MINARET

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RENEWABLE ENERGY ASSESSMENT – KARAK

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Table of Contents

1. Executive Summery

In this report, site assessments of different buildings located in Karak – Jordan, were conducted in order to observe the potential of installing photovoltaics system on rooftops and installing solar hot water systems.

The site assessment was undertaken through site visits to determine site obstacles, assess Jordan's status, share goals and results, meet with stakeholders and collect information on the country's regulation.

The total capacity of the PV system was calculated based on both annual consumption and available area on rooftops per location. Moreover, all electric water heaters were replaced with a solar hot-water system to cover domestic use in this regard, in the building.

The report is divided into two parts;

1) PV analysis and findings.
2) Solar hot water system analysis and findings.

The site assessment was conducted at the following locations in Karak:

a. The municipality main building.
b. Central municipal building.
c. Al-Adnanya administrative building.
d. Al-Ghweir administrative building.
e. Health care center.
f. Al-Marj administrative building.
g. Zaid Ebn Hareth administrative building.
h. Workshop building.
i. Al-Thanya administrative building.
j. Zahoum administrative building.
k. Manshiet Abo-Hammour administrative building.
l. Ader municipality administrative building.
m. Al-Shahabye administrative building.
n. Rakien administrative building.
o. Al-Jdaydeh administrative building.
p. Wadi Karak administrative building.
q. Baddan & Barda administrative buildings.
r. Al-Hawieh administrative building.

The report also includes total saving energy, estimated cost of the system and simple payback period per location. The report concludes with recommendations from the site assessment.

2. Introduction

2.1 Background

The MENA Region Initiative, as a Model of NEXUS Approach and Renewable Energy Technologies (MINARET), is developed to address unique sustainability challenges and opportunities in the MENA region, by increasing local and regional sustainability capacities using the synergies between renewable energy technologies and efficiency, water management and food security.

The project works on a regional level to create a platform for regional dialogue among experts and specialists in renewable energy, sustainable development and water who share experiences and discuss policies and techniques that are appropriate to the area.

2.2 Objectives and scope

- Build municipalities' resilience to climate change through the adoption of renewable energy resources (RER), energy efficiency (EE) applications, water management techniques and food security approaches.
- Strengthen institutional capacities of relevant government authorities involved in the project, by promoting policy dialogue and implementing different capacity-building programs.
- Promote inter-municipal regional cooperation to enhance good governance and equitably deal with human needs and rights, particularly among refugees who are fighting for survival in and around municipalities.
- Reinforce roles of women, youth and marginalized groups in developing and implementing the NEXUS approach.
- Develop a MENA dialogue platform focusing on knowledge sharing, education and lessons learnt on national and regional policy levels.

3. Methodology

3.1 Methods: data collection and analysis methods

Water, energy and food security on a global level can be achieved through a NEXUS approach. The NEXUS approach integrates management and governance across sectors and levels.

This report covers the renewable energy part.

The methodology was conducted through site visits, meetings with stakeholders and gathering governmental data and studies that are relevant to the project. Available and suitable areas for installing systems were scrutinized and calculated. However, the final total capacity was calculated based on the electric bills according to the current regulations in Jordan.

regarding the PV part, different tools and software were used to analyze the acquired data. Each location was modeled in 3D via simulation tools, in which real data such as the sun path and shading analysis were used to calculate the anticipated energy production for that specific location. A simple payback period for the PV systems was also calculated assuming that the cost of 1 kWp PV system is 750 JD.

On the other hand, the methodology of the solar water heater system analysis was conducted by replacing all electric solar heaters (already installed in the buildings) with solar hot water systems based on currently available systems in the market. A simple payback period for the solar hot water systems has also been calculated assuming that the cost of 100-litre capacity of domestic hot water is 350 JD and a 200-litre capacity of domestic hot water is 500 JD.

3.2 Data validation

This data is valid for five years as the loads may change or buildings may get upgraded in addition to the new emerging technologies that may be adopted.

3.3 Limitations

Two locations had no electricity bills. The team had to estimate consumption based on installed and utilized appliances to calculate the payback period of the PV system for one location building. The payback period for the other building was not calculated.

One location had zero potential of installing a PV and solar hot water system due to shading from large trees that surrounded the building.

One location could not cover the whole demand due to limited rooftop surface area.

Finally, the team learnt that the rooftop of one location was not associated with the administrative building; therefore, the rooftop could not be exploited to install any RE systems.

4. General Overview

Current situation

Securing energy supply and diversifying energy sources is one of the main objectives of the energy strategy of Jordan. Jordan is committed to increasing the share of renewable energies (RE) to 10% in 2020; the major share of RE is to come from wind power (800 MW) and solar power (800MW) in addition to 30 - 50 MW from the conversion of waste to energy. Concurrently, the Ministry of Energy and Mineral Resources (MEMR) and the National Electric Power Company (NEPCO) are committed to adapt the electricity network to the challenges of both increasing electricity quantities and fluctuating input from RE.

Based on the above, the Renewable Energy and Energy Efficiency Law was passed as a permanent Law in 2012 and was amended in 2014.This law allows investors to identify and develop grid-connected electricity production projects through the so-called unsolicited or direct proposal submission.

The Jordanian renewable energy (RE) market is a promising arena that encourages developers, investors, engineers and companies to develop and install pure RE and RE hybrid projects for the production of electricity. Additionally, Jordan is currently a leading country of Renewable Energy in the MENA Region. It also had a significant share in decreasing the world's pollution, which is mainly produced from crude oil and other oil derivatives due to the following reasons:

1. Jordan has laid down the necessary policy and regulatory frameworks for renewable energy and is now ready to attract and receive commercial investments.
2. Templates for contractual documents (PPAs) and instructions for developing RE projects do exist.
3. Grid reinforcement (Green Corridor) is undergoing by NEPCO in order to install more RE capacities.
4. The tax incentive regime bylaws on tax exemptions have been issued for RE and EE systems and equipment.
5. A well-founded reference price list (ceiling prices) is provided for different renewable technologies.

5. Analysis and Findings

5.1 Photovoltaics analysis

There are several locations affiliated with the municipality of Karak that have the potential of installing photovoltaics system:

1. Municipality main building.
2. Central municipal building.
3. Al-Adnanya administrative building.
4. Al-Ghweir administrative building.
5. Health care center.
6. Al-Marj administrative building.
7. Zaid Ebn Hareth administrative building.
8. Workshop buildings.
9. Al-Thanya administrative building.
10. Zahoum administrative building.
11. Manshiet Abo-Hammour administrative building.
12. Ader Municipality administrative building.
13. Al-Shahabye administrative building.
14. Rakien administrative building.
15. Al-Jdaydeh administrative building.
16. Wadi Karak administrative building.
17. Baddan & Barda administrative buildings.

PV systems may be categorized as grid-connected vs. stand-alone systems; or building-integrated vs. rack-mounted systems. According to the preliminary study, all systems in Karak are grid-connected due to the availability of the grid. A civil study for all considered buildings is a prerequisite requirement prior to the installation of any system in order to determine a building's tolerance level due to additional weight resultant from installing PV panels.

5.1.1 Municipality main building

- Coordinates: 31°10'57.4"N 35°42'09.4"E

The electricity bills for the municipality main building **were not available**. Therefore, the capacity of the PV system was measured based on the available space on the rooftop of the building. The available space on the rooftop can fit 10 kWp.

The PV system generates approximately 15,600 kWh/year. The total investment of the system is approximately 7,500 JD. However, the real capacity can be either lower or higher based on the electrical consumption.

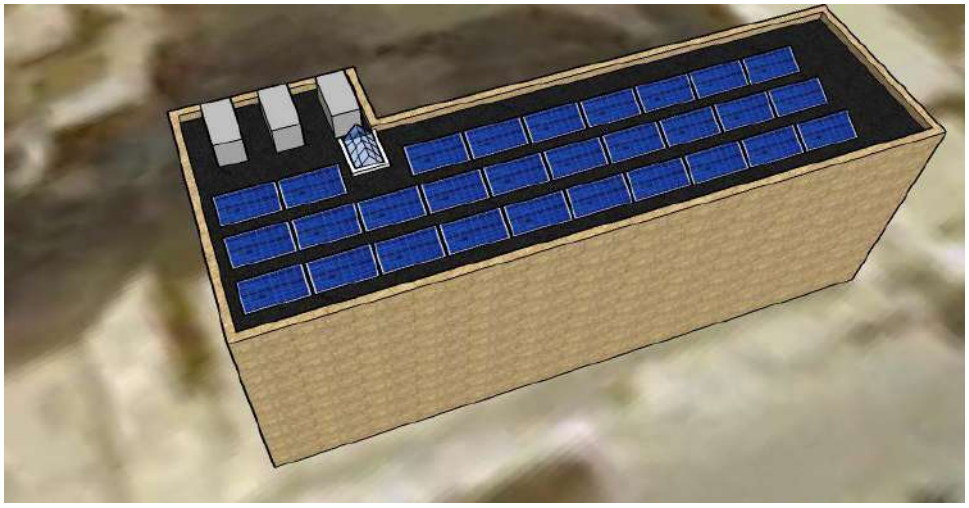


***Figure 1**: 3D model of the municipality main building*

5.1.2 Central municipal building

- Coordinates: 31◦10′56.7″N 35◦42′09.7″E

Based on the electrical consumption of the central municipal building, the total capacity needed to cover the consumption is 54 kWp. The available space on the rooftop can fit the required capacity. The PV system generates approximately 84,240 kWh/year, which **covers 100%** of the total consumption that equals to approximately 20,170 JD/year. The total investment of the system is approximately 40,500 JD and the payback period is 2 years.

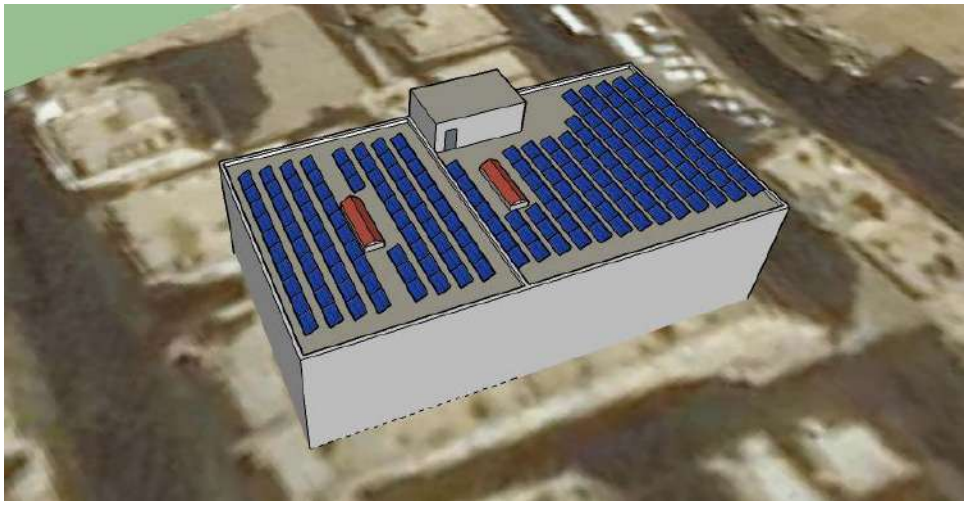


Figure 2: *3D model of the central municipal building*

5.1.3 Al-Adnanya administrative building

- Coordinates: 31◦07′16.5″N 35◦41′48.1″E

Based on the electrical consumption of Al-Adnanya administrative building, the total capacity needed to cover the consumption is 1.4 kWp. The available space on the rooftop can fit the required capacity. The PV system generates approximately 2,184 kWh/year, which **covers 100%** of the total consumption that equals to approximately 151 JD/year. The total investment of the system is approximately 1,050 JD and the payback period is 7 years.

Figure 3: *Al-Adnanya Administrative building*

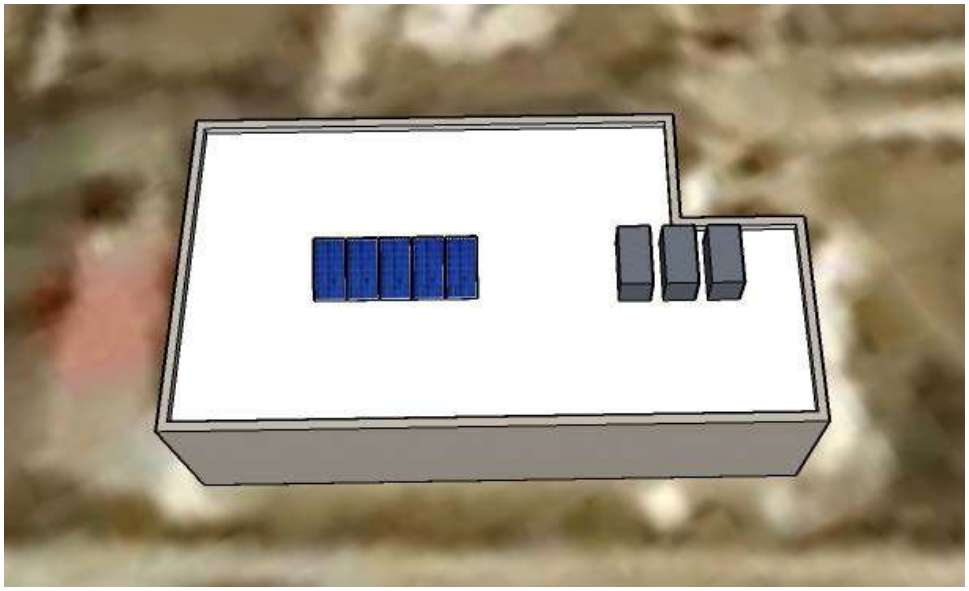


Figure 4: *3D model of the Al-Adnanya administrative building*

5.1.4 Al-Ghweir administrative building

- Coordinates: 31◦08′26.6″N 35◦45′16.1″E

Based on the electrical consumption of Al-Ghweir administrative building, the total capacity needed to cover the consumption is 0.7 kWp. The available space on the rooftop can fit the required capacity. The PV system generates approximately 1092 kWh/year, which **covers 100%** of the total consumption that equals to approximately 84 JD/year. The total investment of the system is approximately 525 JD and the payback period is 6.5 years.

Figure 5: *3D model of the administrative building in Al-Ghweir*

5.1.5 Health Centre Building

- Coordinates: 31◦11′02.9″N 35◦42′29.8″E

The available space on the rooftop of the health centre building can fit approximately 2.3 kWp on-grid system. However, based on the electrical consumption of the municipality, the total capacity needed to cover the consumption is 3 kWp. Therefore, the PV system will not cover the total consumption of the building.

The PV system generates approximately 3,588 kWh/year and **saves energy of 75%** of the total consumption, which equals to approximately 323 JD/year. The total investment of the system is approximately 1,725 JD and the payback period is 5.5 years.

Figure 6: *Health center building*

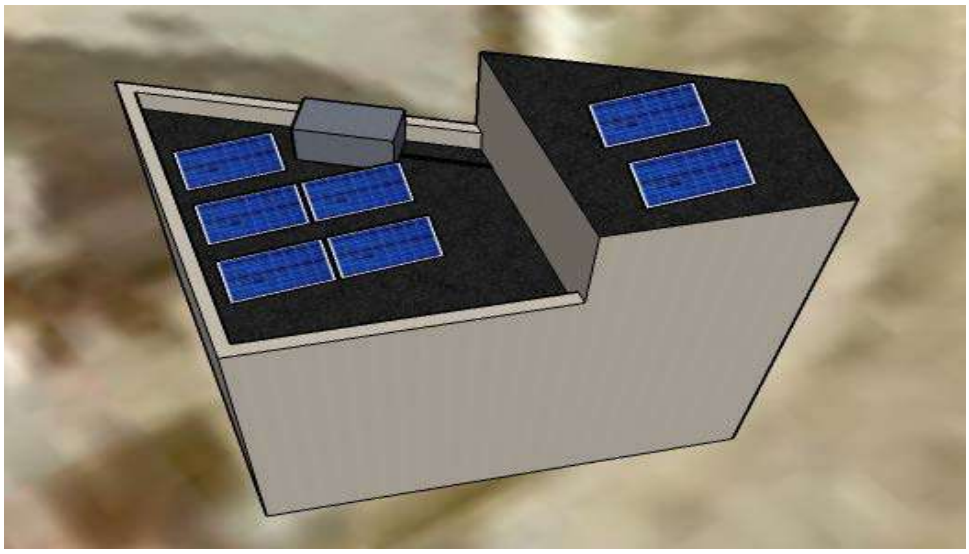


Figure 7: *3D model of the health center building*

5.1.6 Al-Marj administrative building

- Coordinates: 31◦10′48.8″N 35◦42′42.9″E

Based on the electrical consumption of Al-Marj administrative building, the total capacity needed to cover the consumption is 12.2 kWp. However, surrounding large trees from all directions cause shading over the rooftop - as shown in Figures 7 and 8, hence the Marj building **is deemed unusable to install the PV system.**

Figure 8: *Al-Marj administrative building*

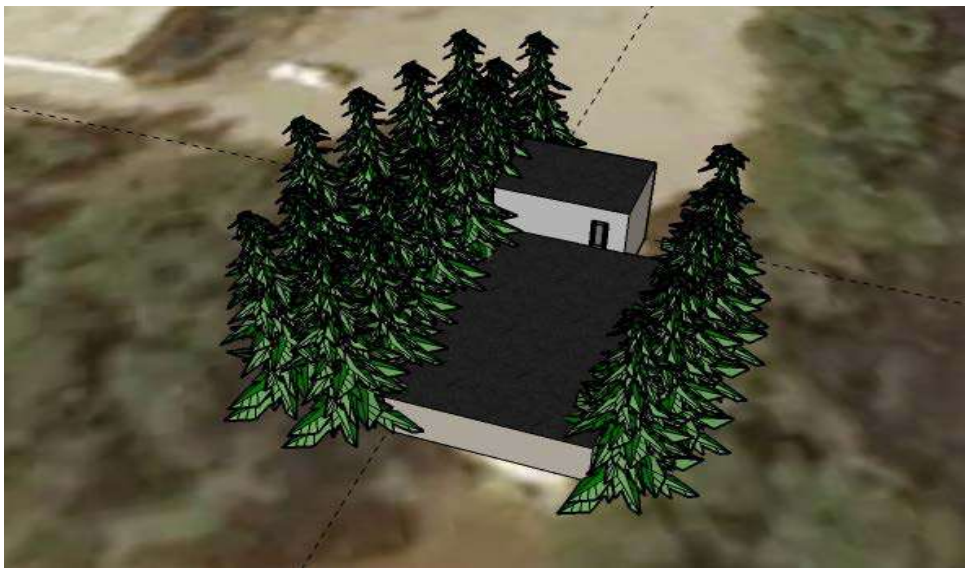


Figure 9: *3D model of Al-Marj administrative building*

5.1.7 Zaid Ebn Harethah administrative building

- Coordinates: 31◦06′07.9″N 35◦43′17.6″E

Based on the electrical consumption of Zaid Ebn Harethah administrative building, the total capacity needed to cover the consumption is 4 kWp. The available space on the rooftop can fit the required capacity. The PV system generates approximately 6,240 kWh/year, which **covers 100%** of the total consumption that equals to approximately 571 JD/year. The total investment of the system is approximately 3,000 JD and the payback period is 5.5 years.

Figure 10: *Zaid Ben Hartheh administrative building*

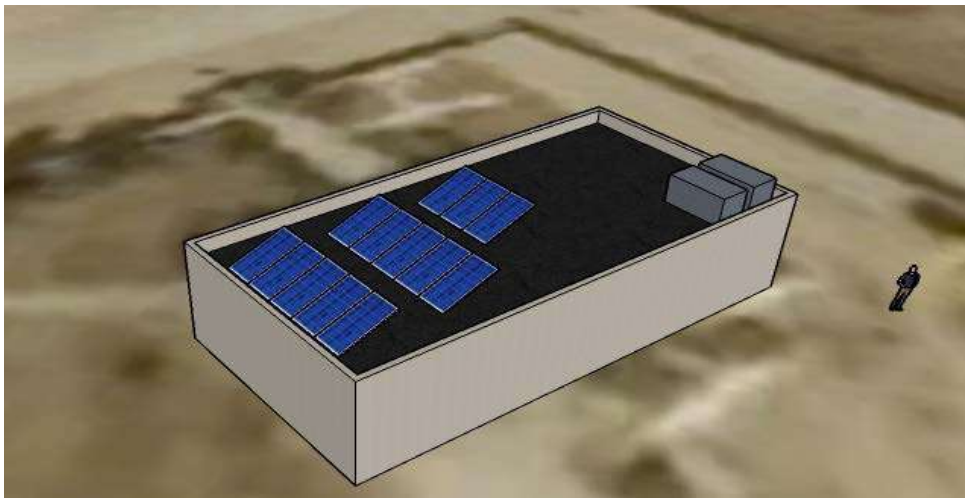


Figure 11: *3D model of Zaid Ebn Hareth administrative building*

5.1.8 Workshop Building

- Coordinates: 31◦10′30.2″N 35◦42′11.8″E

Based on the electrical consumption of Workshop Buildings, the total capacity needed to cover the consumption is 6 kWp. The available spaces on the rooftops can fit the required capacity. The owner has the choice to either install building number one or building number 2 as shown in the

figures 12 and 13 below. The PV system generates approximately 9,360 kWh/year, which **covers 100%** of the total consumption that equals to approximately 1,107 JD/year. The total investment of the system is approximately 4,500 JD and the payback period is 4 years.

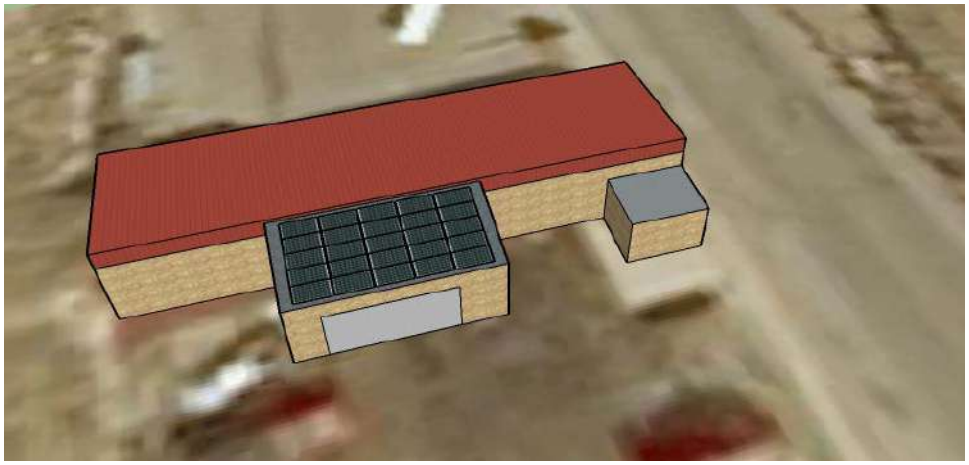


Figure 12: *3D model of workshop – building #1*

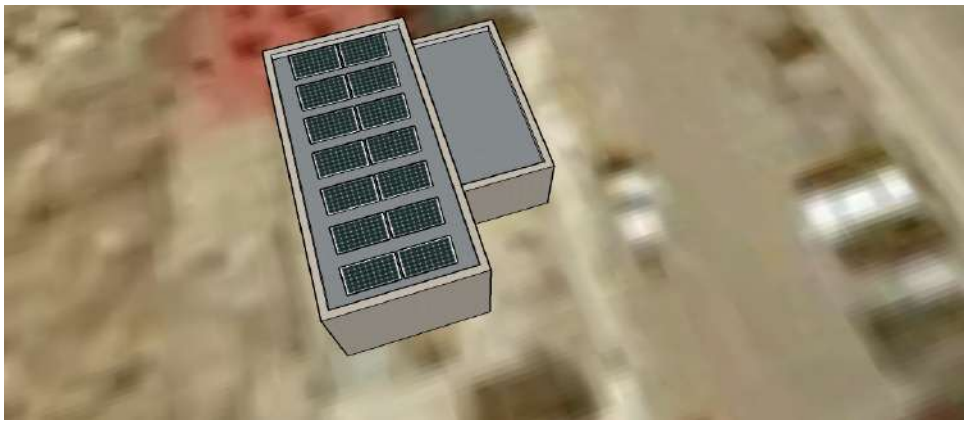


Figure 13: *3D model of workshop - building # 2*

5.1.9 Al-Thanyah administrative building

- Coordinates: 31◦10′08.4″N 35◦43′28.7″E

Based on the electrical consumption of Al-Thanyah administrative building, the total capacity needed to cover the consumption is 3.4 kWp. The available space on the rooftop can fit the required capacity. The PV system generates approximately 5,304 kWh/year, which **covers 100%** of the total consumption that equals to approximately 463 JD/year. The total investment of the system is approximately 2,550 JD and the payback period is 5.5 years.

Figure 14: *Al-Thanyah administrative building*

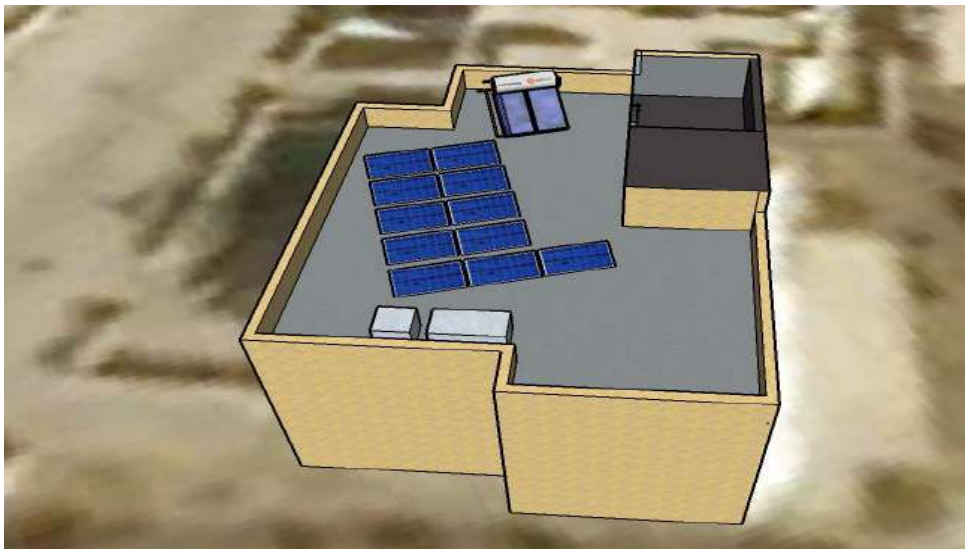


Figure 15: *3D model of workshop of Al-Thanya administrative building*

5.1.10 Al-Zahoum administrative building

- Coordinates: 31◦10′06.8″N 35◦45′44.2″E

The electrical consumption of the Al-Zahoum administrative building is very small. The total capacity needed to cover the consumption is 0.6 kWp. The total investment of the system is approximately 450 JD and the payback period is 6.5 years. However, the rooftop of the building is not part of the municipality building property; therefore, **the municipality cannot install PV system.**

5.1.11 Manshiet Abu-Hammour administrative building

- Coordinates: 31◦11′30.5″N 35◦44′20.9″E

Based on the electrical consumption of Mansheit Abu-Hammour administrative building, the total capacity needed to cover the consumption is 4.8 kWp. The available space on the rooftop can fit the required capacity. The PV system generates approximately 7,488 kWh/year, which **covers 100%** of the total consumption that equals to approximately 765 JD/year. The total investment of the system is approximately 3,600 JD and the payback period is 4.5 years.

Figure 16: *Manshiet Abu-Hammour administrative building*

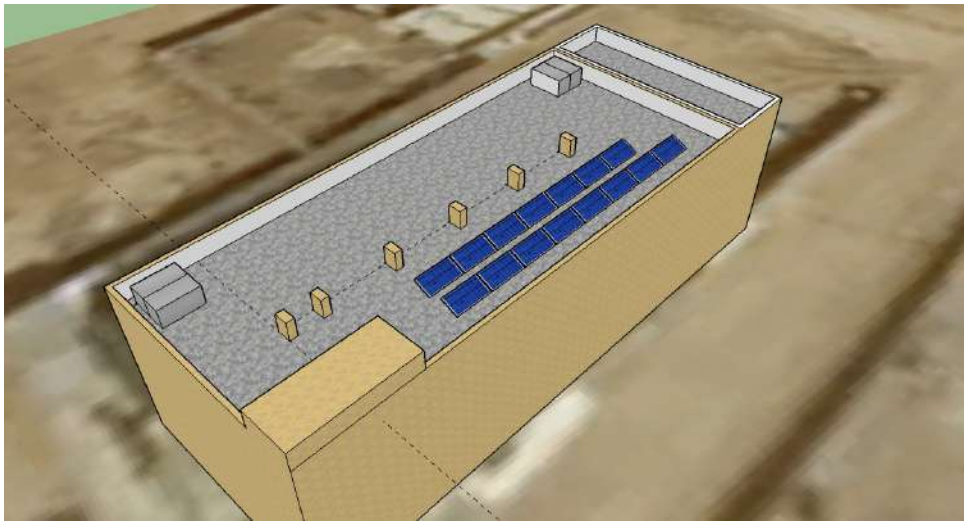


Figure 17: *3D model of Manshiet Abu-Hammour administrative building*

5.1.12 Ader administrative building

- Coordinates: 31◦11′57.1″N 35◦45′31.3″E

Based on the electrical consumption of Ader administrative building, the total capacity needed to cover the consumption is 3.3 kWp. The available space on the rooftop can fit the required capacity. The PV system generates approximately 5,148 kWh/year, which **covers 100%** of the total consumption that equals to approximately 443 JD/year. The total investment of the system is approximately 2,475 JD and the payback period is 5.5 years.

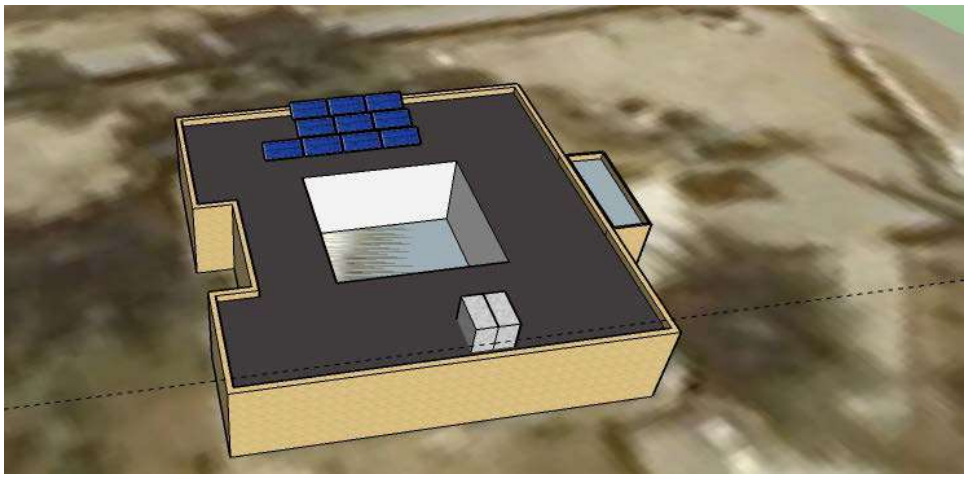


Figure 18: *3D model of Ader administrative building*

5.1.13 Al-Shahabyeh administrative building

- Coordinates: 31◦10′28.7″N 35◦41′12.2″E

Based on the electrical consumption of Al-Shahabyeh administrative building, the total capacity needed to cover the consumption is 1.6 kWp. The available space on the rooftop can fit the required capacity. The PV system generates approximately 2,500 kWh/year, which **covers 100%** of the total consumption that equals to approximately 181 JD/year. The total investment of the system is approximately 1,200 JD and the payback period is 6.5 years.

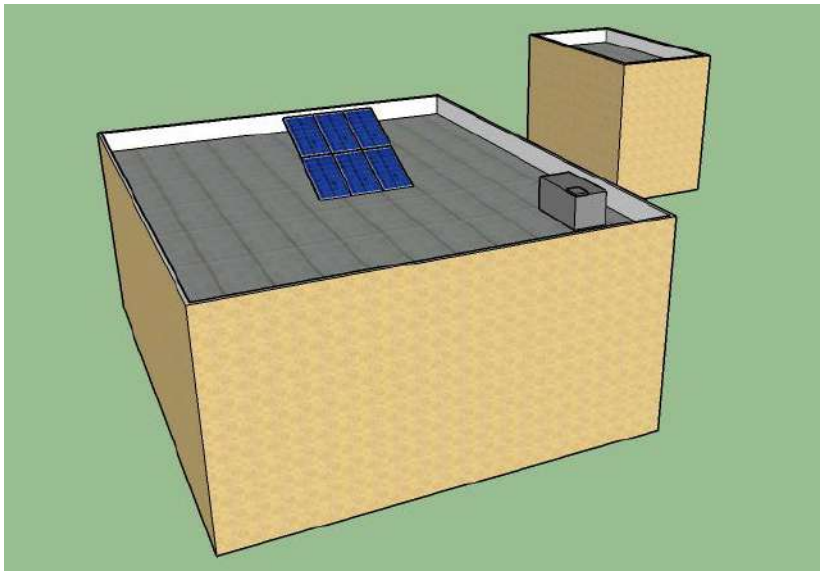


Figure 19: *3D model of Al-Shahabyeh administrative building*

5.1.14 Rakien administrative building

- Coordinates: 31◦13′20.5″N 35◦42′44.9″E

Based on the electrical consumption of Rakien administrative building, the total capacity needed to cover the consumption is 1 kWp. The available space on the rooftop can fit the required capacity. The PV system generates approximately 1,560 kWh/year, which **covers 100%** of the total consumption that equals to approximately 110 JD/year. The total investment of the system is approximately 750 JD and the payback period is 7 years.

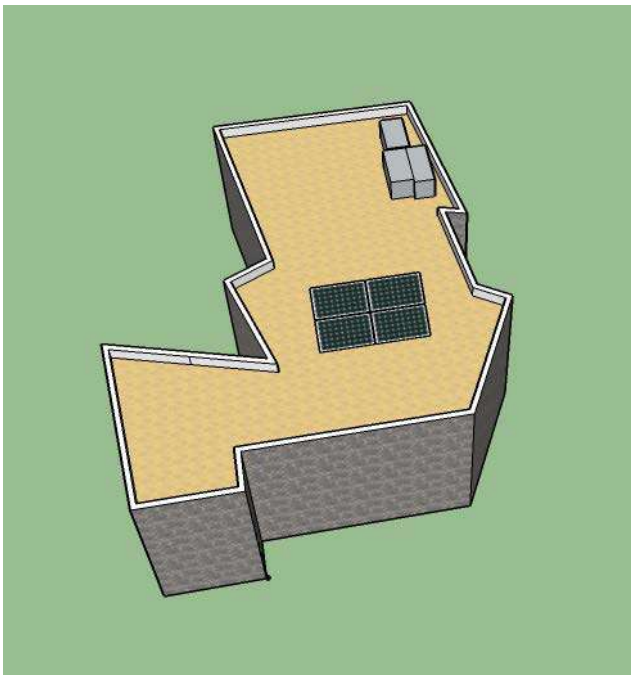


Figure 20: *3D model of Rakien administrative building*

5.1.15 Al-Jdaydeh administrative building

- Coordinates: 31◦15′11.5″N 35◦48′29.0″E

Based on the electrical consumption of Al-Jdaydeh administrative building, the total capacity needed to cover the consumption is 1.3 kWp. The available space on the rooftop can fit the required capacity. The PV system generates approximately 2,028 kWh/year, which **covers 100%** of the total consumption that equals to approximately 120 JD/year. The total investment of the system is approximately 975 JD and the payback period is 8 years.

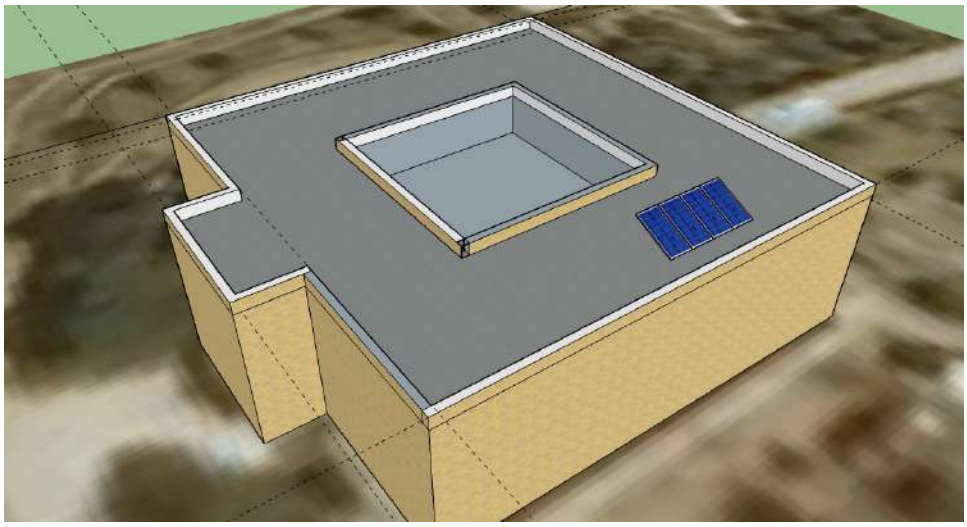


Figure 21: *3D model of Al-Jdaydeh administrative building*

5.1.16 Wadi Karak administrative building

- Coordinates: 31◦13′20.5″N 35◦42′44.9″E

Based on the electrical consumption of Wadi Karak administrative building, the total capacity needed to cover the consumption is 1.5 kWp. The available space on the rooftop can fit the required capacity. The PV system generates approximately 2,340 kWh/year, which **covers 100%** of the total consumption that equals to approximately 168 JD/year. The total investment of the system is approximately 1,125 JD and the payback period is 7 years.

Figure 22: *Wadi Karak administrative building*

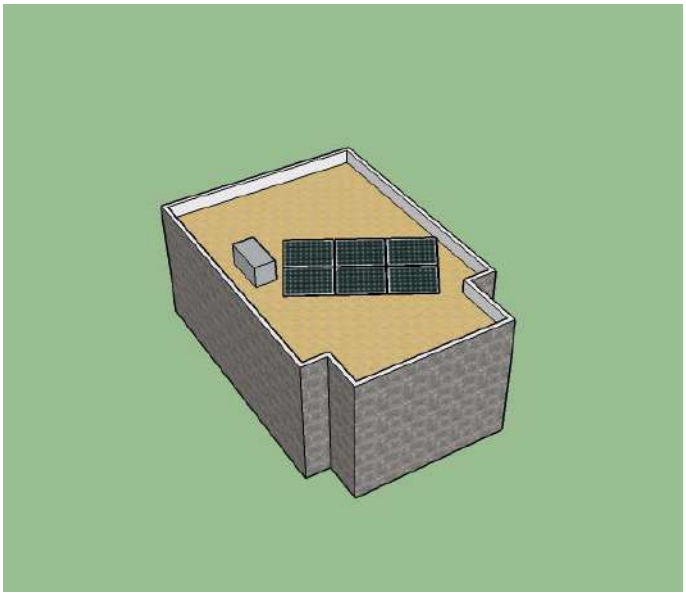


Figure 23: *3D model of Wadi Karak administrative building*

5.1.17 Baddan and Barda administrative building

- Coordinates: 31◦12′42.3″N 35◦40′39.9″E

Based on the electrical consumption of Baddan & Barda administrative buildings, the total capacity needed to cover the consumption is 1.1 kWp. The available space on the rooftop can fit the required capacity. The PV system generates approximately 1,716 kWh/year which **covers 100%** of the total consumption that equals to approximately 110 JD/year. The total investment of the system is approximately 825 JD and the payback period is 7.5 years.

Figure 24: *Baddan and Barada administrative building*

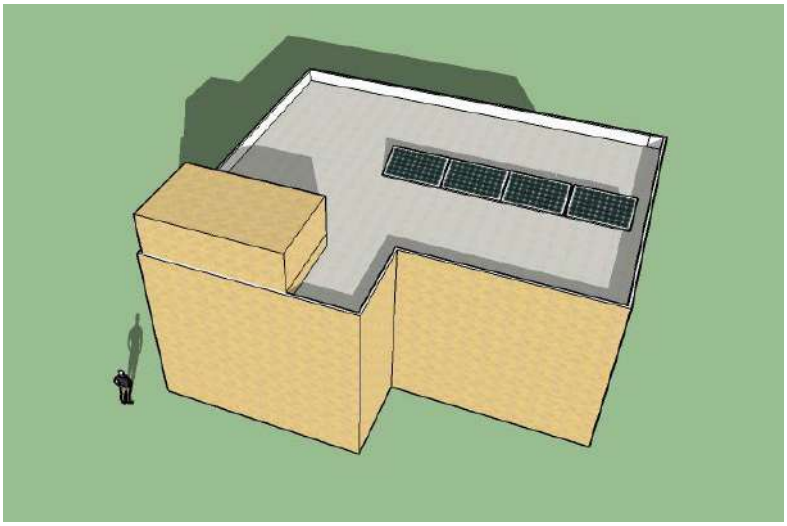


Figure 25: *3D model of Baddan and Barada administrative buildings*

5.1.18 Al-Hawieh administrative building

- Coordinates: 31◦09′05.8″N 35◦42′02.5″E

The electricity bills for Al-Hawieh administrative building **were not available**. However, the team estimated the electricity bills based on the electrical loads installed and utilized by the building. The available space on the rooftop can fit 7 kWp. The required capacity to cover the estimated consumption is 3.8 kWp. The PV system generates approximately 5,600 kWh/year, which **covers 100%** of the total consumption that equals to approximately 542 JD/year. The total investment of the system is approximately 2,850 JD and the payback period is 5.5 years.

Figure 26: *Al-Hawieh administrative building*

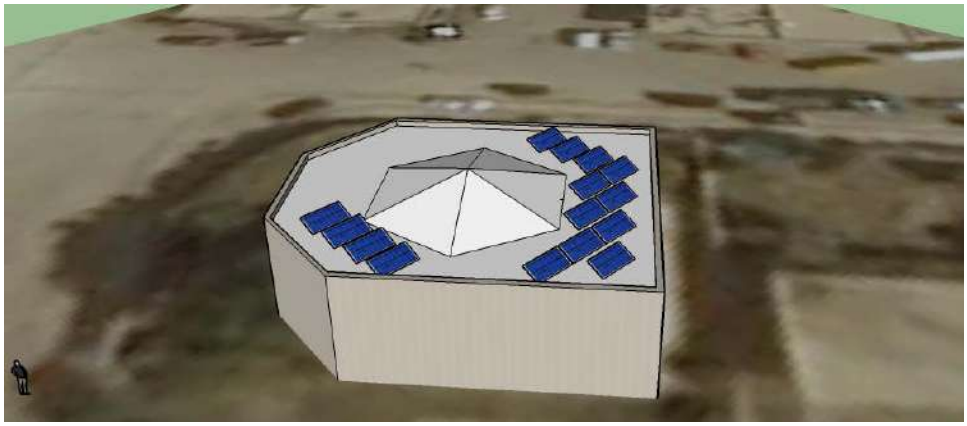


Figure 27: *3D model of Al-Hawieh administrative building*

5.2 Solar hot water System

The following buildings were assessed for the installation of the solar hot water systems:

a. Central municipal building.
b. Al-Adnanya administrative building.
c. Al-Ghweir administrative building.
d. Health Care Center.
e. Al-Marj administrative building.
f. Zaid Ebn Hareth administrative building.
g. Workshop Building.
h. Al-Thanya administrative building.
i. Zahoum administrative building.
j. Manshiet Abo-Hammour administrative building.

k. Ader Municipality administrative building.
l. Al-Shahabye administrative building.
m. Rakien administrative building.
n. Al-Jdaydeh administrative building.
o. Wadi Karak administrative building.
p. Baddan & Barda administrative buildings.

5.2.1 Central municipal building

The central municipality building contains **7 electric water heaters** with a capacity of **30 liters** as a source of heating in winter, distributed as follows:

Table 1*:The electric water heater at the Central municipal building*

Location	No	Capacity (Liter)	Power consumption (W)	Annual energy saving (KWh)	Annual cost saving (JD)	Solar hot water cost (JD)
Central Municipal Building	7	30	9100	2270.00	544.8	500

5.2.2 Al-Adnanya administrative building

Al-Adnanya Administrative building contains 1 electric water heater with a capacity of 50 liter as a source of heating in winter, distributed as follows:

Table 2: *The electric water heater in Al-Adnanya administrative building*

Location	No	Capacity (Liter)	Power consumption (W)	Annual energy saving (KWh)	Annual cost saving (JD)	solar hot water cost (JD)
Al-Adnanya administrative building	1	50	1500	550	38.5	350

5.2.3 Al-Ghweir administrative building

Al-Ghweir Administrative building contains 1 electric water heater with a capacity of 50 liter as a source of heating in winter, distributed as follows:

Table 3: *The electric water heater in Al-Ghweir administrative building.*

Location	No	Capacity (Liter)	Power consumption (W)	Annual energy saving (KWh)	Annual cost saving (JD)	Solar hot water cost (JD)
Al-Ghweir administrative building.	1	50	1500	550	44	350

5.2.4 Health Care Centre

The health care centre contains 1 electric water heater with a capacity of 50 liter as a source of heating in winter, distributed as follows:

Table 4: *The electric water heater in the health center building*

Location	No	Capacity (Liter)	Power consumption (W)	Annual energy saving (KWh)	Annual cost saving (JD)	Solar hot water cost (JD)
Health Care Centre	1	50	1500	550	99	350

5.2.5 Al-Marj administrative building

Al-Marj Administrative building contains 1 electric water heater with a capacity of 50 liter as a source of heating in winter, distributed as follows:

Table 5: *The electric water heater in Al-Marj administrative building.*

Location	No	Capacity (Liter)	Power consumption (W)	Annual energy saving (KWh)	Annual cost saving (JD)	Solar hot water cost (JD)
Al-Marj administrative building	1	50	1500	550	99	350

5.2.6 Zaid Ebn Harethah administrative building

Zaid Ebn Hareth administrative building contains 1 electric water heater with a capacity of 50 liter as a source of heating in winter, distributed as follows:

Table 6: *The electric water heater in Zaid Ebn Harethah administrative building.*

Location	No	No	Capacity (Liter)	Power consumption (W)	Annual energy saving (KWh)	Annual cost saving (JD)
Zaid Ebn Harethah administrative building	1	50	1500	550	49.5	350

5.2.7 Workshop Building

Workshop building contains 1 electric water heater with a capacity of 30 liter as a source of heating in winter, distributed as follows:

Table 7: *The electric water heater in Workshop building.*

Location	No	Capacity (Liter)	Power consumption (W)	Annual energy saving (KWh)	Annual cost saving (JD)	Solar hot water cost (JD)
Workshop building	1	30	1300	340	40.8	350

5.2.8 Al-Thanyah administrative building

Al-Thanya Administrative building contains 1 electric water heater with a capacity of 50 liter as a

source of heating in winter, distributed as follows:

Table 8: *The electric water heater in Al-Thanya building.*

Location	No	Capacity (Liter)	Power consumption (W)	Annual energy saving (KWh)	Annual cost saving (JD)	Solar hot water Cost (JD)
Al-Thanya administrative building	1	50	1500	550	49.5	350

5.2.9 Al-Zahoum administrative building

Al-Zahoum Administrative building contains 1 electric water heater with a capacity of 50 liter as a source of heating in winter, distributed as follows:

Table 9: *The electric water heater in Al-Zahoum administrative building*

Location	No	Capacity (Liter)	Power consumption (W)	Annual energy saving (KWh)	Annual cost saving (JD)	Solar hot water Cost (JD)
Al-Zahoum administrative building	1	50	1500	550	55	350

5.2.10 Manshiet Abu-Hammour administrative building

The Manshiet Abu-Hammour administrative building contains 2 electric water heaters with a capacity of 50 liter as a source of heating in winter, distributed as follows:

Table 10: *The electric water heater in Manshiet Abu-Hammour administrative building.*

Location	No	Capacity (Liter)	Power consumption (W)	Annual energy saving (KWh)	Annual cost saving (JD)	Solar hot water Cost (JD)
Manshiet Abu-Hammour Administrative building	2	50	3500	1,100.00	110	350

5.2.11 Ader administrative building

Ader Municipality Administrative building contains 1 electric water heater with a capacity of 50 liter as a source of heating in winter, distributed as follows:

Table 11: *The electric water heater in Ader Administrative building*

Location	No	Capacity (Liter)	Power consumption (W)	Annual Energy Saving (KWh)	Annual Cost Saving (JD)	Solar Hot Water Cost (JD)
Ader Administrative building	1	50	1500	550	49.5	350

5.2.12 Al-Shahabyeh administrative building

The Al-Shahabyeh administrative building contains 1 electric water heater with a capacity of 20 liter as a source of heating in winter, distributed as follows:

Table 12: *The electric water heater in Al-Shahabyeh administrative building.*

Location	No	Capacity (Liter)	Power consumption (W)	Annual Energy Saving (KWh)	Annual Cost Saving (JD)	Solar Hot Water Cost (JD)
Al-Shahabyeh Administrative building	1	20	1200	240	16.8	350

5.2.13 Rakien administrative building

The Rakien administrative building contains 2 electric water heaters with a capacity of 30 liter as a source of heating in winter, distributed as follows:

Table 13: *The electric water heater in Rakien administrative building*

Location	No	Capacity (Liter)	Power consumption (W)	Annual Energy Saving (KWh)	Annual Cost Saving (JD)	Solar Hot Water Cost (JD)
Rakien Administrative building	2	30	2600	1,100.00	77	350

5.2.14 Al-Jdaydeh administrative building

Al-Jdaydeh administrative building contains 1 electric water heater with a capacity of 50 liter as a

source of heating in winter, distributed as follows:

Table 14: *The electric water heater in Al-Jdaydeh administrative building.*

Location	No	Capacity (Liter)	Power consumption (W)	Annual Energy Saving (KWh)	Annual Cost Saving (JD)	Solar Hot Water Cost (JD)
Al-Jdaydeh Administrative building	1	50	1500	550	38.5	350

5.2.15 Wadi Karak administrative building

Wadi Karak administrative building contains 1 electric water heater with a capacity of 20 liter as a source of heating in winter, distributed as follows:

Table 15: *The electric water heater in Wadi Karak administrative building*

Location	No	Capacity (Liter)	Power consumption (W)	Annual Energy Saving (KWh)	Annual Cost Saving (JD)	Solar Hot Water Cost (JD)
Wadi Karak Administrative building	1	20	1200	240	16.8	350

5.2.16 Baddan and Barda administrative buildings

Baddan and Barda administrative buildings contains 1 electric water heater with a capacity of 50 liter as a source of heating in winter, distributed as follows:

Table 16: *The electric water heater in Baddan and Barda administrative buildings.*

Location	No	Capacity (Liter)	Power consumption (W)	Annual Energy Saving (KWh)	Annual Cost Saving (JD)	Solar Hot Water Cost (JD)
Baddan and Barda Administrative building	1	50	1500	550	38.5	350

6 Recommendations

6.1 Recommendation for PV systems

Most of the buildings stand a high potential for installing photovoltaics systems except for Al-Zahoum and Al-Marj administrative buildings. However, the payback period for some locations was found out to be high, such as Al-Jdaydeh, Al-Adnanya, Wadi Al-Karal, Rakien administrative building and Baddan & Barada administrative buildings.
Although all these locations have a potential for installing PV systems, the civil study is fundamental and has to be conducted prior installation for buildings that have a high number of PV modules, in order to determine the building's tolerance level due to the additional weight of installing PV panels. The civil study results will determine the possibilities of installing the solar systems. Furthermore, any building that does not have access to its rooftops; should install a ladder during and after the project implementation.

6.2 Recommendation on the solar hot water systems

Most of the buildings have potentials for installing solar hot water systems. However, the payback period for some locations is considered to be high such as Al-Jdaydeh, Al-Adnanya, Wadi Al-Karal, Rakien, Baddan, Ader, Al-Shahabyeh, Al-Thanya, Al-Ghweir, Zaid Ebn Hareth and Zahoum administrative buildings.

Furthermore, any building that has no access to its rooftop(s), has to install a ladder during and after the project implementation.

Note: Should the solar hot water system not be considered, then the electric heater system (Gazer) will be covered by the photovoltaic cell system.

7 Conclusion

This Report has provided an in depth renewable energy analysis, evaluation and assessment of the Karak Municipality in Jordan. The results have showed high potentials for installing PV and solar hot water systems for most of the buildings.

All buildings were modeled using a using three-dimensional (3D) modeling and a simulation tool, as well as real data, such as sun path and shading analysis.

Table 17 below, summarizes the outputs of the PV system assessment, whereas Table 18 summarizes the output of the solar hot water system assessment per location.

Table 17: *Site assessment summary of the photovoltaics systems*

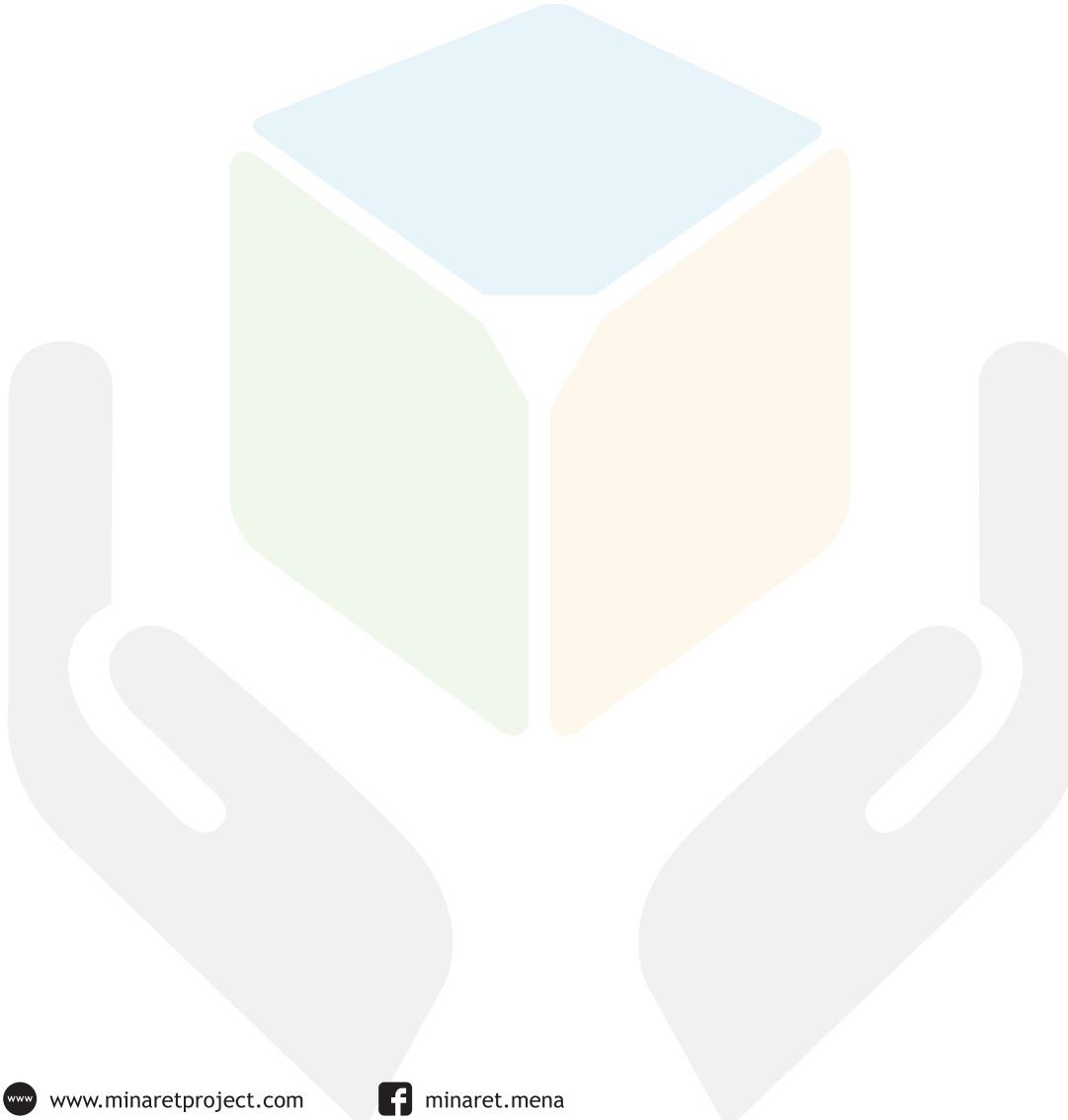
Location	Capacity (kWp)	Percentage of Saving %	Total Investment (JD)	Payback Period (years)
The Municipality Main Building	10	NA	7,500	NA
Central Municipal Building	54	100%	40,500	2
Al-Adnanya (A) Building	1.4	100%	1,050	7
Al-Ghweir (A) Building	0.7	100%	525	6.5

Health Care Center	2.3	75%	1,725	5.5
Al-Marj (A) Building	0	NA	0	NA
Zaid Ebn Haretheh (A) Building	4	100%	3,000	5.5
Workshops Building	6	100%	4,500	4
Al-Thanya (A) Building	3.4	100%	2,550	5.5
Al-Zahoum (A) Building	0.6	100%	450	6.5
Manshiet Abu-Hammour (A) Building	4.8	100%	3,600	4.5
Ader (A) Building	3.3	100%	2,475	5.5
Al-Shahabye (A) Building	1.6	100%	1,200	6.5
Rakien (A) Building	1	100%	750	7
Al-Jdaydeh (A) Building	1.3	100%	975	8
Wadi Karak (A) Building	1.5	100%	1,125	7
Baddan & Barda (A) Building	1.1	100%	825	7.5
Al-Hawieh (A) Building	3.8	100%	2,850	5.5

Table 18: *Site assessment summary of the solar water heater systems*

Location	Annual Electricity Energy (KWh)	Solar Hot Water Capacity (Lit/day)	Annual Energy Saving (KWh)	Annual Cost Saving (JD)	Solar Hot Water Cost (JD)	Payback (year)
Central Municipal Building	2,900.00	200	2,270.00	544.8	500	1
Al-Adnanya (A) Building	700	100	550	38.5	350	9
Al-Ghweir (A) Building	700	100	550	44	350	11
Health Care Center	700	100	550	99	350	4
Al-Marj (A) Building	700	100	550	99	350	4
Zaid Ebn Hareth A. Building	700	100	550	49.5	350	10
Workshop Building	400	100	340	40.8	350	12
Al-Thanya (A) Building	700	100	550	49.5	350	10
Zahoum (A) Building	700	100	550	55	350	9

Manshiet Abo-Hammour (A) Building	1,400.00	100	1,100.00	110	350	3
Ader Municipality A. Building	700	100	550	49.5	350	10
Al-Shahabye (A) Building	300	100	240	16.8	350	30
Rakien (A) Building.	1,400.00	100	1,100.00	77	350	6
Al-Jdaydeh (A) Building	700	100	550	38.5	350	13
Wadi Karak (A) Building	300	100	240	16.8	350	30
Baddan & Barda (A) Buildings	700	100	550	38.5	350	13



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