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RENEWABLE ENERGY FOR WADI RUM AND DISSI CAMPS

Installing PV systems in Wadi Rum and Dissi Camps

Aqaba Community and Economic Development (ACED II) Program

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DISCLAIMER

The author's views expressed in this publication do not necessarily reflect the views of the United States Agency for International Development, AECOM International Development or the ACED II Program.

ACED II Program Frequently-Used Acronyms and Abbreviations

(Not all of the following will appear in every ACED II Program document)

ACED Program	Aqaba Community and Economic Development Program (USAID)
ASEZ	Aqaba Special Economic Zone
ASEZA	Aqaba Special Economic Zone Authority
CSO	Civil Society Organization
MSME	Micro, Small & Medium Enterprises
NGO	Non-Governmental Organization
PMP	Performance Management Plan
PPP	Public Private Partnership
SME	Small and Medium Enterprises
TVET	Technical and Vocational Education and Training
USAID	United States Agency for International Development
USD	United States Dollar
VTC	Vocational Training Center
WAEDAT	Women's Access to Entrepreneurial Development and Training

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EXECUTIVE SUMMARY

This assignment aimed to determine the technical specifications of the PV systems project and procure and install solar electric generation solutions for the Wadi Rum and Disi camps. The study has started by reviewing and updating the feasibility study findings and results in terms of suggested options and alternatives based on the current situation of the camps and proposed unified solution and expected budget required for the procurement and installation of the system in each camp. Then, a set of criteria for the identification and selection of the most suitable camps to implement the solar power generation system were set. These criteria were then discussed with ASEZA to select the participating camps based on these criteria. The technical specifications and the RFQ (Request for Quotations) including the Bill of Quantities (BOQ) for the PV systems to ensure equipment high quality, and system reliability and durability were prepared. All technical and financial proposals from vendors for the supply of solar equipment were evaluated to select the most appropriate one in response to the RFQ. All equipment received from the vendor was inspected against the set of technical specifications. Then, all PV systems were installed in 12 camps in Wadi Rum and Disi. Finally, all PV systems were tested and successfully commissioned. In addition, a training workshop on the PV maintenance was given to the camps owners to ensure proper functioning of these systems and another training course was given to the ASEZA and Aqaba Vocational Training Center staff to build the capacity in PV systems installation, maintenance and testing.

ASEZA sent a letter of appreciation to the ACED II program for the installation of 12 PV units in 12 different camps in Wadi Rum and Dissi area (6 in Wadi Rum and 6 in Dissi)

INTRODUCTION

Unlike many of its neighboring Arab countries, Jordan is a non-oil producing country with limited natural resources and minerals with its economy based primarily on agriculture and farming, with tourism quickly becoming one of the most important sectors in the country's economy. In 2010, 8 million tourists from various countries visited Jordan, with tourist receipts amounting to about 3.5 billion dollars. Its major tourist attractions include visiting historical sites, religious places, and natural locations.

Wadi Rum and Disi is a desert region full of mountains and hills located in the south of Jordan. The area is popular for its natural beauty as well as a variety of sports that are practiced there such as rock-climbing. It is also known for its connection to Lawrence of Arabia. The area is now also one of Jordan's important tourist destinations, and attracts an increasing number of foreign tourists, particularly trekkers and climbers, camel and horse safaris, and day-trippers from Aqaba or Petra. The influx of tourists to this once isolated area has substantially increased the financial fortunes of the Bedouin people, which have now become the sole source of income for many.

Tourist camps in Wadi Rum and Disi currently depend mainly on burning fossil fuel to meet their energy demands for lighting, cooking, space heating, domestic hot water, and transportation purposes. In addition to environmental problems, both emissions and noise, these practices have a negative impact on the touristic experience, and they are costly and difficult to obtain and maintain. Therefore, it is highly important to seek for other options that could potentially replace the current energy usages practices.

Following an environmental review, the USAID Aqaba Community and Economic Development (ACED II) Program procured and installed Photovoltaic (PV) systems (more commonly known as solar panels) for twelve camps in Wadi Rum and Disi camps to replace the current dependency on fossil fuels.

METHODOLOGY

In order to achieve the purposes and objectives needed from this assignment, the following procedures have been adopted:

DETERMINE THE MOST IMPORTANT APPLIANCES THAT SHOULD BE AVAILABLE TO THE TOURISTS

From the previous study report conducted by the same expert under ACED I program, it was found that lights as well as mobile chargers are the most important appliances that tourists need. Therefore, the system has been designed to supply the camps with 28 LED five-watt light bulbs and two mobile phone chargers with a continuous operation of eight hours for two consecutive days.

The PV system that satisfies these requirements is categorized as standalone PV (photovoltaic) systems. The standalone PV systems are used when it is impractical to connect to the utility grid. The design criteria for standalone systems are generally more complex than the design criteria for utility interactive systems, where most of the critical system components are incorporated in the design.

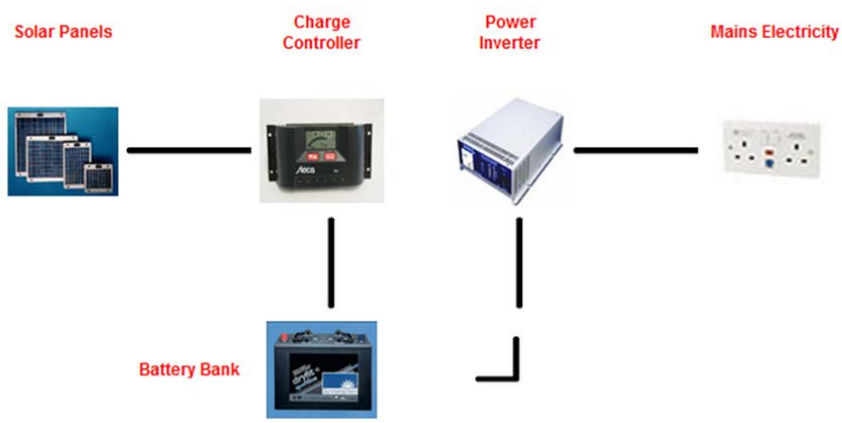

Figure 1: Main Components of the Standalone PV System

The PV modules must supply all the energy required. The Direct Current (DC) electricity produced by the solar panel or module(s) is used to charge batteries via a solar charge controller. The Alternating Current (AC) appliances are powered via an inverter connected to batteries or charge controller.

The schematic diagram (Figure 1) shows the design for standalone PV system that covers the base appliances that should exist in a typical camp while Table 1 summarizes the assumptions used in the analysis.

If the system is fully utilized, this will save annually around 350 liters of diesel for each camp which is equivalent to 225 JD at current prices. The avoided carbon dioxide emissions are expected to be 460 kg annually for each camp.

Table 1: Assumptions Used in Analysis

Charger Efficiency	0.98
Inverter Efficiency	0.90
Wire Losses	0.02
System trip losses	0.90
Battery Discharge	0.80
Autonomy Days	2
Irradiance Level (kWh/m^2.day)	4.0
System Voltage	24
Diesel Price (JD/L)	0.68

SELECTION OF THE MOST SUITABLE CAMPS

Solar photovoltaic panels should ideally face south at an elevation of approximately 25-30o. The panels can point east or west; however they will produce lower results. In addition, systems should be in locations bright locations with minimal (if any) shade at all times of day if possible. Mountains in Wadi Rum and Disi camps are identified as potentially shading the modules particularly in the early morning

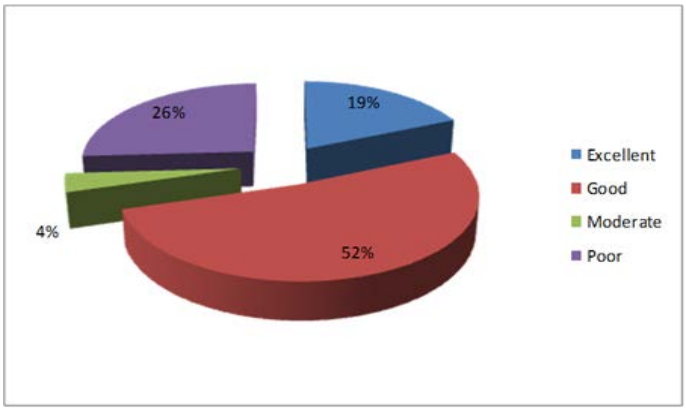

Figure 3: Suitability of Locations in Wadi Rum

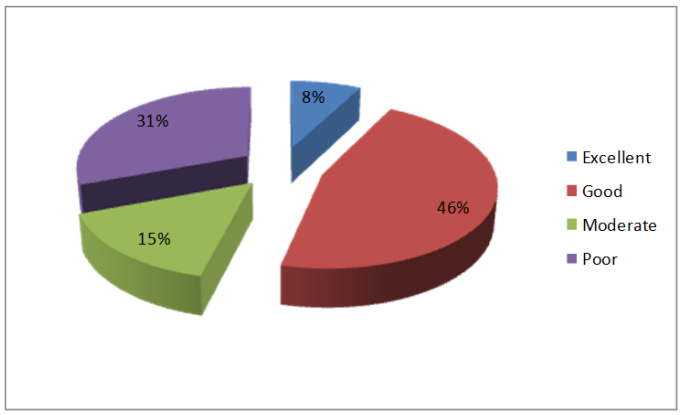

Figure 2: Suitability of Locations in Disi

and late afternoon. The performance of the system will be affected even if small part of it is shaded. Figures 2 and 3 show the suitability of camps locations in Wadi Rum and Disi regions. The twelve camps were selected according to their location suitability and have a minimum rating of "good".

In figures 2 and 3, excellent location means that the camp is directly facing south and the location is an ideal case for solar system installation while good means that the system performance will be affected by 10-20% of its performance due to shading. On the other hand, moderate means that 40-50% of system performance will be lost due to shading effect and poor means that the solar system is almost shaded during the day and not suitable for solar system application. As can be seen from figure 4, considerable percentage of camps in both areas are affected by shading effect that will reduce the performance of solar systems. In order to overcome this problem, the size of solar system needs to be oversized or installed far away from the camp to ensure sun rays to reach arrays. Photos below show examples of excellent and poor locations.

Figure 4: Excellent Location (left), Poor Location (right)

PREPARE THE TECHNICAL SPECIFICATIONS AND THE REQUEST FOR QUOTATIONS (RFQ)

In order to ensure that the solar panels are of high quality, are reliable and durable, an RFQ should be written in a high professional manner. The following technical specifications have been prepared, and an RFQ was published in local newspaper:

PV Modules	
1	The output power of all modules should be at least 500 Wp (positive tolerance) at standard conditions (solar irradiance =1000 W/m2, module temperature =25 OC and air mass=1.5).
2	The type of the PV technology is either Mono or Poly-crystalline (72 small or large cells)
3	Operating PV temperature should be between -40 OC and +85 OC.
4	Module's temperature coefficient of peak power should not exceed - 0.45%/ OC.
5	PV module's junction box: protection against water baths and dust IP65.
6	Protection against partial shading via bypass diodes.
7	PV module design and type approval qualification standard: IEC/EN 61215, TUV, and UL.
8	Workshop warranty for defect modules after installation should be 10 years.
Off-Grid Inverter	
1	Nominal Input Voltage is 24 VDC.
2	Rated continuous power is 500 W.
3	Minimum surge power for the inverter is 1,000 W.
4	Nominal Output Voltage is 230 + 10 %VAC.
5	Full load efficiency is minimum of 85 %.
6	Protections: Battery Low alarm/Battery Low shutdown/Over voltage/ Over temperature /Output short/Input polarity reverse/Over load.
7	Manufacturer's warranty is minimum of 1 year.
Charge Controller	
1	Battery voltage is 24 V and rated current of at least 25 A.
2	Integrated maximum power point tracking (MPPT).
3	Temperature operating range : up to 50 OC.
4	Protections: over-voltage and under-voltage.
5	Manufacturer's warranty is 1 year.
Storage Batteries	
1	Nominal voltage:12 V. The total number of batteries should be 2, or 4, or 6.
2	Capacity for all batteries should be at least 260 AH @ 10 hr rate.
3	Battery cell technology: deep cycle, applicable for solar PV application.
4	Specially designed for frequent cyclic discharges usage
5	Manufacturer's warranty is 1 year.

Mounting Structure. The structure should be designed to accommodate the proposed number of modules. The material is galvanized steel 2 mm thickness. The assembly should be using stainless steel screws (no welding is permitted).

Each system should have at least four blocks of reinforced concrete (30 cm x 30 cm x 40 cm).

Miscellaneous requirements:

- For each system, a combiner box (IP65) with 2 DC switches (single pole of 25 A rated current).
- For each system, all batteries should be contained in one metal box.
- For each system, 4 DC switches (single pole of 25 A rated current).
- For all systems, wires of total length of 1000 m of 4 mm2 cross section (half black and half red).

- For each system, AC breaker of 5 A (double poles).
- For each system a total number of LED lamps (bulb type, 220 V) of 35. Each bulb power is 5-10 W. The warranty should be at least 2 years.

PROCUREMENT AND INSTALLATION

Following the RFQ, a procurement committee and technical specialist evaluated the proposals against the set of technical specifications and accordingly one vendor has been chosen and a vendor was selected. Then, an "Environmental Review" report was prepared for each camp of the proposed Bedouin camps in Wadi Rum and Dissi. This document has been submitted separately to USAID. It assessed the likely environmental impacts of installing the PV system in the camps.

After determining that the installation of the solar panels would have a negligible impact on the environment, the receiving and installation process began. Upon receiving the equipment from the vendor, all equipment was inspected against a set of technical specifications and were found to be in full compliance. All PV systems were then installed successfully in twelve Bedouin tourist camps in the Wadi Rum and Dissi area. During each installation, a technical specialist ensured that each PV system installation was carried out according to specified standard to ensure system durability and credibility.

TESTING AND COMMISSIONING

In this stage, the technical expert tested all of the PV systems to ensure that they were functioning properly. As a part of the test, the battery is discharged through powering a 400 Metal Halide lamp for approximately one hour while disconnecting the PV panels. Then, the PV panels are re-connected while disconnecting the lamp and waiting until the battery is fully charged. By comparing the charging time against the test conditions, the expert can assess the PV system functionality. All of PV systems installed in these camps were found to be properly functioning. The photo to the left shows the equipment used in the proposed testing method.

CREATING A SUSTAINABLE SOLUTION

The stand-alone PV systems need to be managed properly. Users need to know the limitations of a system and tailor energy consumption according to how sunny it is and the state of charge (SOC) of the battery. Therefore, a tailored training course was prepared and given to the camps owners to achieve the following objectives:

- How to deal with the system.
- How to maintain and clean the system.
- How to avoid poor practices of system usages.

- How to diagnose that the system is functioning as it is designed to be.

Furthermore, to ensure project sustainability and satisfaction of future demand on PV at local communities, the ACED II Program installed one solar unit at the Aqaba Vocational Training Institute (AVTI). ACED II used this module to conduct a training workshop on the installation and maintenance of the solar systems for the ASEZA staff and local practitioners. Training these local professionals to install and upkeep the systems will create a sustainable solution for years to come in Wadi Rum and Dissi. Furthermore, this module will be used to train the VTC students and equip them with new skills in line with market demands.

Installing this clean, renewable energy source in Wadi Rum and Dissi for the Bedouin tourist camps has already resulted in improved customer experiences and reduced energy costs. As Jordan moves to become a nation more dependent on tourism while lacking natural resources reserves, PV systems are beginning to demonstrate a potential solution to overcoming these challenges.

Training the camp owners on operating and managing their systems

Wadi Rum Cooperative Chairman and a camp owner next to the installed PV system