Preliminary Audit Report & Solarization Potential for Gebran Tueini School – Karantina

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UNDP

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1. Introduction

1.1 Objective

The following report presents a description of the operations and equipment of the facility carried out through a combination of a site survey and in-office energy analysis, then proposes a prefeasibility study with technical information and estimated budget for the installation of a solar Photovoltaic (PV) system and energy efficiency measures for Gebran Tueini School in Karantina, Beirut.

1.2 Site Visit Details

The analysis of the report was based on a site visit by the UNDP team on 25/10/2022, comprising of:

- Mr. Alain Abi Saad
- Mr. Mazen Awada
- Ms. Layal Mostafa
- Mr. Rodolph Al Mallah

2. General Description

FACILITY NAME: Gebran Tueini Public School

CITY: Karantina, Beirut

COUNTRY: Lebanon

FACILITY'S DESCRIPTION:

The school was originally located in Ashrafieh region, but due to land issues, the school has moved temporarily to Karantina.

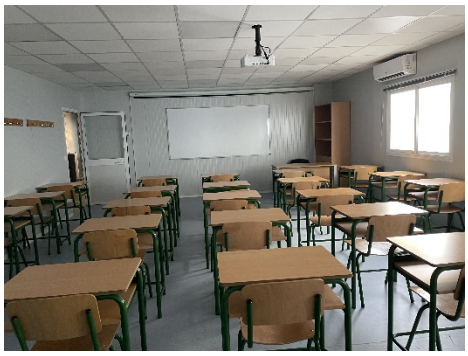
Gebran Tueini School is a one-level prefabricated building established in 2021 by the Spanish Cooperation under the project "*Installation of a modular school as an early rehabilitation initiative in the area affected by the Beirut port explosion*" funded by the Spanish Agency for International Development Cooperation (AECID).

The school serves 125 students (Lebanese and non-Lebanese) and ready to occupy up to 500 students. The land is owned by the Municipality of Beirut, and the municipality has granted a part of the land for the construction of the school.

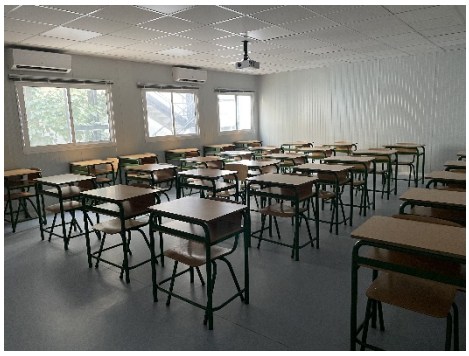
Due to the current situation (fuel crisis and teachers' wages), the facility is currently operating four (4) days per week from Monday till Thursday from 7:00am till 3:00pm (8 hours). It might go back to operate five (5) days per week from Monday till Friday. The school consists of sixteen (16) rooms, one (1) computer room, one (1) library, and other small administrative offices.

School Exterior

School Interior



Classroom



Classroom

Computer Room

Library

The layout of a typical floor and its orientation is shown below:

Orientation: 33.89,35.52
Longitude: 35° 31' 54.472'' E
Latitude: 33° 53' 59.958'' N

Figure 1 – Gebran Tueini School Location

3. Existing Systems & Equipment

3.1 Electric Power Feeders

The Gebran Tueini Public School is supplied by electricity through a 3x50A EDL feeder. The school doesn't own any backup generator, and due to the long hours of electricity cut-offs, the school is recently operating in the dark without any source of electricity.

Main Distribution Board outside the facility

Distribution Board in the technical room

3.2 Electrical Load Profile

There is no set load profile; however, upon the site visit and data collection from the school, a general overview of the consumption was found as indicated in Table 1.

Load Source	Quantity	Rating
AC split units	32 (2 per classroom)	9,000 BTU
LED Lighting all over the school	~80	~40 W
LCD Projectors in classrooms	13 (1 per classroom)	3.3A

Photocopy Machines	2	~2,000 W
Computers	~ 40	200 W
Water Pump	2	1.5hp & 0.5hp

Table 1. Observed consuming appliances

3.3 Mechanical System

3.3.1 HVAC

The main source of ventilation in the building is split unit air conditioners. The HVAC system consists of thirty-two (32) split units rated at 9000 BTU, which make up the big bulk of the energy consumption in the school.

Split Units

Air Conditioner & LCD Projector

3.3.2 Water Network

The water network consists of four (4) water tanks with a capacity of 10,000 Liter each located at ground level. The water is supplied by the civil defense, who fills the tanks with clean water twice a month. water is pumped directly to the toilets and faucets in the school using a 1.5hp booster pump. Therefore, unless electricity is available, water can't reach the school. It is recommended to pump the water to the two (2) water tanks with a capacity of 2000 Liter each elevated at a 3-meter steel mounting structure.

10000 Liters Water Tanks

2000 Liters Water Tanks

1.5hp booster pump (operational) & 0.5hp booster pump (redundant)

4. Proposed Solutions

Due to the lack of data found and the lack of electricity to measure the consumption, several assumptions will be considered to establish the sizing of the PV System, coupled with the consideration related to the limitation in the available area on the roof for PV solar installation.

4.1 Photovoltaic solar System

The overall available roof area is around 900m^2, with a lot of shading from the surrounding buildings covering more than half the area at most times of the day. It is also important to note that a playground was established at about 50m walking distance from the school.

The playground roof was damaged from previous storms; hence, it is not that recommended to use it for solar PV installation. In addition to that, the playground has several entrances other than the entrance from the school's property limits.

Area Available on the rooftop of the school

Shading Effect from surrounding Buildings

Playground

Available Space for additional solar panels

4.1.1 Load profile

The Load profile was identified as a Day Load with the working hours from 7:00 am till 3:00 pm (8 hours), but due to high shading effect and area limitation, it is recommended to install a solar hybrid PV system with batteries.

The following figure shows the schematic diagram of the solar hybrid PV system with battery storage with its inputs and outputs:

Figure 2 – PV system schematic diagram

4.1.2 PV solar system Sizing

Due to area limitations, a Solar PV System of 41 kWp can be installed on the roof with 3-phase Hybrid Inverters of total rating greater than 40 kWe and storage of 80 kWh Lithium-ion batteries.

The system will be able to recharge the batteries during the afternoon and provide around 30A per phase to the school distribution board during working hours.

The Lithium-ion Battery storage will provide a continuous load of 3x15A for 8 hours considering 90% Depth of Discharge (DoD).

Figure 3 – PV layout for Solar Panels on School Rooftop

The following table shows the production of the PV system throughout the months of the year:

Month	Monthly Production (kWh)
January	2,626.40
February	3,148.80
March	4,874.30
April	5,524.80
May	7,031.90
June	7,398.60
July	7,210.70
August	6,916.50
September	5,417.60
October	4,619.50
November	3,183.40
December	2,507.20
Total	**60 MWh**

To overcome shading, the PV panels were placed on the western edge of the building. The shading from the surrounding buildings was taken into account, and a shading simulation was performed showing only 0.4% shading losses over the year.

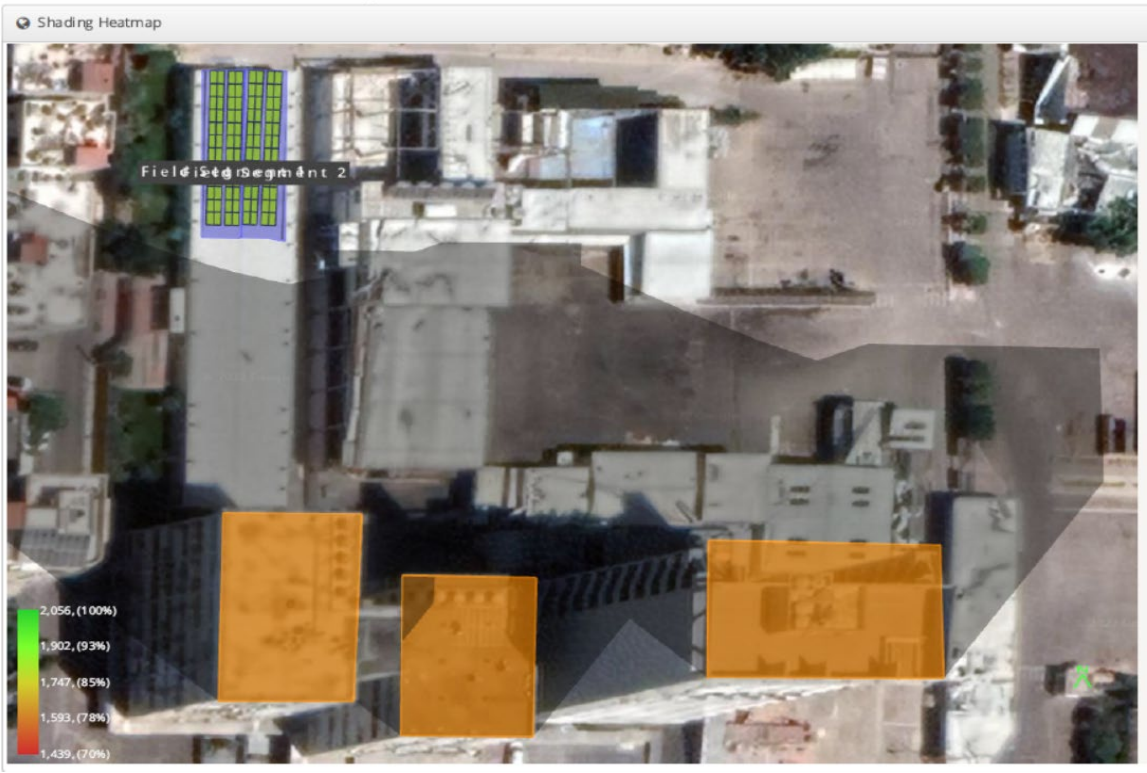


Figure 4 – Shading Simulation for solar PV Panels

4.1.3 Estimated Cost

The estimated cost is detailed as per the below table:

PV system	Estimated Budget
41 kWp hybrid PV with 80 KWh Lithium batteries system includes: - Solar PV modules - Structure (to be installed on the corrugated roof) - PV inverter - Battery / Charger inverters - 80 KWh Lithium-ion Batteries - Monitoring and datalogger - AC and DC cabling	**~ 75,000 USD**

The technical specifications for the required equipment are available upon request.

4.1.4 Estimated Savings and Payback Period

The estimated savings and payback period are presented in the below table:

Estimated Savings	PV system annual production: 60 MWh Assuming 0.4 $/kWh for diesel generator Estimated savings: ~ 24,000 USD / year
Estimated Payback Period	3 Years
Estimated CO_2 emissions savings	48 Tons/Year