on solar irradiance.

Each station will record data each 30 second, which will be aggregate and averaged for providing data based on minute, hours and daily basis. The data will be transmitted every day to the central server. Before deploying the sensors, it will be installed here at TH Köln where other pyranometer was installed to check the accuracy of sensor and will be compared with those.

The system architecture and technical specifications of the solar irradiance monitoring stations are presented below.

System Architecture:

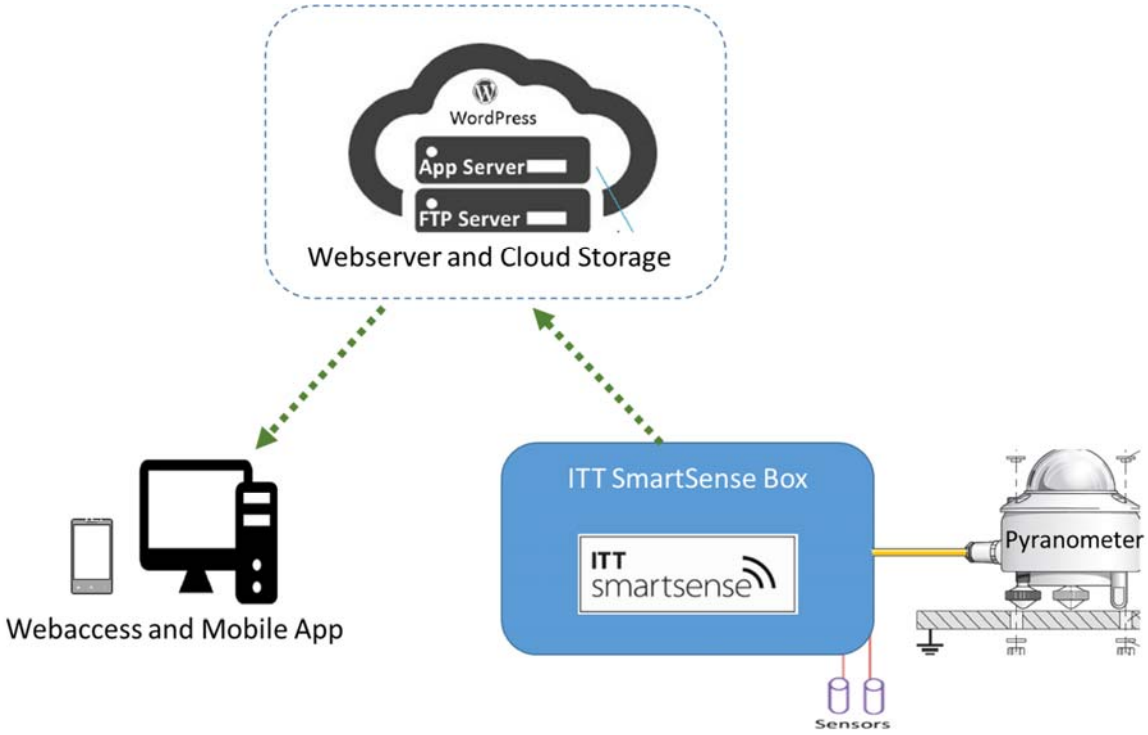

Fig-3: ITTSmartsense System Architecture and management system

"ITT Smart Sense Solar Irradiation" box is state of the art data logger that can provide remote monitoring of solar irradiation. The box is compatible with state-of-the-art Pyranometer and solar radiation sensors. It is bundled with software platform for free of the charge. The radiation measurements can be stored and accessed remotely via Smart Sense web portal. The data logger has 2 GB built-in storage and will retain up to 10 million data set entries (each of 200bytes). It comes with three additional input ports to connect additional pyranometers or industrial sensors (temperature, wind-speed etc.) if required. The device transfers the measured radiation and other sensor data wirelessly using a cellular network. However, there is possibility to replace cellular connectivity with other wireless radio technologies like Wifi, Sigfox, LoRa WAN and Xbee.

Features:

- Powered by Rechargeable internal Lithium polymer battery
- IP67 Weather proof protection – The device can withstand harsh weather conditions like rain, wind, snowfall etc.
- Supports multiple radio technologies to send measured data to the web server via HTTP/FTP.
- Bundled with online platform to access the radiation data remotely.

Technical Specifications:

Enclosure

- Material: polycarbonate
- Sealing: polyurethane
- Cover screws: stainless steel
- Ingress protection: IP65
- Impact resistance: IK08

Microcontroller: ATmega1281
Clock speed: 14.7456 MHz
Memory: SRAM - 8 kB, EEPROM - 4 kB, FLASH - 128 kB
Number of Input ports/channels: 4
Sensor Communication: Modbus RTU
Internal Memory: 2 GB

Supported radio technologies: GSM/GPRS (default), Wifi, Sigfox, Xbee, LoRa WAN
Data Communication Protocol: HTTP
Weatherproof: Yes
Power Source: Battery and Solar Panel
Environmental

- Ambient temperature (min.): -10 °C
- Ambient temperature (max.): 50 °C
- Approximate weight: 500 g

SMP 10 Pyranometer:

According to International Standard ISO 9060:1990 and the World Meteorological Organisation (WMO) a pyranometer is the designated type of instrument for the measurement of hemispherical (global or diffuse) solar radiation integrated over the wavelength range from 0.3 -m to 3 -m (300 nm to 3000 nm). State-of-the-art Secondary standard SMP 10 pyranometer from Kipp&Zonnen will be used to collect the irradiation measurements. The SMP10 has an internal drying cartridge that will last for at least 10 years if the housing is not opened. This minimizes maintenance significantly. This is the state-of-the-art

pyranometer used by several research institutes, universities and numerous other public/private organizations.

Specifications of SMP 10 Pyranomter

Spectral range (50% points)	**285 to 2800 nm**
Classification to ISO 9060:1990	Secondary Standard
Response time (63%)	< 0.7 s
Response time (95%)	< 2 s
Zero offset A	< 7 W/m²
Zero offset B	< 2 W/m²
Directional response (up to 80° with 1000 W/m² beam)	< 10 W/m²
Temperature dependence of sensitivity (-20 ºC to +50 ºC)	< 1 %
Analogue output (-V version)	0 to 1 V
Analogue output (-A version)	4 to 20 mA
Digital output	2-wire RS-485
Ingress Protection (IP) rating	IP67
MTBF (Mean Time Between Failures	>10 years

Humidity range	0 to 100%
Operating and storage temperature range	-40 ˚C to +80 ˚C
Detector type	Thermopile

For measurement of Diffused irradiation, an additional SMP 10 Pyranomter with Shading ball would be used.

C. Data and Information Management

The data and other information will be directly hosted at SREDA server based on http protocol. The stations will be communicated directly to the local server and will be stored based on a predefined data structure at the SREDA server. The minimum technical requirement for the data transmission will be provided by ITTrms.

The measurement data from all the stations would be uploaded to webserver once a day at specified time. Therefore, the irradiation data on SERDA's website would be updated once in a day.

D. Reporting, assessments and mobile app development

A high-quality report on solar irradiance in Bangladesh will be developed. The aim of this study is to design and implement an integrated system for the real-time monitoring of the available solar potential in Bangladesh using measurements from the proposed solar irradiance monitoring stations, estimations from satellite images and data. This study, which will be unique in Bangladesh, combines measurements of solar energy from an organized network of stations, with satellite images of cloudiness, satellite data of atmospheric suspensions and model calculations, leading to the production of maps and graphs of the capture of solar energy over Bangladesh in refined temporal and spatial scales. The ultimate goal is that the products developed in the project are useful tools for designing and estimating the energy productivity of solar power units and devices.

The report will be developed based on the following key principles and will serve as a guiding document for the Solar irradiance study.

The report will cover In-depth literature review including comparison with other neighbor countries or similar geographical location.

The report will address the existing solar radiation pattern throughout Bangladesh and will be supported by sufficient maps to exhibit the spatial and temporal solar radiation patterns on monthly and seasonal bases. This will provide the first approximation of the solar radiation situation of Bangladesh.

Secondly, the report will provide a detailed description of the existing solar monitoring stations, the technical details of the data and information generated by the solar radiation stations and state of the art of the technology for data transmission, accessibility and management of the data.

Third, the report will analyze the data collected by the installed solar radiation monitoring stations through the Web-server RBIS and provide analytical maps of solar radiation. The analysis will further highlight the potential locations of solar PV projects and assess of radiation patterns.

Fourth, the report will also address the policy aspects and guiding principles of renewable energy development, based on solar photovoltaic energy and its development trend at the local, regional and national levels. This report will provide both quantitative and directional guidance to assist the decision-makers for solar PV related projects.

The report will also cover the mobile apps development and its features and wider applicability to monitor the solar radiation data. It will also help individuals to decide upon potential locations to install solar panels for energy production. Thus, it will provide a tool to transfer the data into appropriate information for the benefit of the wider community.

A solar radiation mobile app will be developed in order to provide the wider access of the solar radiation data and related information to the community, decision makers and also the research community.

E. Results and technology transfer

A comprehensive training and capacity building program has been envisaged in this project. Two different training and capacity building session have been considered. The first approach is more technically oriented. This will offer a comprehensive training over two days basis to demonstrate how the solar irradiance monitoring stations will be assembled and maintained. Additionally, a trained individual will show how to solve specific problems in the event of failure. An Instruction manual for the detailed instrumentation and assembly of the monitoring station will be provided, which will include a step by step guide on how to develop the monitoring devices and deploy them.

The next component is the transfer of technology and knowledge sharing for the solar irradiance study. Within the scope of this project, project personnel from Bangladesh will travel to Germany for two months to undertake thorough training and capacity building on solar irradiance topics, in particular, on how remote sensing technology and cloud-based information support solar irradiance quantification both globally and in Bangladesh. Information exchange is also crucial, and therefore, while preparing the high-quality report, this project also foresees some input from the counterparts in Bangladesh. ITTrms will cooperate with CIRE- Cologne Institute of Renewable Energy for the training and capacity building.

2.2 IMPLEMENTATION ARRANGEMENT

The project implementation and management will be guided by the UNDP's standard rules, condition and regulations as agreed by the contract document. ITTrms will report to Project Manager, SREPGen in close coordination with Programme Specialist (Environmental Sustainability and Energy) of Resilience and Inclusive growth cluster of UNDP Bangladesh. Project Manager will provide oversight and quality assurance who will also carry out a performance evaluation after successful completion of the assignment.

The project team from ITTrms side has been designed in a way that it will accomplish each objective maintaining the high quality with commitment of timely delivery. The proposed team leads by a Team leader, a project coordinator, one program specialist, with support of two research associates and operational assistants. The project coordinator of ITTrms will be responsible person to communicate with

UNDP project manager for this project. The following table provides a detail overview of the project implementation team and their responsibilities.

Table1- Project Personnel and Implementation arrangement

Key Personal	**Designation**	**Responsibility**
Prof. Dr. Lars Ribbe	Team Leader	1. Overall project management 2. Providing necessary input for the National Solar Irradiance Study 3. Policy recommendation
Prof. Dr. Johanna May	Specialist (Solar Radiation Studies)	1. Preparation of National Solar Irradiance Study 2. Supporting other technical aspects of the projects e.g, sensor technology, mobile apps development, and solar irradiance data and analysis
Aaron Firoz	Project coordination and specialist (sensor technology)	1. Coordinating the project- management, administration and logistic. 2. Leading ITTsmartSense technology for solar radiation station 3. Cluster Analysis for suitable site selection 4. Supporting for preparation of national solar irradiance study. 5. RBIS data management
Ashraf Elmiligy	Research assistant (Solar Radiation Station)	1. Developing ITTsmartsense for Solar radiation station, data transmission and management
Venkatesh Pampana	Research assistant (Web-based solution for data transmission and management)	1. Solar radiation data transmission, management and web-interface development 2. Mobile apps development for solar radiation
Student Assistant	Master's student	1. Supporting different aspects of project

2.3 KEY OUTPUT AND DELIVERABLES

The final outputs/deliverables produced under this consultancy, to be developed in collaboration with the UNDP and GoB team, are the following:

Table-2: Project output and deliverables

No	**Key activities and deliverables**	**Time**
1	Inception Report with methodology and detail work Plan	30 June, 2018
2	Pre-feasibility report for potential monitoring sites	30 Sep, 2018
3	Installation of the 10 Nos. IttsmartSense (Solar Radiation stations)	30 Nov, 2018
4	Cookbook for operation and maintenance of the SmartSense	15 Dec, 2018
5	Two training and Capacity building session with report	15 Jan, 2019

6	Draft report on Solar Irradiance Study, Mobile Apps for Solar Radiation measurement	30 April 2019
7	Final Report and final apps	30 May, 2019

3 ANNEX- 1: LOGICAL FRAMEWORK OF THE PROJECT

Project Description	Objectively Verifiable Indicators	Means of verification	Assumption
Overall Objectives: **Installation of Solar Radiation monitoring station and National PV resources assessment**	By end of November 2018, 10 Nos. Solar irradiance monitoring stations (4 GHI and 3 GHI plus 3 Diffuse irradiance) will be installed; by end of May 2019 National PV resources assessment will be delivered	Data transmission of 10 Nos station from Webserver, Report	All the sensors and equipment will be transferred without any problem to Bangladesh, UNDP/SREDA will provide necessary logistic support for providing location where the monitoring station can be installed.
Output 1: Suitable site selection for monitoring station	Cluster based analysis for suitable site selection of solar radiation station	Map and Report	Long-term solar radiation data on Bangladesh is available, satellite based information can be accessed
Output 2: Installation of Solar Radiation Station, Data transmission and RBIS installation	NA	Data received from 10 nos station, RBIS_SREDA Installation and data transmission	All the monitoring site is under mobile network coverage. Each location has security to protect the installed devices
Output 3: National Solar Irradiance Study	Assessment of solar radiation and its potential for photovoltaic energy will be evaluated. Suitable policy options will be integrated.	Report and workshop	Suggestion and feedback will be provided by UNDP and SREDA officials. Content of the report will be developed jointly by UNDP, SREDA and ITTrms
Output 4: Training and Capacity Building and Workshop	Technology transfer and dissemination of knowledge	2 International Training, Workshop in Bangladesh	The UNDP team will decide where the training will take place. ITTrms will support the logistic and other arrangement. UNDP and

Project Description	Objectively Verifiable Indicators	Means of verification	Assumption
			SREDA will provide locational support to organize the workshop

4 ANNEX-2: PROJECT PLAN AND TIME FRAME