NEAR EAST UNIVERSITY

INSTITUTE OF GRADUATE STUDIES

DEPARTMENT OF ENVIRONMENTAL SCIENCES AND ENGINEERING

ASSESSMENT OF SOLAR ENERGY IN LEBANON USING THE NASA POWER DATASET

M.Sc. THESIS

FRANCIS SURFIA DIOH

Nicosia

June 5, 2023

FRANCIS SURFIA DIOH

POTENTİAL OF SOLAR ENERGY İN LEBANON FOR SOLVİNG ELECTRİCİTY SHORTAGE AND REDUCİNG CO2 EMİSSİONS

MASTER THESIS

June 5, 2023

NEAR EAST UNIVERSITY

INSTITUTE OF GRADUATE STUDIES

DEPARTMENT OF ENVIRONMENTAL SCIENCES AND ENGINEERING

ASSESSMENT OF SOLAR ENERGY IN LEBANON USING THE NASA POWER DATASET

M.Sc. THESIS

FRANCIS SURFIA DIOH

Supervisor
Prof. Dr. Hüseyin GÖKÇEKUŞ

Nicosia

June 5, 2023

Approval

We certify that we have read the thesis submitted by Francis Surfia Dioh. Titled **"ASSESSMENT OF SOLAR ENERGY IN LEBANON USING THE NASA POWER DATASET"** and that in our combined opinion it is fully adequate, in scope and in quality, as a thesis for the degree of Master of Environmental Sciences and Engineering.

Examining Committee	Name-Surname	Signature
Head of the Committee:	Prof. Dr. Aşkın KİRAZ	………………………
Committee Member:	Assoc. Prof. Dr. Fidan ASLANOVA	………………
Committee Member:	Assist. Prof. Dr. Mustafa Alas	………………………………
Supervisor:	Prof. Dr. Hüseyin GÖKÇEKUŞ	………………………
Co-Supervisor	Assoc. Prof. Dr. Youssef KASSEM	………………………

Approved by the Head of the Department

…06../05…../2023

……………………………

Assoc. Prof. Dr. Fidan ASLANOVA

Head of Department

Approved by the Institute of Graduate Studies

…06../…05../2023

Prof. Dr. Kemal Hüsnü Can Başer

Head of the Institute

Declaration

I hereby declare that all information, documents, analysis and results in this thesis have been collected and presented according to the academic rules and ethical guidelines of Institute of Graduate Studies, Near East University. I also declare that as required by these rules and conduct, I have fully cited and referenced information and data that are not original to this study.

FRANCIS SURFIA DIOH

…..06 /….05. /2023

Dedication

I dedicate this thesis to God Almighty, my creator, tower of strength, and source of inspiration, wisdom, knowledge, and comprehension. Christ has been the source of my strength throughout this program, and I have only flown on His wings. I also dedicate this work to my late mother, whose words of discipline and courage helped me go this far. Finally, I dedicate my thesis to my dear senior brother Abraham W. Dioh, who has inspired me throughout and whose motivation has ensured that I give it everything I have to finish what I have started. Thank you very much. My love for you is immeasurable. God's blessings on you.

.

Acknowledgements

First and foremost, I want to thank the Almighty God for preserving my life and keeping me well during my time in Cyprus, allowing me to progress so far in my academic career. I am particularly grateful to my supervisor and co-supervisor, Prof. Dr. Hüseyin GÖKÇEKUŞ and Assoc. Prof. Dr. Youssef Kassem, for their invaluable guidance, unwavering support, and patience throughout my M.Sc. studies. Their enormous knowledge and abundance of experience have assisted me in both my academic and personal lives. I'd also like to thank my academic advisor, Assoct.Prof.Dr. Fidan Aslanova, for her help during my studies. I'd want to thank everyone in the Near East University Civil and Environmental Faculty.

Finally, I want to thank my father Mr. Isaac P.K. Dioh for his words of couragement and moral support. I am and will forever be grateful. To my dear big brother, Abraham W. Dioh, It would have been difficult for me to finish my studies without your wonderful understanding, encouragement, support and guidance throughout the last few years; I am forever grateful.

.

FRANCIS SURFIA DIOH

Abstract

Assessment of Solar Energy in Lebanon using the NASA Power Dataset

FRANCIS SURFIA DIOH
M.Sc. Department of Environmental Sciences and Engineering,
June 5,2023, 93 Pages

We can have a cleaner and better way of growing by using renewable energy like solar power. Using solar power has many benefits. The installation of small solar panels on buildings in Lebanon was examined in this research as a means of utilizing the sun to generate electricity. This has never been studied before in Lebanon. The research also checked if it's financially and technically possible to install small solar panels on rooftops to be connected to the electricity grid. NASA collected information about how much sunlight hits certain parts of Lebanon every month. This is used to see how much energy from the sun those areas could make into power. Also, a computer program called RETScreen was used to see if putting solar panels on rooftops and connecting them to the electricity grid could help solve the problem of not having enough electricity right now. This study found that in certain areas, there is a yearly amount of GSR that ranges between 1737 and 1764kWh/m2, and as such, the chosen cities and regions can give solar power systems to homes for people to use.

This research found that putting solar panels on rooftops can help with the electricity crisis, use less fossil fuels, and reduce pollution. Also, solar energy can be used to power small machines that turn salt water into drinking water and help with the water crisis. The study found that putting solar panels on rooftops that are connected to the electricity grid is a good way to make electricity. It's good for the environment, makes economic sense and works well. It also reduces the need for using fossil fuels.

Keywords: Grid-connected, Lebanon, RETScreen, small scale PV system, solar energy potential.

Özet

NASA GÜÇ VERİ SETİ KULLANARAK LÜBNAN'DA GÜNEŞ ENERJİSİNİN DEĞERLENDİRİLMESİ

FRANCIS SURFIA DIOH

M.Sc. Çevre Bilimleri ve Mühendisliği Bölümü,

Joon, 5 ,2023, 93 Sayfa

Güneş enerjisi gibi yenilenebilir enerji kullanarak daha temiz ve daha iyi bir büyüme yöntemine sahip olabiliriz. Güneş enerjisi kullanmanın birçok faydası vardır. Bu araştırmada, Lübnan'daki binalara küçük güneş panellerinin yerleştirilmesi, elektrik üretmek için güneşten yararlanma aracı olarak incelenmiştir. Bu Lübnan'da daha önce hiç çalışılmamıştı. Araştırma ayrıca, elektrik şebekesine bağlanacak çatılara küçük güneş panelleri kurmanın finansal ve teknik olarak mümkün olup olmadığını da kontrol etti. NASA, her ay Lübnan'ın belirli bölgelerine ne kadar güneş ışığı düştüğü hakkında bilgi topladı. Bu, bu alanların güneşten ne kadar enerji sağlayabileceğini görmek için kullanılır. Ayrıca, çatılara güneş panelleri yerleştirmenin ve bunları elektrik şebekesine bağlamanın şu anda yeterli elektriğin olmaması sorununu çözmeye yardımcı olup olmayacağını görmek için RETScreen adlı bir bilgisayar programı kullanıldı. Bu çalışma, belirli alanlarda yıllık 1737 ile 1764kWh/m2 arasında değişen bir GSR miktarının olduğunu ve bu nedenle seçilen şehir ve bölgelerin insanların kullanması için evlere güneş enerjisi sistemleri verebileceğini buldu.

Bu araştırma, çatılara güneş panelleri yerleştirmenin elektrik krizine yardımcı olabileceğini, daha az fosil yakıt kullanabileceğini ve kirliliği azaltabileceğini buldu. Ayrıca güneş enerjisi, tuzlu suyu içme suyuna çeviren ve su krizine yardımcı olan küçük makinelere güç sağlamak için kullanılabilir. Çalışma, elektrik şebekesine bağlı çatılara güneş panelleri yerleştirmenin elektrik üretmenin iyi bir yolu olduğunu buldu. Çevre için iyidir, ekonomik açıdan mantıklıdır ve iyi çalışır. Ayrıca fosil yakıtlara olan ihtiyacı da azaltır.

Anahtar Kelimeler: Güneş enerjisi potansiyeli, küçük ölçekli PV sistemi, Lübnan, RETScreen, şebeke bağlantılı.

Table of Contents

List of Tables

List of Figures

List of Abbreviations

ALCS:	Annual Life Cycle Saving
CF:	Capacity Factor
EG	Electricity Generation
EP:	Equity Payback
EU:	European Union
FAO:	Food Agriculture Organization
GEF:	Global Environment Facility
GEG:	Green Economic Growth
GHG:	Greenhouse Gas
GHI:	Global Horizontal Index
GSR:	Global Solar Radiation
GW:	Groundwater
GWh:	Gaga Witt Per Hour
IWRM:	Integrated Water Resource Management
LCOE:	Levelized Cost of Energy
MW:	Mega Witt
NASA:	National Aeronautics and Space Administration
NGOS:	Non-Governmental Organizations
NPV:	Net Present Value
PGE:	Power Generating Factor

PV: Photovoltaic

CHAPTER I

Introduction

This chapter discusses the overview of renewable energy in Lebanon. Also, the scope and aim of the study are explained. The significance and limitation of this thesis is also highlighted in detail.

Background

Burning fossil fuels like oil and gas is causing the quality of air on the planet to deteriorate. The weather is changing, and it's hurting the environment. We need to start doing things differently from now on. One issue we face is that we are damaging the earth's surroundings. We have to figure out how to get energy that doesn't harm the environment. The way wind and solar power work can change depending on where and when they're used. Many countries are using both old and new forms of energy to make electricity. Utilizing electricity stimulates economic advancement by enabling the operation of electricity-powered devices and enhancing the quality of lighting. Many people in Lebanon are worried because they may not have electricity and this is making them upset. There are individuals who prefer using renewable energy sources to promote Earth's safety and well-being. Energy that does not have an end can be created by using sunlight, subterranean heat, wind and plant resources. Using sunlight to generate electricity is the best option as it can reduce costs for everyone. The best way to have a good future is to use the sun's energy, which is called solar energy.

Lebanon sometimes doesn't have electricity because they don't have enough power. Lebanon might not have electricity for a while because they need to bring in fuel from other places to generate it. Kassem Y says that Lebanon uses oil, water power, and things they bring in from other places to make electricity. Et al 2019 means that a group of people wrote a research paper that was released in 2019. The generation of electric power in Lebanon is accomplished through the utilization of power stations that operate by harnessing heat and water. Some of it is water (252). We have two ways to make electricity. One way is using wind and sun power, and it gives us 6 million watts of electricity. The other way is by burning things, which gives us 2,764 million watts of electricity. In 2015, most of the energy (97%) came from thermal plants, and only a little (2. 3%) came from other sources. Five percent came from other sources. Out of all the power used, 6% of it came from water. Lebanon has a problem with not having enough electricity, and this is causing a lot of trouble for regular people, stores, and small businesses every day. Lebanon is having a big problem with electricity because it keeps going out. This problem has been going on for a while, but there isn't a good fix yet.

Lebanon's ability to maintain order is becoming less strong. Lebanon's electricity industry is having trouble because they don't have enough energy. They don't have enough power, so they have to use old machines. They have to discover different methods to produce energy without using oil. Renewable energy is becoming more significant nowadays because the number of individuals is increasing, and they require more energy to function.

We really need a lot of energy. The land is being put under a lot of pressure because many people live there and live well. Lebanon has a problem with energy for its people. The problem can be addressed through the use of energy efficiency and renewable energy sources, which is a favorable outcome. Lebanon can use renewable energy because it's often sunny. This can help the country avoid building extra power plants.

Climate of the Lebanon

The country of Lebanon is situated in the South-West Asian region by the Mediterranean Sea and it is relatively small. The location typically measures 10,452 square kilometers and has a width of about 45 kilometers. It can be found in a certain area, with specific numbers like 33 and 36, and direction like north and east. Lebanon has two big groups of mountains that are split by a valley called Bekaa. These mountains line up next to the Mediterranean Sea, going northeast to southwest. Lebanon has pleasant and dry summers, but its winters are cold and stormy. While there's excessive rain during the months of November to April, July and August witness little precipitation. Water resources are relatively abundant in Lebanon, in contrast to other Middle Eastern nations.

Lebanon has more water than its nearby countries in the Middle East. There exist two spots in Lebanon where water can be found. One is close to the ocean, and the other is deeper inside. There are lots of little rivers that go into 16 bigger rivers. Fourteen of these bigger rivers go to the Mediterranean Sea and 23 of them are not man-made. The average water flow of these rivers is 3,900 million cubic meters annually with a length measuring 730 kilometers. Winter is when we have the most rain or snow. Although there is an abundance of water during winter, in numerous locations, there is insufficient water to last the entire year. The coastal area has a higher temperature of 15°C while the mountains and Bekaa Valley have cooler temperatures of 8°C and 6°C respectively. Annually, the coastal region experiences rainfall ranging from 700 to 1000 millimeters. This happens more frequently in the northern part. Northern and central Lebanon receive substantial rainfall and snowfall of up to 1500 mm thanks to its mountains. The climate on the two sides of Mount Lebanon, east and west, is dissimilar. The weather is not very hot and sticky, and it usually rains about 600mm.

In January, some places in Lebanon usually get a lot of rain. In some areas called the Northern Bekaa Valley, it can rain 50 millimeters. Other places named the Central Bekaa Valley can get up to 150 millimeters of rain. Laqlouq is a town in the mountains up north and in January it usually has rain that measures 350mm. Jezzine is a town in the mountains that gets about 300 millimeters of rain. Normally, the coast gets 200 millimeters of rain. The temperature on the coast is usually around 19 degrees every year. When you go higher up, the temperature becomes colder. For every 500 meters you climb, the temperature goes down by about 3 degrees Celsius. At 5°C, it gets colder until it reaches 215°C. The higher you climb a mountain, the colder it gets. At a height of 1000 meters, the temperature is around 15 degrees Celsius. At 2000 meters, the temperature drops to around 9 degrees Celsius. It was very chilly in January. It was colder in the mountains (4°C) than on the coast (7°C). July is the warmest month of the year. In some places, it can get very hot and temperatures can reach up to 35°C. This mostly occurs in the Bekaa Valley. It feels nicer near the coast because there is more moisture in the air which affects the temperature.

The concept of Renewable Energy

Renewable energy sources are derived from nature and they constantly replenish themselves, including the sun, wind, plants, heat from the Earth and water resources. This kind of power can make electricity and fuel. Maintaining cleanliness and preserving natural resources is crucial in achieving sustainability objectives and enhancing the quality of life. Currently, the Earth is getting hotter, and this is causing damage to both living things and humans.

The group in charge of businesses and governments creates a lot of CO_2 pollution, around 25% of it. This dirty air makes gases that trap heat and make the Earth hotter. The United Nations wants all countries to work together to meet the Sustainable Development Goals. Experts suggest that if we want to lessen the effect of climate change, we need to use less energy individually and rely more on using renewable sources of energy to fulfill our needs.

Vakulchuk and his friends. Smart people say that by 2030, we should get most of our energy from clean sources – about 80% – so that the planet doesn't become too hot. By the year 2050, we should use only clean sources for all our energy needs. We need to use more renewable energy, like wind and solar power, so that it makes up a large portion of the energy we use. We need important things like transportation, power, and water. The way we use them can impact the weather. The weather can easily change the systems that give us resources. It's important to manage assets to make sure both moderating and adapting things work well.

Advantages of Renewable Energy

. Renewable energy is a good thing because it can help meet our energy needs when we run out of fossil fuels. It's becoming more important because we need more power, but have limited fossil fuel sources. Using renewable energy is good for the environment. Earth's renewable energy resources can be harnessed to generate power without causing harm to the planet. Renewable energy doesn't create much or any harmful gases that pollute the air. According to Maradin, it is possible to generate heat and electricity without emitting harmful gases into the atmosphere by utilizing sustainable energy sources. People are switching to renewable energy because it is getting more popular.

Table 1.1

Advantages of renewable energy

Advantages
Environmental protection (reduced greenhouse gas emission)
Reduced fossil fuel consumption
Reduced energy imports dependence
Stimulating the development of innovation and the economy
Increasing employment

Rural development
Reduction of energy scarcity (expansion of rural electrification capacities)

Source: Maradin, D(2021)

Disadvantages of Renewable Energy

Renewable energy is good in some ways, but there are also some problems and limits when we use it every day. Renewable energy is based on the location and weather because of how they work. They can be hard to use because they're not always predictable or stable.

Table 1.2

Disadvantages of renewable energy

Disadvantages
Weather conditions dependence
Non-continuity and unpredictability
Acceptance of renewable electricity in the power system
Low ability to produce electricity
Low energy efficiency
Low maximum capacity utilization/low capacity factor
Relatively high cost of electricity production

Source: Maradin, D(2021)

Renewable Energy Sources

In the future, we will use more natural sources of energy. There are three types of ways we can get energy: nuclear, renewable, and fossil fuels. Renewable energy sources are natural resources that we can use over and over to make energy. Examples include wind, solar, biomass, and geothermal power. Renewable energy is good because it doesn't create pollution or harmful gases when used to power homes..

Table 1.3

Renewable energy sources

Energy source	Energy conversion and usage options
Hydropower	Power generation
Modern biomass	Heat and power generation, pyrolysis, gasification, digestion
Geothermal	Urban heating, power generation, hydrothermal, hot dry rock
Solar	Solar home system, solar dryers, solar cookers

Direct solar	Photovoltaic, thermal power generation, water heaters
Wind	Power generation, wind generators, windmills, water pump
Wave	Numerous designs
Tidal	Barrage, tidal stream

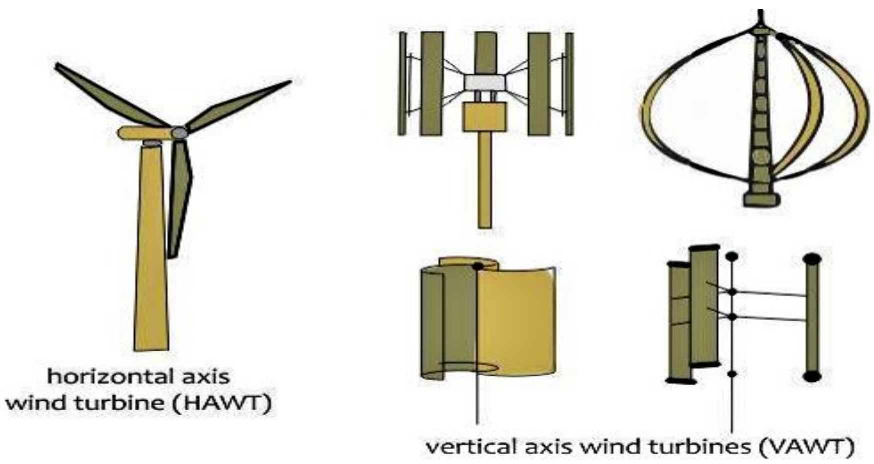
Source: N.L. Panwar et al 2011

Wind Energy

The wind blows all over the world and some places have more wind power. Wind power is made by using the power of moving air. Generating electricity using big turbines in the ocean or on land is one way to help stop climate change in both saltwater and freshwater environments

Figure 1.1

Horizontal and vertical axis wind turbine



Hydropower Energy

Hydropower gets energy by using water that goes downhill to make electricity with turbines. Hydropower projects are different sizes and some use dams or rivers to make electricity. This means using technology to make power from water that comes and goes at different times of the year.

Figure 1.2

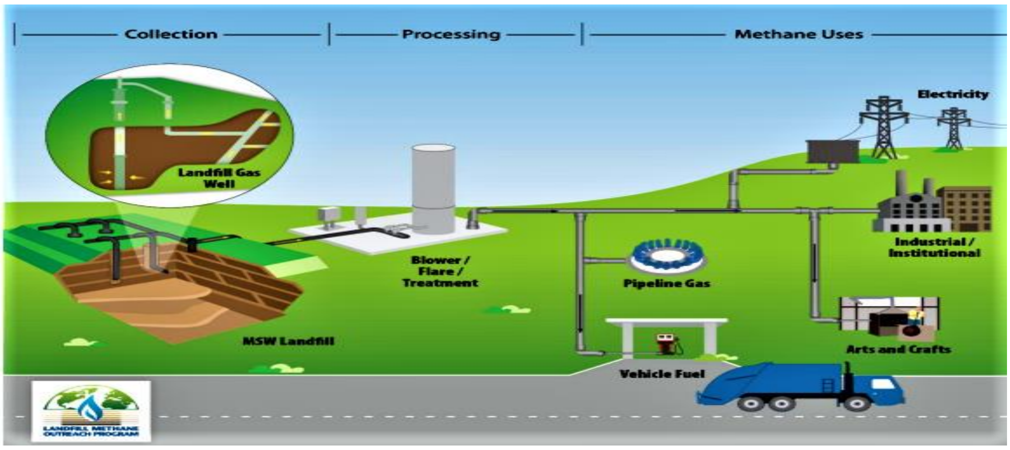
Hydropower plant

Bioenergy

Bioenergy may be a sort of energy that comes from living things. Bioenergy could be a kind of fuel made from plants and creatures. We are able utilize it to control vehicles, make power, cook nourishment, and warm buildings. It's critical since it's a huge source of vitality. Bioenergy gets materials from diverse sources like remains from cultivating (like sugar cane squander), scraps from ranger service (like bits of wood), and scraps from taking care of creatures (like dairy animals crap).

Figure 1.3

Biogas procedure

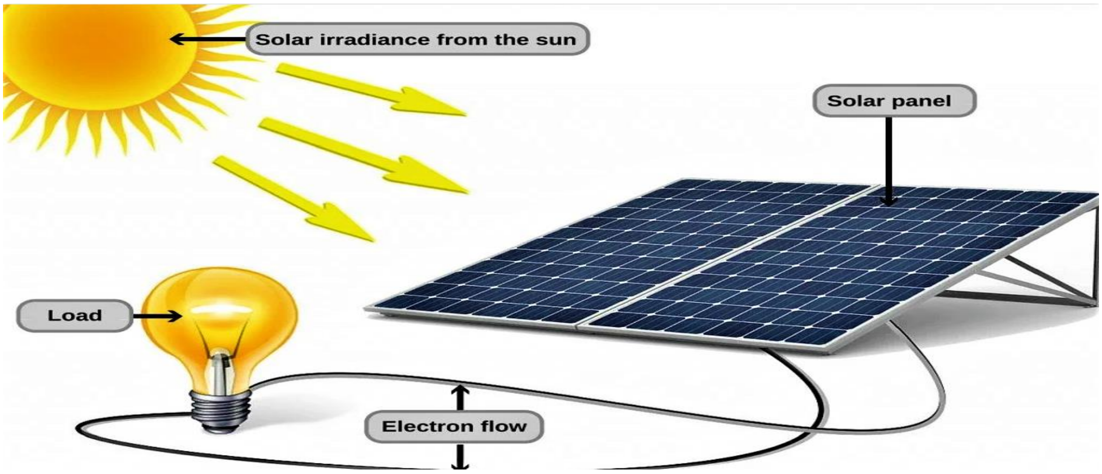


Direct Solar Energy

Direct sun powered vitality implies utilizing the Sun's vitality straightforwardly for renewable vitality innovations. The sun's vitality is utilized by a few machines that are neighborly to the environment like wind turbines and sea warm machines. The vitality is taken from the ground that has retained it from the sun and after that changed into distinctive sorts of vitality

Figure 1.4

Solar energy procedure



Geothermal Energy

Geothermal vitality comes from interior the Soil and could be a type of vitality that can be utilized to make warm. The way the inside of the planet is built and what happens there has got to do with where the warm comes from. The soil incorporates a part of warm in its outside and lower parts, but it's not equitably spread out. Now and then it's as well profound to utilize for control.

Figure 1.5

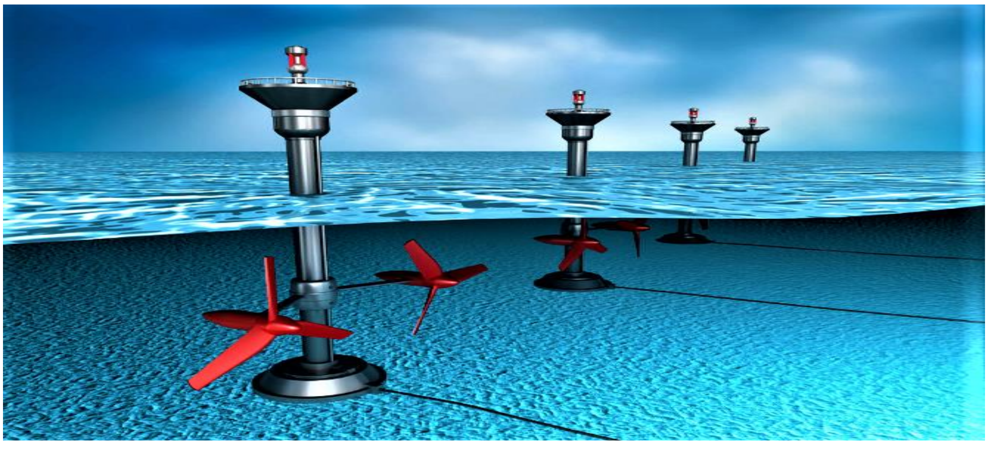
Geothermal power plant

Ocean Energy (Tide And Wave)

When the wind blows over the sea, it makes waves on the surface of the water. The more the wind blows quick and distant, the more vitality it makes. It moreover makes greater waves and keeps making vitality for a longer time. The sea includes a part of vitality within the frame of waves, tides, streams, and heat on its surface. This vitality is sufficient to supply power for the complete world.

Figure 1.6

Oceanic power plant



Scope of the Study

The main scope of the current study was to assess the possibility of the installation of small solar panels on buildings in Lebanon as a means of utilizing the sun to generate electricity. The research also checked if it's financially and technically possible to install small solar panels on rooftops to be connected to the electricity grid in Lebanon for the first time. To meet this aim, as a result of the lack of actual data, average monthly global solar radiation data collected by NASA is used to assess the solar energy potential in the chosen areas of Lebanon. The RETScreen software is used to examine the small-scale grid-connected rooftop PV system as a potential remedy for the current electricity issue.

Significance of the Study

This research is about finding out if using the sun's energy to make electricity is possible and affordable in Lebanon. Specifically, they want to see if putting solar panels on rooftops and connecting them to the power grid would work. This is the first time anyone has looked into this in Lebanon. Right now, every country is trying to use renewable energy instead of fossil fuels to help prevent climate change. Using the sun's energy to make power is a new way to solve the world's electricity problems and use less fossil fuels. In the past few years, people have started using more renewable energy instead of traditional sources. This is also happening in Lebanon because there are more people living there and they need more energy to use.

Solar energy is a popular way to make electricity without using non-renewable resources. We can turn sunlight into electricity with special panels called photovoltaic (PV) panels. Lebanon has ways to make energy from things that won't run out and is in a place with some sun. Investing in these ways to make energy might mean making more ways to make energy. This research is important because using solar power can help us fix the electricity problem and make electricity cheaper. The sun's energy can be used to make clean water from salt water in a small machine, which can help with the problem of not having enough water. Using solar energy systems can fix the problem of not having enough electricity and also make less CO2 gas.

Problem Statement

Lebanon is one of the few countries that doesn't have a regular way of getting electricity, and it's also facing a serious energy problem. Lebanon needs to import fuel oil and diesel to keep the country running. Sometimes there are power outages that last a long time. Lebanon has 13 power plants that can make up to 3016 MW of electricity. This includes 252. 6 MW from hydroelectricity and 2764 MW from heat energy.

Electricity shortage is a big problem that people in Lebanon face every day, especially those who rent, own shops or have small businesses. It has been a problem for a long time. Power outages in Lebanon are a big problem that has been going on for a long time without any real solutions. The electricity in Lebanon is not working well. Most of the electricity in Lebanon comes from fossil fuels (97%), while a small amount comes from hydropower (3%). The increasing use of modern technology has caused more energy to be used due to the increased size and need for equipment. Due to masses expansion and the advancing need for present day broad and small equipment, control utilization has extended. (Yassem Kassam et al. 2022). Due to the debasement of developing control plants in the midst of the past few a long time, the nation has been experiencing a veritable imperativeness crisis. (Yassem Kassam et al. 2022). As a result, tenants directly association control power outages for longer than 13 hours each day. Citizens depend on modest household generators or family control generators as a result, both of which are especially exorbitant. (Yassem Kassam et al. 2022). Wehbe, N. (2020), and Farhat, R. A. (2020), claim that private generators are utilized over the country to supply.

Aim of the Study

The number of people in the world is increasing, and they need more energy to use. Renewable energy is becoming more important in Lebanon and other places because it can be used instead of non-renewable energy. Lebanon does not use solar power systems a lot. Not many studies looked at using the sun as a way to make electricity. Hence, the aim of this research was to assess the possibility of the installation of small solar panels on buildings in Lebanon as a means of utilizing the sun to generate electricity. The research also checked if it's financially and technically possible to install small solar panels on rooftops to be connected to the electricity grid in Lebanon for the first time, this involved using a special computer program called RETScreen. Using NASA's information on how much sunlight is shining across the world each month, the research looked at how much energy could come from the sun in certain parts of Lebanon.

Limitation of the study

The research is evaluating the feasibility of utilizing solar energy from rooftops in Lebanon. The assessment will entail verifying the expense and determining its potential for connection to the power grid. This investigation is something that have never been attempted before. This work has limitations and it's crucial to acknowledge them. The projected financial figures were determined by examining the past earnings. The computer program didn't include things like dust, light, heat, and moisture because it wasn't able to. To estimate the project cost, we analyzed the amount spent by others on similar projects.

CHAPTER II

Literature Review

This chapter reviews relevant literature on the energy status of Lebanon, solar, wind energy and water resources of Lebanon. The renewable energy potential of Lebanon is also discussed.

Energy Status in Lebanon

Lebanon has a big problem with not having enough energy. This means they don't have electricity all the time. Lebanon sometimes experiences longer power outages because they have to rely on buying fuel oil and diesel from other countries to create energy. Lebanon uses oil, water power and imports to make electricity, as said by Kassem, Y. "et al" means. Lebanon's energy system is composed of thermal and hydroelectric power stations. Lebanon has 13 sources of power that can make 3016 MW of energy. Some of this energy comes from water (252. 6 MW) and some of it comes from heat (2764 MW). In 2015, most of the energy produced came from thermal plants - they made 97% of it. Hydropower only contributed a small amount - 2. 6% of all energy. Many people in Lebanon are worried about a big problem with electricity that has been going on for a long time. This problem affects how people live, as well as small businesses and shops every day. The power in Lebanon has been turning off for a long time and nobody has fixed it. This is causing a big problem.

Lebanon's electricity system has problems. Usually, the electricity goes off daily for different lengths of time depending on where you live. It can last from 3 to 13 hours. Families have to pay two electricity bills. One is for electricity from Electricity Provider of Lebanon and the other is for generators that they buy to have electricity all the time. Electricity is being limited more now. Right now, people need more than 3458MW of power, but we only have the ability to produce around 2000MW. Making electricity costs a lot of money. The EDL only provides some of the electricity needed when people use the most energy, which is probably not enough.

The quality of electricity in Lebanon is getting worse. The Lebanon News said that the cities in the country have less electricity every day. The electrical industry in Lebanon has some problems. One problem is that they don't have enough petroleum substitutes. Another problem is that they can't make enough electricity to meet the demand. They need to build new factories to make more.

Related Literature on Solar and Wind energy Potential of Lebanon

Based on research from 2010 to 2021, this information is about using renewable energy and water resources in Lebanon. Many scientists have studied how we can use solar and wind energy in different parts of Lebanon. They are also looking into using water as a renewable resource.

The power sector in the country makes up 58% of all the CO2 emissions, and private generators are responsible for 25% of that. This was found by Kassem Y and his team in 2022. Using solar energy instead of non-renewable energy like gas and oil can help us use less of these harmful fuels and create electricity in a cleaner way.

Youssef Kassem and his team studied the possibility of using solar and wind power in Rayak, Lebanon. They also looked at how the use of wind and solar energy could make sense financially. This area has lots of sunlight, but not much wind. It's a great place for using solar power because it gets a lot of sunshine each year.

Youssef Kassem and other researchers studied how strong the wind can be in Tripoli, Sidon, and Beirut in Lebanon. The study showed that the wind is blowing between 2. 627 meters per second and 3. 56 meters per second in that area. Also, the strength of the wind is not very strong; it's between 14. 634W/m2 to 25280W/m2Clean energy comes from natural sources like the sun, wind, and water. We call it clean because it doesn't harm the planet. Renewable energy sources are natural and don't cost anything. In Lebanon, we use water power, energy from outside and oil products to make electricity. Most of the energy we use comes from oil products, but only a very small amount comes from renewable sources. The map shows that the mountains have a lot of wind power, but it might be expensive to put wind turbines there. Usually, we use special machines to measure how fast the wind blows in different areas, and this helps us figure out how much energy we can get from the wind. Many scientists looked at different parts of Lebanon to see if they could use the power of the sun and wind to create energy.

The authors, Dolf Gielen and his team, looked at how we can switch to using renewable energy faster by 2050. They used new information and studied how this change would affect technology and money. Saving energy and using clean energy like wind or solar power are very important to making a big change, and they work together too. Good economic situation, resources that can be easily reached, technology that can be expanded, and benefits for society all make it possible for this change to happen. Renewable energy can provide enough power for two-thirds of the world, and using these sources will help reduce pollution that causes global warming. This will help keep the world from getting too hot by 2050.

Scientists studied the advantages and disadvantages of solar energy systems in a research paper published in 2017. We need new solar energy technology to provide enough energy for the world. The study found out that many new big solar energy projects are starting to operate, such as concentrated solar power. Solar energy is facing some problems that are making it difficult to improve. These problems include solar panels not working very well, the systems that support them not working well, it being too expensive to start using, and not enough people who know how to work with it. The CSP system is more costly compared to PV technology, but it works well in places where there are no clouds or haze. Right now, PV technologies might continue to be the most popular way to create solar energy. Not many people are using solar systems that work independently because rules and organizations that help them aren't changing very quickly. Even though solar technology has become cheaper, it is still expensive to create solar power. The solar energy industry needs incentives and rebates to grow, but these policies can still cost a lot of money. We need new ideas to make these policies more affordable. The companies that make solar panels and other solar products need to focus more on making their technology better and improving it.

Imad Wazn studied why Lebanese people like using solar energy. This was in 2022. The study shows that people prefer to choose renewable energy if they like it and want to buy it.

Nour Wehbe looked at different ways to make energy in Lebanon, and figured out how much each one cost overall. This study predicts how much money it will cost to use different technologies in Lebanon until 2030. It makes guesses based on how each technology works and how it affects things like money, the environment, and its abilities. The LCOE approach is commonly used to compare the cost of producing electricity from renewable and traditional sources. The findings indicate that by the year 2030, renewable energy will be cheaper than using fossil fuels. If the government does things like charging companies for emitting carbon, then using renewable energy could become a better option. This would make it more likely for companies to plan to use renewable energy and for it to be cheaper than other types of energy.

In 2021, Christy Lahoud and others talked about a special cooling machine called the single-effect absorption chiller. They also talked about the different parts of the machine and how it could use the sun's energy to work. Past research shows that Lebanon gets a lot of sunny days, which makes using solar power systems a good solution for their problems with electricity and garbage.

Hossein Eslam and others looked at how we could use solar panels on buildings in cities. They thought about things like how much money it would cost and how it would affect the environment. We looked at how much sunlight each building gets and how much electricity is used by each building. Using this information, we figured out if it makes financial sense to install solar panels on the roof of each building. The study found that solar panels on rooftops would make money for 73% of the buildings in the group they looked at. Each building in Beirut would get around $8300 on average as NPV. If more rooftop area is available for solar panels, fewer buildings would have a positive financial return (called "NPV"). For example, in this new scenario, only 69% of buildings would make money, compared to the original scenario where more buildings (probably around 70%) would be profitable.

Houda Elmustapha and Thomas Hoppe studied two things: 1) what problems do businesses face with solar energy 2) what new ideas could help developing countries. They found that in the beginning, businesses needed money from donors to start up and grow. Later, people realized that the attention had moved to small loans and ways to start a business, which showed good potential for increasing. People found out that making new ways of doing business that involve customers better are based on sharing knowledge and making communities stronger.

In the Rayak area of Lebanon, Youssef Kassem and others looked at how much electricity could be made from sunlight and wind. They also studied whether using wind and solar power would make sense for businesses. The research found that temperature, pressure, and humidity are the most important things to consider when predicting how fast the wind will be each day. Experts looked at information about how much sunshine the entire world gets each month to understand how wind energy works. The chosen area gets a lot of sun and is great for using solar power because it gets 1877. 41 kWh/m2 of sunlight every year.

In 2021, Camur and their team studied a solar system for homes in Lebanon with solar panels that come in two types (mono-crystalline silicon and poly-crystalline silicon). They also looked at different ways the panels can move to follow the sun. The solar system can generate 5kW of power and be connected to the power grid. It can be installed on the roof of houses. The study found that a 5kW solar panel that is angled correctly can produce 8564. 47 to 877681 units of electricity each year. A solar panel that tracks the sun can produce even more electricity, ranging from 11511. 67 to 1210092 units per year. If we could make a lot of energy, we wouldn't have a big energy problem in our country.

Youssef Kassem and his team studied how fast the wind blows in three areas near the coast of Lebanon called Beirut, Sidon, and Tripoli. They used ten different types of math formulas to do this. The study found that small wind turbines can be used to make use of the strong wind in the area. We used a method called present value cost to figure out how much money four types of wind turbines would cost. Studies show that vertical wind turbines can work better than horizontal wind turbines in cities.

The study by Hüseyin Gökçekuş et al. focused on eight areas in the north of Lebanon: Aabboudiye, Darine, Hekr El Dahri, Saadine, Semmaqiyeh, Tal Aabbas El Gharbi & Charqi, Tal El Bireh, and Tal Keri. The study found that the wind speed at 10 meters above the ground is more than 2 meters per second on average every year. The wind in the places we looked at isn't very strong, with energy values ranging from 38. 76 to 13429 watts per square meter at a height of 50 meters. This means these areas aren't the best for using wind power. Therefore, it has been determined that the places being studied can benefit from having little wind turbines that can make electricity.

Youssef Kassem and his team looked at how much wind power could be generated in Tripoli, Sidon, and Beirut regions of Lebanon. The results showed that the wind in the place they studied was not very strong, with speeds between 2. 627 m/s and 3. 56The wind is not very strong and produces low energy. The wind measures between 14. 634W/m2 and 25280W/m2The study found that it's okay to use small wind turbines to make electricity in the areas they looked at. This study looked at different ways to figure out how much wind energy and power was available at different heights. The power density method was the best way to estimate wind data. In one month, the shape and size change a lot. In some places called Daher El Baydar and Les Cedres, the amount of power that comes from the sun changes throughout the year. The strongest it gets is 2397 watts per square meter, and the weakest it gets is 784 watts per square meter.

Youssef Kassem et al. , (2021) wanted to see if there was enough wind energy in different places in Lebanon like Akkar, Baalbek, Beirut, Zahlé, Baabda, Nabatieh, Tripoli, and Sidon. The study found that the winds at the different places varied between 3. 695 m/s and 4. 457 m/s when measured 10 meters up. Also, they figured out how much wind energy there is every year at different heights (10 meters, 30 meters, and 50 meters). The study found that it's a good idea to use small wind turbines to make electricity from wind in the places they looked at.

Joshua TIn 2019, a group of people wanted to improve how small wastewater treatment plants are managed. They came up with new ideas and ways to analyze the situation. The research found that a basic system can predict the quality of wastewater that comes out of small treatment plants. This works by looking at three things: the amount of ammonia, the pH balance, and the organic matter going into the plant.

According to what people have written, it's hard to use wind power in lots of places in Lebanon. It doesn't last very long and isn't a good option. Kassem Y and other researchers looked at how much wind energy could be produced in nine areas over 37 years. They found that the potential for producing wind energy in those areas was not very good.

Water Resources of Lebanon

A group of researchers, led by Rima Baalbaki, looked at the quality of water underground in a village in South Lebanon. They found that the water was dirty.

May Alives in Al-Chouf Caza in Lebanon. In 2009, some people checked how well the systems for managing wastewater were working. The research showed that the equipment for cleaning the water is either broken or not very good. This means it's hard to make the water clean enough to drink.

The water from the Tripoli Aquifer cannot be drank. In 2016, Omar Kalaoun and others studied how the increasing number of people living there is affecting the amount of saltwater getting mixed in with the fresh groundwater. The study found that the area is getting very affected by climate change, and it's becoming saltier.

El-Osmani and his team studied how much pollution from pesticides is in the water underground in Northern Lebanon. The study found that pesticides used in farming have polluted the water underground.

Nadim Farajalla and Ricardo Khoury looked into the problems that stop people from protecting the water in Lebanon from bad farming methods. The study showed that farming affects the water in Lebanon a lot.

In 2013, Amin Shaban and his team wanted to see where hot water was located in Lebanon based on the way the rocks and earth affect how it moves around.

Samira Ibrahim Korfali and Mey Jurdi (2008) assessed how much water people use in their homes in Beirut. The results showed that all three sources of water were not good for drinking or using. We could see that many people were getting sick from drinking water because of certain things in the water.

Based on appropriate ways of determining value and information specific to the country, M. In 2003, El-Fadel and others looked at how the quality of drinking water affects people's health and money in Lebanon. The study showed that dirty things like germs and bacteria can make water unsafe to use.

Hamed Assaf and Mark Saadeh (2008) wanted to explain how a tool called an integrated decision support system (DSS) can help people who make decisions about policies come up with ideas and evaluate them. This system was made to help people understand how sewage can harm the water in ULB. It is meant for people who make important decisions and others with a stake in the matter. The water quality in the Upper Litani Basin is getting worse and needs quick action to fix it. There isn't enough clean water for everyone because it's very dirty. This is especially concerning when lots of people need water.

To understand if it's important to manage risk in rural areas like Bekaa Valley in Lebanon, Amale Mcheik, Ali Awad, and their team studied how germs from animal poop can get into irrigation water and contaminate vegetables. The test results showed that there are a lot of germs in the water.

Maria Georges Saidy studied how brackish and seawater can be used for reverse osmosis in three different places in Beirut, Lebanon: buildings, communities, and the whole city. We looked at how much money each system would make after considering things like how salty the water is, any impacts on the environment, and how big it is. Centralized seawater RO systems are better for the environment because they are really big, don't hurt the environment too much, and can follow the rules. Compared to a machine that cleans salt water in a building, a family can save $1 for every cubic meter of water by getting their water cleaned by a big machine located in one place. The plan to move water between different areas wasn't as costly as using a water treatment process called reverse osmosis.

Alexandros I and his team wanted to understand pollution and find ways to protect the groundwater in Beirut, Lebanon. They studied how pollutants get into the water and how to detect them. They hope that their work will help keep the water clean and safe for people to use. Scientists have found harmful things in the water that can make people sick, like heavy metals and nitrate. These things are called groundwater contaminants. Researchers also discovered new harmful things that were not known before.

This text cannot be simplified as it is only a list of two names. In 2019, Saad and Slim studied the chemicals in Lebanon's groundwater and how human activities affect its quality. The dirt samples had different metals in them like calcium, potassium, iron, chromium, zinc, nickel, manganese, and lead. The amounts of these metals varied in the different samples. The amount of Ca, Mg, Na, and K was low, while the amount of Cd, Pb, Fe, Mn, Cu, Cr, Zn, and Ni was higher and varied between different values. Only the springs in Barook and Labweh had high levels of Cd.

To learn more about the pollution of underground water in Akkar, Northern Lebanon caused by people, weather, and nature, Sudarshan Kurwadkar (2019) studied articles from 2018. The study showed that there is poison from metals and arsenic in some places where there's water underground.

In 2021, Maria Aoun and her team checked how much radium (Rn) was in the water that people drink in parts of Lebanon called North and Beqaa. The study showed that drinking water doesn't have a lot of Rn, only less than 100 Sv. The safe level of radon in drinking water, according to WHO, is lower than the level found in the places where they did research, so it's okay to drink.

Mohammad Hassan Halawi, Roudaina Nasser, and others checked how good the water was in different parts of Lebanon: Akkar and North Lebanon, Baalback-El Hermel, Mount Lebanon, Bekaa, South Lebanon, and Nabatieh(2020).

Sima Tokajian, Rima Moghnieh, and their colleagues studied how many germs called Escherichia coli that have a special enzyme were in Lebanon's wastewater pipes and if more came when refugees arrived. The study shows that tiny living things called microorganisms have entered rivers and lakes because of the way Lebanon's sewage system is set up.

In 2022, Rana Salim and other researchers looked at how climate change and more people are hurting the water in the Upper Litani River Basin. They studied how much water there is and how good it is. The study found that people doing unsafe things, factories or homes putting dirty water into rivers, too much fishing, and not enough clean water are making our water bad.

Jeffrey Joseph Fadlallah looked at how clean the water underground is in a faraway place called Akkar in Lebanon. He then made suggestions on how to make sure they have enough safe water. The water in the area was found to be polluted, so the people in charge suggested that the community follow some rules for the next five years to make sure they have safe water to use.

Nada Nehme and Chaden Moussa Haidar, along with others, came up with a way to clean the water in the Al Houjair area of the Litani River. Besides, they wanted to group the different types and origins of pollution and determine how they could harm nearby communities. The study showed that the river may have gotten dirty because Israel attacked Southern Lebanon. The study found that the physical and chemical properties of the water were higher than what is needed for surface water, no matter where it was sampled.

Amin Shaban study looked at how much water there was in Beirut, Lebanon. He looked at the water on the surface and under the ground, and compared the information in pictures and numbers to see if there was more or less water available.

The results showed that there was less water available. This shows how different the sources are by getting smaller.

In 2017 and 2018, a group of researchers studied how much bacteria in Lebanese rivers could resist antibiotics at the place where they meet the sea. They studied water samples and bacterias by using culture techniques and high throughput (qPCR) experimental methods. They also did qualitative analysis of ARB and analyzed the Lebanes.

The Plain of Akkar is a farming area in Lebanon. Nour Tarek and El Korex studied the water there in 2018. Farmers in Akkar are digging underground to get water for their crops because they can't easily get water from the surface and the surface water is not being used or managed properly. The biggest issues were bad leadership, low-quality services from the government, and lots of competition in the market.

Adnan Falah, Husein Yemendzhiev, and others looked at how much pollution there is in the saltwater along the coast of Lebanon. They checked things like how the water looks and measures like temperature in different areas of the coast. The study found that the groundwater is not as good as it used to be.

The researchers studied the dirty water in Naameh village to see if the landfill there was causing pollution. The research showed that the landfill did not handle garbage properly and now the water underground is dirty.

To learn more about how human activities affect the water quality in the Al-Zahrani River Basin, a group of researchers studied different factors like bacteria and chemicals in the water. The study found that harmful germs from factories and dirty water were polluting the area.

In 2019, Ahmad Moustafa, Mariam Hamz, and others checked the soil and water in Akkar for small pieces of metal. The study showed that the dirty water under the ground had dangerous substances in it that could make people sick if they drank it or used it for cooking.

Y wanted to study the quality of surface water in different parts of Lebanon. They looked at information in books and articles about water resources, focusing on surface water and its physical and chemical features. Kassem, H is a person's name.

This text is about a research study written by Gökçeku and others in the year 2020. The quality of the water on and under the ground is getting worse.

Khadra et Pieter J. Stuyfzand and others wanted to show the difference between two types of rock called limestone and dolomitic limestone. They did this by comparing the water underground in these rocks in the Eastern Mediterranean (Lebanon). They looked at if the water was salty or not, and how this had changed over the past few decades. The study found that some sea water had mixed with the groundwater, making it salty. However, the amount of minerals in the groundwater was safe to drink.

A garbage dump in Lebanon is making six communities sick, so Michele Citton and Sofie Croonenberg (2020) are studying how it's affecting their water, air, and health. The test showed that there was a lot of bacteria in the water. The water in the lower wells had a lot of things in it, like chemicals and tiny amounts of pollution.

Peter J compared the quality of water in two limestone aquifers in Lebanon that have become slightly more salty over the past few decades. One of the aquifers is made of dolomite rocks, while the other is made of limestone rocks. Connor and Wisam M. are two people. Khadra, Stuyfzand, and others wrote this in 2017. The study showed that although the water had a lot of salt in it, the amount of harmful things in the water was still safe for people to drink.

In 2019, some people checked how clean the Ibrahim River is. This river is important in Lebanon and lots of people use it. The study showed that the water quality is okay and it has been improving over time.

Badr, H. " Holail and others studied how Cd can harm health and checked where it could come from in springs in Mount-Lebanon Governorate, which is not quite a city in Lebanon. The study found that poop was everywhere and there was a lot of pollution from a metal called Cd and another called Pb.

The conclusions after reviewing the previous studies are;

- The utilization of solar power systems in Lebanon is limited.
- Lebanon has a huge solar energy potential when compared to wind energy.
- Solar power systems can reduce fossil fuel consumption and CO2 emissions. Only few studies investigated solar potential as a source of

electricity and techno-economic feasibility small-scale grid-connected rooftop PV power system in Lebanon.

- The quality of water resources in Lebanon has and continued to detiorate as a result of seawater intrusion, the use of pesticide in agriculture activities and heavy metals contiamination.

Status of Solar Energy in Lebanon

The map shows how much sunshine energy hits the ground in different places. The amount of energy can range from 1600 to 2000 kilowatts per square meter for one kind of sunlight, and from 1700 to 2200 watts per square meter for another kind. Solar potential classes show how sunny a country is. The classes can be good, excellent, or outstanding and are determined by looking at the amount of sunlight the country gets. This is based on GHI and DNI values. The amount of sunlight in coastal areas is less than in other places, according to the solar atlas map. Lebanon is having problems with its electricity system. Sometimes the electricity goes out every day and can stay off for a long time, from 3 to 13 hours, depending on where you are..

Figure 2.1

Global horizontal irradiation of Lebanon

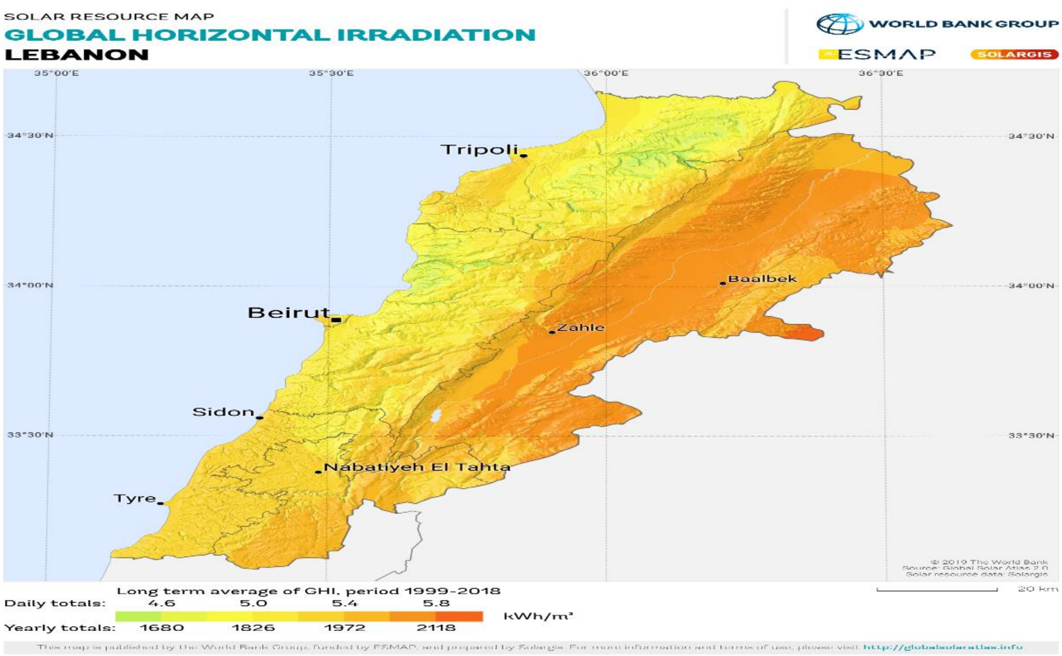
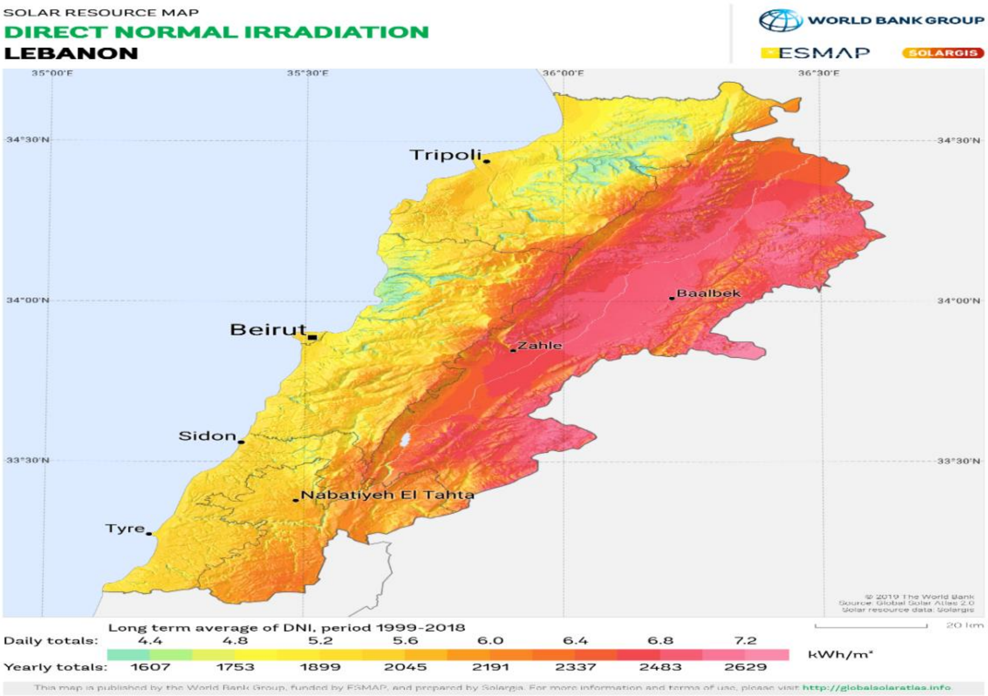


Figure 2.2

Direct normal irradiation of Lebanon



Solar Energy

Solar energy comes from the sun. It can be used to create electricity, heat buildings, and power vehicles. It is a renewable and sustainable source of energy that does not produce harmful pollutants.

Because the world needs more energy but also cares about the environment, it's important to find other ways to make energy instead of using fossil fuels which can run out and harm the planet. One way is to use the power of the sun. Solar energy is energy from the sun that gets saved in other places, like Earth. The sun gets its energy from a reaction called thermonuclear. This reaction changes 650 million tons of hydrogen into helium every second. Heat and electromagnetic waves make radiation. The sun stays warm and keeps burning through a process called thermonuclear reactions. There are three kinds of light that give off energy into space: visible light, infrared light, and ultraviolet radiation.

The sun gives almost all the energy we have, like heat, electricity, and other types. We use different ways to turn this energy into power, like using water, wind, or plants. Long ago, plants and animals grew and died. Their remains eventually became the fossil fuels we use today. There are other ways to create energy such as nuclear power, geothermal energy, and using the tides. The sun makes energy by joining things together in its center. These activities have been happening for 4. 5 billion years and will continue for another 6. 5

To make solar energy work, you need two parts. When sunlight hits something, it takes in some of the energy and changes it into other types of energy, like electricity or heat. Or it just turns into heat. We need a place to store solar energy because sometimes we don't get much radiation from the sun. The energy generator makes less energy when it's dark outside or when there are lots of clouds. These two things are something to collect things and a place to keep them. If you only have one collector, there won't be many collectors. When we make a lot of stuff, we can make more energy than we need. We can save that extra energy in a special place, and use it later when we make less stuff and need less energy.

Solar energy comes from the sun's rays. Although sunlight is free, using it to create energy from solar power is not free. You need both money and technology to turn sunlight into usable energy. Solar energy, just like all other technologies, has good points and bad points.

Figure 2.3

Working of solar energy

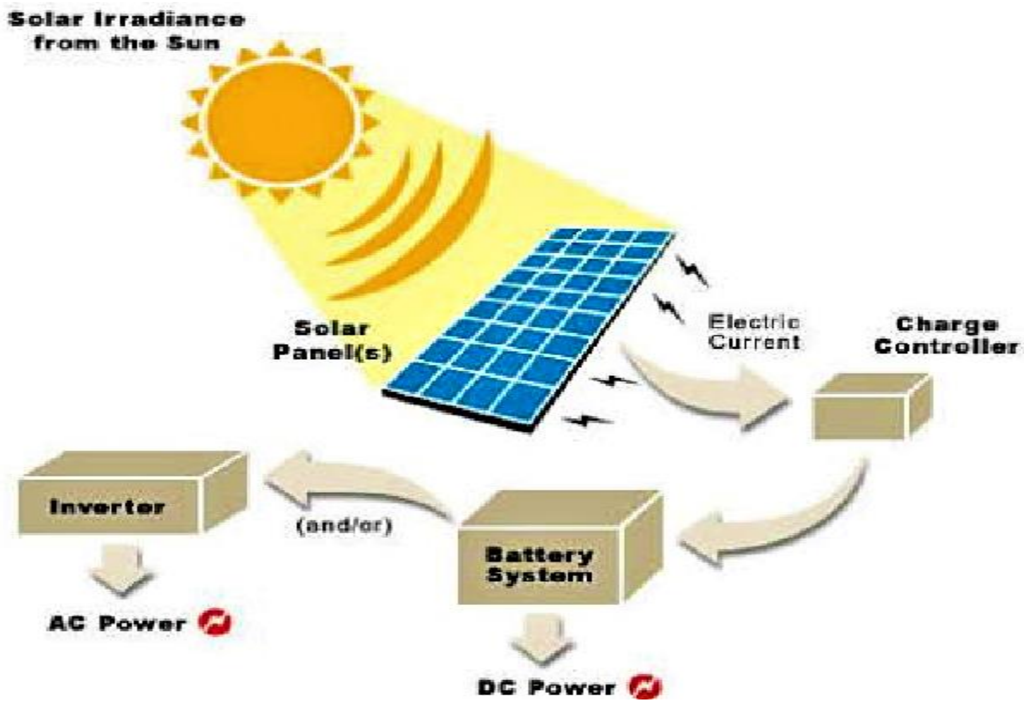


Table 2.1

Advantages of solar energy

Renewable energy source	The most important benefit of solar panels, compared to all the other benefits, is the fact that solar energy is a fully renewable energy source. It can be utilized anywhere over the world and is always available. Solar energy won't run out like some other sources of power do.
Reduces Electricity Bills	Depending on the size of the solar system and how much electricity or heat you use, you can save a variety of amounts on your utility bill. For instance, if your company now uses commercial solar panels, switching to a larger system could significantly reduce your energy costs.
Diverse Applications	Solar energy has a wide range of applications. Using photovoltaics, you may generate power or heat (solar thermal). When clean water is scarce, solar energy can be utilized to distill water, produce electricity when there is no connection to the grid, and even power spacecraft in orbit.
Low Maintenance Costs	In general, solar energy systems don't need much upkeep. They only need to be kept moderately clean, so a few times a year of cleaning will do. Because it is constantly converting solar energy into power and heat, the inverter is typically the sole component that needs to be replaced after 5 to 10 years (solar PV vs. solar thermal).
Technology Development	The technology in the solar energy field is constantly developing, and improvements will quicken in the coming years. Advances in nanotechnology and quantum physics have the potential to increase the efficiency of solar panels and double or even triple the electrical input of solar power systems.

Table 2.2

Disadvantages of solar energy

Cost	A large upfront cost is necessary to purchase a solar power system. The cabling, installation, batteries, inverter, and solar panels are all included in this price. It is reasonable to anticipate that costs will go down in the future as solar technology advances frequently.
Weather-Dependent	On cloudy and wet days, solar energy can still be collected, but the solar system's efficiency is diminished. Solar panels need sunlight to efficiently capture solar energy. As a result, a few days of cloudy, rainy weather can have a big impact on the electricity grid. Additionally, keep in mind that solar energy cannot be collected at night.
Solar Energy Storage Is Expensive	Unless solar energy is kept in massive batteries, it must be used right away. These batteries may be charged during the day in off-grid solar systems so that they can use the energy at night. This is a great alternative for continuously utilising solar energy, despite the high cost.
Uses a Lot of Space	In order to generate more electricity, you will need more solar panels because you want to make the most of the available sunlight. Due to how much space they take up, many roofs cannot support the number of solar PV panels you would like to have.

Solar Energy Uses

There are two main types of systems for getting energy from the sun: solar thermal and solar photo voltaic (PV). A PV system uses sunlight to make electricity directly, while a thermal system uses sunlight to heat buildings, water, and make water drinkable

Solar Thermal Uses

Solar Water Heating

Sun power can make water hot. Heating water to take a bath, wash dishes, and clean clothes is the second most expensive thing people spend money on at home. If you install a solar water heater, you might pay less than half as much for heating your water.

Figure 2.4

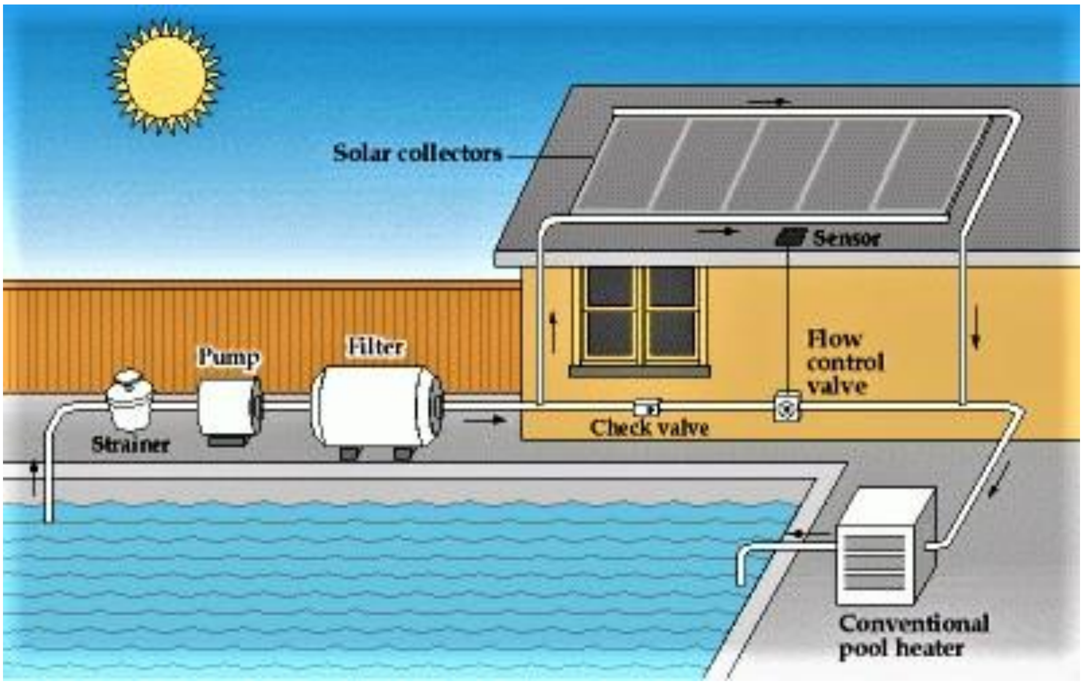
Solar water heater

Solar Water Pool Heating

Using solar energy to heat your pool is an easy and cheap way. Using your pool pump, water is sent to the solar panels. The solar collectors make the water warmer after it passes through them. The hot water goes into your swimming pool through some small holes called inlets.

Figure 2.5

Solar swimming pool heating system

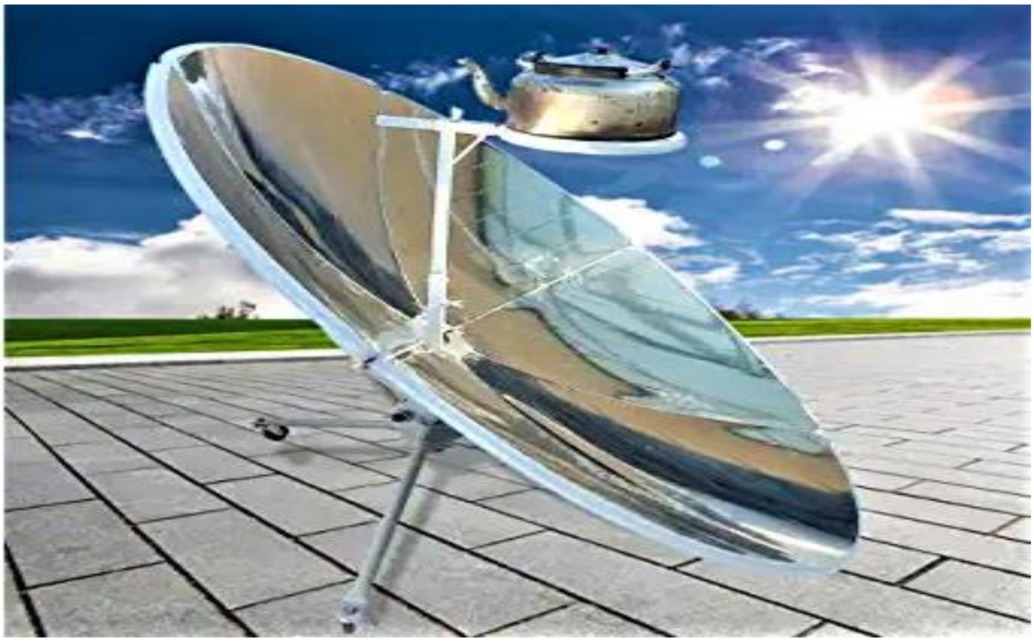


Solar Cooking

A solar cooker is a tool that uses sunlight to heat up and cook food, or make drinks safe to drink

Figure 2.6

Parabolic solar coker



Sewage Treatment

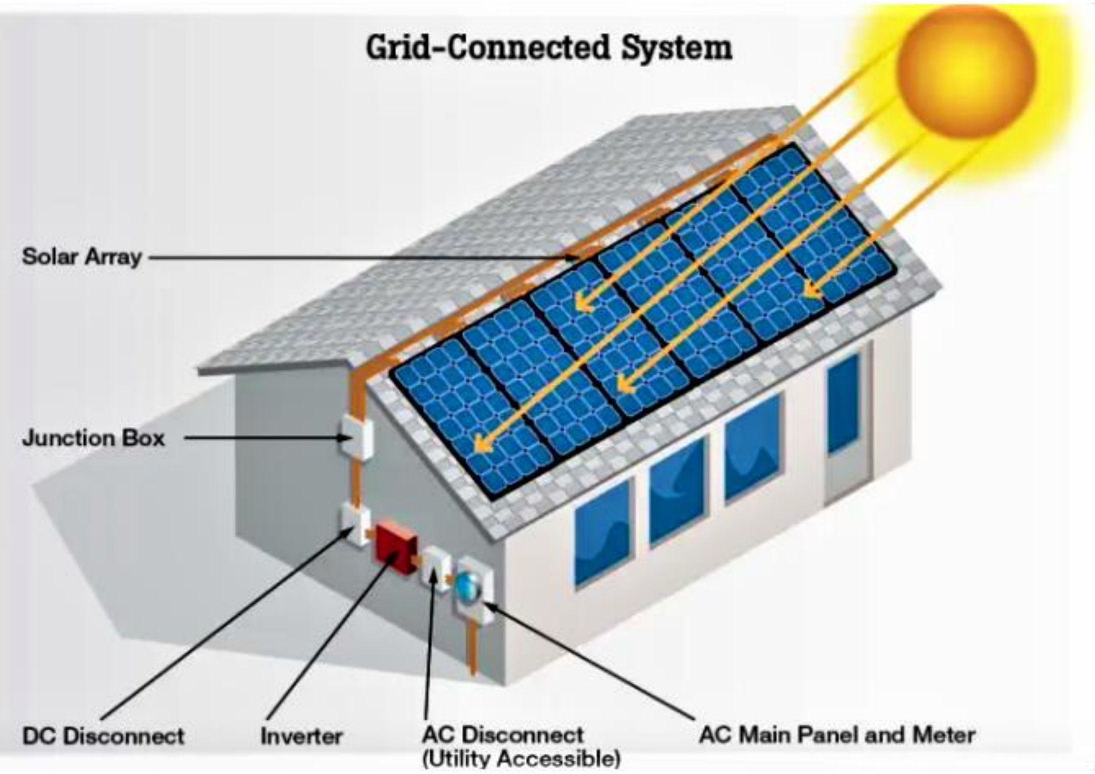
We use sunlight to clean dirty water by getting rid of harmful chemicals in a process called photo degradation

❖ Using the sun's energy to produce electricity

Solar cells are devices that can change sunlight into electricity. When light touches the place where metal and a special material called silicon meet, or where two special materials meet in these cells, a tiny bit of electricity is made. Normally, a solar cell only generates two watts of power. You can make a lot of electrical power with solar panels. You connect many small cells together to make a big one. This can be used in large-scale solar power plants or for homes with big solar arrays

Figure 2.7

Use of solar energy to generate electricity



Use of Solar Panel to Generate Electricity

Photovoltaics, also called PV, is a way of making electricity from light instead of using it to heat up water like Solar Thermal does. Solar power is changed by solar panels into a type of electricity called DC. This is then turned into the type of electricity that people use in their homes, called AC, by a machine called an inverter. To use energy in your home, you need to connect the inverter to your fuse board.

Sun cells are used in solar panels to turn sunlight into electricity. The PV cell is made of silicon or another material that conducts electricity. It has one or two layers. When light shines on a cell's layers, they can conduct electricity and make an electric field. When there is more light, there is more electricity.

When solar panels are in the sun, they make energy. We measure this energy in "kilowatt peak" or kWp. When it's very sunny outside, a lot of energy is made that you might not be able to use. Your solar system will be linked to the power system so that any additional electricity generated can be stored and used later. So, there are four parts of the solar system that make electricity. They are the Photovoltaic panel, charger controllers, inverter, and batteries.

Photovoltaic Panel

A PV panel or module is made up of cells that create electricity when sunlight hits them. The cells are joined together. When the sun shines on the cells, it makes electricity. The sun produces more electric energy when it is very bright and strong. However, the cells can still make electricity even without sunlight and can do it on cloudy days

Figure 2.8

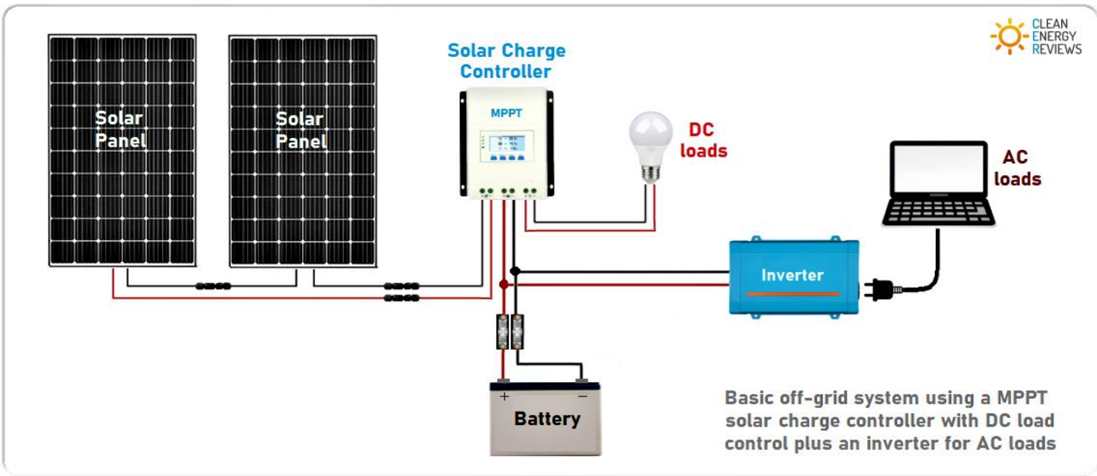
PV panel

Charger Controllers

A device called a charge controller or regulator helps keep batteries from getting too much electricity and getting damaged. It manages the amount of energy that flows from the solar panels to the battery. If you charge batteries too much, they won't work anymore. This can happen if you use a panel that makes more than 12 volts of power. If there are no rules, something bad will occur. Most batteries need about 14 to 14. 5 volts to charge completely.

Figure 2.9

Solar charger controllers



Inverters

The solar inverter is like the brain of a solar PV system. It's really important. It's often put in the attic and changes the type of electrical power from DC to AC. The energy from the solar panels goes through a device called an inverter and then gets connected to a part of your home's electrical system using switches and a small circuit breaker

Figure 2.10

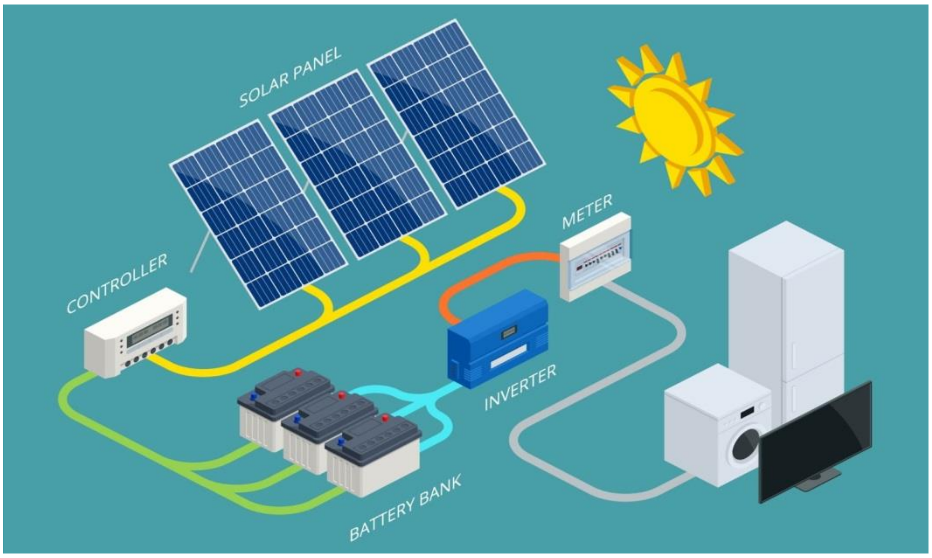
Solar inverter

Batteries

Solar batteries can be used as an alternative to (or in addition to) feeding energy back into the grid

Figure 2.11

How does solar battery works



CHAPTER III

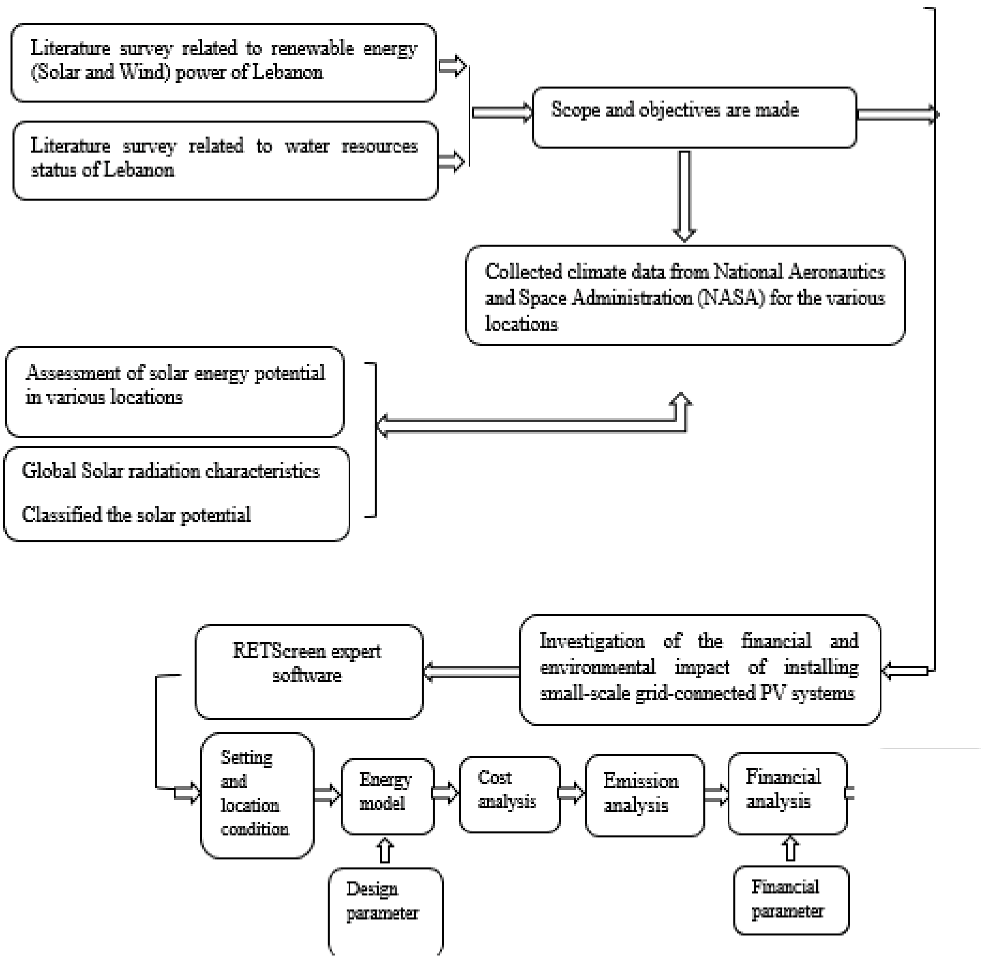
Methodology

Chapter 3 this section explains how solar energy was studied to see if it could be used to make electricity in certain places. It gives specific details about the way this was done.

The information about 99 areas with a Mediterranean climate and their ability to use solar power is looked at using a database from NASA. This database has information about solar radiation. You can find this database here: https://power.larcnasagov/data-access-viewer/ Also, a computer program called RETScreen was used to see if installing a solar panel system on the roof of houses connected to the electricity grid could help solve the problem of not having enough power.

Figure 3.1

Flow chart



Study Area

This work has considered 99 coastal Mediterranean cities located in Lebanon.

Figure 3.2

Map of Lebanon

The study only looks at certain areas and those areas don't include places outside of Lebanon. Lebanon is a small country in the Mediterranean region of South-West Asia that is about 10,452 square kilometers and only about 45 kilometers wide on average. It can be found in a specific area between certain north 34°42 and 33°3′ , east 35°6′ and 36°37′ coordinates. Lebanon has really nice summers that are dry and cool winters that can sometimes be stormy. It rains the most from November to April. July doesn't usually have a lot of rain. A significant amount of water can be found in Lebanon, which is situated in the Middle East.

Location Details

In this work, 99 coastal Mediterranean cities located in Lebanon have been taken into consideration. The geographical coordinates of the selected cities are listed in Table 3.1.

Table 3.1

Coordinates of the Selected Locations

Locations	Longitude	Latitude
Khribe	34.5874	035.9953
Qoubbet Chamra	34.5393	036.0028
Tekrit	34.5207	036.1649
Akkar Governorate	34.5608	036.3901
Manara	33.8966	035.4734
Jisr	33.9063	035.5380
Palais de Justice	33.8812	035.5290
Park	33.8664	035.5084
Mazraat Buyut as Sayad	33.1720	035.1974
Al Bazuriya	33.2513	035.2894
Bouraghliye	33.3224	035.2413
Marwahia	33.1157	035.2908
Mina	34.4493	035.8188
Sea Road Tripoli	34.4476	035.8538
Unnamed Road	34.3995	035.8545
Rifaiyeh, Tripoli	34.4374	035.8401
Byblos	34.1192	035.6464
Keserwan Jbeil	34.1221	035.6547
Qartaba	34.1129	035.8525
Jaj	34.1635	035.8161
Qmatiyeh	33.8008	035.5792
Btalloun	33.7917	035.6478
Khaldeh	33.7837	035.4844
Mount Lebanon Governorate	33.7802	035.7879
Kfar Zaina	34.3615	035.8868
Harf Miziara	34.3411	035.9541
North Governorate I	34.3604	036.1614
North Governorate II	34.3003	036.0585
Sea Highway	34.2645	035.6774
Rachana	34.2197	035.6698
Bchaaleh	34.2010	035.8222

Zane	34.2208	035.7529
Safra	34.0390	035.6506
Jounieh	33.9661	035.6259
Keserwan-Jbeil Governorate	34.0390	035.9445
Aayoun El Siman	33.9911	035.8374
Zakroun	34.3661	035.7632
Chekka	34.3026	035.7385
Kousba	34.2935	035.8456
Amioun	34.3094	035.7852
Dahr El Maghara	33.6717	035.4501
Ainbal	33.6489	035.5627
Fraidis	33.7152	035.7165
Ain Majdalaine	33.5162	035.6231
Ain Qana	33.4772	035.5105
Insar	33.3787	035.3485
Nabatieh	33.3878	035.4583
Roumine	33.4635	035.4391
Arzai	33.3351	035.3018
Haret Saida	33.5574	035.3979
Taaid	33.5688	035.5490
Kfar Taala	33.5665	035.5929
Zandouqa	33.8521	035.6451
Jouret Arsoun	33.8476	035.7220
Tarchich	33.8772	035.8044
Dahr El Baydar	33.8270	0357824
Khirbat Qanafar	33.6374	035.7275
Zillaya	33.4703	035.6726
Aammiq	33.7152	035.7687
El Khiara	33.6992	035.8538
Hadath	33.9342	035.5984
Mar Moussa	33.8977	035.6822
Mount Lebanon Governorate	33.9399	035.8813
Zaarour	33.9057	035.7948
Ezz El Arab	33.4612	035.7330
Khalwat	33.3901	035.7467
Kfarchouba	33.3190	035.6781
Berghoz	33.4131	035.6506
Mejdlaiya	34.4261	035.8683
Mzraat Kefraya	34.4408	035.9651
Miryata	34.4018	035.9259

Aardat	34.4086	035.8799
Tyre	33.2721	035.1964
Qasmiye	33.3161	035.2510
Qaaqait El Jisr	33.3104	035.4233
Hamaouiye	33.2191	035.2633
Damour Mt. Lebanon	33.7307	035.4554
Meshref	33.7106	035.4707
Naameh	33.7528	035.474
Douha	33.7591	035.4618
Kaslik	33.9792	035.6211
Zouk Mosbeh	33.9678	035.6101
Ghadir	33.9786	035.6300
Jounieh,Keserwan-Jbeil	33.9644	035.6300
Qemmanine	34.4114	036.1614
Maaysarah	34.2890	036.2164
Qasr	34.4748	036.4334
Barghash	34.3955	036.3125
Yanar	33.8111	035.5050
Aaynab	33.7700	035.5572
Bhamdoun	33.7928	035.6561
Bedghane	33.7654	035.6698
Baazqoun	34.3785	035.9431
Btormaz	34.4171	036.0392
Wadi en Njass	34.3479	036.1106
Jayroun	34.4216	036.1065
Aabdine	34.2753	035.8113
Blouza	34.2594	035.9431
Bsharri	34.2526	036.0722
El Arz	34.2254	036.4202

Data Collected

Satellite information is useful because it shows us the entire planet and helps us understand the land and atmosphere around it. The research checked how much sun some places receive, but they didn't have much data. The scientists looked at a huge collection of information from NASA. This information tells us how much the sun shines in each month between 1982 and 2021. Experts sometimes use data from space satellites to find out how much sunlight specific regions are getting. Kassem and his friends researched the amount of solar energy from different locations with help from

NASA. The NASA database agrees with info from satellites about how much sunlight reaches Earth, which was found out by Kassem and other scientists. In the year 2020, a team of researchers named Belkilani et al. research was conducted. In 2018, a group of people led by Owolabi researched how much energy could be produced by the sun in six different locations in Nigeria. They got help from NASA to do it. We wanted to see if we could use the sun to make electricity on small roofs. We got information from NASA about how much energy the sun gives off in a month.

Small Scale Grid Connected PV System

This study will make a little sun powered control system that will be associated to the rooftops of homes and buildings in Lebanon to supply power. This means that the framework must deliver more sun based energy than it employments from the network.

$$Einj > Eabs \quad (1)$$

The symbol Ein is greater than the symbol Eabs, according to equation (1).

Einj is the energy from solar panels added to the grid, while Eabs is the energy the system buys from the grid.

A sun powered energy system that's associated to the power arrange usually has sun oriented boards, a gadget called an inverter, something to control the way power streams, and things that utilize the power. Past inquire about appears that grid-connected sun oriented boards offer assistance spare energy, prevent power misfortune within the utility organize, and draw out the require for updates to the transmission and dispersion organize. This system doesn't require a particular sort or estimate of battery to work. So, on the off chance that the framework costs less cash, it is more reasonable and superior for your budget..

Pmax, the maximum power of the anticipated plant, is computed as follows:

$$\text{Pmax} = \frac{EACP\dot{\imath}}{GSRfPVninv} \quad (2)$$

. where fPV is the PV derating figure, EAC is the day by day control utilization in kWh/d, Pi is the sun based radiation at STC in kW/m2, GSR is the worldwide sun based radiation (kwh/m2/d), and inv is the inverter abdicate.

.

PV-Module Selection

There are distinctive sorts of sun based boards like amorphous silicon, mono-crystalline, and poly-crystalline. To choose the most excellent sun oriented board, you would like to think almost things like how much it costs, how solid it is, and how enormous it is. We picked Canadian Sun oriented boards for a little sun oriented control system that will interface to the neighbourhood control grid. The framework needs 17 parts and it'll take up 33 square meters of space.

Utilized equation (3) to choose the correct sun powered board for the proposed sun powered control plant. “The sun powered boards being considered are truly great and can change over more than 16% of daylight into power

$$\text{Panel Selection} = \frac{PV\ module\ capacity * Module\ efficiency}{Module\ price * frams\ area\ of\ the\ module} \quad (3)$$

Table 3.2

PV Module specification

Item	Specification
Module technology	Mono-Si
Manufacturer	Canadian Solar
Model	Mono-SiCS6X-300M
Nominal power [W]	300
Open-circuit voltage[V]	45
Short-circuit current[A]	8.74
Voltage at point of maximum power[V]	36.5
Current at point of maximum power[V]	8.22
Module area[m2]	1.919
Efficiency[%]	15.63
Warranty[year]	25
Cost[USD/Wdc	0.83

PV Inverter Selection

The inverter changes the control from the sun based board into a sort of control that can be utilized in businesses and industrial facilities. There are numerous distinctive sorts of inverters accessible to purchase. It’s critical to think approximately capital taken a toll, how well the inverter employments cash, and how much power it can deliver when picking an inverter. Two huge machines that turn daylight into power are prescribed. They each can make nearly 1 million watts of power and utilize nearly all the daylight they capture; two Sunny Central 850CP XT central inverter units is used.

Two-Axis Tracking PV Arrays

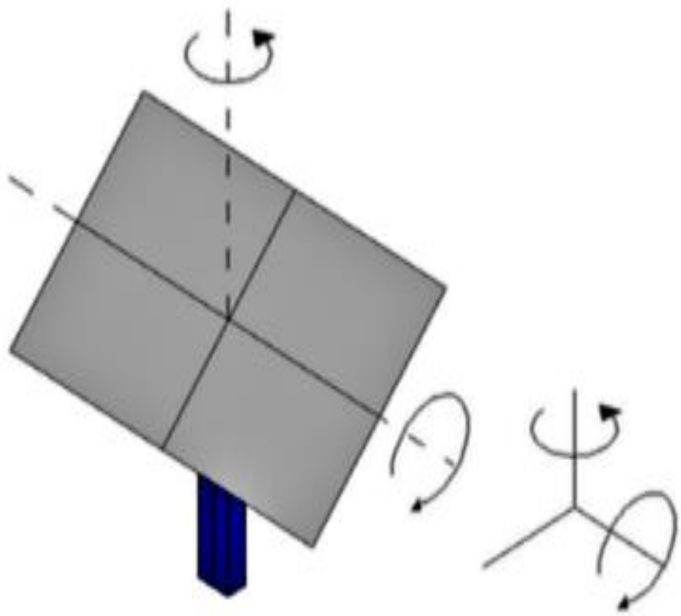
Sun oriented gadgets are utilized to create beyond any doubt that the sun's vitality hits the sun powered boards straightforwardly, which helps the boards make the foremost energy. These frameworks can turn in one course or two bearings. A sun powered system that can move in two bearings can make the foremost vitality. In Figure 1, two-axis PV frameworks are sun powered boards that can move in two directions on a extraordinary structure. A two-axis PV framework needs two engines to create the tomahawks turn around. The framework that moves sun oriented boards depends on where the sun is within the sky. Usually, you would like a control module to coordinate this framework.

Sun based tracker PV frameworks utilize a sensor called SR to form beyond any doubt it is confronting the correct way. The way the PV framework works is influenced by the climate and how each portion of the framework works. We are making support and operation exercises way better for our vitality generators. We need to deliver more control from the PV framework. The O&M is exceptionally imperative for a sun based framework with PV. By progressing how we maintain and work energy frameworks, able to make energy generation cheaper and get way better returns on our speculation. The PV framework can have issues with the climate, parts breaking, and fair getting ancient over time.

So, to create beyond any doubt everything is working well, you wish to require care of it in three diverse ways: by frequently checking and settling things some time recently they break (preventative upkeep), settling things when they do break (remedial support), and keeping an eye on things to capture issues some time recently they ended up enormous issues (condition-based support).

Figure 3.3

Characteristics of two-axis tracker movements



Simulation Tool

RETScreen Software

There are instruments called RETScreen, HOMER, PVsyst, and TRANSYS that can check how well sun oriented power plants work. Of late, numerous individuals have been utilizing RETScreen to check on the off chance that diverse sorts of renewable energy can work well. We figure out the fetched, decrease of carbon outflows, cash potential, and threat of diverse renewable vitality strategies. Too, it calculates how much energy is made and how much is spared.

NASA's month to month climate information is utilized by RETScreen to induce neighbourhood climate data. Typically a instrument that helps to see how well a renewable vitality framework works, and to create it way better for the environment. This thing is truly great. You do not have to be pay for it and it's simple to utilize. Furthermore, it can tell you how well electrical and warm frameworks are working.

Analysts utilized a computer program called RETScreen to think about how much cash is spared by utilizing sun oriented boards that are associated to the power grid. Kassem and his group considered if a enormous sun based vitality plant can be made in 25 cities by the Mediterranean ocean, in different Arabic countries. They utilized a computer program called RETScreen to help with their investigation. The control plant will make 4 things of vitality. This implies that a gadget that produces 2 million watts of power would be associated to the adjacent power organize. Sreenath and other analysts looked at how well sun oriented control plants worked in seven airplane terminals. They checked how much control they create, how much cash they preserve, and how eco-friendly they are. They utilized a computer program called RETScreen.

The study looked at whether it's worth building sun powered boards associated to the electric grid using special computer computer program called RETScreen. They considered how the way sun based boards were calculated influenced how much power they created, and looked at distinctive financial measures like how much money can be spared over time and the effect on the environment; capacity factor (Equation 4), and economic feasibility indicators like Net present value (Equation 5), Levelized cost of energy (Equation 6), Simple payback (Equation 7), Equity payback (Equation 8), Annual life cycle savings (Equation 9) and greenhouse gas (GHG) emissions (Equation 10 . These calculations are utilized to see in case contributing within the PV extend is useful and beneficial. RETScreen can assist you calculate and foresee these estimations.

Capacity Factor (CF):

$$\mathrm{CF} = \frac{Pout}{P \times 8760} \tag{4}$$

Net Present Value (NPV):

$$\mathrm{NPV} = \sum_{i=0}^{n} \frac{Cn}{(1+r)n} \tag{5}$$

Levelized cost energy (LCOE):

$$\mathrm{LCOE} = \frac{sum\ of\ cost\ of\ life\ time}{s\ of\ electricity\ generated\ over\ the\ lifetime} \tag{6}$$

Simple Payback (SP):

$$\mathrm{SP} = \frac{C-IG}{(Cener+Ccapa+CRE+CGHG)-Co\&Cfuel} \tag{7}$$

Equity Payback (EP):

$$\mathrm{EP} = \sum_{n=0}^{N} Cn \tag{8}$$

Annual Life Cycle Savings (ALCS):

$$\text{ALCS} = \frac{NPV}{\frac{1}{r}(1 - \frac{1}{(1+r)N}} \tag{9}$$

Annual GHG emission reduction (A-GHG):

$$\text{A} - \text{GHG} = [(Base\ case\ GHG\ emission\ factor) - (Proposed\ case\ GHG\ emission\ factor)] \times End\ use\ energy\ delivered \tag{10}$$

GHG emission reduction cost (GHG-E-RC):

$$\text{GHG} - \text{E} - \text{RC} = \frac{ALCS}{\Delta GHG} \tag{11}$$

Benefit-Cost ratio (B-C)

$$\text{B} - \text{C} = \frac{NPV + (1 - fd)C}{(1 - fd)C} \tag{12}$$

where Cn is the after-tax cash stream in year n, N is the extend life in a long time, Pout is the yearly vitality generation, P is introduced capacity, and R is the rebate rate The project's introductory capital taken a toll is appeared by the letters C, whereas its generally benefits are signified by the letters B, IG, and Cener, which stands for yearly vitality investment funds or pay. Ccapa stands for the yearly capacity investment funds or income, CRE for the yearly credit for the era of renewable vitality, CGHG for the yearly credit for the lessening of nursery gas emanations, and Co&M for the yearly working and support costs caused by the clean vitality extend. The yearly fetched of fuel, C fuel, is zero for ventures utilizing renewable vitality sources, whereas GHG is he yearly GHG outflow lessening.

Table 3.3

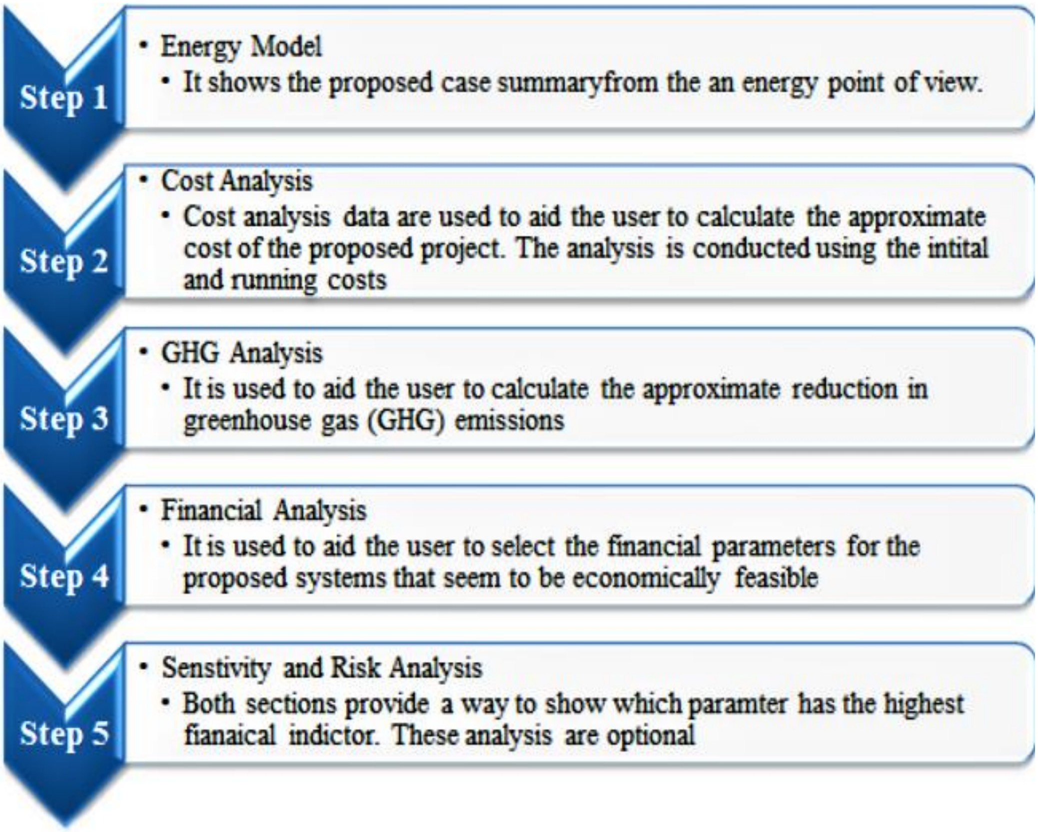
Financial parameters used for analysis

Factor	**Unit**	**Value**
Inflation rate	%	2.5
Discount	%	3
Reinvestment rate	%	9
Project Life	Year	25
Debt ratio	%	50

Debt interest rate	%	0
Debt term	Year	20
Electricity export escalation rate	%	2

Figure 3.4

Standard analysis in RETScreen software



CHAPTER IV

Results and Discussion

Chapter 4 focuses on the results of the assessment of solar energy potential in the 99 selected cities and the economic and environmental analysis of the proposed small-scale grid-connected rooftop PV system.

Solar Energy Characteristics

Sunlight is important for PV systems to work and Global Horizontal Irradiation is a type of sunlight that affects how well those systems work. To check how well PV systems work, only the amount of sunlight was measured in this study. Our analysis of data from 99 locations revealed that sunlight remains consistent in large areas, despite partial obstruction caused by clouds. This discovery agrees with what Bhatia, S.C in 2014 stated, the amount of sunlight staying the same over many region, the sunlight data was split into 7 designated areas in Lebanon owing to the multitude of cities present there. This means that Tables 5a-f show how much sunlight there is in different areas, and the amount ranges from 1737. 32 to 1764 kilowatt hours per square meter each month. Figure1 b shows how much sunlight per month there is. The amount varies between 65. 9 to 221.3, June has the most sunshine and December has the least. The best and worst yearly solar power amounts were observed in 1999 and 1988. They were 1873. 92kWh/m2 and 158547kWh/m2 this information is shown in figure 4. 1

The amount of sunlight that touches the Earth was used to figure out how much solar power could be generated each year (Kassem et al. 2020; Prăvălie et al. 2019). The sunlight that shines all over the world is important to know when figuring out how much energy a solar panel can make if it's flat. Table 4 shows that the sun energy in the areas is pretty great (class 4). The high GSR value in this area makes it a good place to install solar panels.

Table 4.1

Categorization of solar resource

Class	Annual GHI (kWh/m^2)
1 (Poor)	< 1191.8
2 (marginal)	1191.8–1419.7
3 (fair)	1419.7–1641.8
4 (good)	1641.8–1843.8
5 (excellent)	1843.8–2035.9
6 (outstanding)	2035.9–2221.8
7 (superb)	> 2221.8

Source:Kassem Y 2020, Pravalie et al 2019

Figure 4.1

Annual average solar radiation

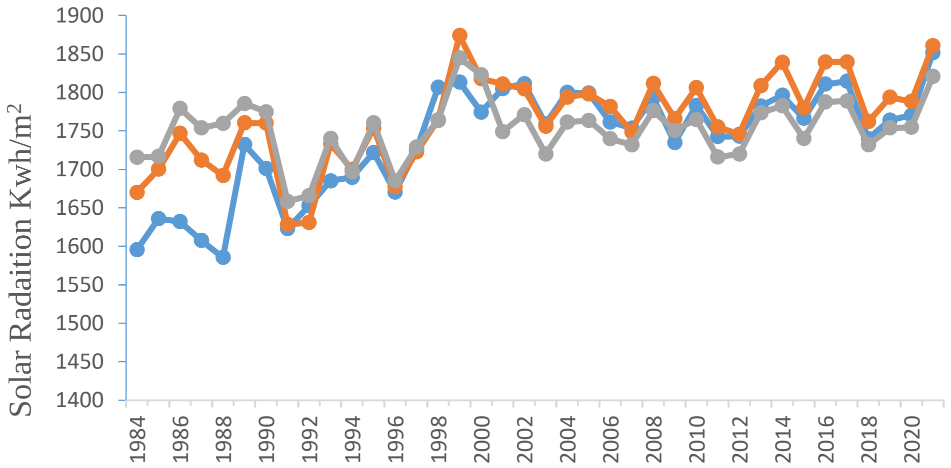


Figure 4.2

Average monthly solar radiation

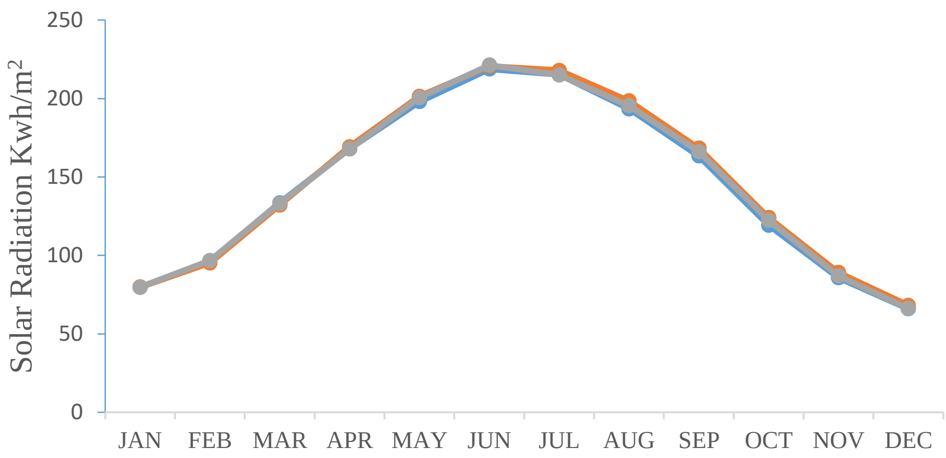


Table 4.2

GHI Classification of Selected locations

A: Zone 1 Akkar

Locations	**GHI Average Annual Value**	**Classification**
1.Khirbe	1751.302	Good (class4)
2.Qoubbet	1737.732	Good (class4)
3.Tekrit	1737.32	Good (class4)
4.Akkar Governorate	1737.32	Good (class4)

B: Zone 2 North Lebanon

Locations	**GHI Average Annual Value**	**Classification**	**Locations**	**GHİ Average Annual Value**	**Classification**
5.Kfar Zaina	1751	Good(class4)	Mejdlaiya	1751	Good(class4)
6.Harf Miziara	1751	Good(class4)	Mzraat Kefraya	1751	Good(class4)
7.NorthGovernorate I	1737	Good(class4)	Miryata	17 1	Good(class4)
8.NorthGovernorate II	1737	Good(class4)	Aardat	1751	Good(class4)
9.Sea Highway	1751	Good(class4)	Mina	1751	Good(class4)
10.Rachana	1751	Good(class4)	Sea Road Tripoli	1751	Good(class4)
11.Bchaaleh	1751	Good(class4)	Unnamed Road	1751	Good(class4)
12.Zane	1751	Good(class4)	Rifaiyeh, Tripoli	1751	Good(class4)
13.Baazqoun	1751	Good(class4)	Byblos	1751	Good(class4)
14. Btormaz	1737	Good(class4)	Keserwan Jbeil	1751	Good(class4)
15.Wadi en Njass	1737	Good(class4)	Qartaba	1751	Good(class4)
16.Jayroun	1737	Good(class4)	Jaj	1751	Good(class4)
17.Aabdine	1737	Good(class4)	Zakroun	1751	Good(class4)
18.Blouza	1751	Good(class4)	Chekka	1751	Good(class4)
19.Bsharri	1737	Good(class4)	Kousba	1751	Good(class4)
20.El Arz	1737	Good(class4)	Amioun	1751	Good(class4)

C: Zone 3 Mount Lebanon

Locations	**GHI Average Annual Value**	**Classification**	**Locations**	**GHI Average Annual Value**	**Classification**
Manara	1764	Good(class4)	Ain Majdalaine	1764	Good(class4)
Jisr	1764	Good(class4)	Safra	1751	Good(class4)
Palais de Justice	1764	Good(class4)	Jounieh	1764	Good(class4)
Park	1764	Good(class4)	Keserwan-Jbeil Governorate	1751	Good(class4)
Damour Mt. Lebanon	1764	Good(class4)	Aayoun El Siman	1764	Good(class4)
Meshref	1764	Good(class4)	Qmatiyeh	1764	Good(class4)
Naameh	1764	Good(class4)	Btalloun	1764	Good(class4)
Douha	1764	Good(class4)	Khaldeh	1764	Good(class4)
Kaslik	1764	Good(class4)		1764	Good(class4)

			Mount Lebanon Governorate		
Zouk Mosbeh	1764	Good(class4)			
Ghadir	1764	Good(class4)			
Jounieh,Keserwan-Jbeil	1764	Good(class4)			
Hadath	1764	Good(class4)			
Mar Moussa	1764	Good(class4)			
Mount Lebanon Governorate	1764	Good(class4)			
Zaarour	1764	Good(class4)			
Zandouqa	1764	Good(class4)			
Jouret Arsoun	1764	Good(class4)			
Tarchich	1764	Good(class4)			
Dahr El Baydar	1764	Good(class4)			
Dahr El Maghara	1764	Good(class4)			
Ainbal	1764	Good(class4)			
Fraidis	1764	Good(class4)			
D: Zone 4 South Lebanon					
Locations	**GHI Average Annual Value**	**Classification**	**Locations**	**GHI Average Annual Value**	**Classification**
Tyre	1764	Good(Class4)	Mazraat Buyut as Sayad	1764	Good(class4)
Qasmiye	1764	Good(Class4)	Al Bazuriya	1764	Good(class4)
Qaaqait El Jisr	1764	Good(Class4)	Bouraghliye	1764	Good(class4)
Arzai	1764	Good(Class4)	Marwahia	1764	Good(class4)
Haret Saida	1764	Good(Class4)	Kfar Taala	1764	Good(class4)
Taaid	1764	Good(Class4)	Hamgouige	1764	Good(class4)
E: Zone 5 Nabatieh					
Locations	**GHI Average Annual Value**	**Classification**			
Ain Qana	1764	Good(class4)			
Insar	1764	Good(class4)			
Nabatieh	1764	Good (class4)			
Roumine	1764	Good (class4)			
F: Zone 6 Beeqa					
Locations	**GHI Average Annual Value**	**Classification**			
Khirbat Qanafar	1764	Good(class4)			
Zillaya	1764	Good(class4)			
Aammiq	1764	Good(class4)			
El Khiara	1764	Good(class4)			
G: Zone 7 Baalbekka Hermel					
Locations	**GHI Average Annual Value**	**Classification**	**Locations**	**GHI Average Annual Value**	**Classification**
Qemmanine	1737	Good(class4)	Bhamdoun	1764	Good(class4)
Maaysarah	1737	Good(class4)	Bedghane	1764	Good(class4)
Qasr	1737	Good(class4)	Ezz El Arab	1764	Good(class4)
Barghash	1737	Good(class4)	Khalwat	1764	Good(class4)
Yanar	1764	Good(class4)	Kfarchouba	1764	Good(class4)

Aaynab	1764	Good(class4)	Berghoz	1764	Good(class4)

Electricity Generation and Capacity Factor

The weather and number of sunny days affect how well the solar power system works, including how much electricity it produces and its efficiency. The table III shows how much electricity the system can make each month. The amount of energy gained from the sun each month is different in different areas. It can be as low as 0. 468 and as high as 1. 342 kWh per square meter. In January, three places had the least amount of energy generation, while in July, 37 areas had the most energy generation.

Also, we discovered that PV systems with two-axis monitoring have an EG value between 9. 357 and 12221 Tekrit had the biggest number for EG, but Qoubbet and Qaaqait El Jisr had the smallest number. Also, the CF values ranged from 21. 60% to 2740% other experts have studied the practicality of a solar power system that is connected to an electricity grid, and they can check if these findings are accurate. Researchers found that the solar power system's efficiency decreased between 16 to 23% in Sudan.

According to Obeng, M et al (2020), the amount of energy produced by solar panels connected to the grid varied between 15. 37% to 1575% Mohammadi (2018) found that the amount of energy harvested from PV systems connected to the grid, with different types of sun tracking, was between 17. 54% and 2742% Also, if you use the two-axis option instead of the fixed-tilt option, you can produce a lot more electricity. So, the results of this study show that the levels found in each location are similar to what is considered appropriate. So, it is possible to make a little solar panel system on rooftops in these places and connect it to the power grid. The EG and CF change depending on where you are.

Performance of the Proposed System

It is essential to figure out if the project makes economic sense and if it can be continued over a long time. Governments and investors learn and benefit from research on whether or not solar power plants can make money. This study looked at how the new system would affect the economy and the environment. Table 6 in the study shows some ideas (financial components) based on research done in other countries about money. According to current market information, we expect the cost of the system in this study to be approximately $5000. The guess is right because we looked at how much things cost in some books.

Table 4.3

Financial Parameters

Factor	Unit	Value
Inflation rate	%	2.5
Discount	%	3
Reinvestment rate	%	9
Project Life	Year	25
Debt ratio	%	50
Debt interest rate	%	0
Debt term	Year	20
Electricity export escalation rate	%	2

Table 6 shows the results of how well the suggested system works financially. The results showed that the project is a good idea because it makes money and is financially sound because of its positive NPV value. It has been found that 52 locations out of 99 have made solar power systems that last for the longest time EP - 2. 7 years. But 34 locations have made systems that last for the shortest time EP - 2. 1 years .The lowest SP values were in Akkar Governorate, Palais de Justice. The highest values of SP were found in 49 places at 5. 3. This research shows that all solar power projects can make enough money to be worth doing. The cheapest price for electricity is 0. 021$/kWh and it can be found in 35 places. The next best price is 0. 023$/kWh and it is available in 8 locations. Researchers found out that out of 44 locations, 9 sites have the highest cost of producing electricity (LCOE) at 0. 027 and 0.026 dollars per kWh.

Typically, the more energy that you utilize, the more money you will need for electricity expenses: In case you utilize between and 100 kilowatt-hours, it costs 0. 0255 dollars per kilowatt-hour. In the event that you utilize between 100 and 300 kilowatt-hours, it costs 0. 04 dollars per kilowatt-hour. If you utilize between 300 and 400 kilowatt-hours, it costs 0. 0584 dollars per kilowatt-hour. In the event that you utilize between 400 and 500 kilowatt-hours, it costs 0. 0875 dollars per kilowatt-hour. And in the event that you employ more than 500 kilowatt-hours, it costs 0. 146 dollars per kilowatt-hour.

In Syria, using up to 100 kWh of energy costs between 0. 005$007$ The more energy you use, the higher the price per kWh. In Egypt, Algeria, and Tunisia, households pay a flat rate per kWh: 0. 045$,04$,077$, respectively This means that if we don't count Libya, the cost of energy produced by the suggested systems is the same as what the electrical companies are charging in the selected countries.

The results proved that the plan can solve the power issue and reduce air pollution. In simple words, the current method tells us whether the project will be profitable in different regions. Furthermore, the results indicate that creating a small solar power system that connects to the power grid is a good idea because it brings positive economic results

Table 4.4

Economic performance of the proposed pv system for all selected locations

Locations	**Net Present Value (NPV) [USD]**	**Simple payback [Year]**	**Equity payback [Year]**	**Annual life cycle savings [USD/year]**	**Energy production cost [USD/kWh]**	**GhG reduction cost**
Yanar	26955	5.3	2.7	1548	0.026	-216
Aaynab	26945	5.3	2.7	1547	0.026	-216
Bhamdoum	26961	5.3	2.7	1548	0.026	-216
Bedghane	26946	5.3	2.7	1,547	0.026	-216
Khirbe	26950	4.2	2.1	2,022	0.021	-224
Qoubbet	35205.00	4.2	2.1	2,022	0.021	-224
Tekrit	35164.00	4.2	2.1	2,019	0.021	-224
Akkar Governorate	29737.00	1	2.5	1,708	0.024	-241
Manara	26999	5.3	2.7	1,551	0.026	-216
Jisr	27543	5.2	2.7	1,651	0.026	-216
Palais de Justice	29755	1	2.5	1,709	0.024	-241
Park	30412	3	2.5	1,833	0.025	-241
Mazraat Buyut	31412	4.6	2.4	1,804	0.023	-324
Al Bazuriya	31457	4.6	2.4	1,807	0.023	-324
Bouraghiye	31416	4.6	2.4	1,804	0.023	-324
Marwahia	31409	4.6	2.4	1,804	0.023	-324
Mina	35124.00	4.2	2.1	2,017	0.021	-224
Sea Road	35122.00	4.2	2.1	2,017	0.021	-224
Unnamed Road	35124.00	4.2	2.1	2,017	0.021	-224
Rifaiyeh	35119.00	4.2	2.1	2,017	0.021	-224
Byblos	35103	4.2	2.1	2,016	0.021	-224
Keserwan Jbeil	27097.00	5.2	2.7	1,556	0.026	-216
Qartaba	34919	4.2	2.1	2,005	0.021	-249
Jaj	27083	5.2	2.7	1,555	0.026	-216
Qmatiyeh	26961	5.3	2.7	1,548	0.026	-216
Btalloun	26954	5.3	2.7	1,548	0.026	-216
Khaldeh	26950	5.3	2.7	1,548	0.026	-216

Mt. Lebanon Governorate	26938	5.3	2.7	1,548	0.026	-216
Kfar Zaina	35075.00	4.2	2.1	2,014	0.021	-249
Harf Miziara	35085.00	4.2	2.1	2,014	0.021	-249
North Governorate I	35066	4.2	2.1	2,014	0.021	-249
North Governorate II	35073.00	4.2	2.1	2,014	0.021	-249
Sea Highway	35070	4.2	2.1	2,014	0.021	-224
Rachana	34988	4.2	2.1	2,009	0.021	-224
Bchadeh	34988.00	4.2	2.1	2,009	0.021	-224
Zane	35074	4.2	2.1	2,014	0.021	-224
Safra	26945	5.3	2.7	1,547	0.026	-216
Jounieh	27034	5.3	2.7	1,553	0.026	-216
Keserwan Jbei Governorate	27087	5.2	2.7	1,556	0.026	-216
Aayoun El Siman	27032	5.3	2.7	1,552	0.026	-216
Zakroun	35068	4.2	2.1	2,014	0.021	-224
Chekka	35055	4.2	2.1	2,013	0.021	-224
Kourb	35021	4.2	2.1	2,011	0.021	-224
Amioun	35032	4.2	2.1	2,012	0.021	-224
Dahr El Maghara	26910	5.3	2.7	1,545	0.026	-216
Ainbal	26903	5.3	2.7	1,545	0.026	-216
Fraidis	26909	5.3	2.7	1,545	0.026	-216
Ain Majdaline	26938	5.3	2.7	1,547	0.026	-216
Ain Qana	26773	5.3	2.7	1,538	0.027	-216
Insar	26787	5.3	2.7	1,538	0.027	-216
Nabatieh	26789	5.3	2.7	1,538	0.027	-216
Roumine	26782	5.3	2.7	1,538	0.027	-216
Arzai	31444	4.6	2.4	1,806	0.023	-324
Haret Saida	31454	4.6	2.4	1,806	0.023	-324
Taaida	26769	5.3	2.7	1,537	0.027	-216
Kfar Taala	31476	4.6	2.4	1,808	0.023	-324
Zandouqa	26931	5.3	2.7	1,547	0.026	-216
Jouret Arsoun	26919	5.3	2.7	1,546	0.026	-216
Tarchich	26926	5.3	2.7	1,546	0.026	-216
Dahr El Baydar	26911	5.3	2.7	1,545	0.026	-216
Khirbat Qanafar	26894	5.3	2.7	1,544	0.026	-216
Zillaya	26899	5.3	2.7	1,545	0.026	-216
Aammiq	26917	5.3	2.7	1,546	0.026	-216
EL Khiara	26914	5.3	2.7	1,546	0.026	-216
Hadath	26975	5.3	2.7	1,549	0.026	-216
Mar Moussa	26970	5.3	2.7	1,549	0.026	-216
Mt. Lebanon Governorate	26952	5.3	2.7	1,548	0.026	-216
Zaarour	26975	5.3	2.7	1,549	0.026	-216
Ezz El Arab	26845	5.3	2.7	1,542	0.027	-216
Khalwat	26803	5.3	2.7	1,539	0.027	-216
Kfarchouba	26810	5.3	2.7	1,540	0.027	-216
Berghoz	34902	4.2	2.2	2,004	0.021	-224

Medlaiya	26875	5.3	2.7	1,543	0.026	-216
Mzraat Kfraya	35103	4.2	2.1	2,016	0.021	-224
Miryata	35105	4.2	2.1	2,016	0.021	-224
Aardat	35099	4.2	2.1	2,016	0.021	-224
Tyre	31455.00	4.6	2.4	1,806	0.023	-324
Qasmiye	26767	5.3	2.7	1,537	0.027	-216
Qaaqait El Jisr	27003	5.3	2.7	1,551	0.026	-216
Hamgouige	26983	5.3	2.7	1,550	0.026	-216
Damour Mt. Lebanon	26928	5.3	2.7	1,546	0.026	-216
Meshref	26924	5.3	2.7	1,546	0.026	-216
Naameh	26936	5.3	2.7	1,547	0.026	-216
Douha	26944	5.3	2.7	1,547	0.026	-216
Kaslik	26943	5.3	2.7	1,547	0.026	-216
Zouk Mosbeh	26933	5.3	2.7	1,547	0.026	-216
Ghadir	26959	5.3	2.7	1,548	0.026	-216
Jounieh Keserwan Jbeil	27032	5.3	2.7	1,552	0.026	-216
Qemmamine	35038	4.2	2.1	2,012	0.021	-224
Maaysarah	35022	4.2	2.1	2,011	0.021	-224
Qasr	30281	4.8	2.4	1,739	0.024	241
Barghash	35038.00	4.2	2.1	2,015	0.021	-224
Baazquon	35084	4.2	2.1	2,015	0.021	-224
Btormaz	35056	4.2	2.1	2,013	0.021	-224
Wadi en Njass	35071	4.2	2.1	2,014	0.021	-224
Jayroun	35043	4.2	2.1	2,012	0.021	-224
Aabdine	35022	4.2	2.1	2,011	0.021	-224
Blouza	35003	4.2	2.1	2,010	0.021	-224
Bsharri	35008	4.2	2.1	2,010	0.021	-224
EL Arz	35005	4.2	2.1	2,010	0.021	-224

Electricity Generation

Figure 4.3.1

Zone 1 Akkar

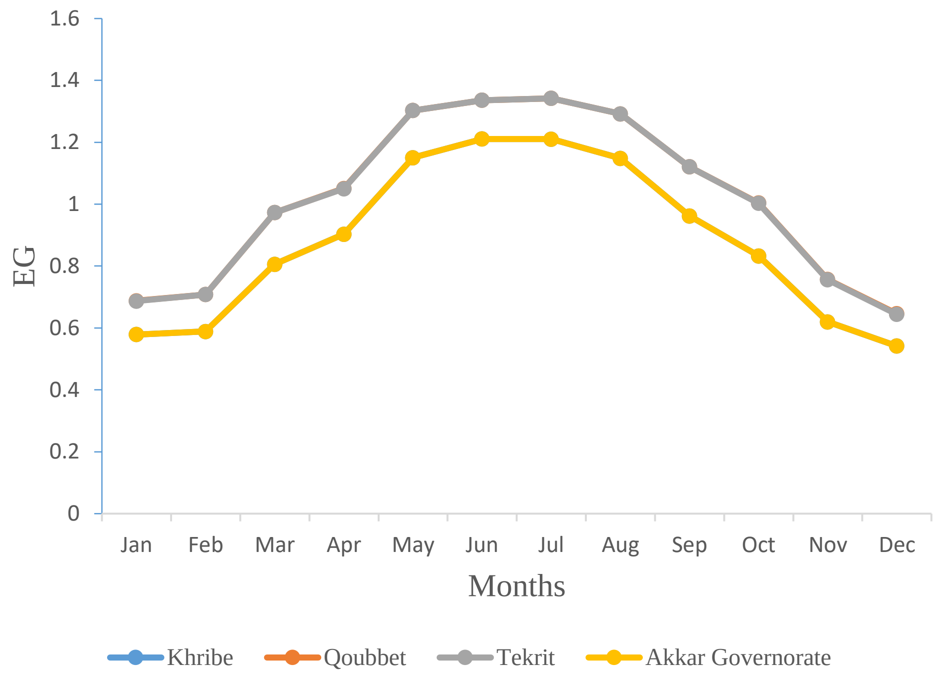


Figure 4.3.2

Zone 2a North Lebanon

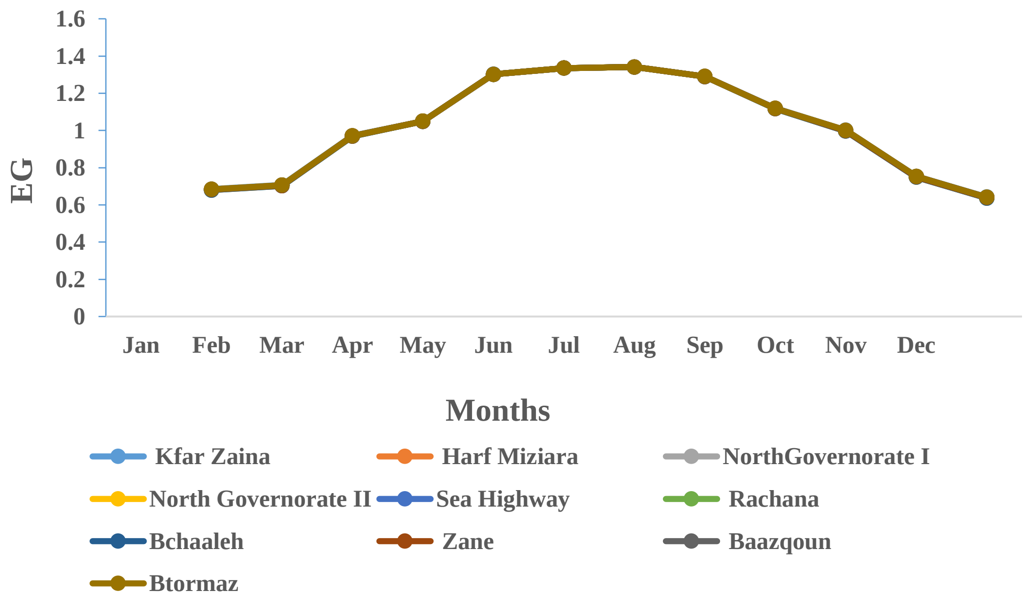


Figure 4.3.3

Zone 2b North Lebanon

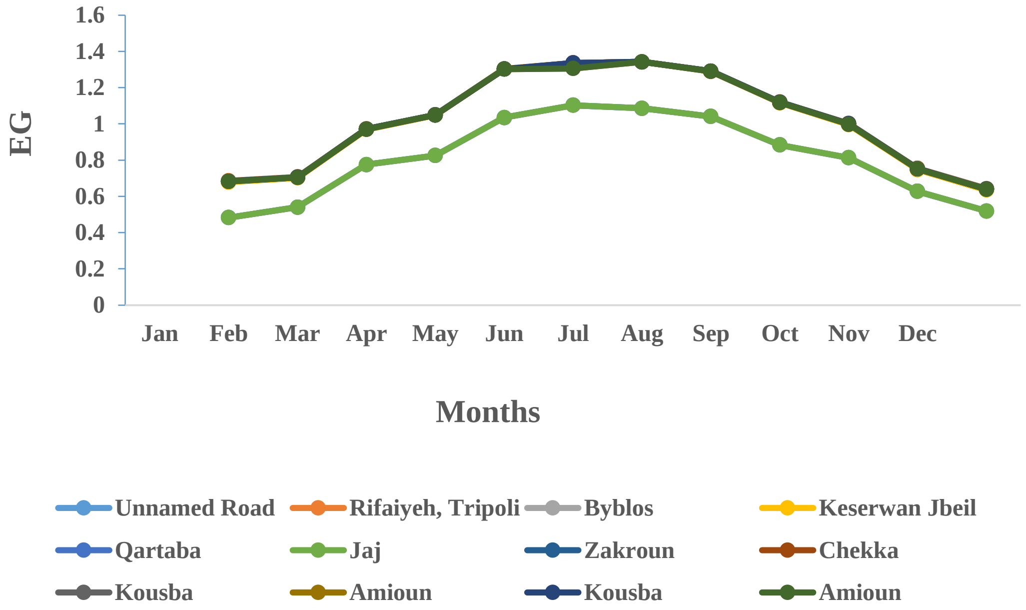


Figure 4.3.4

Zone 2c North Lebanon

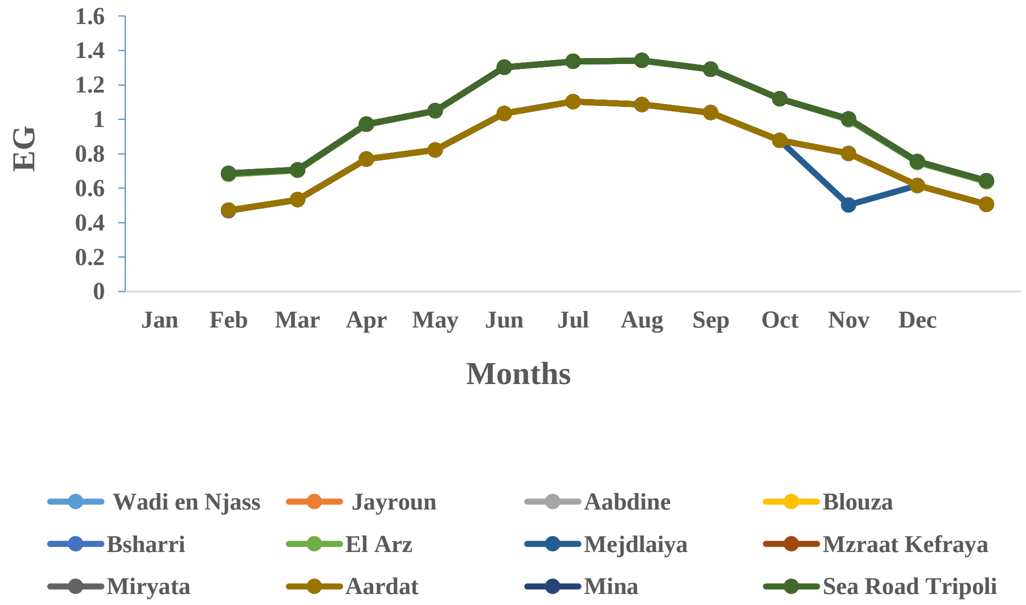


Figure 4.3.5

Zone 3a Mount Lebanon

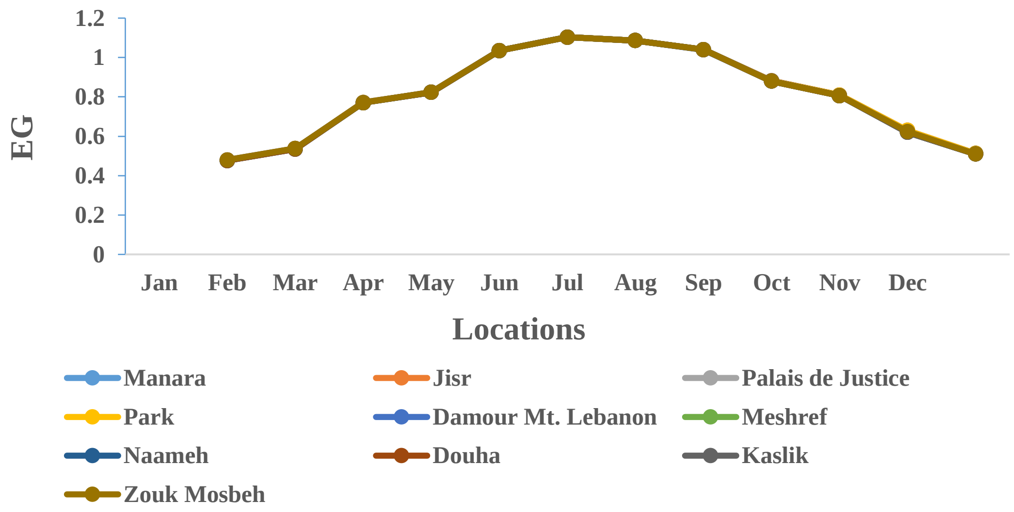


Figure 4.3.6

Zone 3b Mount Lebanon

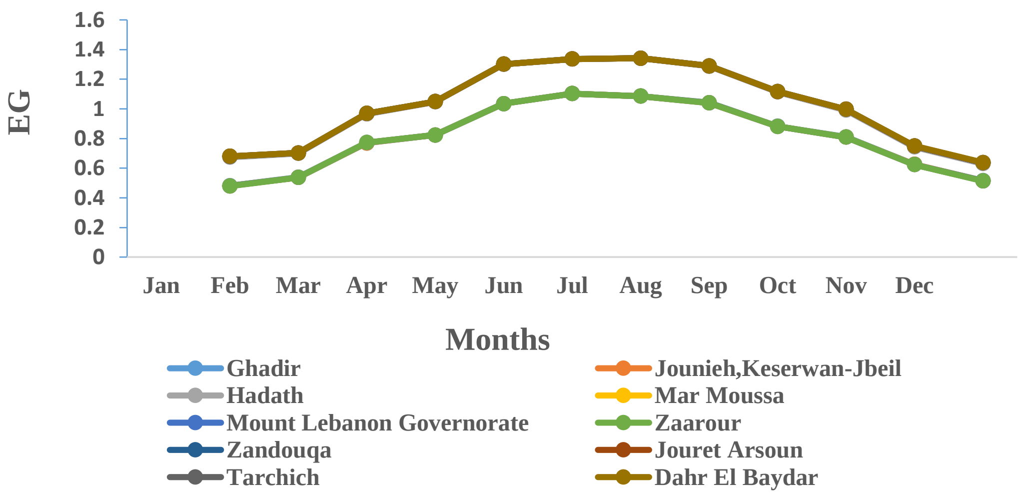


Figure 4.3.7

Zone 3c Mount Lebanon

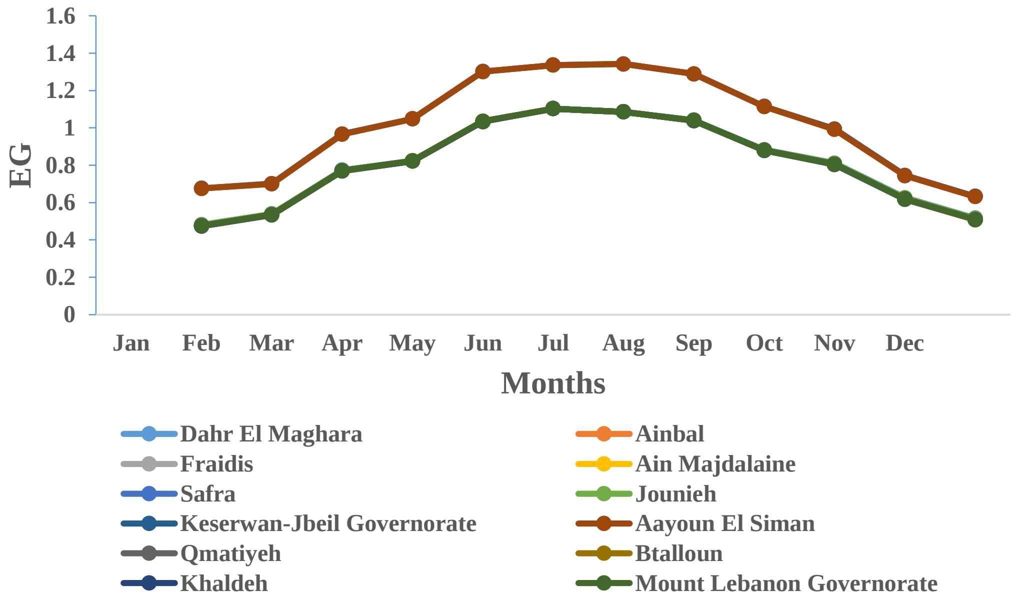


Figure 4.3.8

Zone 4 South Lebanon

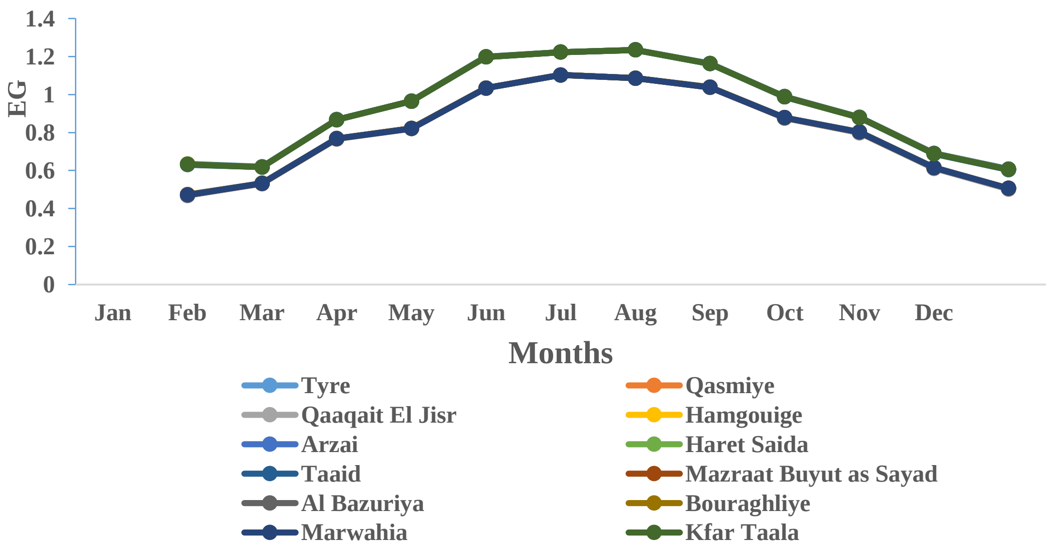
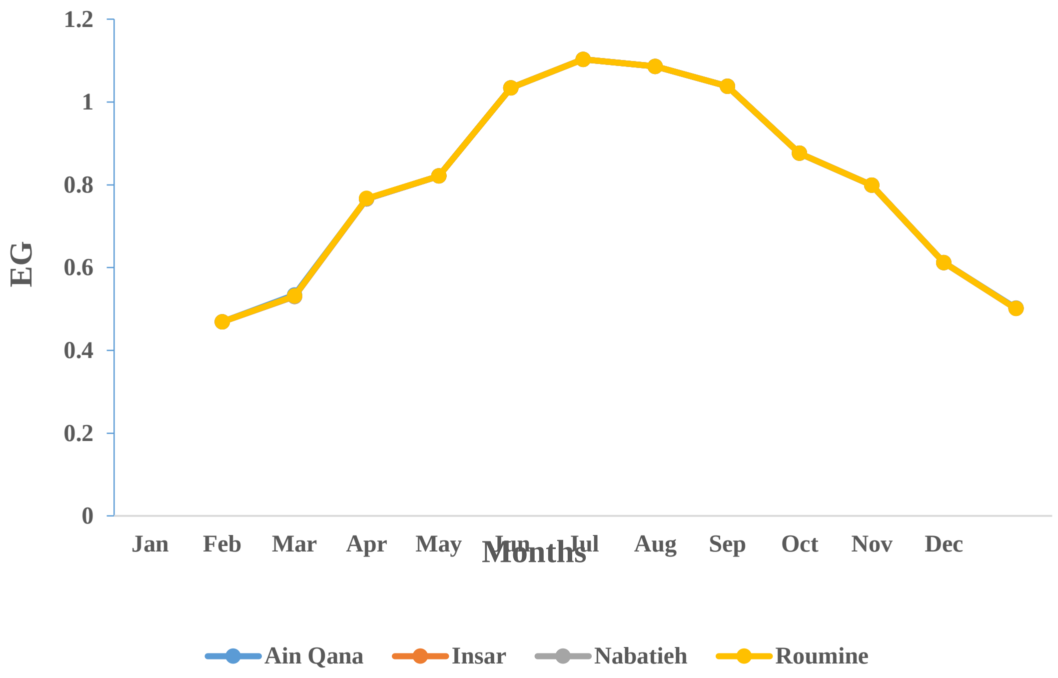


Figure 4.3.9

Zone 5 Nabatieh



Capacity Factors Of Selected Locations

Figure 4.4.1

Zone 6 Beeqa

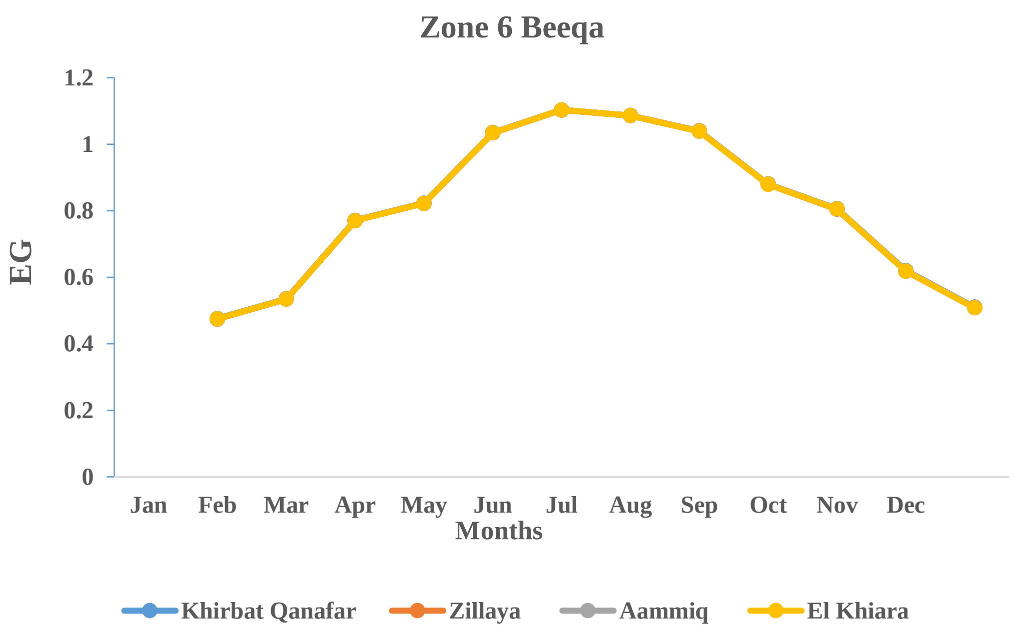


Figure 4.4.2

Zone 1 Akkar

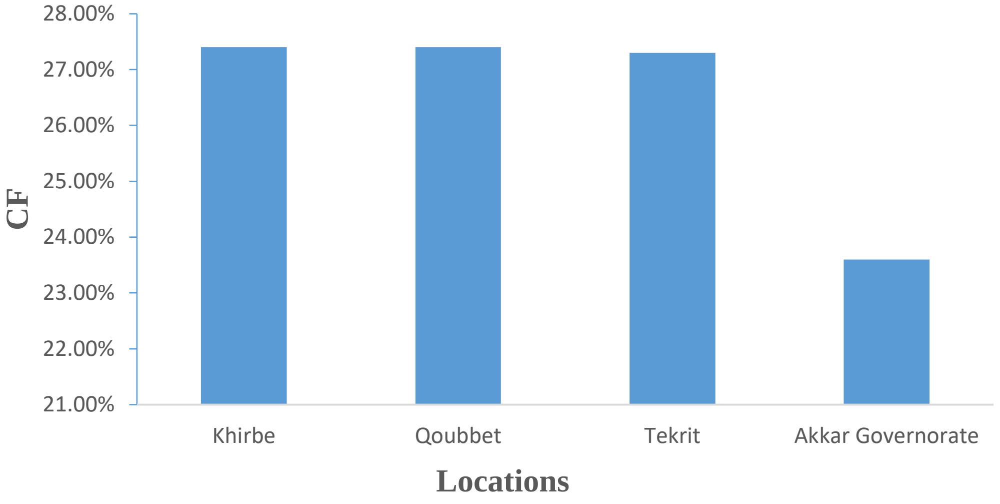


Figure 4.4.3

Zone 2a North Lebanon

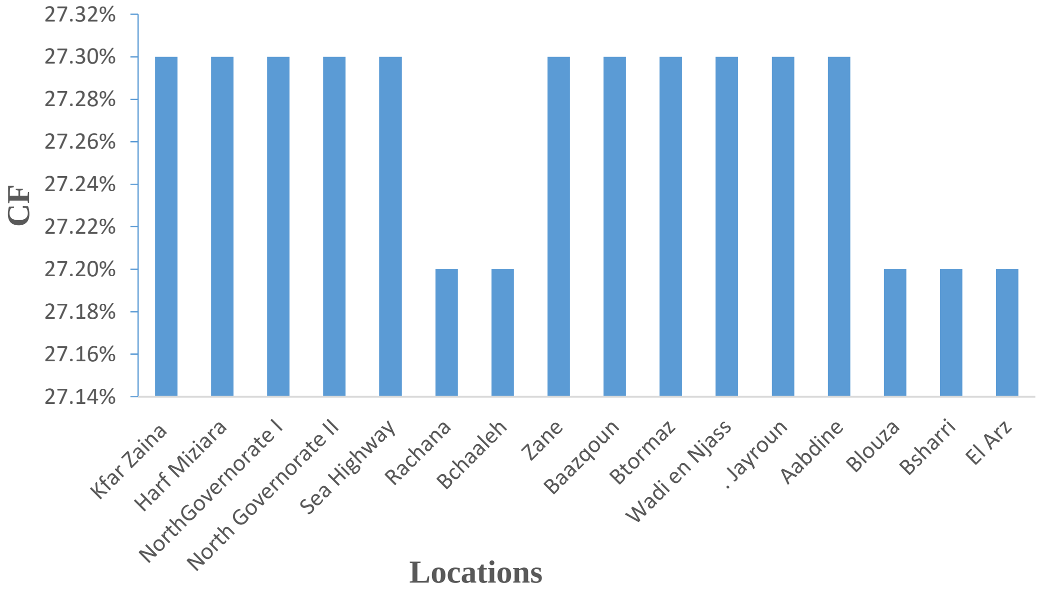


Figure 4.4.4

Zone 2b North Lebanon

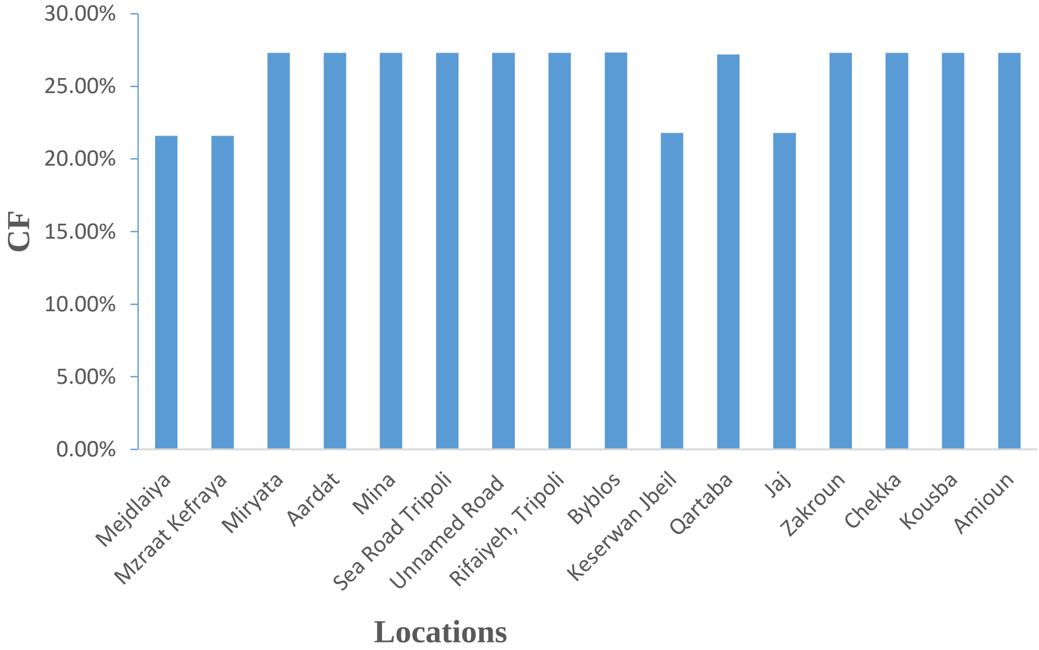


Figure 4.4.5

Zone 3a Mount Lebanon

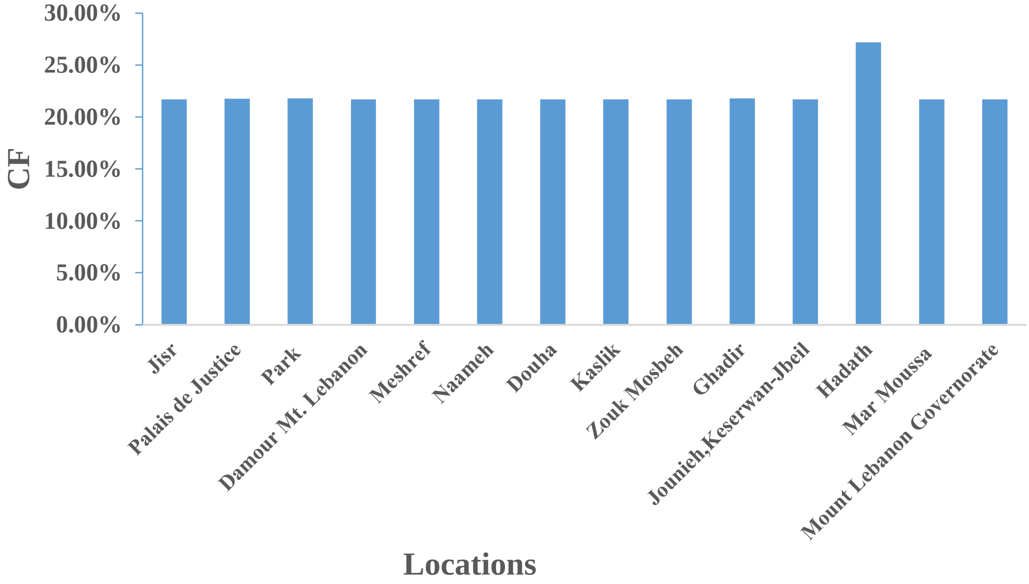


Figure 4.4.6

Zone 3b Mount Lebanon

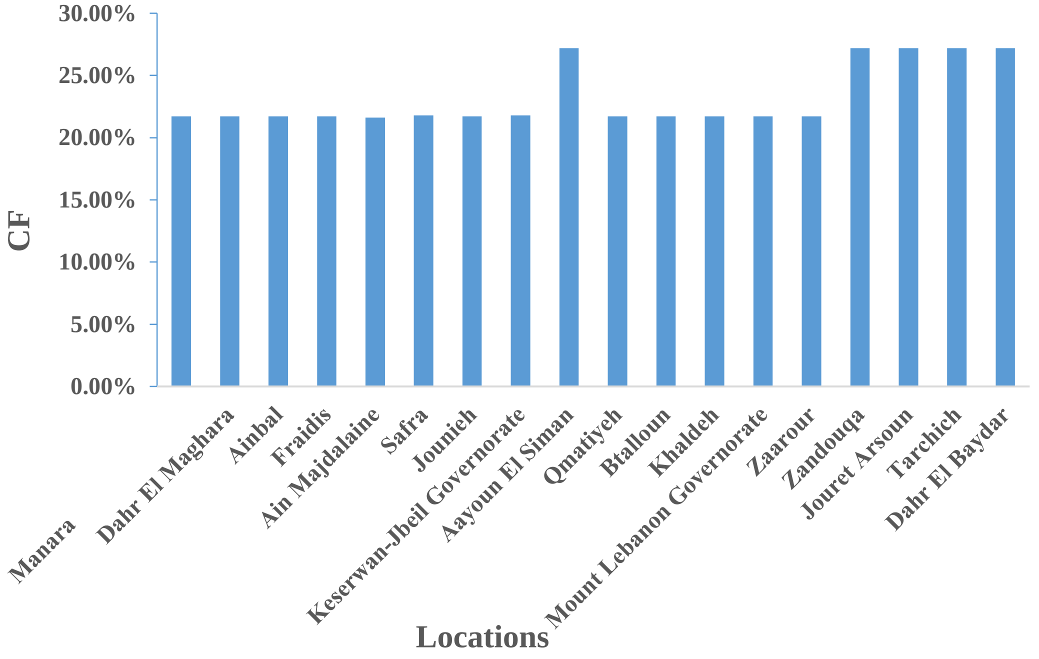


Figure 4.4.7

Zone 4 South Lebanon

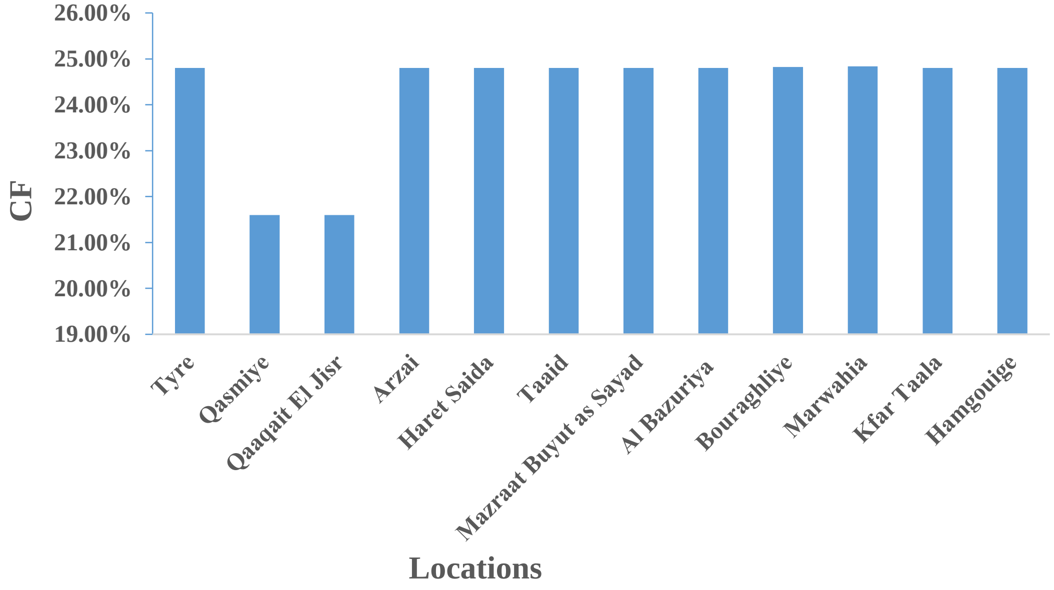


Figure 4.4.8

Zone 5 Nabatieh

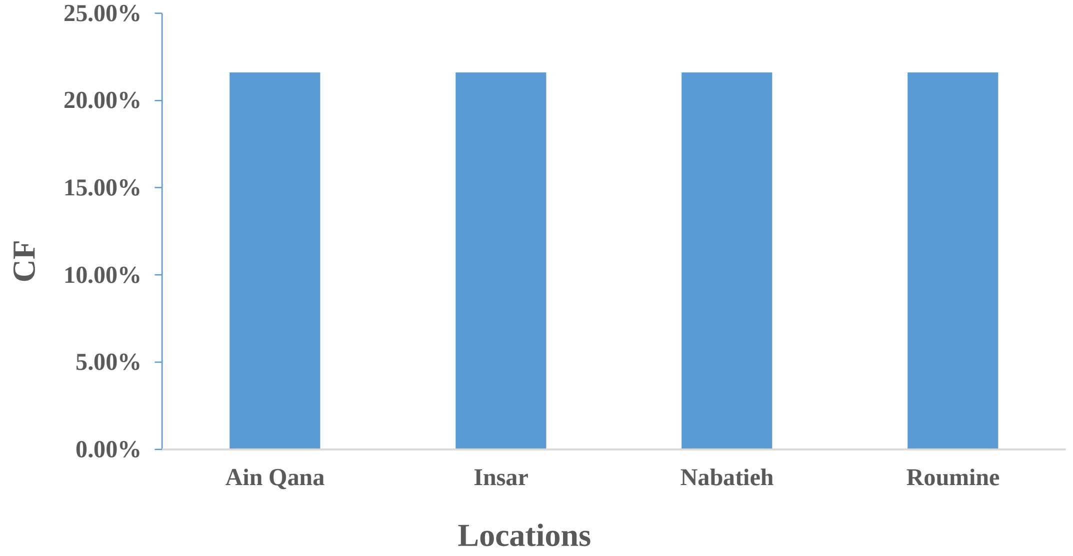


Figure 4.4.9

Zone 6 Beeqa

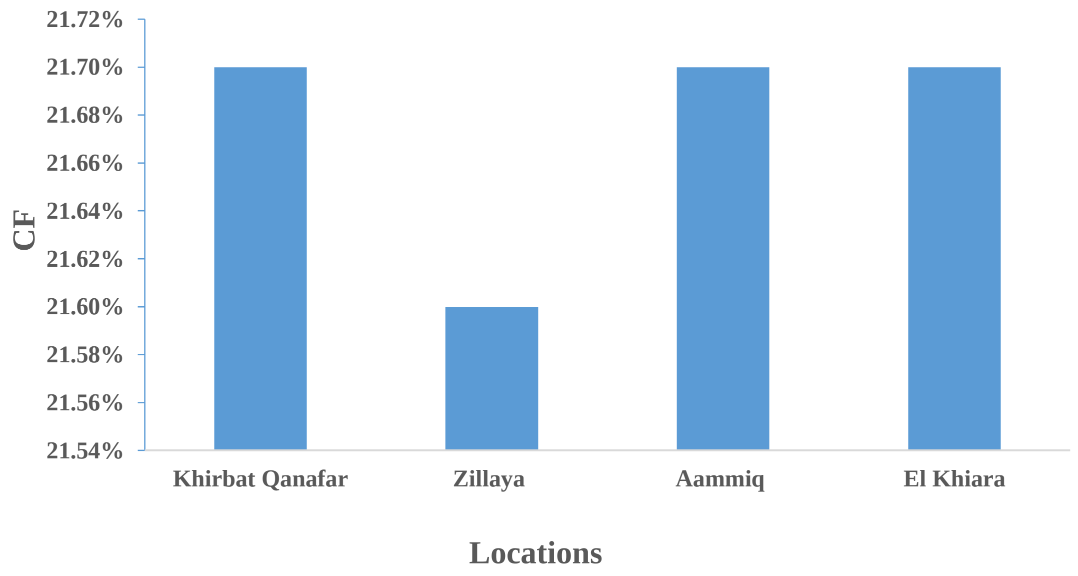


Figure 4.5

Zone 7 Baalbekka Hermel

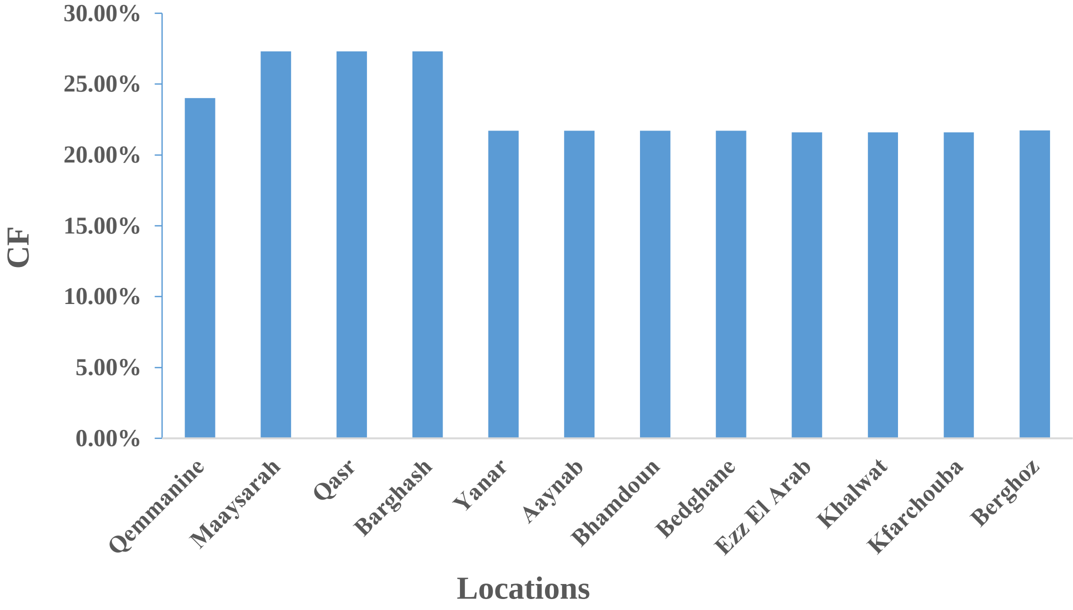


Table 4.5

Average Monthly EG [kWh/m²]

Zone 1												
Months	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Khribe	0.58	0.59	0.81	0.90	1.15	1.21	1.21	1.15	0.96	0.83	0.62	0.54
Qoubbet	0.69	0.71	0.97	1.05	1.30	1.34	1.34	1.29	1.12	1.00	0.76	0.65
Tekrit	0.69	0.71	0.97	1.05	1.30	1.34	1.34	1.29	1.12	1.00	0.76	0.64
Akkar Governorate	0.58	0.59	0.81	0.90	1.15	1.21	1.21	1.15	0.96	0.83	0.62	0.54
Zone 2												
Months	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Kfar Zaina	0.69	0.71	0.97	1.05	1.30	1.34	1.34	1.29	1.12	1.00	0.75	0.64
Harf Miziara	0.68	0.71	0.97	1.05	1.30	1.34	1.34	1.29	1.12	1.00	0.75	0.64
NorthGovernorate I	0.68	0.71	0.97	1.05	1.30	1.34	1.34	1.29	1.12	1.00	0.75	0.64
North Governorate II	0.68	0.71	0.97	1.05	1.30	1.34	1.34	1.29	1.12	1.00	0.75	0.64
Sea Highway	0.68	0.70	0.97	1.05	1.30	1.34	1.34	1.29	1.12	1.00	0.75	0.64
Rachana	0.68	0.70	0.97	1.05	1.30	1.34	1.34	1.29	1.12	1.00	0.75	0.64
Bchaaleh	0.68	0.70	0.97	1.05	1.30	1.34	1.34	1.29	1.12	1.00	0.75	0.64
Zane	0.68	0.70	0.97	1.05	1.30	1.34	1.34	1.29	1.12	1.00	0.75	0.64
Baazqoun	0.68	0.71	0.97	1.05	1.30	1.34	1.34	1.29	1.12	1.00	0.75	0.64
Btormaz	0.68	0.71	0.97	1.05	1.30	1.34	1.34	1.29	1.12	1.00	0.75	0.64
Wadi en Njass	0.69	0.71	0.97	1.05	1.30	1.34	1.34	1.29	1.12	1.00	0.75	0.64
Jayroun	0.68	0.71	0.97	1.05	1.30	1.34	1.34	1.29	1.12	1.00	0.75	0.64
Aabdine	0.69	0.71	0.97	1.05	1.30	1.34	1.34	1.29	1.12	1.00	0.76	0.64
Blouza	0.68	0.70	0.97	1.05	1.30	1.34	1.34	1.29	1.12	1.00	0.75	0.64
Bsharri	0.68	0.70	0.97	1.05	1.30	1.34	1.34	1.29	1.12	1.00	0.75	0.64
El Arz	0.68	0.70	0.97	1.05	1.30	1.34	1.34	1.29	1.12	1.00	0.75	0.64
Mejdlaiya	0.47	0.53	0.77	0.82	1.03	1.10	1.09	1.04	0.88	0.50	0.62	0.51
Mzraat Kefraya	0.47	0.53	0.77	0.82	1.03	1.10	1.09	1.04	0.88	0.80	0.62	0.51
Miryata	0.47	0.53	0.77	0.82	1.03	1.10	1.09	1.04	0.88	0.80	0.62	0.51
Aardat	0.47	0.53	0.77	0.82	1.03	1.10	1.09	1.04	0.88	0.80	0.62	0.51
Mina	0.69	0.71	0.97	1.05	1.30	1.34	1.34	1.29	1.12	1.00	0.76	0.64
Sea Road Tripoli	0.69	0.71	0.97	1.05	1.30	1.34	1.34	1.29	1.12	1.00	0.76	0.64
Unnamed Road	0.69	0.71	0.97	1.05	1.30	1.34	1.34	1.29	1.12	1.00	0.76	0.64

Rifaiyeh, Tripoli	0.69	0.71	0.97	1.05	1.30	1.34	1.34	1.29	1.12	1.00	0.76	0.64
Byblos	0.48	0.54	0.78	0.83	1.04	1.10	1.09	1.04	0.88	0.81	0.63	0.52
Keserwan Jbeil	0.68	0.70	0.97	1.05	1.30	1.34	1.34	1.29	1.12	1.00	0.75	0.64
Qartaba	0.48	0.54	0.78	0.83	1.04	1.10	1.09	1.04	0.88	0.81	0.63	0.52
Jaj	0.48	0.54	0.78	0.83	1.04	1.10	1.09	1.04	0.88	0.81	0.63	0.52
Zakroun	0.68	0.71	0.97	1.05	1.30	1.34	1.34	1.29	1.12	1.00	0.75	0.64
Chekka	0.68	0.71	0.97	1.05	1.30	1.34	1.34	1.29	1.12	1.00	0.75	0.64
Kousba	0.68	0.71	0.97	1.05	1.30	1.34	1.34	1.29	1.12	1.00	0.75	0.64
Amioun	0.68	0.70	0.97	1.05	1.30	1.31	1.34	1.29	1.12	1.00	0.75	0.64
Kousba	0.68	0.71	0.97	1.05	1.30	1.34	1.34	1.29	1.12	1.00	0.75	0.64
Amioun	0.68	0.70	0.97	1.05	1.30	1.31	1.34	1.29	1.12	1.00	0.75	0.64

Zone 3

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Manara	0.48	0.54	0.77	0.82	1.04	1.10	1.09	1.04	0.88	0.81	0.63	0.51
Jisr	0.48	0.54	0.77	0.82	1.04	1.10	1.09	1.04	0.88	0.81	0.63	0.51
Palais de Justice	0.48	0.54	0.77	0.82	1.04	1.10	1.09	1.04	0.88	0.81	0.62	0.51
Park	0.48	0.54	0.77	0.82	1.04	1.10	1.09	1.04	0.88	0.81	0.63	0.51
Damour Mt. Lebanon	0.48	0.54	0.77	0.82	1.04	1.10	1.09	1.04	0.88	0.81	0.62	0.51
Meshref	0.48	0.54	0.77	0.82	1.04	1.10	1.09	1.04	0.88	0.81	0.62	0.51
Naameh	0.48	0.54	0.77	0.82	1.04	1.10	1.09	1.04	0.88	0.81	0.62	0.51
Douha	0.48	0.54	0.77	0.82	1.04	1.10	1.09	1.04	0.88	0.81	0.62	0.51
Kaslik	0.48	0.54	0.77	0.82	1.04	1.10	1.09	1.04	0.88	0.81	0.62	0.51
Zouk Mosbeh	0.48	0.54	0.77	0.82	1.04	1.10	1.09	1.04	0.88	0.81	0.62	0.51
Ghadir	0.48	0.54	0.77	0.82	1.04	1.10	1.09	1.04	0.88	0.81	0.63	0.52
Jounieh,Keserwan -Jbeil	0.48	0.54	0.77	0.82	1.04	1.10	1.09	1.04	0.88	0.81	0.63	0.52
Hadath	0.67	0.70	0.97	1.05	1.30	1.34	1.34	1.29	1.11	0.99	0.74	0.63
Mar Moussa	0.48	0.54	0.77	0.82	1.04	1.10	1.09	1.04	0.88	0.81	0.62	0.52
Mount Lebanon Governorate	0.48	0.54	0.77	0.82	1.04	1.10	1.09	1.04	0.88	0.81	0.62	0.52
Zaarour	0.48	0.54	0.77	0.82	1.04	1.10	1.09	1.04	0.88	0.81	0.62	0.51
Zandouqa	0.68	0.70	0.97	1.05	1.30	1.34	1.34	1.29	1.12	1.00	0.75	0.64
Jouret Arsoun	0.68	0.70	0.97	1.05	1.30	1.34	1.34	1.29	1.12	1.00	0.75	0.64
Tarchich	0.68	0.70	0.97	1.05	1.30	1.34	1.34	1.29	1.12	1.00	0.75	0.64
Dahr El Baydar	0.68	0.70	0.97	1.05	1.30	1.34	1.34	1.29	1.12	1.00	0.75	0.64
Dahr El Maghara	0.47	0.53	0.77	0.82	1.03	1.10	1.09	1.04	0.88	0.80	0.62	0.51
Ainbal	0.47	0.53	0.77	0.82	1.03	1.10	1.09	1.04	0.88	0.80	0.62	0.51
Fraidis	0.48	0.53	0.77	0.82	1.03	1.10	1.09	1.04	0.88	0.81	0.62	0.51
Ain Majdalaine	0.47	0.53	0.77	0.82	1.03	1.10	1.09	1.04	0.88	0.80	0.62	0.51
Safra	0.48	0.54	0.77	0.82	1.04	1.10	1.09	1.04	0.88	0.81	0.63	0.52
Jounieh	0.48	0.54	0.77	0.82	1.04	1.10	1.09	1.04	0.88	0.81	0.63	0.52
Keserwan-Jbeil Governorate	0.68	0.70	0.97	1.05	1.30	1.34	1.34	1.29	1.12	0.99	0.75	0.63
Aayoun El Siman	0.68	0.70	0.97	1.05	1.30	1.34	1.34	1.29	1.11	0.99	0.74	0.63
Qmatiyeh	0.48	0.54	0.77	0.82	1.03	1.10	1.09	1.04	0.88	0.81	0.62	0.51
Btalloun	0.48	0.54	0.77	0.82	1.04	1.10	1.09	1.04	0.88	0.81	0.62	0.51
Khaldeh	0.47	0.53	0.77	0.82	1.03	1.10	1.09	1.04	0.88	0.80	0.62	0.51
Mount Lebanon Governorate	0.48	0.54	0.77	0.82	1.04	1.10	1.09	1.04	0.88	0.81	0.62	0.51

Zone 4

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Tyre	0.64	0.62	0.87	0.97	1.20	1.22	1.24	1.16	0.99	0.88	0.69	0.61
Qasmiye	0.47	0.53	0.77	0.82	1.03	1.10	1.09	1.04	0.88	0.80	0.61	0.51
Qaaqait El Jisr	0.47	0.53	0.77	0.82	1.03	1.10	1.09	1.04	0.88	0.80	0.61	0.50
Hamgouige	0.63	0.62	0.87	0.97	1.20	1.22	1.24	1.16	0.99	0.88	0.69	0.61
Arzai	0.63	0.62	0.87	0.97	1.20	1.22	1.24	1.16	0.99	0.88	0.69	0.61
Haret Saida	0.63	0.62	0.87	0.97	1.20	1.22	1.24	1.16	0.99	0.88	0.69	0.61
Taaid	0.63	0.62	0.87	0.97	1.20	1.22	1.24	1.16	0.99	0.88	0.69	0.60
Mazraat Buyut as Sayad	0.47	0.53	0.77	0.82	1.03	1.10	1.09	1.04	0.88	0.80	0.62	0.51
Al Bazuriya	0.47	0.53	0.77	0.82	1.03	1.10	1.09	1.04	0.88	0.80	0.62	0.51
Bouraghliye	0.47	0.53	0.77	0.82	1.03	1.10	1.09	1.04	0.88	0.80	0.62	0.51
Marwahia	0.47	0.53	0.77	0.82	1.03	1.10	1.09	1.04	0.88	0.80	0.62	0.51
Kfar Taala	0.63	0.62	0.87	0.97	1.20	1.22	1.24	1.16	0.99	0.88	0.69	0.61

Zone 5

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

Ain Qana	0.47	0.53	0.77	0.82	1.03	1.10	1.09	1.04	0.88	0.80	0.61	0.50
Insar	0.47	0.53	0.77	0.82	1.03	1.10	1.09	1.04	0.88	0.80	0.61	0.50
Nabatieh	0.47	0.53	0.77	0.82	1.03	1.10	1.09	1.04	0.88	0.80	0.61	0.50
Roumine	0.47	0.53	0.77	0.82	1.03	1.10	1.09	1.04	0.88	0.80	0.61	0.50
Zone 6												
Months	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Khirbat Qanafar	0.48	0.54	0.77	0.82	1.04	1.10	1.09	1.04	0.88	0.81	0.62	0.51
Zillaya	0.47	0.53	0.77	0.82	1.03	1.10	1.09	1.04	0.88	0.80	0.62	0.51
Aammiq	0.48	0.54	0.77	0.82	1.03	1.10	1.09	1.04	0.88	0.81	0.62	0.51
El Khiara	0.48	0.53	0.77	0.82	1.03	1.10	1.09	1.04	0.88	0.81	0.62	0.51
Zone 7												
Months	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Qemmanine	0.59	0.60	0.82	0.92	1.17	1.22	1.22	1.16	0.98	0.85	0.63	0.55
Maaysarah	0.68	0.70	0.97	1.05	1.30	1.34	1.34	1.29	1.12	1.00	0.75	0.64
Qasr	0.68	0.71	0.97	1.05	1.30	1.34	1.34	1.29	1.12	1.00	0.75	0.64
Barghash	0.68	0.71	0.97	1.05	1.30	1.34	1.34	1.29	1.12	1.00	0.75	0.64
Yanar	0.48	0.54	0.77	0.82	1.04	1.10	1.09	1.04	0.88	0.81	0.62	0.51
Aaynab	0.48	0.54	0.77	0.82	1.04	1.10	1.09	1.04	0.88	0.81	0.62	0.51
Bhamdoun	0.48	0.54	0.77	0.82	1.04	1.10	1.09	1.04	0.88	0.81	0.62	0.51
Bedghane	0.48	0.54	0.77	0.82	1.04	1.10	1.09	1.04	0.88	0.81	0.62	0.51
Ezz El Arab	0.47	0.53	0.77	0.82	1.03	1.10	1.09	1.04	0.88	0.80	0.62	0.51
Khalwat	0.47	0.53	0.77	0.82	1.03	1.10	1.09	1.04	0.88	0.80	0.61	0.50
Kfarchouba	0.47	0.53	0.77	0.82	1.03	1.10	1.09	1.04	0.88	0.80	0.61	0.50
Berghoz	0.47	0.53	0.77	0.82	1.03	1.10	1.09	1.04	0.88	0.80	0.61	0.50

CHAPTER V

Conclusions and Future Work

Chapter 5 this section discusses about a study that looked at the potential for using solar energy in 99 different cities. It also looked at how much it would cost and how it would impact the environment to install small solar panels on rooftops that connect to the power grid.

Conclusions

Because electricity bills are getting higher and people are using less fossil fuels, more and more homeowners are interested in having solar panels installed on their house. The aim of this research was to assess the possibility of the installation of small solar panels on buildings in Lebanon as a means of utilizing the sun to generate electricity. The research also checked if it's financially and technically possible to install small solar panels on rooftops to be connected to the electricity grid. This was done using a special computer program called RETScreen, which helps figure out if it makes sense from a money and technology perspective. Before we talk about the main findings of this study, it's important to understand the things this work can't do. The financial rules were based on old values that were written in books. Secondly, the software could not consider the impact of various factors like dust, sunlight strength, air temperature, and humidity. Thirdly, the expected costs of the proposed projects were estimated by looking at costs that were already mentioned in previous research studies. The investigation determined that the quantity of solar energy accessible in the designated places ranges from 1737 to 1764kWh per square meter each year. According to the information, the study suggests that the selected cities and areas can supply solar power systems for homes. The study found that when using two-tracking systems, small solar power systems in selected areas produced between 9. 357 kWh/m2 and 12. 221 kWh/m2 of energy per year. This study found that solar power panels can handle the most energy usage during the spring and summer seasons.

The study says that it costs between 0. 021 to 0027 dollars to produce energy for each unit of electricity. The suggested system's cost to make energy is like the electricity company rates of some cities in Lebanon. This study found that using solar panels on rooftops can help solve the electricity shortage and lower the amount of pollution from burning fossil fuels. Solar energy could also be used to make clean drinking water. The study shows that using solar power is a good choice for the environment, economy, and technology.

Future Work

Ignoring the impact of weather conditions like temperature and humidity on how well the solar panels work, the researchers thought about money related factors based on past research. Future studies looking at whether rooftop solar panels connected to the electricity grid are a good idea should focus mainly on how much it costs to start the project, how fast prices are going up, and how much money people will save over time.

REFERENCES

Abou Slaymane, R., & Soliman, M. R. (2022). Integrated water balance and water quality management under future climate change and population growth: a case study of Upper Litani Basin, Lebanon. Climatic Change, 172(3-4), 28.

Ahmed, W., Sheikh, J. A., Ahmad, S., Farjana, S. H., & Mahmud, M. P. (2021). Impact of PV system orientation angle accuracy on greenhouse gases mitigation. Case Studies in Thermal Engineering, 23, 100815.

Ahmed, W., Sheikh, J. A., Farjana, S. H., & Mahmud, M. P. (2021). Defects impact on PV system GHG mitigation potential and climate change. Sustainability, 13(14), 7793.

AlYahya, S., & Irfan, M. A. (2016). Analysis from the new solar radiation Atlas for Saudi Arabia. Solar Energy, 130, 116-127.

Al Zohbi, G., Hendrick, P., & Bouillard, P. (2018). Assessment of wind energy potential in Lebanon. Research In Marine Sciences, 3(4), 401-414.

Aoun, M., El Jeaid, H., & El Samad, D. M. O. (2021). 222Rn Concentrations in the Lebanese Drinking Water and its Associated Ingestion Committed Effective Dose to the Public. J. Radiat. Nucl. Appl., 6(1), 83-88.

Baalbaki, R., Ahmad, S. H., Kays, W., Talhouk, S. N., Saliba, N. A., & Al-Hindi, M. (2019). Citizen science in Lebanon—A case study for groundwater quality monitoring. Royal Society Open Science, 6(2), 181871.

Balo, F., & Şağbanşua, L. (2016). The selection of the best solar panel for the photovoltaic system design by using AHP. Energy Procedia, 100, 50-53.

Bhatia, S. C. (2014). Energy resources and their utilisation. In Advanced Renewable Energy Systems,(Part 1 and 2) (pp. 18-48). WPI Publishing.

Çamur, H., Kassem, Y., & Alessi, E. (2021). A techno-economic comparative study of a grid-connected residential rooftop PV panel: the case study of Nahr El-Bared, Lebanon. Engineering, Technology & Applied Science Research, 11(2), 6956-6964.

Cristofari, C., Carutasiu, M. B., Canaletti, J. L., Norvaišienė, R., Motte, F., & Notton, G. (2019). Building integration of solar thermal systems-example of a refurbishment of a church rectory. Renewable Energy, 137, 67-81.

Elavarasan, R. M., Shafiullah, G. M., Padmanaban, S., Kumar, N. M., Annam, A., Vetrichelvan, A. M., ... & Holm-Nielsen, J. B. (2020). A comprehensive review on renewable energy development, challenges, and policies of leading Indian states with an international perspective. IEEE Access, 8, 74432-74457.

El-Bayeh, C. Z., Alzaareer, K., Brahmi, B., Zellagui, M., & Eicker, U. (2021). An original multi-criteria decision-making algorithm for solar panels selection in buildings. Energy, 217, 119396.

Elmustapha, H., & Hoppe, T. (2020). Challenges and opportunities of business models in sustainable transitions: Evidence from solar energy niche development in Lebanon. Energies, 13(3), 670.

Eslami, H., Najem, S., Abi Ghanem, D., & Ahmad, A. (2021). The potential of urban distributed solar energy in transition economies: The case of Beirut city. Journal of Environmental Management, 285, 112121.

Fadlallah, J. J. (2020). Modeling of groudwater flow and contaminant transport in a karstic formation using finite diffference approach (Doctoral dissertation, Notre Dame University-Louaize.).

Farangi, M., Soleimani, E. A., Zahedifar, M., Amiri, O., & Poursafar, J. (2020). The environmental and economic analysis of grid-connected photovoltaic power systems with silicon solar panels, in accord with the new energy policy in Iran. Energy, 202, 117771.

.Gielen, D., Boshell, F., Saygin, D., Bazilian, M. D., Wagner, N., & Gorini, R. (2019). The role of renewable energy in the global energy transformation. Energy Strategy Reviews, 24, 38-50.

Gökçekuş, H., Kassem, Y., & Al Hassan, M. (2019). Evaluation of wind potential at eight selected locations in Northern Lebanon using open source data. Int J Appl Eng Res, 14(11), 2789-2794.

Halawi, Mohammad Hassan, et al. "First Case of Identification of Candida kefyr and Pichia kluyveri in Lebanese Water." Water, Air, & Soil Pollution 231.3 (2020): 1-11.

Himri, Y., Merzouk, M., Merzouk, N. K., & Himri, S. (2020). Potential and economic feasibility of wind energy in south West region of Algeria. Sustainable Energy Technologies and Assessments, 38, 100643.

Kabir, E., Kumar, P., Kumar, S., Adelodun, A. A., & Kim, K. H. (2018). Solar energy: Potential and future prospects. Renewable and Sustainable Energy Reviews, 82, 894-900.

Kalaoun, Omar, et al. "Impact of demographic growth on seawater intrusion: Case of the Tripoli aquifer, Lebanon." Water 8.3 (2016): 104.

Kassem, Y., Gokcekus, H&, Fadel Ali Ramadan Agila(2023) Solar-Powered Solutions for the Water and Energy Shortage Problem: The Case Study of Nahr El Bared, Lebanon DOI: https://doi.org/10.48084/etasr.5858 Vol. 13, No. 3, 2023, 10861-10869

Kassem, Y., Gokcekus, H., & Agila, F. A. R. (2023). Techno-Economic Feasibility Assessment for the promotion of Grid-Connected Rooftop PV Systems in Botswana: A Case Study. Engineering, Technology & Applied Science Research, 13(2), 10328-10337.

Kassem, Y., Gökçekuş, H., & Aljamal, J. (2020, March). Surface water resource and effect of weather parameters in estimating the annual rainfall: A case study in Lebanon. In IOP Conference Series: Materials Science and Engineering (Vol. 800, No. 1, p. 012028). IOP Publishing.(Map of Lebanon; climate.

Kassem, Y., Gökçekuş, H., & Güvensoy, A. (2021). Techno-economic feasibility of grid-connected solar PV system at Near East University hospital, Northern Cyprus. Energies, 14(22), 7627.

Kassem, Y., Gökçekuş, H., & Janbein, W. (2021). Predictive model and assessment of the potential for wind and solar power in Rayak region, Lebanon. Modeling Earth Systems and Environment, 7(3), 1475-1502.

Kassem, Y., Gökçekuş, H., & Lagili, H. S. A. (2021). A techno-economic viability analysis of the two-axis tracking grid-connected photovoltaic power system for 25 selected coastal mediterranean cities. Engineering, Technology & Applied Science Research, 11(4), 7508-7514.

Kassem, Y., Gokcekus, H., Mizran, M. M., & Alsayas, S. M. (2019). Evaluation of the wind energy potential in Lebanon's coastal regions using Weibull distribution function. International Journal of Engineering Research and Technology, 12(6), 784-792.

Kassem, Y., Gökçekuş, H., & Zeitoun, M. (2019). Modeling of techno-economic assessment on wind energy potential at three selected coastal regions in Lebanon. Modeling Earth Systems and Environment, 5(3), 1037-1049.

Kazem, H. A., & Chaichan, M. T. (2012). Status and future prospects of renewable energy in Iraq. Renewable and Sustainable Energy Reviews, 16(8), 6007-6012.

Khair, K., et al. "The environmental impacts of humans on groundwater in Lebanon." Water, Air, and Soil Pollution 78.1 (1994): 37-49.

Lahoud, C., El Brouche, M., Lahoud, C., & Hmadi, M. (2021). A Review of single-effect solar absorption chillers and its perspective on Lebanese case. Energy Reports, 7, 12-22.

Lebanon Maps - Perry-Castañeda Map Collection - UT Library Online (utexas.ed).

Li, C. (2021). Evaluation of the viability potential of four grid-connected solar photovoltaic power stations in Jiangsu Province, China. Clean Technologies and Environmental Policy, 23(7), 2117-2131.

Maradin, D. (2021). Advantages and disadvantages of renewable energy sources utilization. 670216917.

Mardonova, M., & Choi, Y. (2019). Assessment of photovoltaic potential of mining sites in Uzbekistan. Sustainability, 11(10), 2988.

Massoud, M. A., Terkawi, M., & Nakkash, R. (2019). Water reuse as an incentive to promote sustainable agriculture in Lebanon: Stakeholders' perspectives. Integrated Environmental Assessment and Management, 15(3), 412-421.

Mcheik, A., Awad, A., Fadel, A., Mounzer, C., & Nasreddine, S. (2018). Effect of irrigation water quality on the microbial contamination of fresh vegetables in the Bekaa Valley, Lebanon. American Journal of Agriculture and Forestry, 6(6), 191-197.

Mohammadi, K., Naderi, M., & Saghafifar, M. (2018). Economic feasibility of developing grid-connected photovoltaic plants in the southern coast of Iran. Energy, 156, 17-31.

Nehme, Nada, et al. "Study of the water assessment in the Alhoujair valley in Lebanon." (2021).

Obeng, M., Gyamfi, S., Derkyi, N. S., Kabo-bah, A. T., & Peprah, F. (2020). Technical and economic feasibility of a 50 MW grid-connected solar PV at UENR Nsoatre Campus. Journal of Cleaner Production, 247, 119159.

Owolabi, A. B., Nsafon, B. E. K., Roh, J. W., Suh, D., & Huh, J. S. (2019). Validating the techno-economic and environmental sustainability of solar PV technology in Nigeria using RETScreen Experts to assess its viability. Sustainable Energy Technologies and Assessments, 36, 100542.

Owusu, P. A., & Asumadu-Sarkodie, S. (2016). A review of renewable energy sources, sustainability issues and climate change mitigation. Cogent Engineering, 3(1), 1167990.

Prăvălie R, Patriche C, Bandoc G (2019) Spatial assessment of solar energy potential at global scale. A geographical approach. J Clean Prod 209:692–721

Rad, M. A. V., Toopshekan, A., Rahdan, P., Kasaeian, A., & Mahian, O. (2020). A comprehensive study of techno-economic and environmental features of different solar tracking systems for residential photovoltaic installations. Renewable and Sustainable Energy Reviews, 129, 109923.

Reca-Cardeña, J., & López-Luque, R. (2018). Design Principles of Photovoltaic Irrigation Systems. In Advances in Renewable Energies and Power Technologies (pp. 295-333). Elsevier.

Rehman, S., Ahmed, M. A., Mohamed, M. H., & Al-Sulaiman, F. A. (2017). Feasibility study of the grid connected 10 MW installed capacity PV power plants in Saudi Arabia. Renewable and Sustainable Energy Reviews, 80, 319-329.

Said, M.; El-Shimy, M.; Abdelraheem, M.A. Photovoltaics energy: Improved modeling and analysis of the levelized cost of energy (LCOE) and grid parity–Egypt case study. Sustain. Energy Technol. Assess. 2015, 9, 37–48. [Google Scholar] [CrossRef]

Sasikumar, G.; Ayyappan, S. Multi-criteria Decision Making for Solar Panel Selection Using Fuzzy Analytical Hierarchy Process and Technique for Order Preference by Similarity to ideal Solution (TOPSIS): An Empirical Study. J. Inst. Eng. Ser. C 2019, 100, 707–715. [Google Scholar] [CrossRef]

Shaban, A. (2019). Striking Challenges on Water Resources of Lebanon. In Hydrology-The Science of Water. IntechOpen.

Sreenath, S., Sudhakar, K., & Yusop, A. F. (2021). 7E analysis of a conceptual utility-scale land-based solar photovoltaic power plant. Energy, 219, 119610.

STEFANAKIS[1], ALEXANDROS I., DIMITRIOS ZOUZIAS, and A. N. T. O. N. I. O. S. MARSELLOS[1]. "Groundwater pollution: human and natural sources and risks." (2017).

Tarigan, E., & Kartikasari, F. D. (2015). Techno-economic simulation of a grid-connected PV system design as specifically applied to residential in Surabaya, Indonesia. Energy Procedia, 65, 90-99.

Vakulchuk, R., Overland, I., & Scholten, D. (2020). Renewable energy and geopolitics: A review. Renewable and Sustainable Energy Reviews, 122, 109547.

Wehbe, N. (2021). The future costs of renewable electricity generation technologies in Lebanon: what projections for 2030?.

Zgheib, H., Drider, D., & Belguesmia, Y. (2020). Broadening and enhancing bacteriocins activities by association with bioactive substances. International Journal of Environmental Research and Public Health, 17(21), 7835.

Appendix

FRANCIS SURFIA DIOH

INBOX | VIEWING: NEW ASSIGNMENTS ▾

Submit File

Online Rating Report | Edit assignment settings | Not reporting e-mail

WRITER	TITLE	SIMILARITY	RATE IT	REPLY	FILE	HOMEWORK NUMBER	HISTORY
Francis Surfia Dioh	Abstract	0%	-	-		2118940037	19-Jun-2023
Francis Surfia Dioh	Chapter 5: Conclusion and Future work	0%	-	-		2118942983	19-Jun-2023
Francis Surfia Dioh	Chapter 4: Results and Discussion	5%	-	-		2118942516	19-Jun-2023
Francis Surfia Dioh	Chapter 1: Introduction	9%	-	-		2118940918	19-Jun-2023
Francis Surfia Dioh	final thesis	14%	-	-		2118939586	19-Jun-2023
Francis Surfia Dioh	Chapter 2: Literature Review	15%	-	-		2118941621	19-Jun-2023
Francis Surfia Dioh	Chapter 3: Materials and Methods	18%	-	-		2118942057	19-Jun-2023

Supervisor: PROF. DR. HUSYIN GOKCEKUS________________________

Co-supervisor: ASSOC. PROF. DR. YOUSSEF KASSEM__________________