NEAR EAST UNIVERSITY

FACULTY OF ENGINEERING

DEPARTMENT OF MECHANICAL ENGINEERING

SOLAR ENERGY POTENTIAL IN MEDITERRANEAN COUNTRIES

ME400

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HOSAM MATALKAH

Nicosia
January, 2022

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Acknowledgements

We thank our parents for the unconditional love and support they gave us during these four difficult years of our life and the opportunity and confidence they gave us to be able to stand in this position. We would like to express our sincere gratitude to several individuals for supporting us throughout my Graduate study. First, we wish to express our sincere gratitude to our supervisor, Assoc. Prof. Dr.YousufKassem, for his enthusiasm, patience, insightful comments, helpful information, practical advice and unceasing ideas that have helped me tremendously at all times in my research and writing of this thesis. His immense knowledge, profound experience and professional expertise in the department have enabled us to complete this research successfully. Without his support and guidance, this project would not have been possible. We could not have imagined having a better supervisor in our study.

We also wish to express our sincere thanks to the Near East University for accepting us into the graduate program.

SOHAIB SHABIH
HOSAM MATALKAH

Abstract

SOLAR ENERGY POTENTIAL IN MEDITERRANEAN COUNTRIES

SOHAIB SHABIH 20173939, HOSAM MATALKAH 20181714

Department of Mechanical Engineering

January 2022, 107 pages

The vast sustainable and renewable worldwide transmission of energy is being aided by annual growth in global energy consumption, as well as environmental difficulties and concerns. Throughout the previous decade, solar energy systems have gotten the most attention out of all the other renewable energy systems. However, even renewable energies can have negative environmental consequences; as a result, more attention and precautionary measures should be taken. For the sake of solar energy deployment, this article focuses on cities located near the Mediterranean Sea. The research goes on to discuss some of the relevant advancements as well as some of the critical components in their systems. The approach follows all the stages, starting with the cities longitude and latitude, their solar radiation impact and the most suitable geographical location.

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LIST OF ABBREVIATIONS

SPS: Solar Panel System
PV: Photovoltaic volts
DC: Direct current
AC: Alternating current
PVGIS: Photovoltaic Geographical Information System
EU: European Union
JRC: Joint Research Center

CHAPTER I

Introduction

Mediterranean Countries

The Mediterranean Sea is a sea connected to the Atlantic Ocean, surrounded by the Mediterranean Basin and almost completely enclosed by land: on the north by Western and Southern Europe and Anatolia, on the south by North Africa, and on the east by the Levant. The Sea has played a central role in the history of Western civilization. Although the Mediterranean is sometimes considered a part of the Atlantic Ocean, it is usually referred to as a separate body of water. Geological evidence indicates that around 5.9 million years ago, the Mediterranean was cut off from the Atlantic and was partly or completely desiccated over a period of some 600,000 years during the Messinian salinity crisis before being refilled by the Zanclean flood about 5.3 million years ago.

The Mediterranean countries are those that surround the Mediterranean Sea. Twenty sovereign countries in Southern Europe, the Levant and North Africa regions border the sea itself, in addition to two island nations completely located in it are Malta and Cyprus.

Portugal, Andorra, San Marino, Vatican City, Kosovo, Serbia, Bulgaria, North Macedonia, Romania, Mauritania, Western Sahara, and Jordan are sometimes listed in lists of Mediterranean countries despite not having a Mediterranean coastline. Their geographical, economic, geopolitical, historical, ethnic, and cultural (language, art, music, cuisine) linkages to the region as a whole are used to classify them. Climate and flora are also important considerations. The countries that border to the Mediterranean are as listed below.

CHAPTER I.I

Geographical Location

Figure 1: A geographical image marking the territory of the Mediterranean countries and its sea.

The Mediterranean is surprisingly mountainous, in contrast to the conventional sandy beach imagery depicted in most tourist brochures. Mountains may be seen from nearly every location. High mountains, rocky coasts, dense scrub, semi-arid steppes, coastal wetlands, sandy beaches, and a plethora of islands of varying shapes and sizes strewn amidst the pure blue sea make up the Mediterranean Region's ever-changing landscape.

The Mediterranean Levant is located at the eastern end of the Mediterranean Sea, and is bordered on the east and south by the Syrian and Negev deserts. It encompasses the western and southern regions of the Anatolian peninsula, excluding the temperate-climate Mountains of central Turkey, in Western Asia. The Atlas Mountains separate the northern Maghreb region of north-western Africa from the Sahara Desert, which stretches throughout North Africa. With the exception of the northern fringe of Libya's peninsula of Cyrenaica, which has a dry Mediterranean climate, the Sahara stretches to the Mediterranean's southern shore in the eastern Mediterranean.

The Iberian Peninsula, the Italian Peninsula, and the Balkan Peninsula, all of which are located to the north of the Mediterranean, expand into and encompass much of the Mediterranean climate zone. The Pyrenees, which separate Spain and France, the Alps, which separate Italy from Central Europe, the Dinaric Alps, which run along the eastern Adriatic, and the Balkan and Rila-Rhodope mountains, which run through the Balkan Peninsula, divide the Mediterranean from the temperate climate regions of Western, North Western or Northern Europe, Central Europe, and Eastern Europe.

As you can see in 'Figure 2' the climates are warm on the south regime and on the north regime it is more of semi-arid climate. They mostly have a Mediterranean climate with mild to cool, rainy winters and warm to hot, dry summers which generally supports the characteristics of Mediterranean forests, woodlands and scrub vegetation.

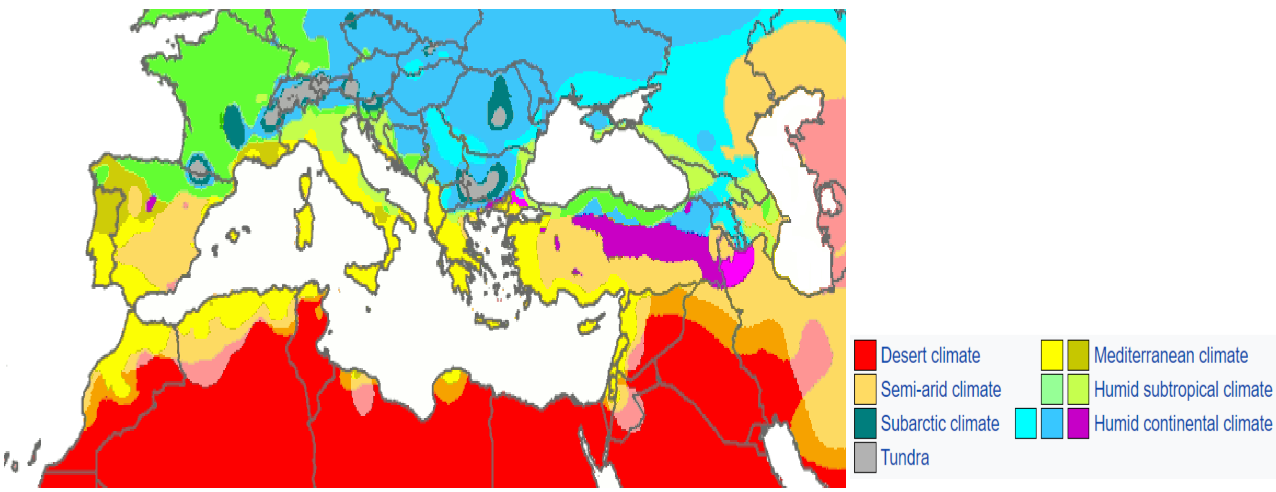


Figure 2: Temperature and climate image description

CHAPTER I.II

Introduction on Renewable Energy

Energy sources can be classified into two groups which are; Non-renewable energy and renewable energy. In non-renewable energy the types we have are; conventional and fossil fuel, their supplies are limited and we cannot produce as much fossil fuel in a short period of time, most of our electricity is generated based on non-renewable energy resources and the fossil fuel types are coal, petroleum and natural gas. In renewable energy we have the following types; Alternative energy, sustainable energy that includes biomass, geothermal energy, hydro-power, solar energy and wind energy. Due to their regeneration in a small amount of time they are called renewable energy. We use renewable energy sources mainly to make electricity and provide heat applications.Renewable energy comes from naturally renewing but flow-limited sources; renewable resources are nearly limitless in terms of length but have a finite amount of energy per unit of time. Energy can't be created nor destroyed but it can be converted from one form to another; such that, mechanical energy is transformed into heat energy. Figure 3 shows the analysis on the growth in electricity generation from renewable sources since 1990 to 2010.

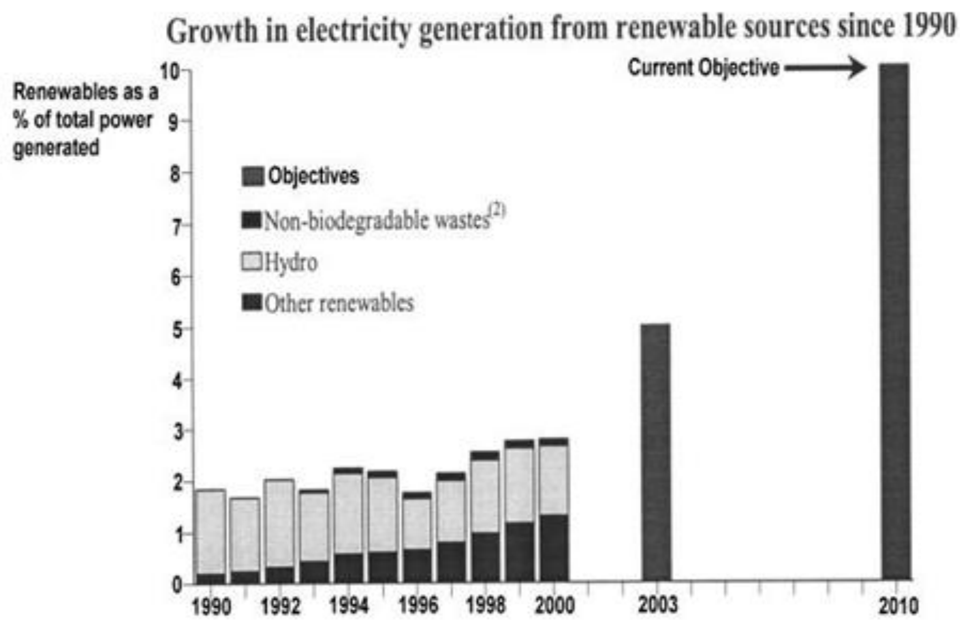


Figure 3: Growth in electricity generation from renewable sources since 1990

Renewable Energy

We will be discussing about the renewable energy in a detailed way and how it can be used to produce electricity. The main sources we will be discussing about are firstly the solar panels and then we will be putting some light on the wind turbines, both being environmental friendly to our planet earth. We will discuss the advantages, importance and the types of renewable energy below in an easy way.

The advantages of renewable energy:

- It should not ever deplete
- The fact that they are renewable, we will never run out of sources of renewable energy.
- Photovoltaic system is flexible, highly reliable and last long.

The importance of photovoltaic system:

- Produces no pollution to the environment,
- Reduces the growth dependency brought in energy and electricity,

- Decreases the cost of complying with existing and upcoming ecological regulations,
- Conserves nature for future generations,
- Improves the stability of energy supplies,
- Protects our environment and public health by preventing or decreasing emissions of CO2.
- Cost effective operation in remote areas where it can be expensive or impossible to rum power.

Types of Renewable energy

As we discussed before, there are two types of renewable energy which are wind energy and solar energy. Solar energy is an energy source that involves tapping the radiant light energy that is emitted by the sun to convert it to electricity. The photovoltaic (PV) system is composed of one or more panels with an inverter and other electrical and mechanical hardware that use energy from the sun to generate electricity. PV systems can greatly vary in size. This system works by the light from the sun, made up of packets of energy called 'photons' that fall onto a solar panel, creating an electric current through a process called the photovoltaic effect. This electricity that is being produced is in the form of direct current (DC), although many electronic devices use DC electricity, including our laptops and phones. Using an inverter we can convert the DC current produced to alternating current (AC). This alternating current (AC) can then be used to power electronics locally and the excess produced can then be sent to the grid station through the help of wires and meters to be used elsewhere in the locality. The solar panel consists of many solar cells with semiconductor properties encapsulated within a material to protect it from the environment. These properties enable the cell to capture more light. On either side of the semiconductor is a layer of conducting material which collects the electricity produced. The solar panels consist of a coating that has the properties of anti-reflection to minimize the losses due to reflection. Second of all, we will now be discussing about the wind energy which is also a very important method to produce renewable energy into the form of electrical energy. The wind energy is produced by wind turbines. The terms ‘wind energy’ and ‘wind power’ both describe the process by which wind is used to generate mechanical power. This mechanical power can then be converted using generators into electrical power. A wind turbine turns wind energy into electricity using the aerodynamic force from the rotor blades which work like an airplane wing, decreasing the pressure across the blades. As the blades of a turbine turn, it also spins a generator which therefore creates electricity. The wind turbine produces an ample amount of sound pollution to the environment. Therefore, wind turbines are often placed further away from cities towards the coastal areas in order to generate electricity. Wind turbines electricity production can vary depending on the size and location of the placement; usually they produce around 8 MegaWattsdepending on their placement.

Keeping in mind, from our perspective the best renewable energy is from solar panels instead of wind turbines because solar panels do not cause any harm to the environment at all. Whereas, wind turbines cause noise pollution to the environment and are not easy to install near the cities.

In-depth explanation of Solar Panel System (SPS):

The earth intercepts a lot of solar power of around 173x10^15 watts. That is ten thousand times more power than the planet's population usage. So is it possible that one day the world will be completely reliant on solar energy? To answer this question we first need to examine how solar panels convert solar energy to electrical energy.

Solar panels are made up of smaller units called solar cells. Most solar panels are finished from a semi-conductor that is the second most abundant element on Earth. In a solar cell, crystalline silicon is sandwiched between conductive layers. Each silicon atom is connected to its neighbours by four strong bonds, which keep the electrons in place so no current can flow. A silicon solar cell uses two different layers of silicon; n-type silicon has extra electrons and p-type silicon has extra spaces for electrons called holes where two types of silicon meet. The electrons wander across the P & N junction leaving a positive charge on each one side and creating a negative charge on the other. Light can be considered as the flow of tiny particles called photons shooting out from the Sun. When one of these photons strikes the silicon cell with enough energy it can knock an electron from its bond leaving a hole. The negatively charged electron and location of the positively charged hole are now free to move around but because of the electric field at the P/N junction they will only go one way. The electrons are drawn to the n-side while the hole is drawn to the p-side. The mobile electrons are then collected by the metal fingers at the top of the cell. From there, they flow through an external circuit doing electrical work like powering a lightbulb before returning through the conductive aluminium sheet on the back. Each silicon cell only puts out half a volt but you can string them together in modules to get more power. Approximately twelve photovoltaic cells are enough to charge a cellphone while it takes many modules to power an entire house. Electrons are the only moving part in a solar cell so that makes it really reliable energy source because there is almost no wear and tear.

Advantages of solar panels:

The sun is a strong energy source, and while we can only gather a fraction of it, harnessing this power by installing solar panels may have a big impact on the environment.While it was widely criticised for being expensive and inefficient, solar energy has proved to be beneficial to both environment and private economy. Some of its advantages are listed below;

1. It reduces electricity bills,
2. Low maintenance costs – Solar energy generally does not require a lot of maintenance. The only possible maintenance it requires is cleaning.
3. Highly reliable/Low wear and tear; some solar companies provide 20-25 years warranty on their panels but due to the inverter having a 10 year life, they need to be changed within 10 years.
4. Technology Development; the solar power industry has been consistent in advancing and improving using nanotechnology that increases the effectiveness of solar output.

Disadvantages of solar panels:

With pros there are always cons with anything that is made in the world. Therefore, this technology has more advantages compared to disadvantages. We gathered some disadvantages below for better understanding:

1. Weather dependant: In cloudy and rainy regions the system does not perform that well. This technology is dependent on mostly sunlight but this does not stop it from producing electricity. Electricity is still produced during cloudy and rainy seasons but compared to sunny days it is less.
2. High installation cost: The panels themselves do not cost a lot but to install the inverter and batteries it is a little costly. Solar energy is supposed to be used right away or it can send its output to be stored in large batteries. Some countries have allowed house owners to send their electricity output towards the off-grid station in their area to provide electricity to other homes instead of

them purchasing expensive batteries to store the energy.
3. Uses space: The more electricity output one requires could lead to using more area for placement. This theory depends individually.

CHAPTER II

Literature Review

Abstract:
Only 48 countries out of 154 enacted the renewable energy assistance policies by 2005. By 2017, 128 countries enacted towards these policies. The policies were critical in assisting countries in making the transition from conventional to renewable energy by removing impediments to renewable energy production. This paper reviews the studies which outlined the policies used by different governments to support development renewable energy which included tax incentives, loans, feed-in tariff and renewable portfolio standard. The study looked at the effects of renewable energy on economic growth, jobs, welfare, emissions, power cost, fuel imports and lastly CO2 emissions amongst all. The methodological approaches along with the time periods in all nations were studied using a variety of approaches.

Analytical Framework and Related Literature

Understanding how PV systems are developed, manufactured, sold, and managed throughout their lifetimes demands a value chain view. The concept of a value chainwas coined by Michael Porter as a means of breaking down the activities of the firm into strategically relevant stages, processes, and relationships related to a product or service during the process of delivering "value" for a customer. Such activities involve product manufacturing, product delivery to consumers, and product disposal and/or reprocessing after use. Although initially developed to help understand the value creation process at the firm level, the value chain concept is now also used as a tool for understanding value creation in industries and countries. At the industry level, a value chain analysis provides a comprehensive view of an industry, thereby supporting strategic and technology planning for incumbents and new entrants, as well as policy making at a higher level. The accelerated transition to a CE requires research on all relevant aspects of the value chain. In the literature, terms such as “circular value chain,” “circular supply chain,” “supply chain management in a circular economy,” or “closed-loop supply chain” are sometimes used interchangeably. Different from the traditional linear value chain explained above, we define the value chain concept in this article as the myriad of activities involved both in the supply and the take-back chain of the PV industry. Our base definition therefore covers “all stages of the life cycle from idea/concept, raw material sourcing, production, distribution, and end customer use to the point where the product returns to a biological or technical cycle, thus closing the loop”. A value chain perspective has therefore been chosen as means to identify hotspots for value creation at different stages of the PV lifecycle. Despite the holistic view proposed in this article, most of the published systematic literature reviews linked to solar PV have showed a technical focus, covering topics such as: advances in solar cell research and testing, energy losses and degradation of PV modules, forecasting of solar photovoltaic radiation and electricity generation, digital technologies for PV monitoring, and leaching of metals from EOL PV waste. Other review articles have been more market-oriented, highlighting the need for government interventions in supporting PV diffusion; the factors influencing residential households’ adoption of PV systems; and descriptions of the current PV market, its associated costs, and available technologies. Finally, a growing stream of literature focusing on the management of EOL PV modules has also emerged. For instance, suggests that monitoring and reporting systems at the national and regional level can support the identification and management of current and future streams of PV waste. The authors also stress the need for reverse logistics between geographically close nodes and recycling centers. Furthermore, while analyzing the drivers, barriers, and enablers for the EOL management of PV and battery energy storage systems, suggests that besides technology-related research, socio-economic research is also necessary to boost successful EOL implementation. Different from other review publications, the contribution of this article lies not only in showcasing the current barriers that impede PV and LIB reuse and recycling, and the overall achievement of industry circularity, but also in unveiling untapped opportunities for different stakeholders along the PV value chain.

CHAPTER III

‘The Methodology’

The Research:

In this research we used the longitude and latitudes of the Mediterranean countries to determine what country will be the most suitable for the placement of solar energy. We have explained all the necessary information above in the chapters regarding the Mediterranean countries and the relevant information of the solar energies. We collected the monthly data analysis from January 2005 to December 2016 for the following:

- Irradiation on horizontal plane,
- Irradiation on optimally inclined plane,
- Irradiation on a plane always normal to sun rays,
- Average temperature.

We then made the solar radiation by month graph to air-temperature graph to determine which country would be more suitable for the placement of renewable energy. Three cities will be taken as an example to explain the process done in this paper.

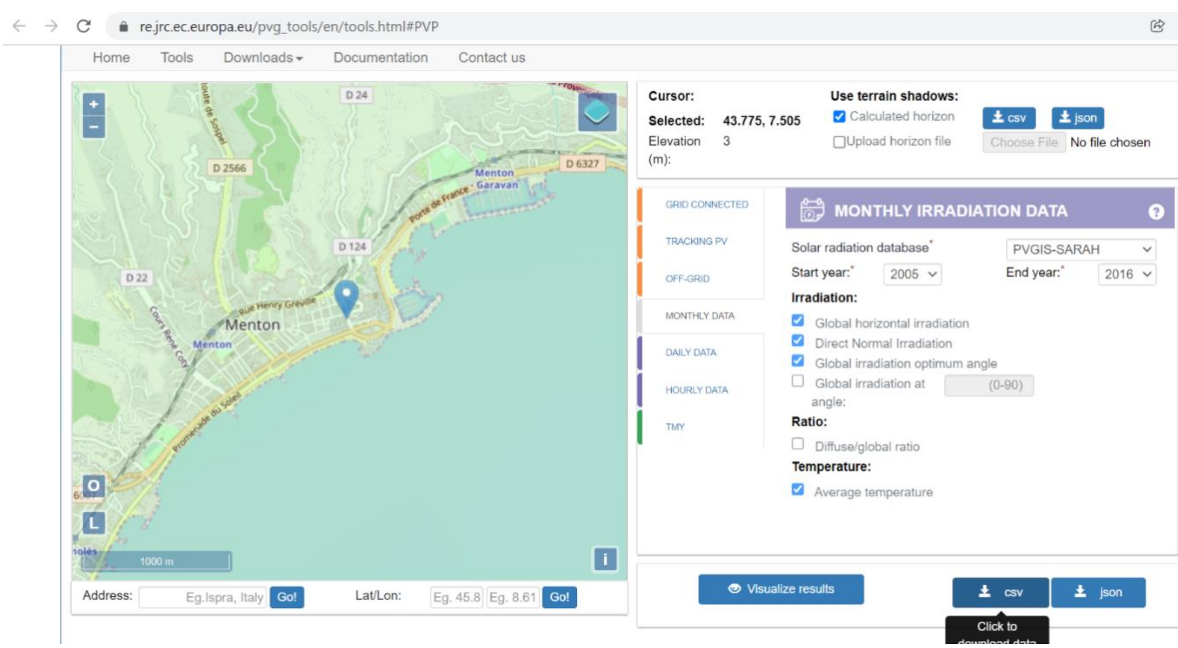
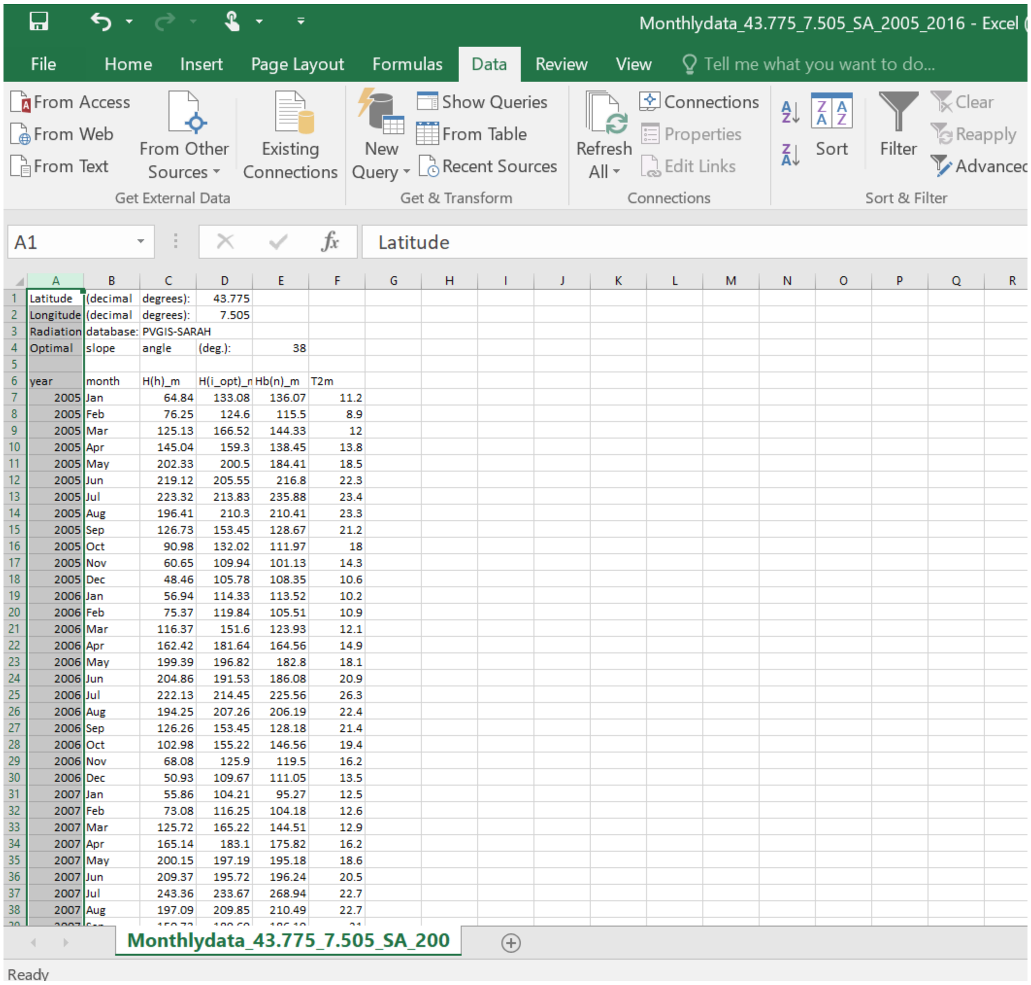


Figure 4: Menton PVGIS website data screenshot.



Latitude	(decimal	degrees):	43.775		
Longitude	(decimal	degrees):	7.505		
Radiation	database:	PVGIS-SARAH			
Optimal	slope	angle	(deg.):	38	
year	month	H(h)_m	H(i_opt)_m	Hb(n)_m	T2m
2005	Jan	64.84	133.08	136.07	11.2
2005	Feb	76.25	124.6	115.5	8.9
2005	Mar	125.13	166.52	144.33	12
2005	Apr	145.04	159.3	138.45	13.8
2005	May	202.33	200.5	184.41	18.5
2005	Jun	219.12	205.55	216.8	22.3
2005	Jul	223.32	213.83	235.88	23.4
2005	Aug	196.41	210.3	210.41	23.3
2005	Sep	126.73	153.45	128.67	21.2
2005	Oct	90.98	132.02	111.97	18
2005	Nov	60.65	109.94	101.13	14.3
2005	Dec	48.46	105.78	108.35	10.6
2006	Jan	56.94	114.33	113.52	10.2
2006	Feb	75.37	119.84	105.51	10.9
2006	Mar	116.37	151.6	123.93	12.1
2006	Apr	162.42	181.64	164.56	14.9
2006	May	199.39	196.82	182.8	18.1
2006	Jun	204.86	191.53	186.08	20.9
2006	Jul	222.13	214.45	225.56	26.3
2006	Aug	194.25	207.26	206.19	22.4
2006	Sep	126.26	153.45	128.18	21.4
2006	Oct	102.98	155.22	146.56	19.4
2006	Nov	68.08	125.9	119.5	16.2
2006	Dec	50.93	109.67	111.05	13.5
2007	Jan	55.86	104.21	95.27	12.5
2007	Feb	73.08	116.25	104.18	12.6
2007	Mar	125.72	165.22	144.51	12.9
2007	Apr	165.14	183.1	175.82	16.2
2007	May	200.15	197.19	195.18	18.6
2007	Jun	209.37	195.72	196.24	20.5
2007	Jul	243.36	233.67	268.94	22.7
2007	Aug	197.09	209.85	210.49	22.7

Figure 5: Menton PVGIS excel data.

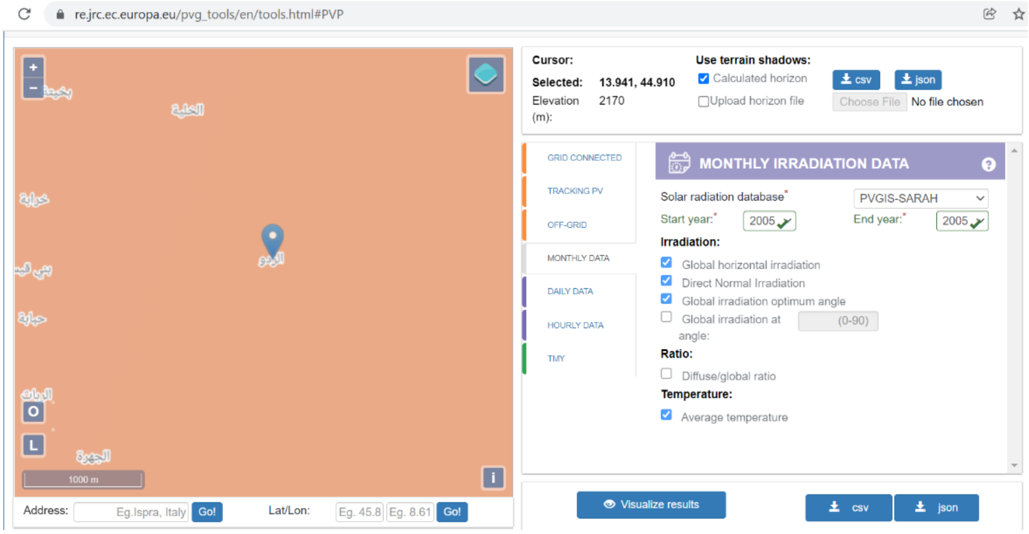
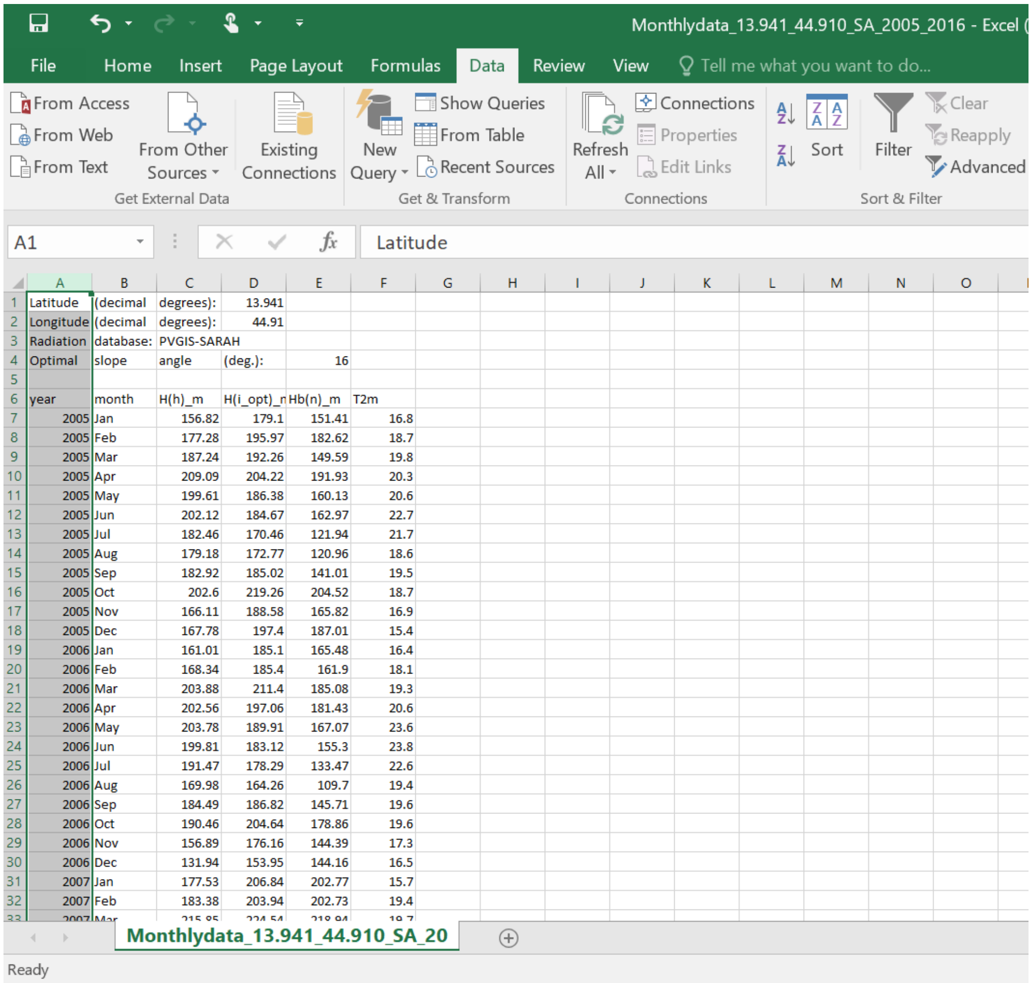


Figure 6: Arish PVGIS website data screenshot.



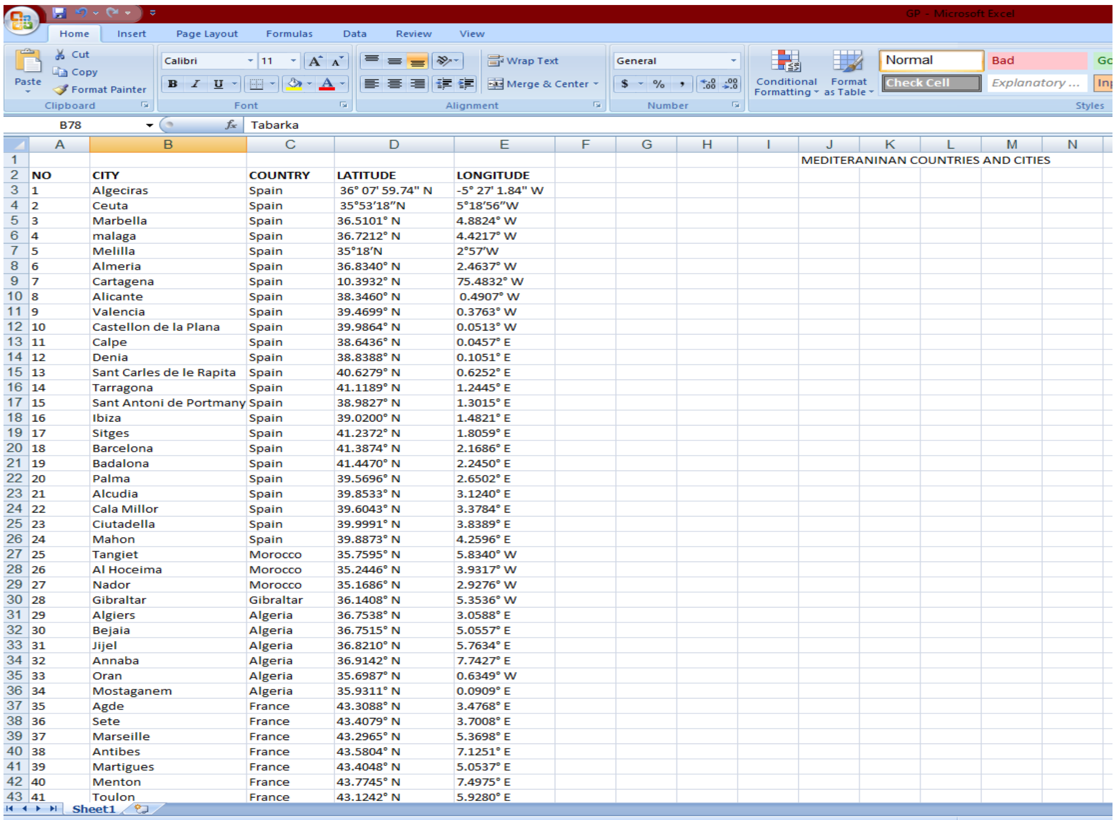
	A	B	C	D	E	F
1	Latitude	(decimal	degrees):	13.941		
2	Longitude	(decimal	degrees):	44.91		
3	Radiation	database:	PVGIS-SARAH			
4	Optimal	slope	angle	(deg.):	16	
5						
6	year	month	H(h)_m	H(i_opt)_m	Hb(n)_m	T2m
7	2005	Jan	156.82	179.1	151.41	16.8
8	2005	Feb	177.28	195.97	182.62	18.7
9	2005	Mar	187.24	192.26	149.59	19.8
10	2005	Apr	209.09	204.22	191.93	20.3
11	2005	May	199.61	186.38	160.13	20.6
12	2005	Jun	202.12	184.67	162.97	22.7
13	2005	Jul	182.46	170.46	121.94	21.7
14	2005	Aug	179.18	172.77	120.96	18.6
15	2005	Sep	182.92	185.02	141.01	19.5
16	2005	Oct	202.6	219.26	204.52	18.7
17	2005	Nov	166.11	188.58	165.82	16.9
18	2005	Dec	167.78	197.4	187.01	15.4
19	2006	Jan	161.01	185.1	165.48	16.4
20	2006	Feb	168.34	185.4	161.9	18.1
21	2006	Mar	203.88	211.4	185.08	19.3
22	2006	Apr	202.56	197.06	181.43	20.6
23	2006	May	203.78	189.91	167.07	23.6
24	2006	Jun	199.81	183.12	155.3	23.8
25	2006	Jul	191.47	178.29	133.47	22.6
26	2006	Aug	169.98	164.26	109.7	19.4
27	2006	Sep	184.49	186.82	145.71	19.6
28	2006	Oct	190.46	204.64	178.86	19.6
29	2006	Nov	156.89	176.16	144.39	17.3
30	2006	Dec	131.94	153.95	144.16	16.5
31	2007	Jan	177.53	206.84	202.77	15.7
32	2007	Feb	183.38	203.94	202.73	19.4

Figure 7: Arish monthly excel data.

Procedure:

To explain further, each step of the research will be analysed down below:

Step 1: In this step, we collected all the cities that lie near the Mediterranean Sea in one excel file. After that we collected the longitude and latitude from 2005 to 2016 using Wikipedia.

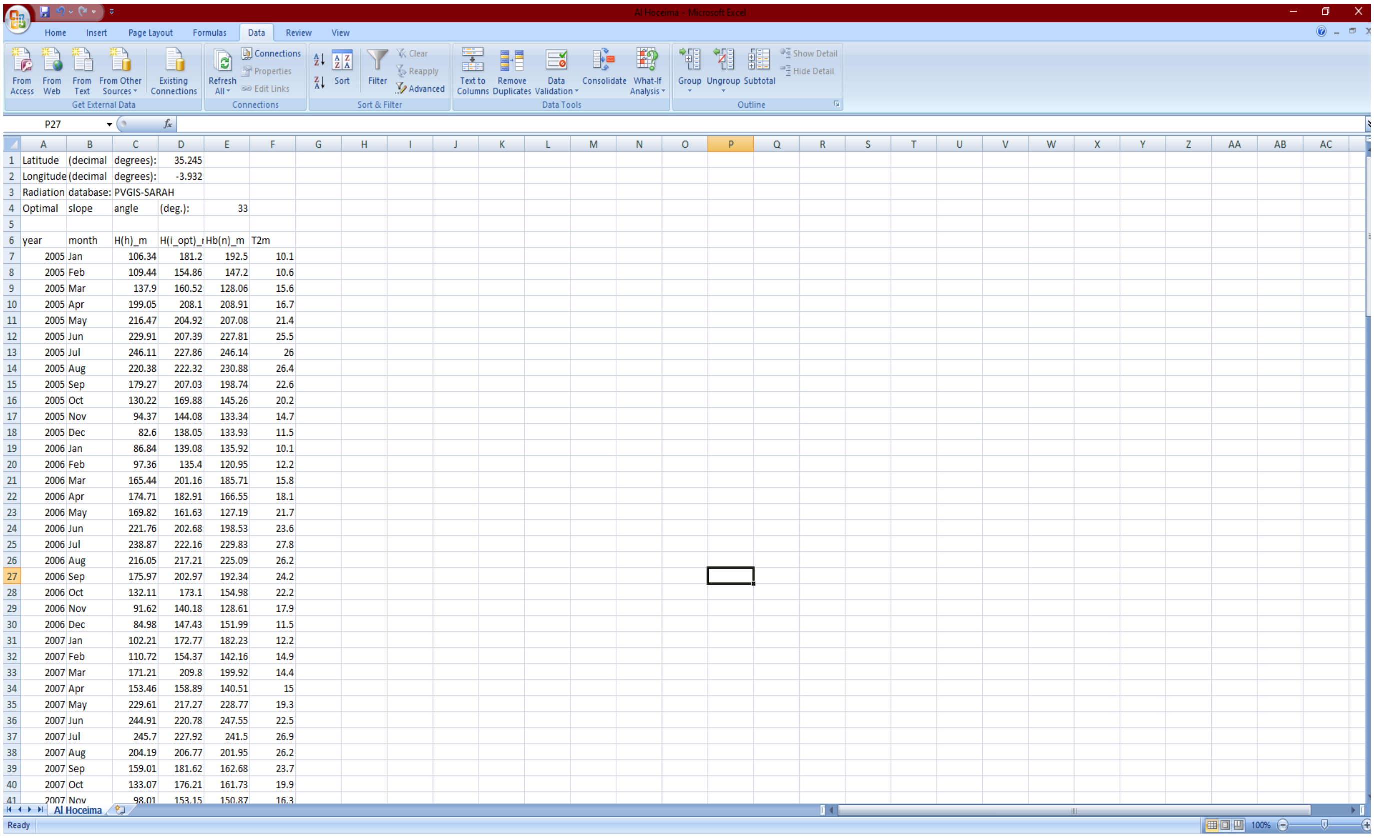


MEDITERANINAN COUNTRIES AND CITIES

NO	CITY	COUNTRY	LATITUDE	LONGITUDE
1	Algeciras	Spain	36° 07' 59.74" N	-5° 27' 1.84" W
2	Ceuta	Spain	35°53′18″N	5°18′56″W
3	Marbella	Spain	36.5101° N	4.8824° W
4	malaga	Spain	36.7212° N	4.4217° W
5	Melilla	Spain	35°18′N	2°57′W
6	Almeria	Spain	36.8340° N	2.4637° W
7	Cartagena	Spain	10.3932° N	75.4832° W
8	Alicante	Spain	38.3460° N	0.4907° W
9	Valencia	Spain	39.4699° N	0.3763° W
10	Castellon de la Plana	Spain	39.9864° N	0.0513° W
11	Calpe	Spain	38.6436° N	0.0457° E
12	Denia	Spain	38.8388° N	0.1051° E
13	Sant Carles de le Rapita	Spain	40.6279° N	0.6252° E
14	Tarragona	Spain	41.1189° N	1.2445° E
15	Sant Antoni de Portmany	Spain	38.9827° N	1.3015° E
16	Ibiza	Spain	39.0200° N	1.4821° E
17	Sitges	Spain	41.2372° N	1.8059° E
18	Barcelona	Spain	41.3874° N	2.1686° E
19	Badalona	Spain	41.4470° N	2.2450° E
20	Palma	Spain	39.5696° N	2.6502° E
21	Alcudia	Spain	39.8533° N	3.1240° E
22	Cala Millor	Spain	39.6043° N	3.3784° E
23	Ciutadella	Spain	39.9991° N	3.8389° E
24	Mahon	Spain	39.8873° N	4.2596° E
25	Tangiet	Morocco	35.7595° N	5.8340° W
26	Al Hoceima	Morocco	35.2446° N	3.9317° W
27	Nador	Morocco	35.1686° N	2.9276° W
28	Gibraltar	Gibraltar	36.1408° N	5.3536° W
29	Algiers	Algeria	36.7538° N	3.0588° E
30	Bejaia	Algeria	36.7515° N	5.0557° E
31	Jijel	Algeria	36.8210° N	5.7634° E
32	Annaba	Algeria	36.9142° N	7.7427° E
33	Oran	Algeria	35.6987° N	0.6349° W
34	Mostaganem	Algeria	35.9311° N	0.0909° E
35	Agde	France	43.3088° N	3.4768° E
36	Sete	France	43.4079° N	3.7008° E
37	Marseille	France	43.2965° N	5.3698° E
38	Antibes	France	43.5804° N	7.1251° E
39	Martigues	France	43.4048° N	5.0537° E
40	Menton	France	43.7745° N	7.4975° E
41	Toulon	France	43.1242° N	5.9280° E

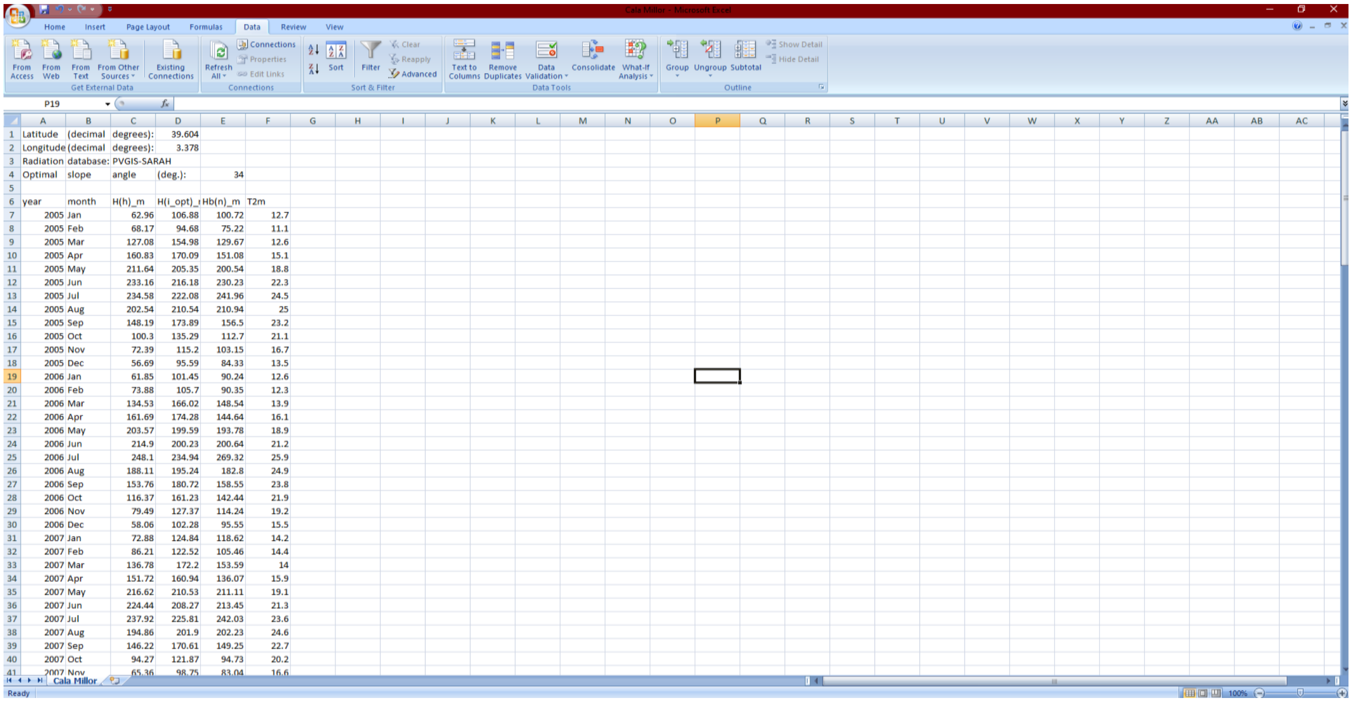
Figure 8: Excel file screenshot.

Step 2: We collected this data shown in figure 5 below using 'JRC Photovoltaic Geographical Information System (PVGIS)' website. We will be using three cities as an example to explain in detail below.



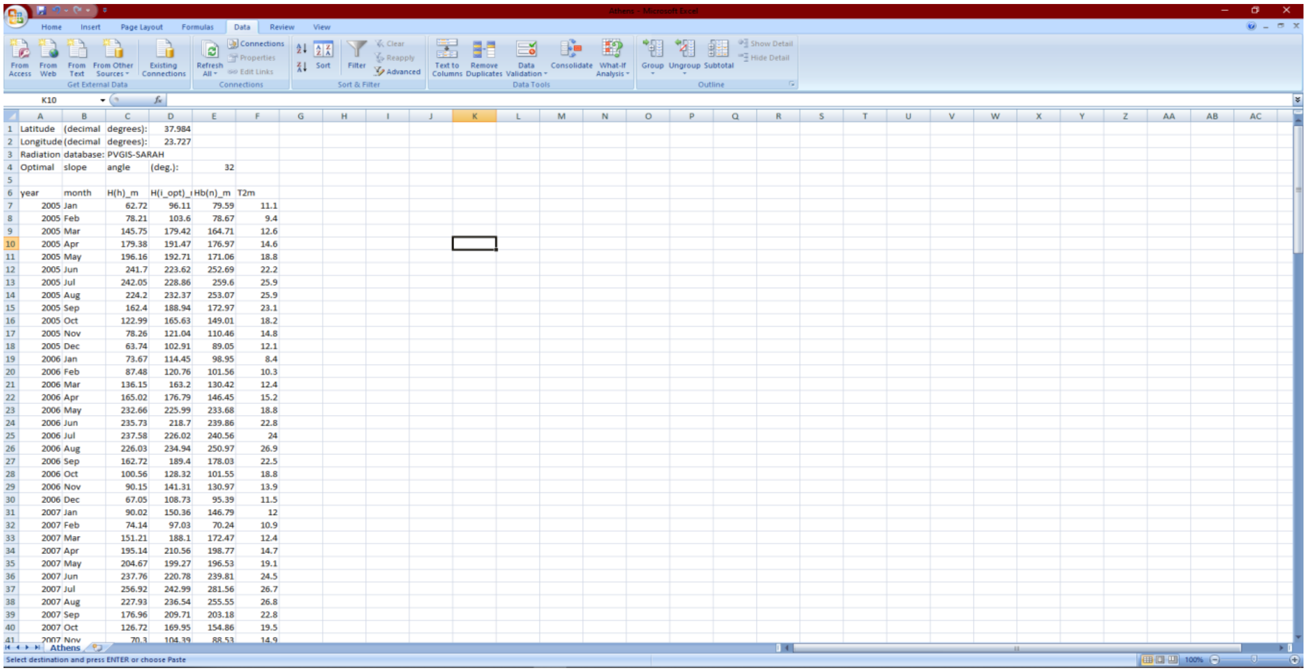
	A	B	C	D	E	F
1	Latitude	(decimal	degrees):	35.245		
2	Longitude	(decimal	degrees):	-3.932		
3	Radiation	database:	PVGIS-SARAH			
4	Optimal	slope	angle	(deg.):	33	
5						
6	year	month	H(h)_m	H(i_opt)_	Hb(n)_m	T2m
7	2005	Jan	106.34	181.2	192.5	10.1
8	2005	Feb	109.44	154.86	147.2	10.6
9	2005	Mar	137.9	160.52	128.06	15.6
10	2005	Apr	199.05	208.1	208.91	16.7
11	2005	May	216.47	204.92	207.08	21.4
12	2005	Jun	229.91	207.39	227.81	25.5
13	2005	Jul	246.11	227.86	246.14	26
14	2005	Aug	220.38	222.32	230.88	26.4
15	2005	Sep	179.27	207.03	198.74	22.6
16	2005	Oct	130.22	169.88	145.26	20.2
17	2005	Nov	94.37	144.08	133.34	14.7
18	2005	Dec	82.6	138.05	133.93	11.5
19	2006	Jan	86.84	139.08	135.92	10.1
20	2006	Feb	97.36	135.4	120.95	12.2
21	2006	Mar	165.44	201.16	185.71	15.8
22	2006	Apr	174.71	182.91	166.55	18.1
23	2006	May	169.82	161.63	127.19	21.7
24	2006	Jun	221.76	202.68	198.53	23.6
25	2006	Jul	238.87	222.16	229.83	27.8
26	2006	Aug	216.05	217.21	225.09	26.2
27	2006	Sep	175.97	202.97	192.34	24.2
28	2006	Oct	132.11	173.1	154.98	22.2
29	2006	Nov	91.62	140.18	128.61	17.9
30	2006	Dec	84.98	147.43	151.99	11.5
31	2007	Jan	102.21	172.77	182.23	12.2
32	2007	Feb	110.72	154.37	142.16	14.9
33	2007	Mar	171.21	209.8	199.92	14.4
34	2007	Apr	153.46	158.89	140.51	15
35	2007	May	229.61	217.27	228.77	19.3
36	2007	Jun	244.91	220.78	247.55	22.5
37	2007	Jul	245.7	227.92	241.5	26.9
38	2007	Aug	204.19	206.77	201.95	26.2
39	2007	Sep	159.01	181.62	162.68	23.7
40	2007	Oct	133.07	176.21	161.73	19.9
41	2007	Nov	98.01	153.15	150.87	16.3

Figure 9: A screenshot of the city Al Hoceima data.



Latitude	(decimal	degrees):	39.604		
Longitude	(decimal	degrees):	3.378		
Radiation	database:	PVGIS-SARAH			
Optimal	slope	angle	(deg.):	34	
year	month	H(h)_m	H(i_opt)_	Hb(n)_m	T2m
2005	Jan	62.96	106.88	100.72	12.7
2005	Feb	68.17	94.68	75.22	11.1
2005	Mar	127.08	154.98	129.67	12.6
2005	Apr	160.83	170.09	151.08	15.1
2005	May	211.64	205.35	200.54	18.8
2005	Jun	233.16	216.18	230.23	22.3
2005	Jul	234.58	222.08	241.96	24.5
2005	Aug	202.54	210.54	210.94	25
2005	Sep	148.19	173.89	156.5	23.2
2005	Oct	100.3	135.29	112.7	21.1
2005	Nov	72.39	115.2	103.15	16.7
2005	Dec	56.69	95.59	84.33	13.5
2006	Jan	61.85	101.45	90.24	12.6
2006	Feb	73.88	105.7	90.35	12.3
2006	Mar	134.53	166.02	148.54	13.9
2006	Apr	161.69	174.28	144.64	16.1
2006	May	203.57	199.59	193.78	18.9
2006	Jun	214.9	200.23	200.64	21.2
2006	Jul	248.1	234.94	269.32	25.9
2006	Aug	188.11	195.24	182.8	24.9
2006	Sep	153.76	180.72	158.55	23.8
2006	Oct	116.37	161.23	142.44	21.9
2006	Nov	79.49	127.37	114.24	19.2
2006	Dec	58.06	102.28	95.55	15.5
2007	Jan	72.88	124.84	118.62	14.2
2007	Feb	86.21	122.52	105.46	14.4
2007	Mar	136.78	172.2	153.59	14
2007	Apr	151.72	160.94	136.07	15.9
2007	May	216.62	210.53	211.11	19.1
2007	Jun	224.44	208.27	213.45	21.3
2007	Jul	237.92	225.81	242.03	23.6
2007	Aug	194.86	201.9	202.23	24.6
2007	Sep	146.22	170.61	149.25	22.7
2007	Oct	94.27	121.87	94.73	20.2
2007	Nov	65.36	98.75	83.04	16.6

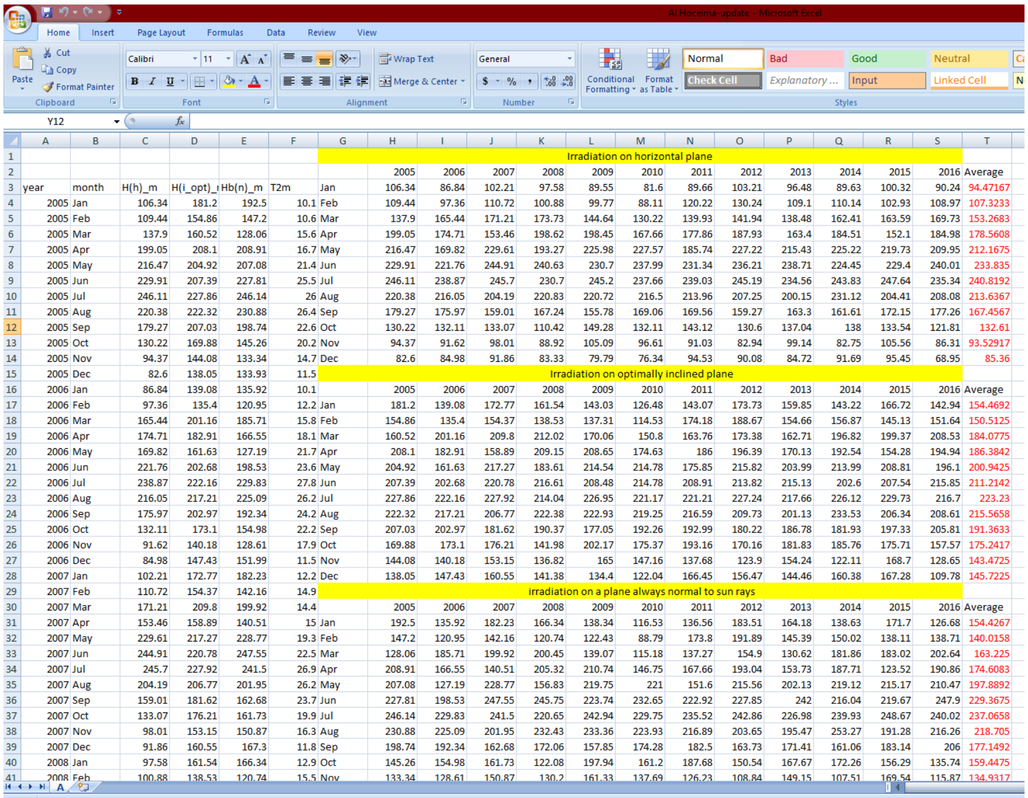
Figure 10: A screenshot of the city Cala Milor data.



Latitude	(decimal	degrees):	37.984		
Longitude	(decimal	degrees):	23.727		
Radiation	database:	PVGIS-SARAH			
Optimal	slope	angle	(deg.):	32	
year	month	H(h)_m	H(i_opt)_	Hb(n)_m	T2m
2005	Jan	62.72	96.11	79.59	11.1
2005	Feb	78.21	103.6	78.67	9.4
2005	Mar	145.75	179.42	164.71	12.6
2005	Apr	179.38	191.47	176.97	14.6
2005	May	196.16	192.71	171.06	18.8
2005	Jun	241.7	223.62	252.69	22.2
2005	Jul	242.05	228.86	259.6	25.9
2005	Aug	224.2	232.37	253.07	25.9
2005	Sep	162.4	188.94	172.97	23.1
2005	Oct	122.99	165.63	149.01	18.2
2005	Nov	78.26	121.04	110.46	14.8
2005	Dec	63.74	102.91	89.05	12.1
2006	Jan	73.67	114.45	98.95	8.4
2006	Feb	87.48	120.76	101.56	10.3
2006	Mar	136.15	163.2	130.42	12.4
2006	Apr	165.02	176.79	146.45	15.2
2006	May	232.66	225.99	233.68	18.8
2006	Jun	235.73	218.7	239.86	22.8
2006	Jul	237.58	226.02	240.56	24
2006	Aug	226.03	234.94	250.97	26.9
2006	Sep	162.72	189.4	178.03	22.5
2006	Oct	100.56	128.32	101.55	18.8
2006	Nov	90.15	141.31	130.97	13.9
2006	Dec	67.05	108.73	95.39	11.5
2007	Jan	90.02	150.36	146.79	12
2007	Feb	74.14	97.03	70.24	10.9
2007	Mar	151.21	188.1	172.47	12.4
2007	Apr	195.14	210.56	198.77	14.7
2007	May	204.67	199.27	196.53	19.1
2007	Jun	237.76	220.78	239.81	24.5
2007	Jul	256.92	242.99	281.56	26.7
2007	Aug	227.93	236.54	255.55	26.8
2007	Sep	176.96	209.71	203.18	22.8
2007	Oct	126.72	169.95	154.86	19.5
2007	Nov	70.3	104.39	88.53	14.9

Figure 11: A screenshot of the city 'Athens' data.

Step 3: Using excel file we managed to calculate the 'irradiation on horizontal plane', 'irradiation on optically inclined plane', 'irradiation on a plane always normal to sun rays' and 'average temperature'.



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
1							Irradiation on horizontal plane													
2								2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	Average
3	year	month	H(h)_m	H(i_opt)_	Hb(n)_m	T2m	Jan	106.34	86.84	102.21	97.58	89.55	81.6	89.66	103.21	96.48	89.63	100.32	90.24	94.47167
4	2005	Jan	106.34	181.2	192.5	10.1	Feb	109.44	97.36	110.72	100.88	99.77	88.11	120.22	130.24	109.1	110.14	102.93	108.97	107.3233
5	2005	Feb	109.44	154.86	147.2	10.6	Mar	137.9	165.44	171.21	173.73	144.64	130.22	139.93	141.94	138.48	162.41	163.59	169.73	153.2683
6	2005	Mar	137.9	160.52	128.06	15.6	Apr	199.05	174.71	153.46	198.62	198.45	167.66	177.86	187.93	163.4	184.51	152.1	184.98	178.5608
7	2005	Apr	199.05	208.1	208.91	16.7	May	216.47	169.82	229.61	193.27	225.98	227.57	185.74	227.22	215.43	225.22	219.73	209.95	212.1675
8	2005	May	216.47	204.92	207.08	21.4	Jun	229.91	221.76	244.91	240.63	230.7	237.99	231.34	236.21	238.71	224.45	229.4	240.01	233.835
9	2005	Jun	229.91	207.39	227.81	25.5	Jul	246.11	238.87	245.7	230.7	245.2	237.66	239.03	245.19	234.56	243.83	247.64	235.34	240.8192
10	2005	Jul	246.11	227.86	246.14	26	Aug	220.38	216.05	204.19	220.83	220.72	216.5	213.96	207.25	200.15	231.12	204.41	208.08	213.6367
11	2005	Aug	220.38	222.32	230.88	26.4	Sep	179.27	175.97	159.01	167.24	155.78	169.06	169.56	159.27	163.3	161.61	172.15	177.26	167.4567
12	2005	Sep	179.27	207.03	198.74	22.6	Oct	130.22	132.11	133.07	110.42	149.28	132.11	143.12	130.6	137.04	138	133.54	121.81	132.61
13	2005	Oct	130.22	169.88	145.26	20.2	Nov	94.37	91.62	98.01	88.92	105.09	96.61	91.03	82.94	99.14	82.75	105.56	86.31	93.52917
14	2005	Nov	94.37	144.08	133.34	14.7	Dec	82.6	84.98	91.86	83.33	79.79	76.34	94.53	90.08	84.72	91.69	95.45	68.95	85.36
15	2005	Dec	82.6	138.05	133.93	11.5	Irradiation on optimally inclined plane													
16	2006	Jan	86.84	139.08	135.92	10.1		2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	Average
17	2006	Feb	97.36	135.4	120.95	12.2	Jan	181.2	139.08	172.77	161.54	143.03	126.48	143.07	173.73	159.85	143.22	166.72	142.94	154.4692
18	2006	Mar	165.44	201.16	185.71	15.8	Feb	154.86	135.4	154.37	138.53	137.31	114.53	174.18	188.67	154.66	156.87	145.13	151.64	150.5125
19	2006	Apr	174.71	182.91	166.55	18.1	Mar	160.52	201.16	209.8	212.02	170.06	150.8	163.76	173.38	162.71	196.82	199.37	208.53	184.0775
20	2006	May	169.82	161.63	127.19	21.7	Apr	208.1	182.91	158.89	209.15	208.65	174.63	186	196.39	170.13	192.54	154.28	194.94	186.3842
21	2006	Jun	221.76	202.68	198.53	23.6	May	204.92	161.63	217.27	183.61	214.54	214.78	175.85	215.82	203.99	213.99	208.81	196.1	200.9425
22	2006	Jul	238.87	222.16	229.83	27.8	Jun	207.39	202.68	220.78	216.61	208.48	214.78	208.91	213.82	215.13	202.6	207.54	215.85	211.2142
23	2006	Aug	216.05	217.21	225.09	26.2	Jul	227.86	222.16	227.92	214.04	226.95	221.17	221.21	227.24	217.66	226.12	229.73	216.7	223.23
24	2006	Sep	175.97	202.97	192.34	24.2	Aug	222.32	217.21	206.77	222.38	222.93	219.25	216.59	209.73	201.13	233.53	206.34	208.61	215.5658
25	2006	Oct	132.11	173.1	154.98	22.2	Sep	207.03	202.97	181.62	190.37	177.05	192.26	192.99	180.22	186.78	181.93	197.33	205.81	191.3633
26	2006	Nov	91.62	140.18	128.61	17.9	Oct	169.88	173.1	176.21	141.98	202.17	175.37	193.16	170.16	181.83	185.76	175.71	157.57	175.2417
27	2006	Dec	84.98	147.43	151.99	11.5	Nov	144.08	140.18	153.15	136.82	165	147.16	137.68	123.9	154.24	122.11	168.7	128.65	143.4725
28	2007	Jan	102.21	172.77	182.23	12.2	Dec	138.05	147.43	160.55	141.38	134.4	122.04	166.45	156.47	144.46	160.38	167.28	109.78	145.7225
29	2007	Feb	110.72	154.37	142.16	14.9	irradiation on a plane always normal to sun rays													
30	2007	Mar	171.21	209.8	199.92	14.4		2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	Average
31	2007	Apr	153.46	158.89	140.51	15	Jan	192.5	135.92	182.23	166.34	138.34	116.53	136.56	183.51	164.18	138.63	171.7	126.68	154.4267
32	2007	May	229.61	217.27	228.77	19.3	Feb	147.2	120.95	142.16	120.74	122.43	88.79	173.8	191.89	145.39	150.02	138.11	138.71	140.0158
33	2007	Jun	244.91	220.78	247.55	22.5	Mar	128.06	185.71	199.92	200.45	139.07	115.18	137.27	154.9	130.62	181.86	183.02	202.64	163.225
34	2007	Jul	245.7	227.92	241.5	26.9	Apr	208.91	166.55	140.51	205.32	210.74	146.75	167.66	193.04	153.73	187.71	123.52	190.86	174.6083
35	2007	Aug	204.19	206.77	201.95	26.2	May	207.08	127.19	228.77	156.83	219.75	221	151.6	215.56	202.13	219.12	215.17	210.47	197.8892
36	2007	Sep	159.01	181.62	162.68	23.7	Jun	227.81	198.53	247.55	245.75	223.74	232.65	222.92	227.85	242	216.04	219.67	247.9	229.3675
37	2007	Oct	133.07	176.21	161.73	19.9	Jul	246.14	229.83	241.5	220.65	242.94	229.75	235.52	242.86	226.98	239.93	248.67	240.02	237.0658
38	2007	Nov	98.01	153.15	150.87	16.3	Aug	230.88	225.09	201.95	232.43	233.36	223.93	216.89	203.65	195.47	253.27	191.28	216.26	218.705
39	2007	Dec	91.86	160.55	167.3	11.8	Sep	198.74	192.34	162.68	172.06	157.85	174.28	182.5	163.73	171.41	161.06	183.14	206	177.1492
40	2008	Jan	97.58	161.54	166.34	12.9	Oct	145.26	154.98	161.73	122.08	197.94	161.2	187.68	150.54	167.67	172.26	156.29	135.74	159.4475
41	2008	Feb	100.88	138.53	120.74	15.5	Nov	133.34	128.61	150.87	130.2	161.33	137.69	126.23	108.84	149.15	107.51	169.54	115.87	134.9317

Figure 12: A screenshot defining the irradiation data. 'Al Hoceima' city.

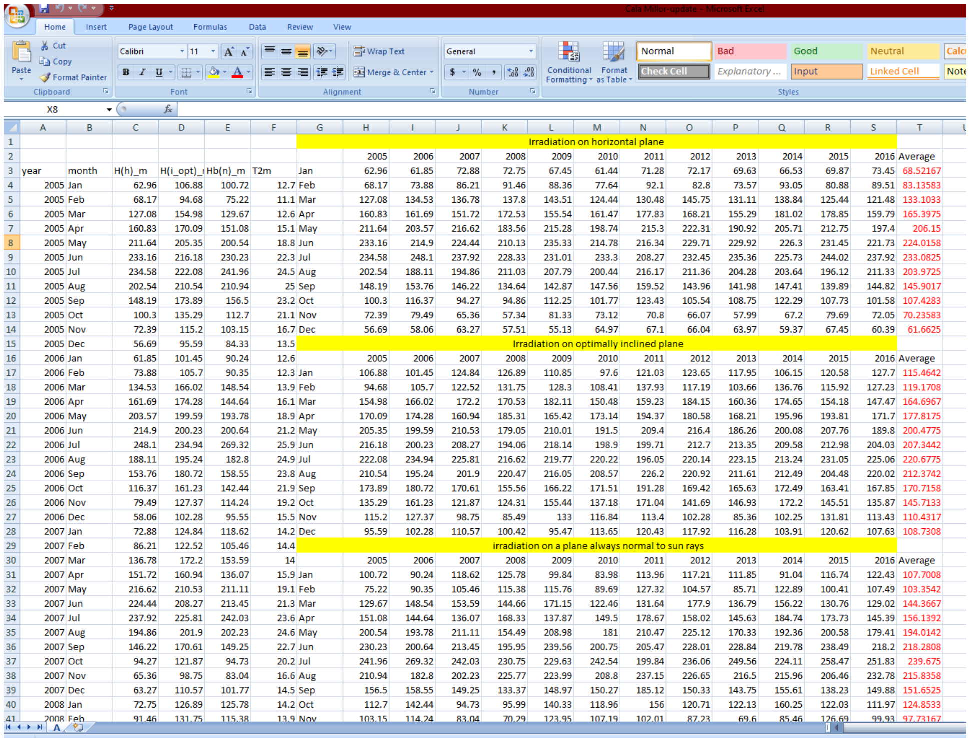


Figure 13: A screenshot defining the irradiation data. 'Athens' city.

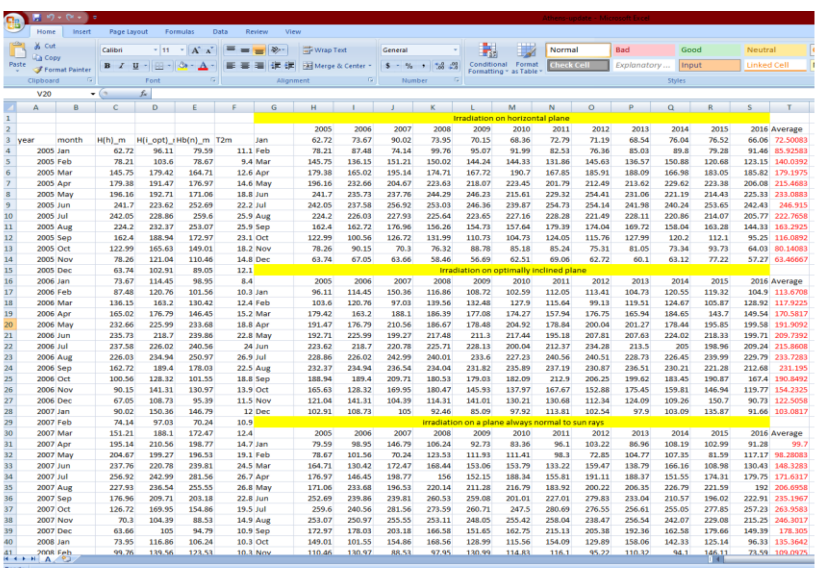


Figure 14: A screenshot defining the irradiation data. 'Cala Milor' city.

Step 4: We used the data we showed in the last step to analysis the graph. The graph shows us the four data; 'Irradiation on horizontal plane', 'irradiation on optically inclined plane', 'irradiation on a plane always normal to sun rays' and 'average temperature'.

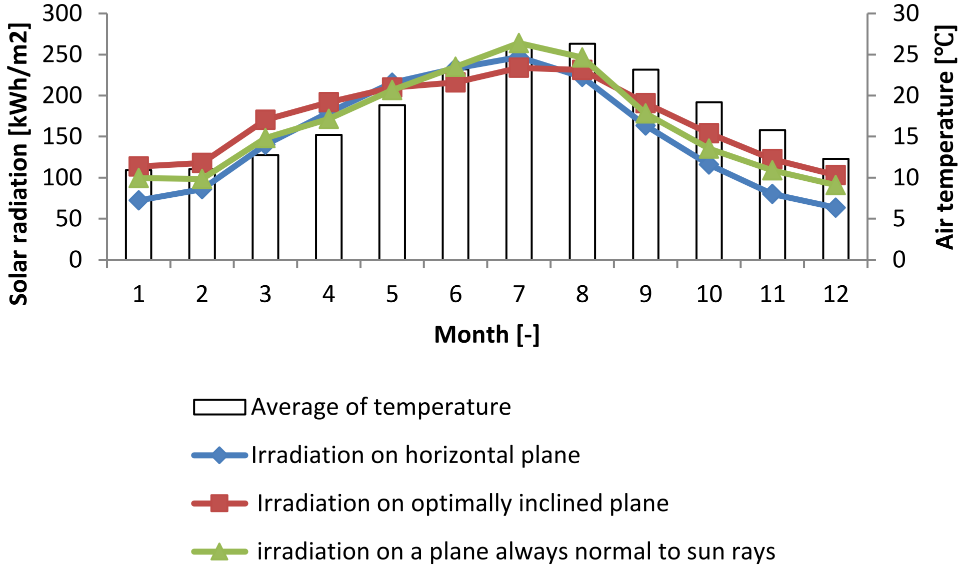


Figure 15: The data graph from the city 'Athens'.

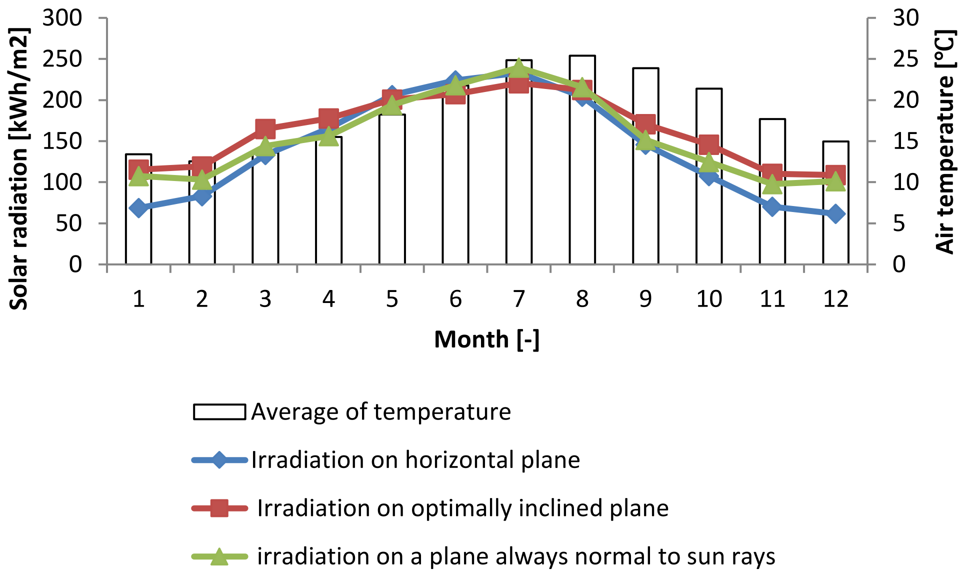


Figure 16: The data graph from the city 'Cala Milor'.

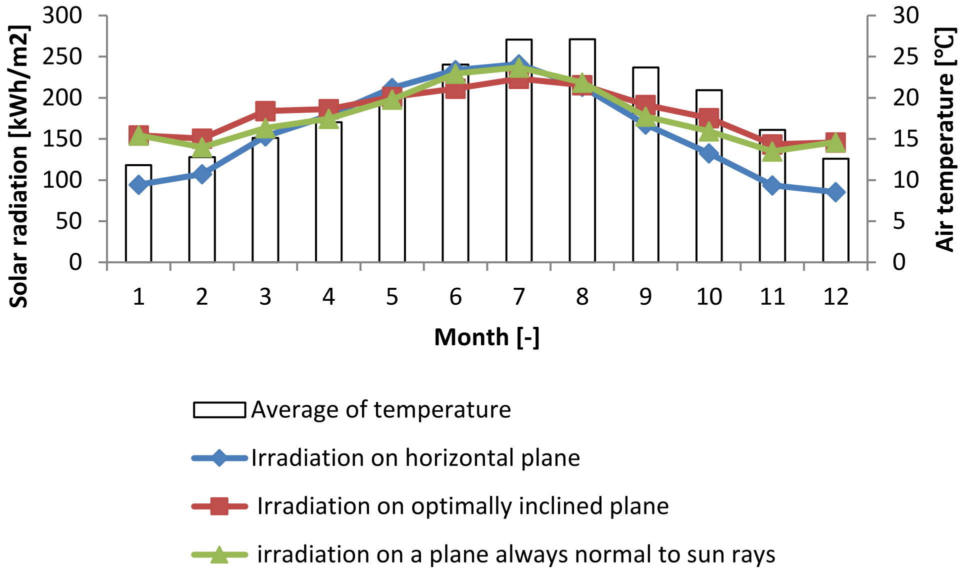


Figure 17: The data graph from the city 'Al Hoceima'.

Step 5: In this step, we combined the data for all the cities in four excel sheets to get the maximum and minimum value for 'average temperature', 'irradiation on a horizontal plane', 'irradiation on optimally inclined plane', and 'irradiation on a plane always normal to sun rays'.

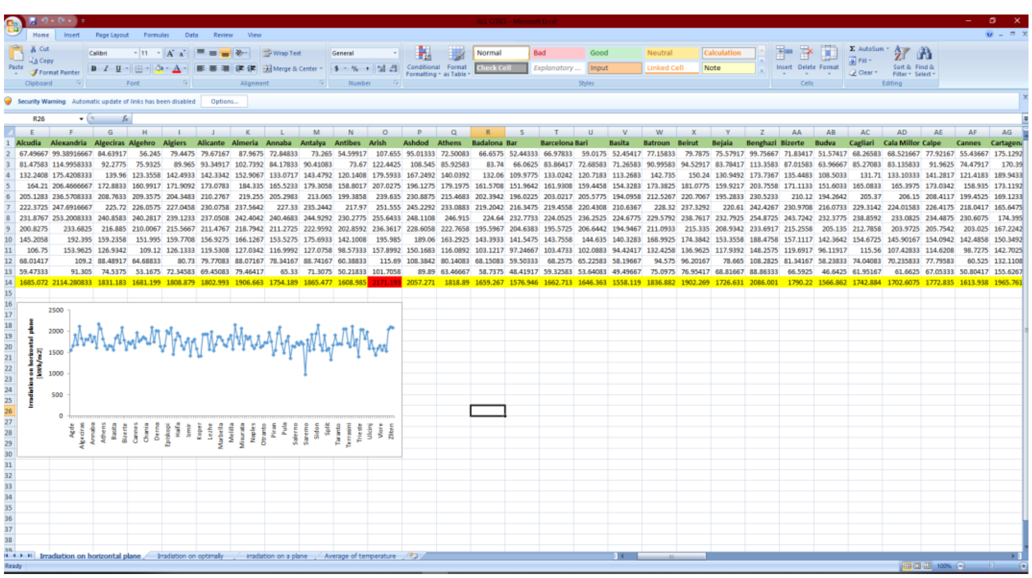
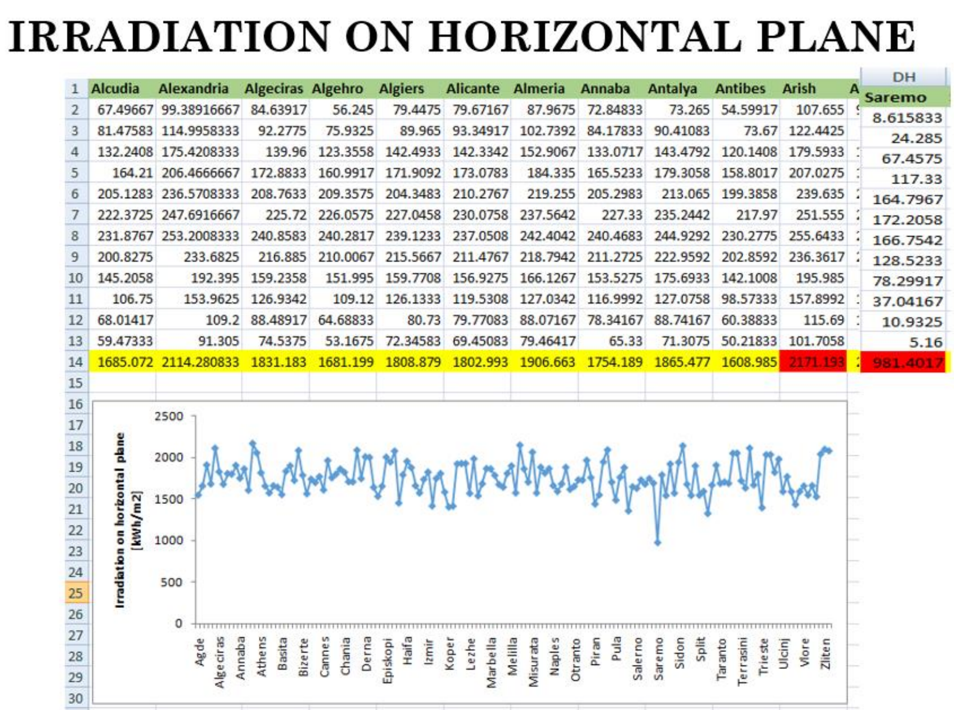


Figure 18: The combined data for maximum and minimum average.

CHAPTER IV

Results

The results we got for ‘irradiation on a horizontal plane’ were as follows; Saremo with the minimum value of 981 kWh/m^2 and Arish with the maximum value of 2171 kWh/m^2 shown in figure 19. For ‘irradiation on optimally inclined plane’ the results were also the same cities with Saremo having the minimum value 1180 kWh/m^2 and Arish having the maximum value 2396 kWh/m^2 as shown in figure 20. For ‘irradiation of a plane always normal to the sun rays’ we found the same cities; Arish with the maximum value 2345 kWh/m^2 and Saremo having the minimum value 1032 kWh/m^2 as shown in figure 21. The only different cities we got was in ‘average temperature’ which were Menton and Saremo. Menton having the maximum value 1817 kWh/m^2 and Saremo having the minimum value 93.68 kWh/m^2 as shown in figure 22.



1	Alcudia	Alexandria	Algeciras	Algehro	Algiers	Alicante	Almeria	Annaba	Antalya	Antibes	Arish	DH Saremo
2	67.49667	99.38916667	84.63917	56.245	79.4475	79.67167	87.9675	72.84833	73.265	54.59917	107.655	8.615833
3	81.47583	114.9958333	92.2775	75.9325	89.965	93.34917	102.7392	84.17833	90.41083	73.67	122.4425	24.285
4	132.2408	175.4208333	139.96	123.3558	142.4933	142.3342	152.9067	133.0717	143.4792	120.1408	179.5933	67.4575
5	164.21	206.4666667	172.8833	160.9917	171.9092	173.0783	184.335	165.5233	179.3058	158.8017	207.0275	117.33
6	205.1283	236.5708333	208.7633	209.3575	204.3483	210.2767	219.255	205.2983	213.065	199.3858	239.635	164.7967
7	222.3725	247.6916667	225.72	226.0575	227.0458	230.0758	237.5642	227.33	235.2442	217.97	251.555	172.2058
8	231.8767	253.2008333	240.8583	240.2817	239.1233	237.0508	242.4042	240.4683	244.9292	230.2775	255.6433	166.7542
9	200.8275	233.6825	216.885	210.0067	215.5667	211.4767	218.7942	211.2725	222.9592	202.8592	236.3617	128.5233
10	145.2058	192.395	159.2358	151.995	159.7708	156.9275	166.1267	153.5275	175.6933	142.1008	195.985	78.29917
11	106.75	153.9625	126.9342	109.12	126.1333	119.5308	127.0342	116.9992	127.0758	98.57333	157.8992	37.04167
12	68.01417	109.2	88.48917	64.68833	80.73	79.77083	88.07167	78.34167	88.74167	60.38833	115.69	10.9325
13	59.47333	91.305	74.5375	53.1675	72.34583	69.45083	79.46417	65.33	71.3075	50.21833	101.7058	5.16
14	1685.072	2114.280833	1831.183	1681.199	1808.879	1802.993	1906.663	1754.189	1865.477	1608.985	2171.193	981.4017

Figure 19: Results for Irradiation on horizontal plane.

IRRADIATION ON OPTIMALLY INCLINED PLANE

Month	Agde	Ajaccio	Al Hoceim	Alcudia	Alexandri	Algeciras	Algehro	Algiers	Alicante	Almeria	Annaba	Antalya	Antibes	Arish	Saremo
1	102.815	93.095	154.4692	114.3542	140.6575	135.1725	89.3025	126.3225	139.5042	149.9733	111.8483	116.5175	105.0492	155.3392	19.68417
2	120.9417	111.59	150.5125	117.1317	147.5367	125.7975	107.0325	123.8383	137.2008	150	112.2792	125.9075	116.3958	159.0883	45.90333
3	154.3358	153.8642	184.0775	163.8617	203.4142	166.1492	151.4958	171.7008	177.0158	188.2425	157.8892	174.1883	157.0792	208.2875	99.22917
4	170.4458	177.0067	186.3842	176.6517	214.0242	182.0458	174.5558	182.0058	184.7492	194.9908	175.8542	191.0992	176.4783	214.4133	144.2492
5	186.8375	205.015	200.9425	199.7233	224.525	200.055	206.0467	197.0325	202.1783	208.1692	199.535	205.0283	196.6233	227.25	178.6642
6	194.6842	210.5583	211.2142	205.96	223.9567	206.7275	212.0067	209.0592	209.9142	213.8458	211.6625	215.0367	204.0817	226.5408	174.0092
7	209.6683	229.4233	223.23	219.975	232.8142	225.5658	230.3642	225.34	221.1775	223.9775	228.6425	228.8792	221.035	235.1392	171.8342
8	202.075	221.6092	215.5658	209.0758	233.0408	221.415	221.1767	221.4492	217.3308	222.4767	217.9058	229.2008	216.8825	235.9692	146.2858
9	169.425	181.1958	191.3633	170.4025	214.7183	182.0842	181.4858	184.105	184.3133	193.35	176.2258	206.6892	175.6383	218.8092	104.5583
10	131.825	150.6575	175.2417	145.59	193.5825	167.5308	150.6367	168.3633	165.2225	171.9825	152.8817	172.7025	145.8383	199.3217	61.61417
11	102.1408	103.1575	143.4725	106.5	152.0292	135.1725	100.4517	121.41	129.3725	139.9642	115.62	140.8517	108.6742	163.5808	21.36333
12	99.58583	91.41167	145.7225	104.895	133.3308	122.71	89.64667	120.1158	125.48	141.9917	102.055	121.475	106.51	152.6	13.02417
Annual	1844.78	1928.584	2182.196	1934.121	2313.63	2070.426	1914.202	2050.743	2093.459	2198.964	1962.399	2127.576	1930.286	2396.339	1180.419

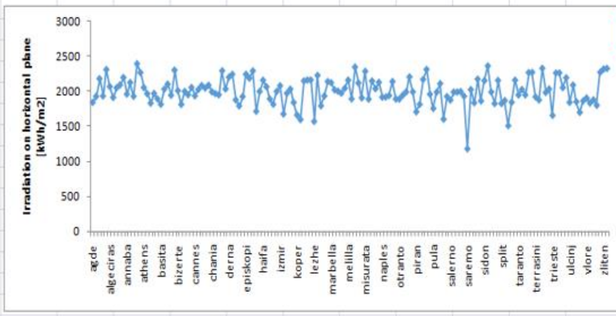


Figure 20: Results for irradiation on optimally inclined plane.

IRRADIATION ON A PLANE ALWAYS NORMAL TO THE SUN RAYS

Month	Agde	Ajaccio	Al Hoceim	Alcudia	Alexandri	Algeciras	Algehro	Algiers	Alicante	Almeria	Annaba	Antalya	Antibes	Arish	Saremo
1	98.57417	83.76167	154.4267	106.7858	124.6425	130.5283	76.02667	115.7375	140.7208	151.5167	99.73833	106.2567	101.79	139.5358	16.68333
2	111.7933	98.3375	140.0158	101.9925	127.4983	110.255	89.43833	107.6308	128.7433	145.1283	90.24333	110.855	105.8167	138.575	39.06
3	137.49	131.1992	163.225	143.3542	184	145.1917	127.5467	148.7342	161.2167	175.7733	129.9342	154.3283	141.07	184.7475	82.56
4	156.2783	158.1833	174.6083	156.8958	201.3833	161.3167	151.56	161.3433	174.4017	194.1608	144.6392	173.5658	163.6967	196.0275	127.9717
5	179.1783	199.9117	197.8892	193.1675	229.6358	193.9942	201.1967	186.2092	200.22	215.5842	186.1408	202.72	191.4142	225.9667	168.5817
6	201.2425	219.0317	229.3675	215.6683	254.8867	214.7933	222.76	217.5525	228.6742	240.9733	213.9667	241.7533	212.7542	258.5558	164.7683
7	222.6592	253.0683	237.0658	237.5992	266.3583	241.3058	256.0717	234.5417	245.0383	251.9408	238.4192	260.0117	245.6842	265.3508	152.3542
8	205.2483	233.5367	218.705	212.4558	249.6075	225.8142	232.5	222.8042	229.8217	239.3417	214.135	246.7275	230.745	247.5325	119.8333
9	158.0758	168.86	177.1492	152.1842	212.12	163.9992	169.9025	166.5717	174.7767	187.3058	153.2583	209.9958	165.6792	215.3175	82.53667
10	115.0392	135.8217	159.4475	125.435	181.4575	150.9608	134.2583	151.4575	153.8858	160.3367	130.7167	163.6692	133.3133	182.8733	49.60667
11	94.08667	91.2725	134.9317	93.40167	138.9642	127.3775	86.655	107.5017	122.5542	133.3742	100.595	138.7258	101.965	150.2192	16.78667
12	96.06417	83.91	146.0925	97.16083	120.3375	117.2192	78.7	112.12	123.9483	143.6542	87.99167	117.5767	108.1025	140.6958	11.41917
Annual	1775.73	1856.894	2132.924	1836.101	2290.892	1982.756	1826.616	1932.204	2084.002	2239.09	1789.778	2126.186	1902.031	2345.398	1032.162

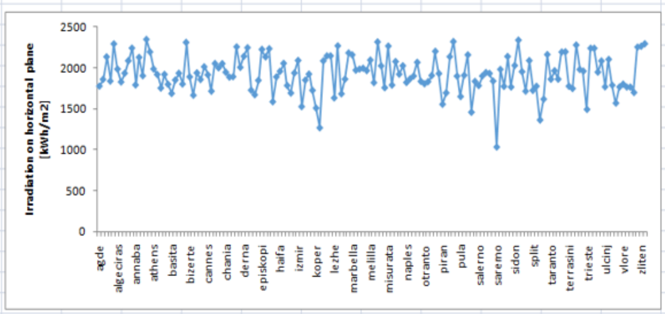
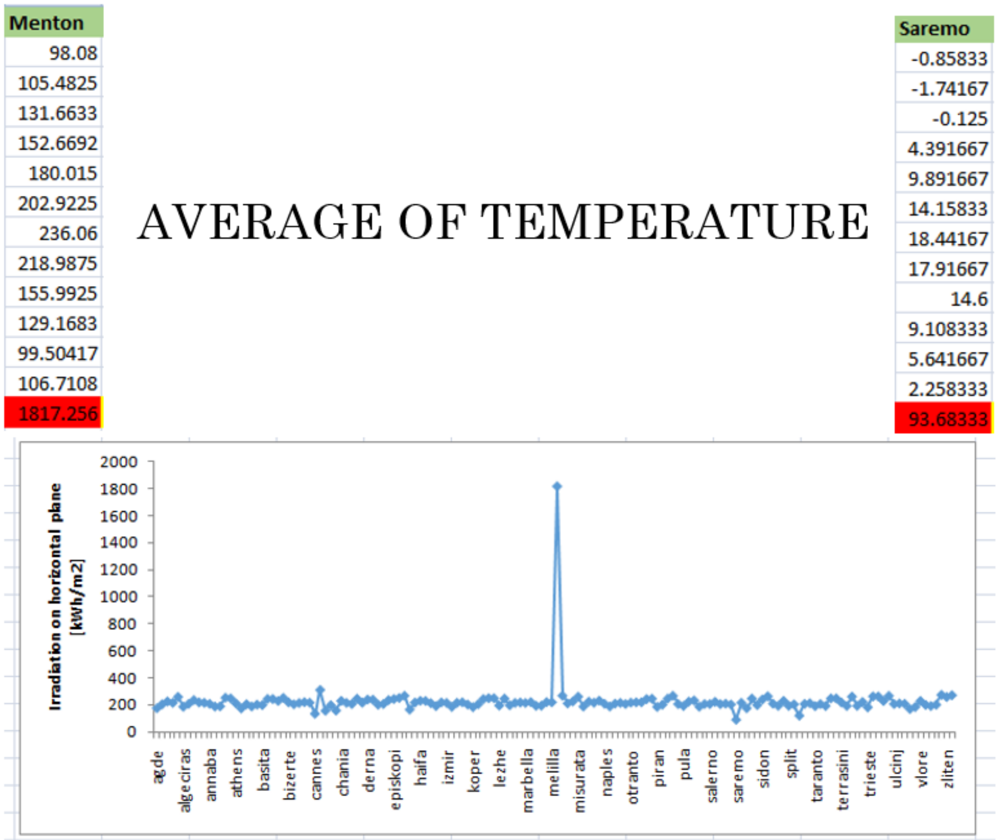


Figure 21: Results for irradiation on a plane always normal to the sun rays.



Menton
98.08
105.4825
131.6633
152.6692
180.015
202.9225
236.06
218.9875
155.9925
129.1683
99.50417
106.7108
1817.256

Saremo
-0.85833
-1.74167
-0.125
4.391667
9.891667
14.15833
18.44167
17.91667
14.6
9.108333
5.641667
2.258333
93.68333

Figure 22: Results for average of temperature.

Below we have obtained the data results into graphs for every city that lies near the Mediterranean, representing the Solar radiation and air temperature on monthly basis. We also divided the cities by their directions below for better understanding.

South European coast, (West to East):

1. Spain

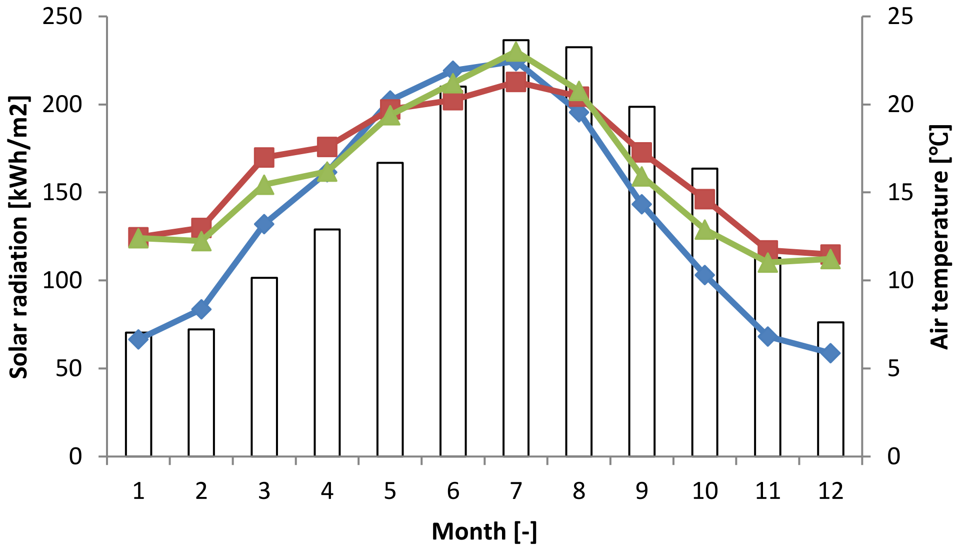


Figure 23 Badelona

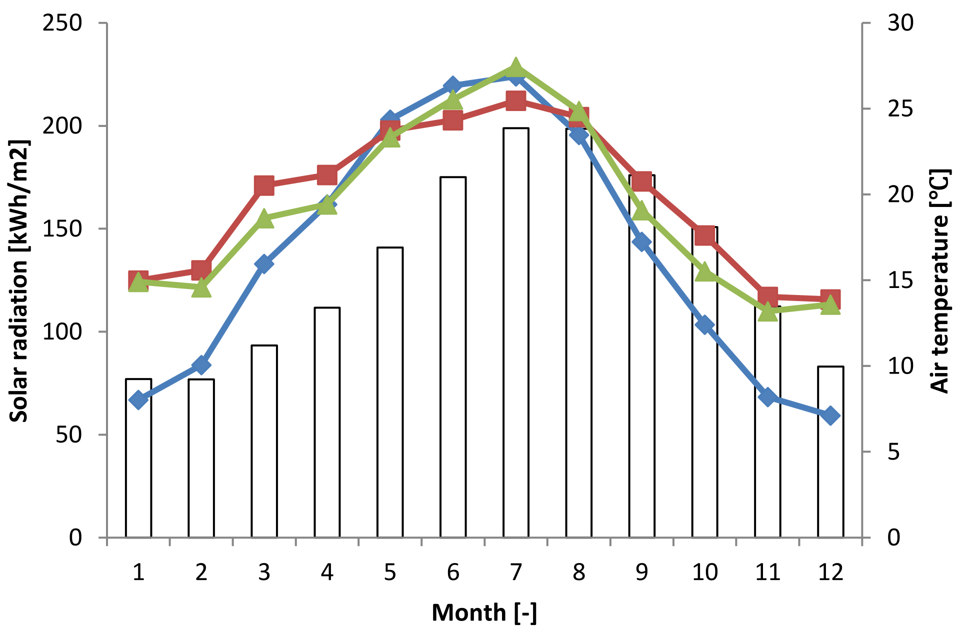


Figure24: Barcelona

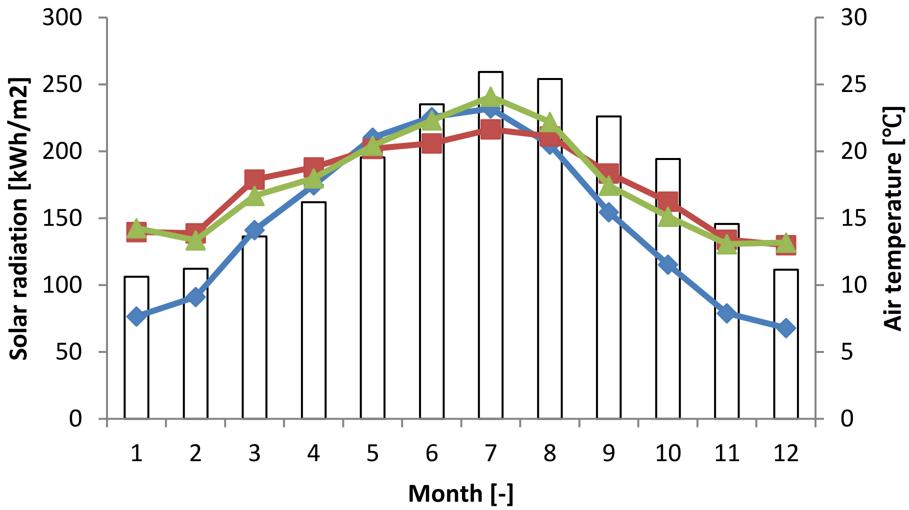


Figure25: Valencia

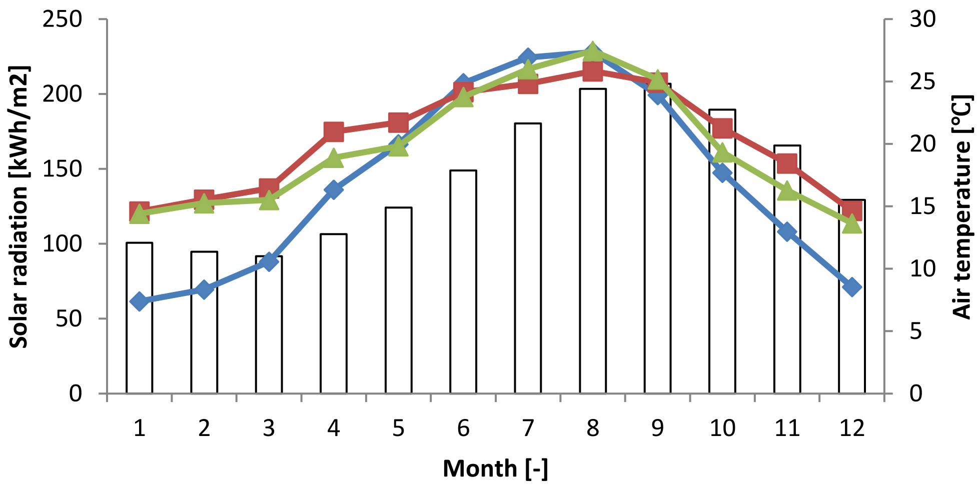


Figure 26: Tarragona

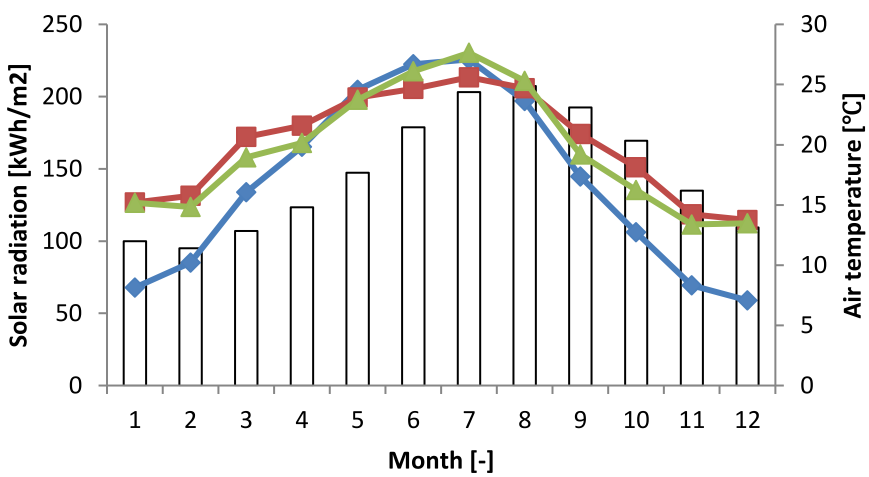


Figure 27: Sitges

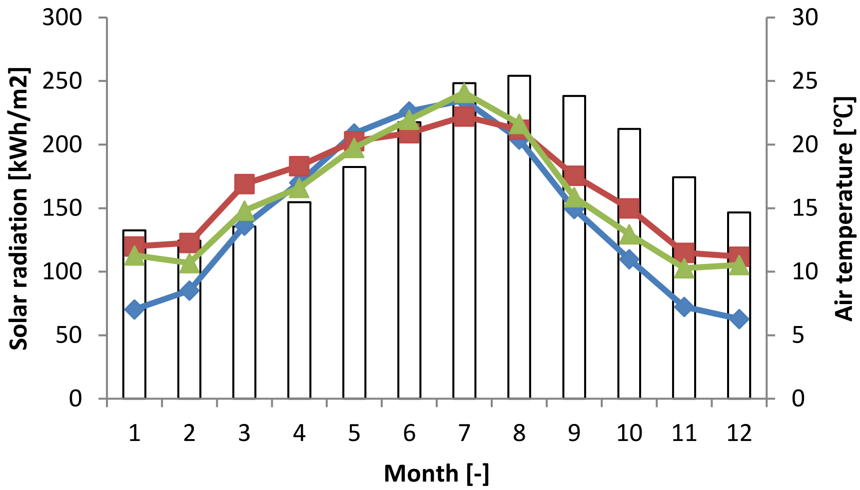


Figure 28: Palma

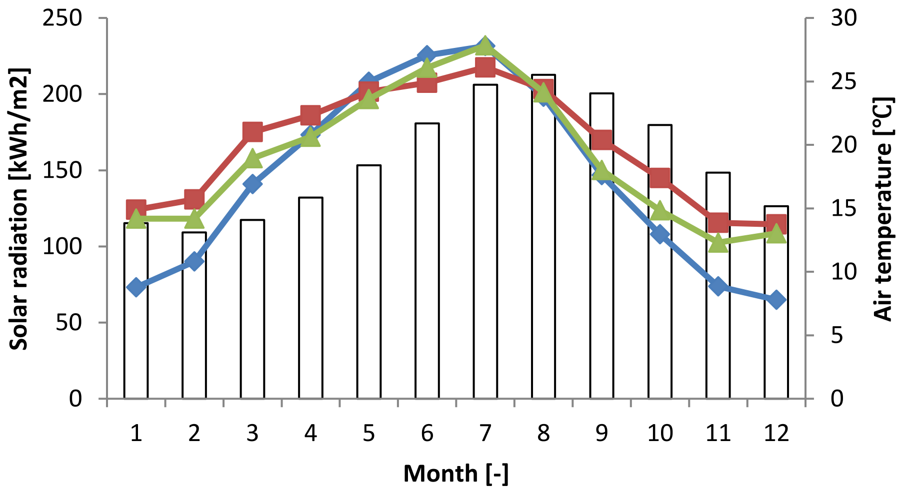


Figure 29: Sant Antonio De Portmary

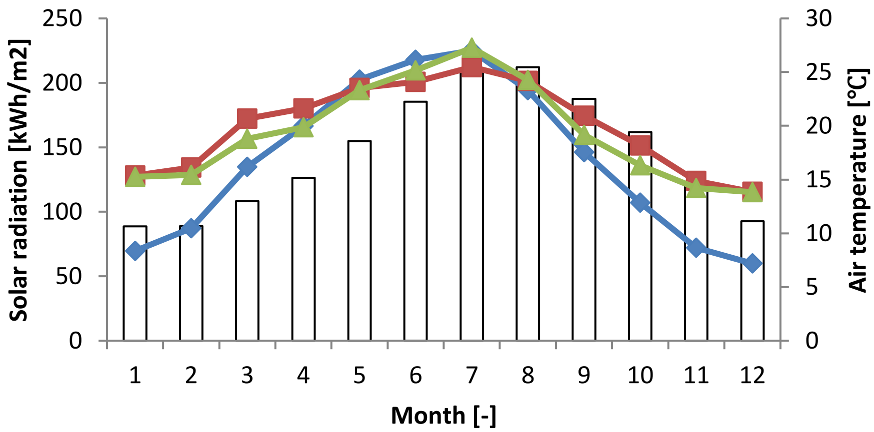


Figure 30: Sant Carles

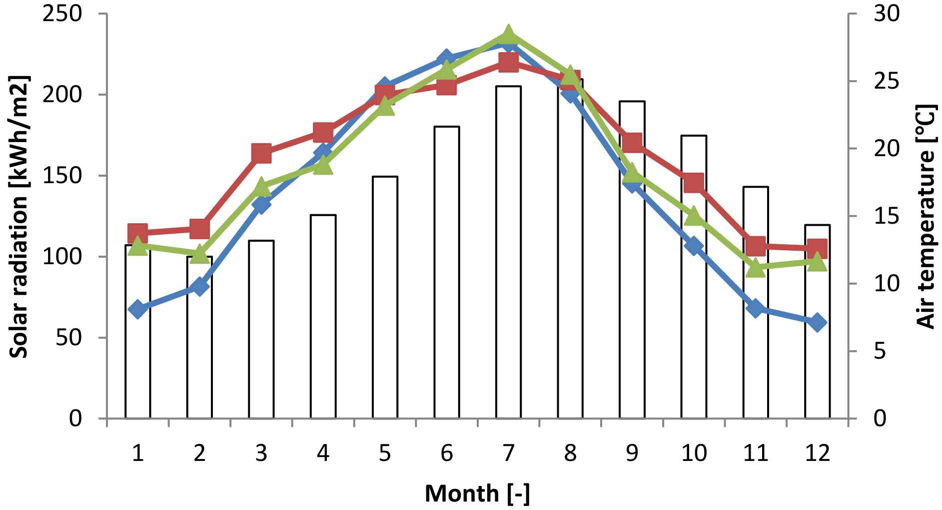


Figure 31: Alcudia

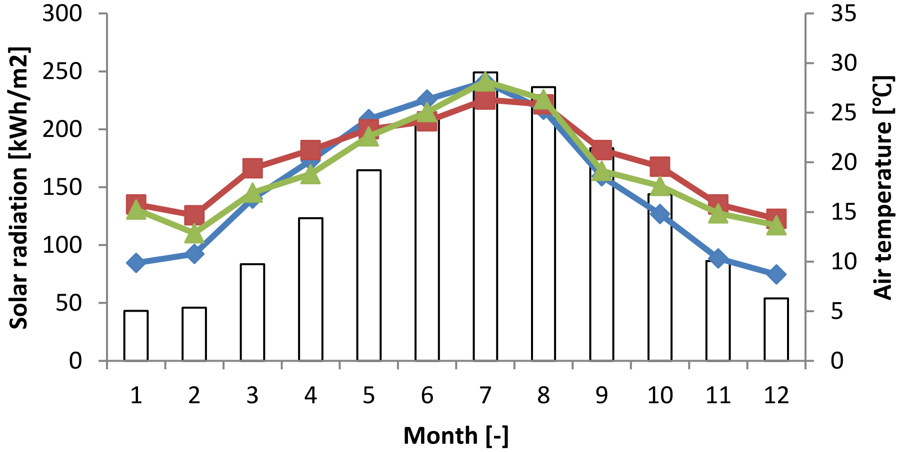


Figure 32: Algeciras

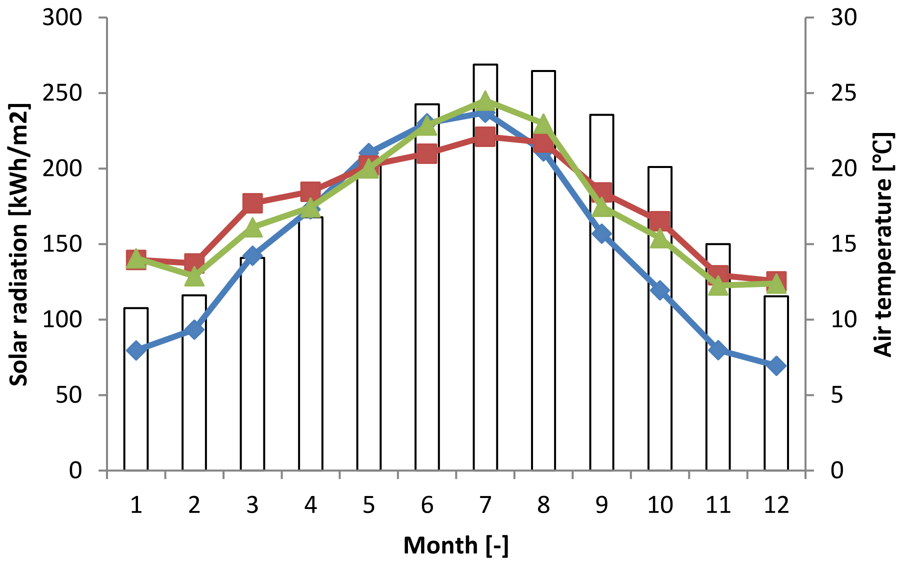


Figure 33: Alicante

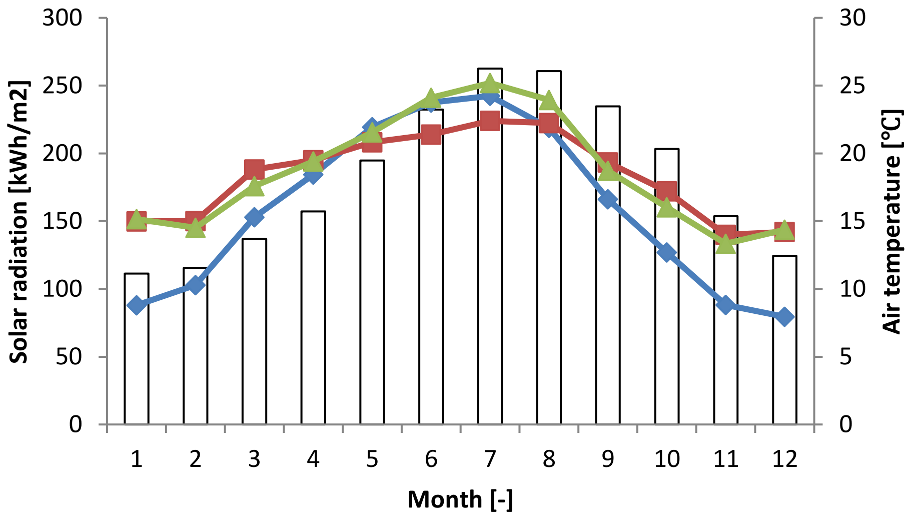


Figure 34: Almeria

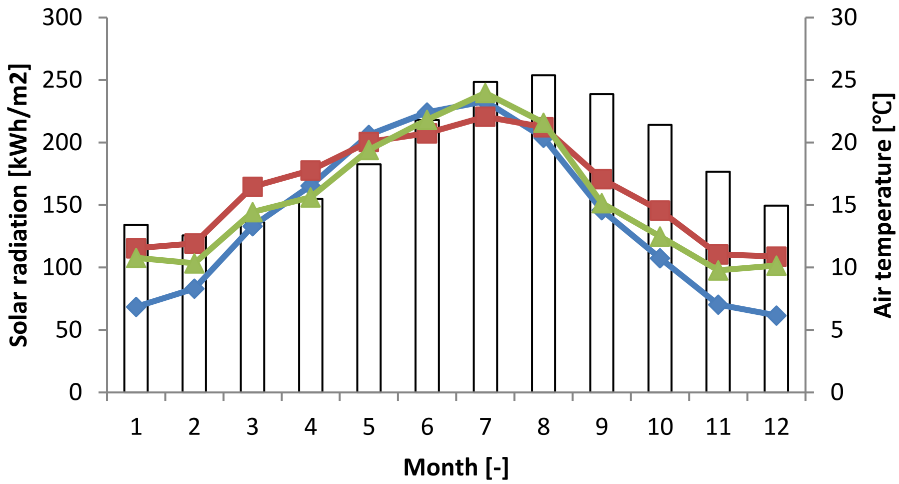


Figure 35: Cala Millor

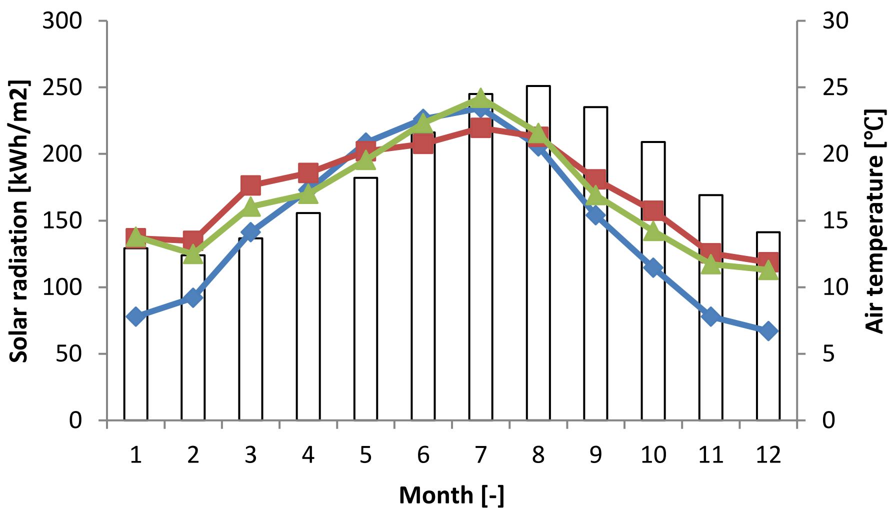


Figure 36: Calpe

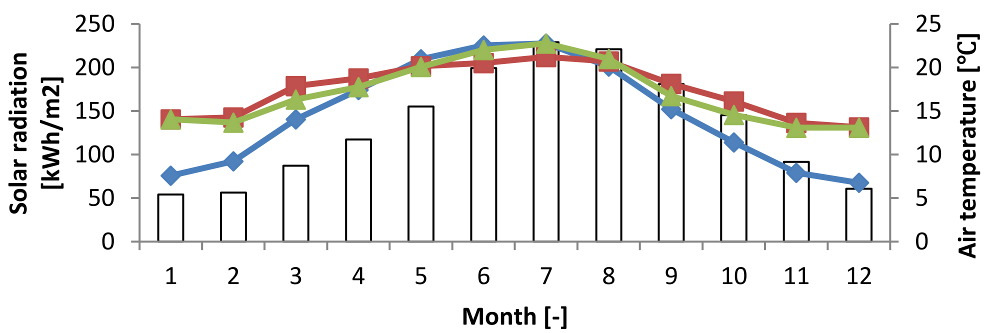


Figure 37: Castellon De La Plana

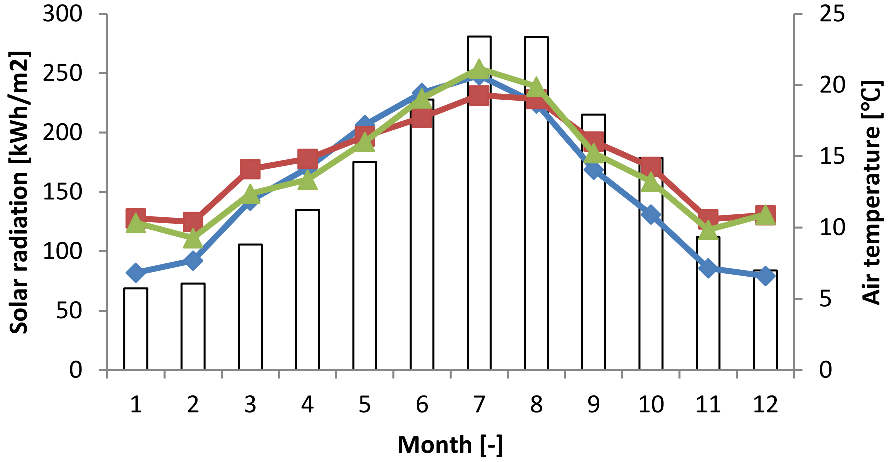


Figure 38: Ceuta

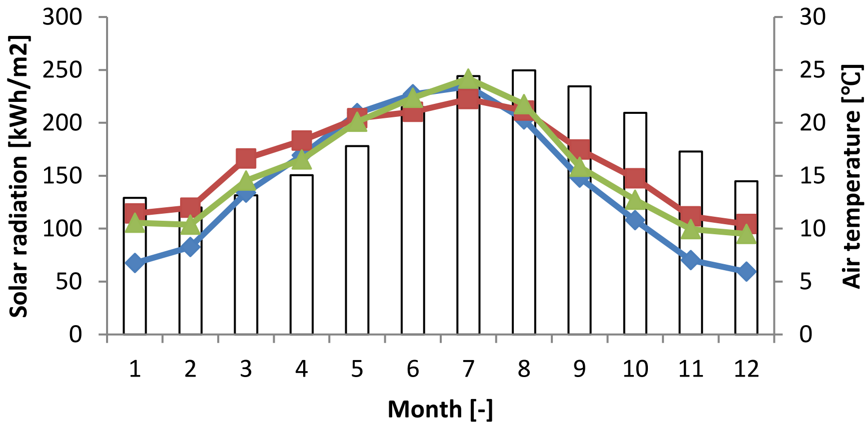


Figure 39: Ciutadella De Menorca

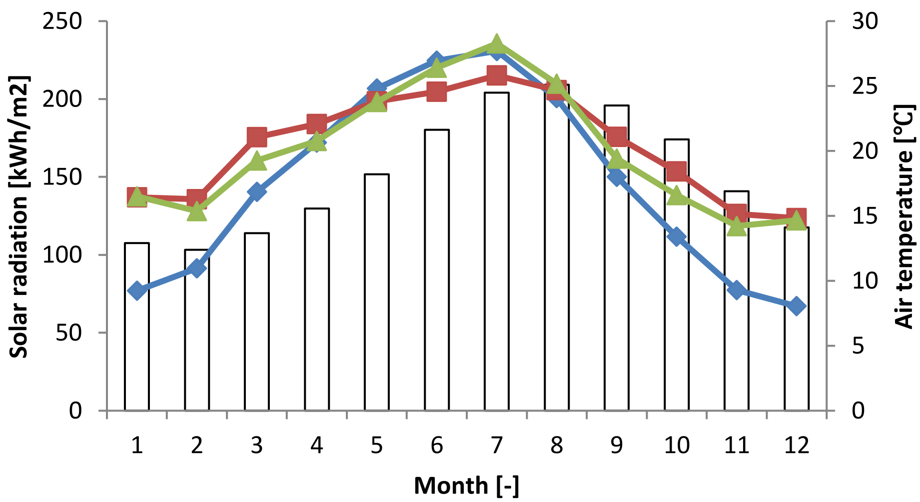


Figure 40: Denia

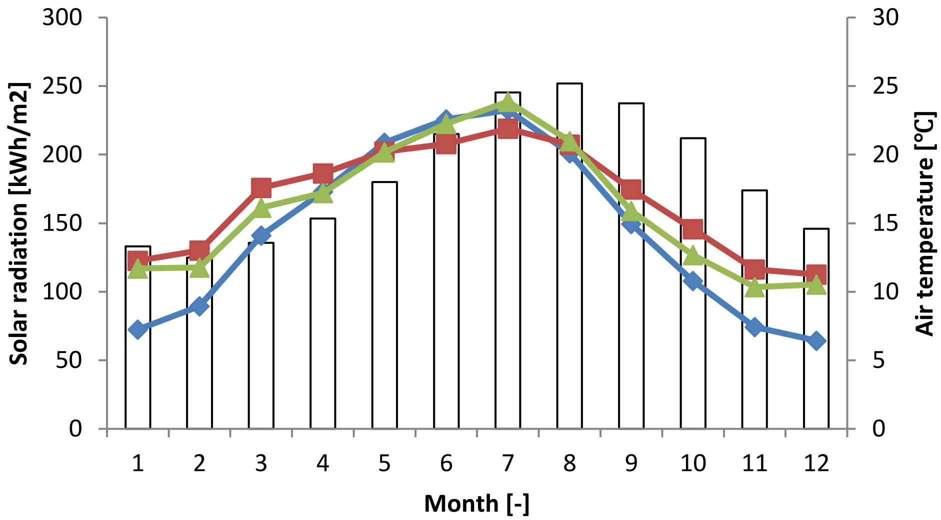


Figure 41: Ibiza

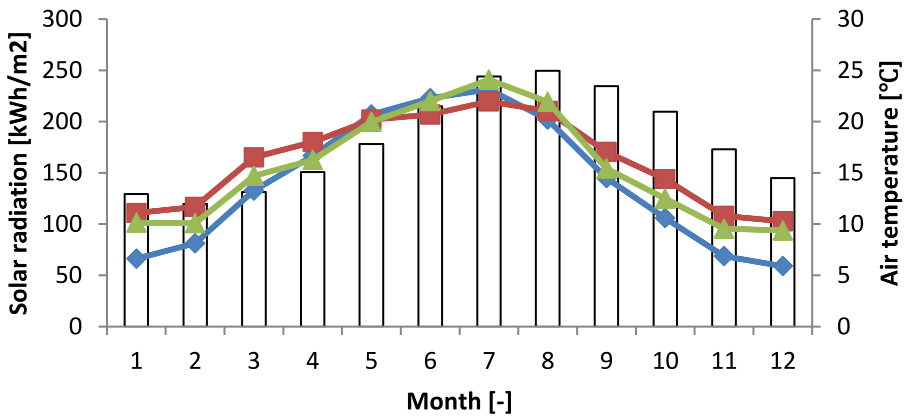


Figure 42: Mahon

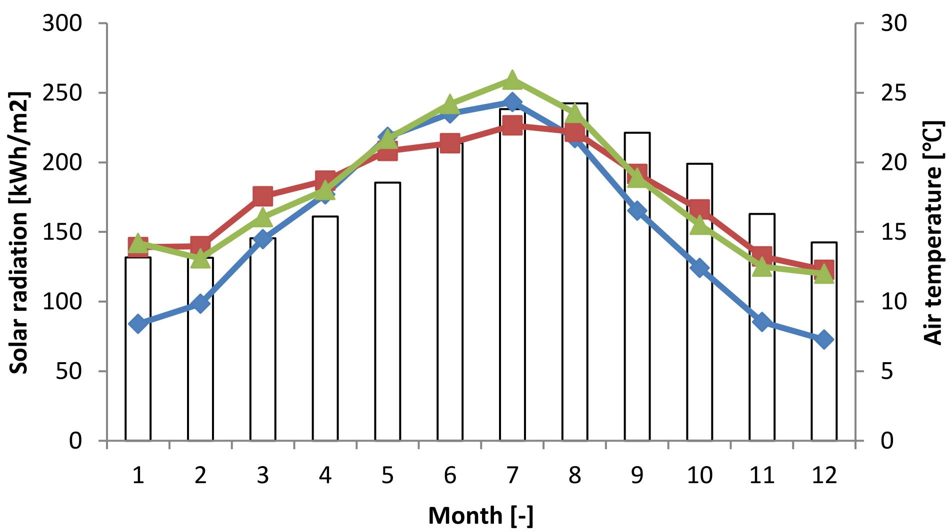


Figure 43: Marbella

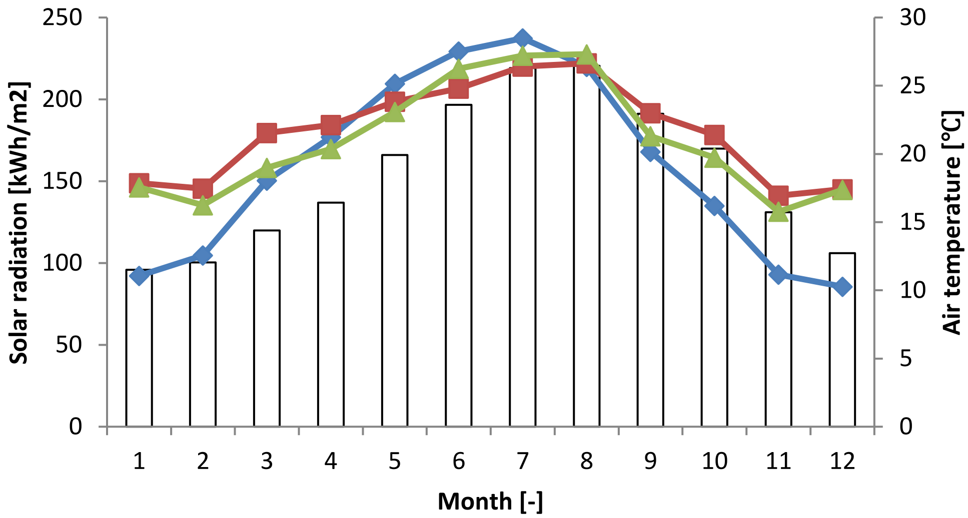


Figure 44: Melilla

2. Italy

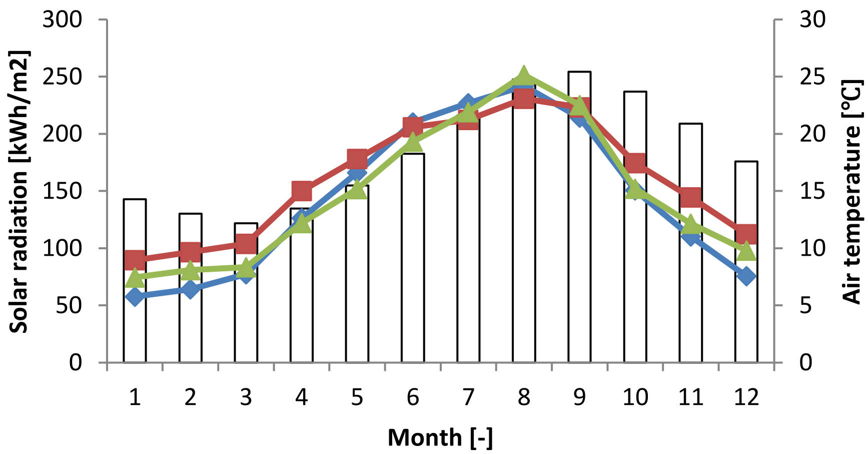


Figure 45: Terrasini

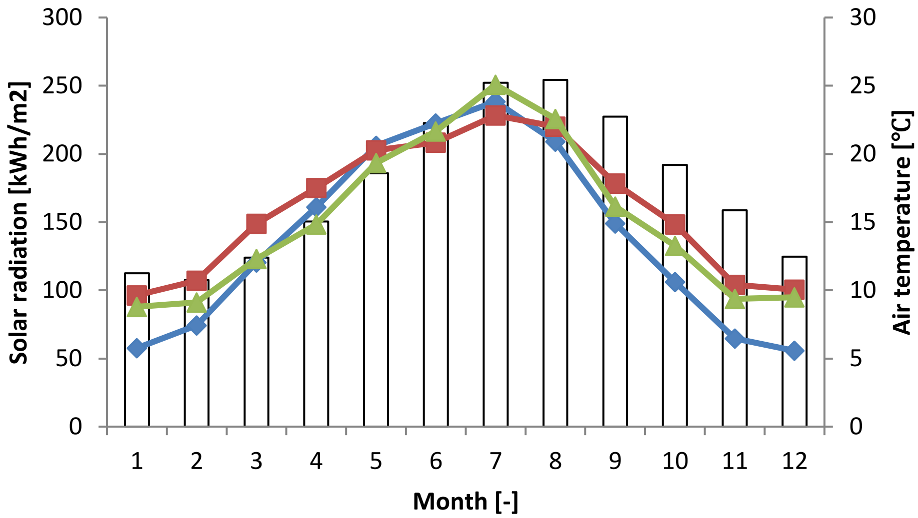


Figure46: Naples

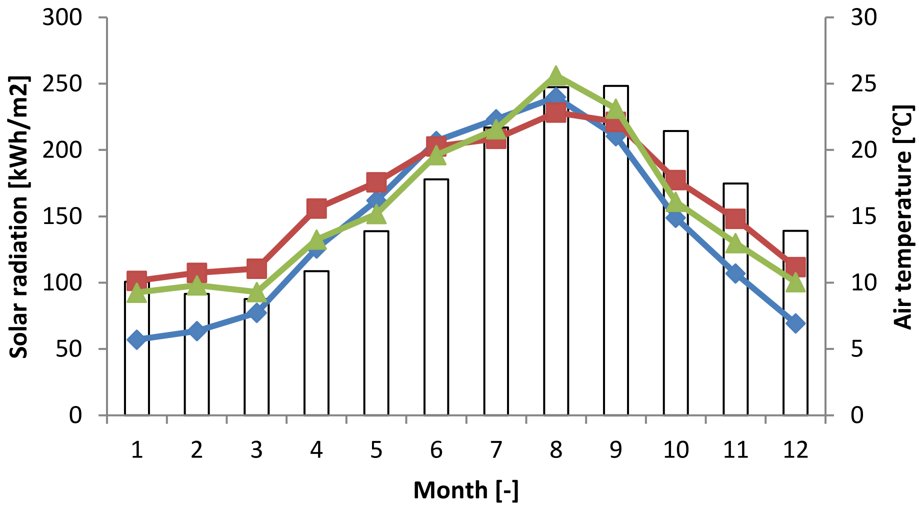


Figure 47: Taranto

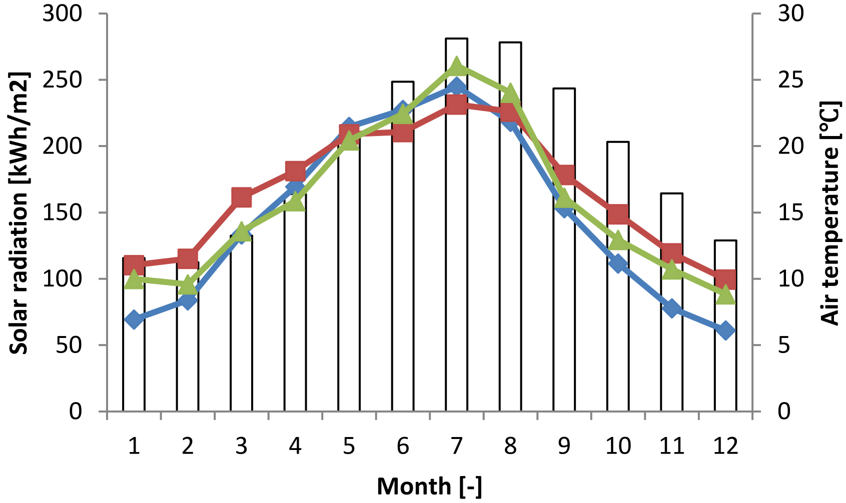


Figure 48: Reggio Calabria

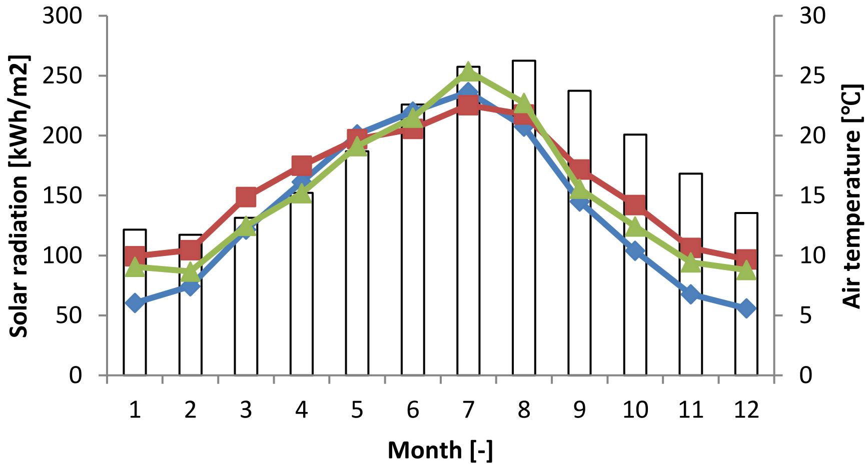


Figure 49: Otranto

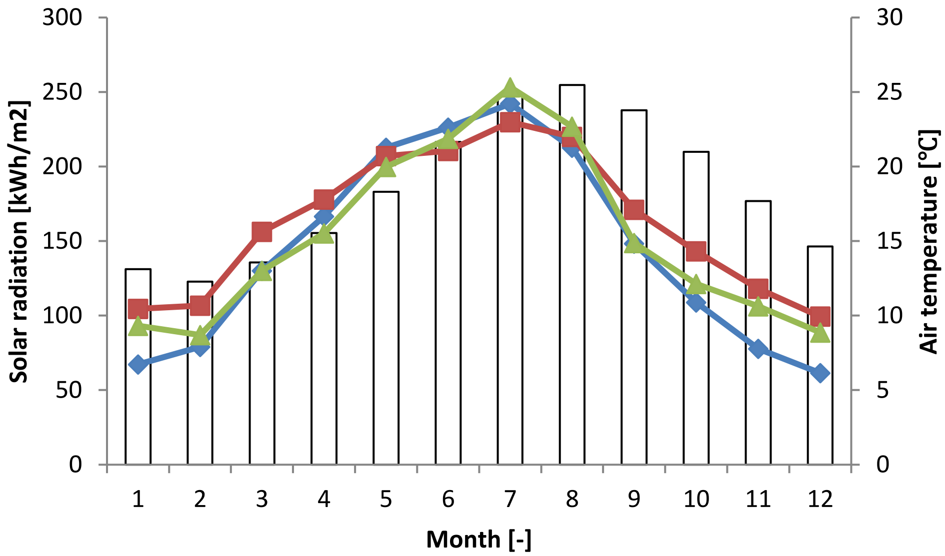


Figure 50: Palermo

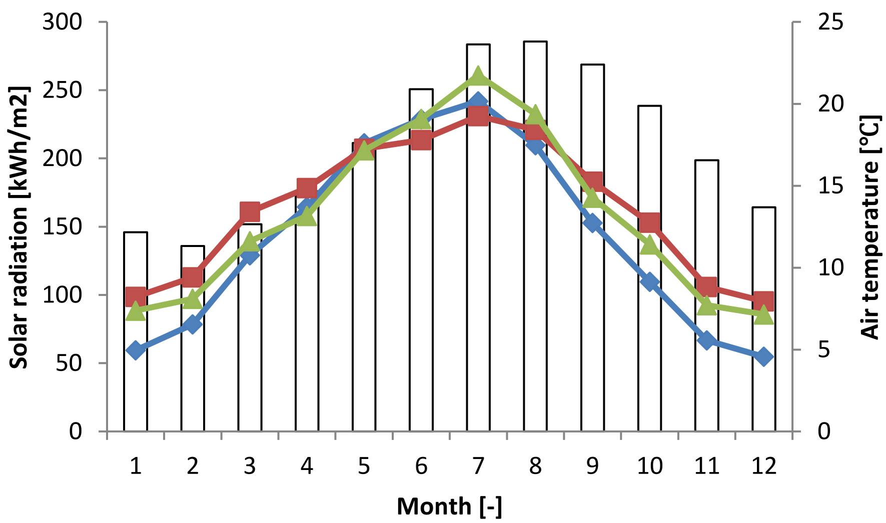


Figure 51: Porto Torres

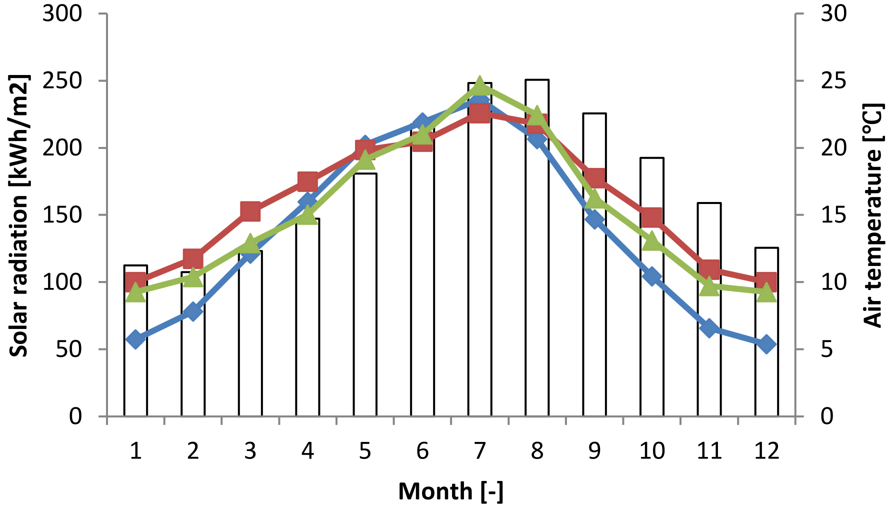


Figure 52: Rome

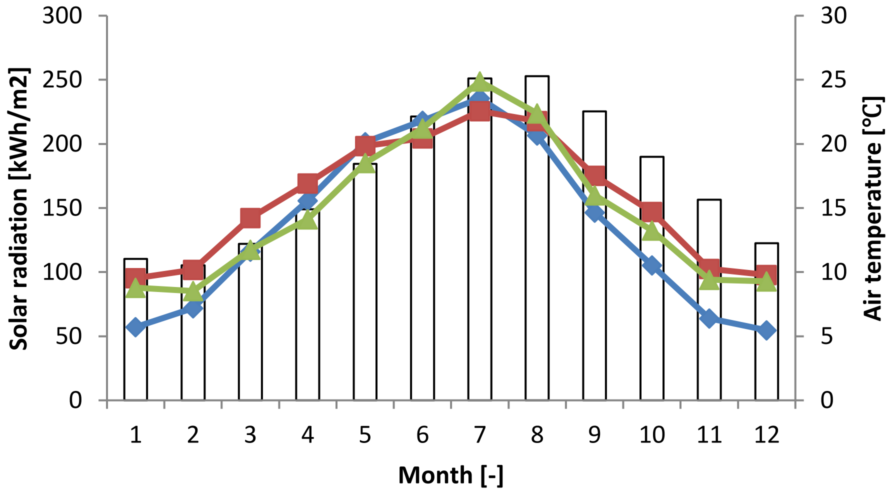


Figure 53: Salerno

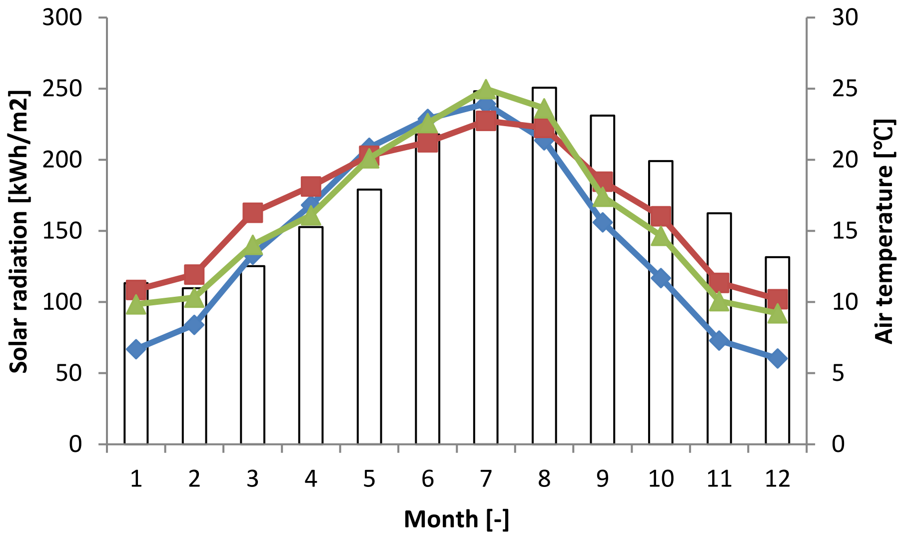


Figure 54: Salerno

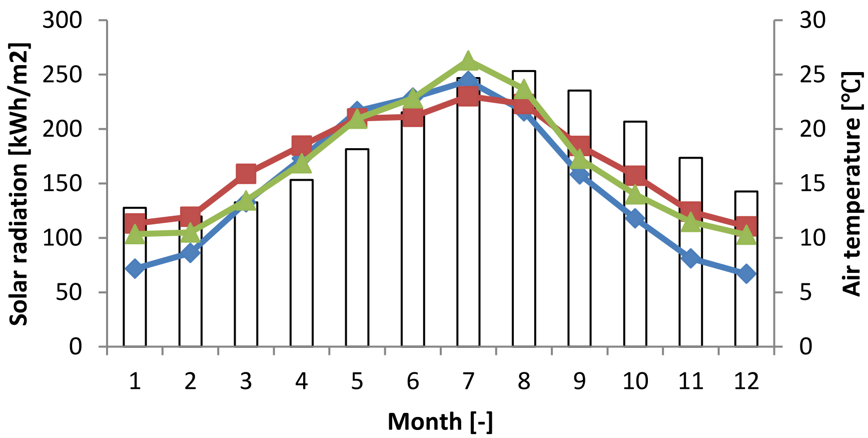


Figure 55: Sciacca

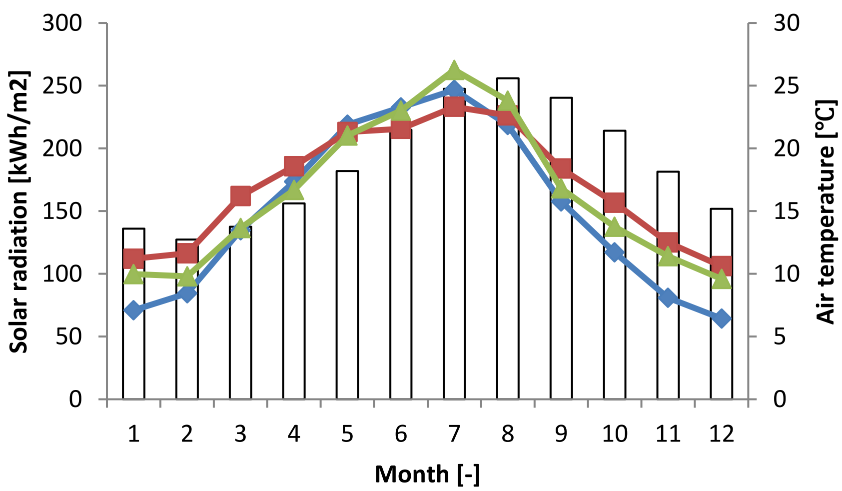


Figure 56: Trapani

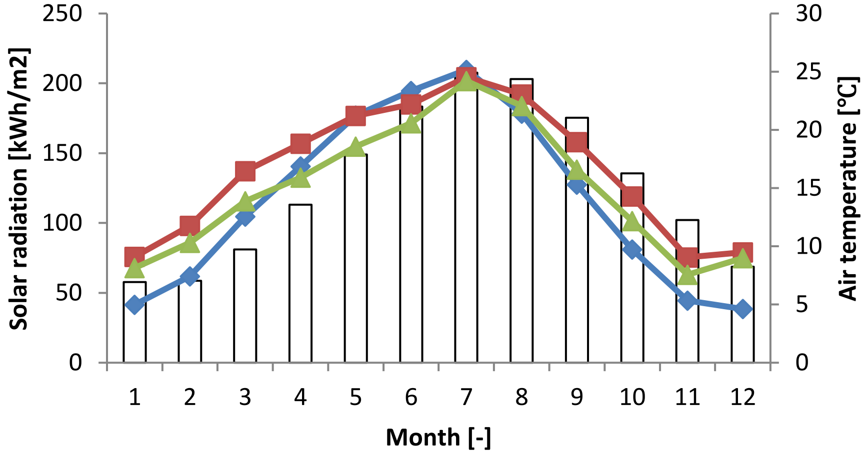


Figure 57: Triesta

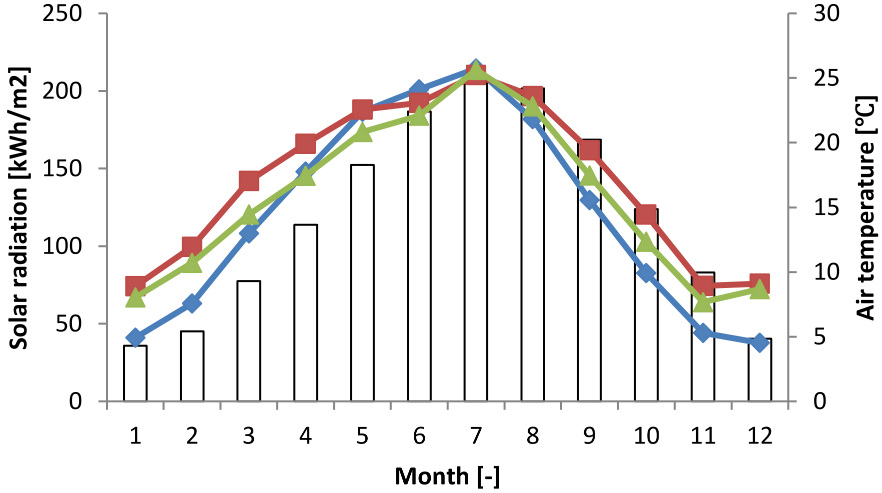


Figure 58: Venice

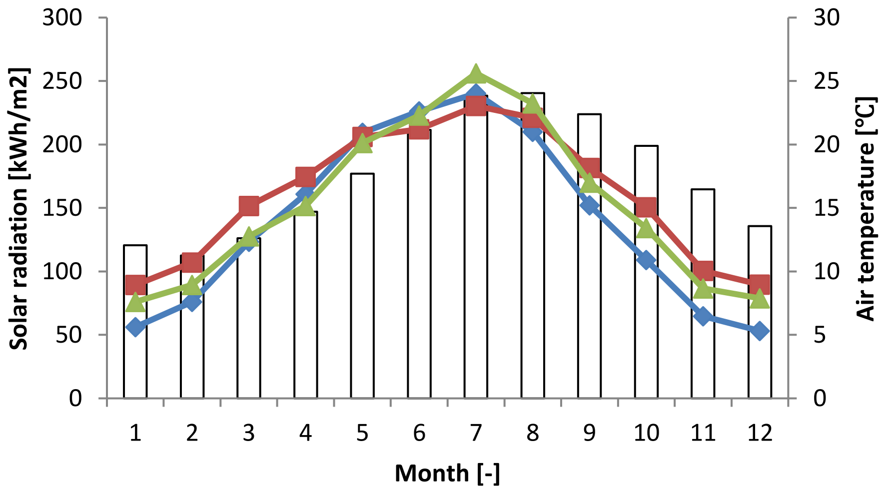


Figure 59: Alghero

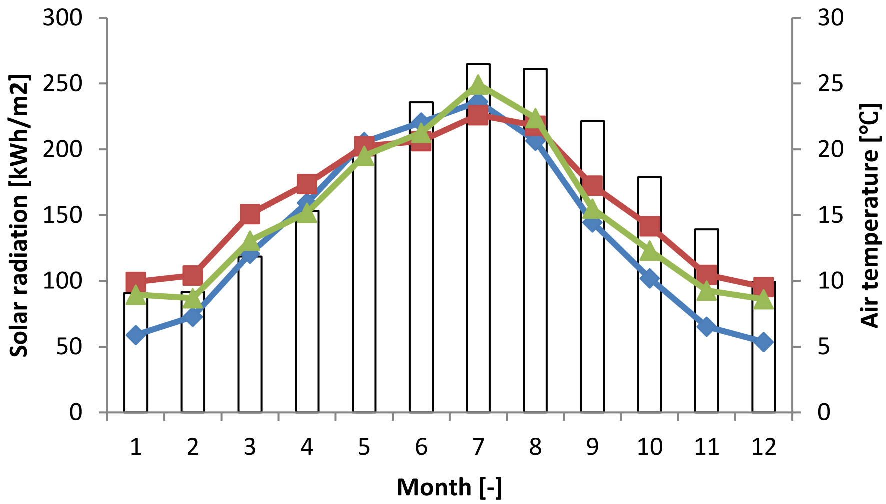


Figure 60: Bari

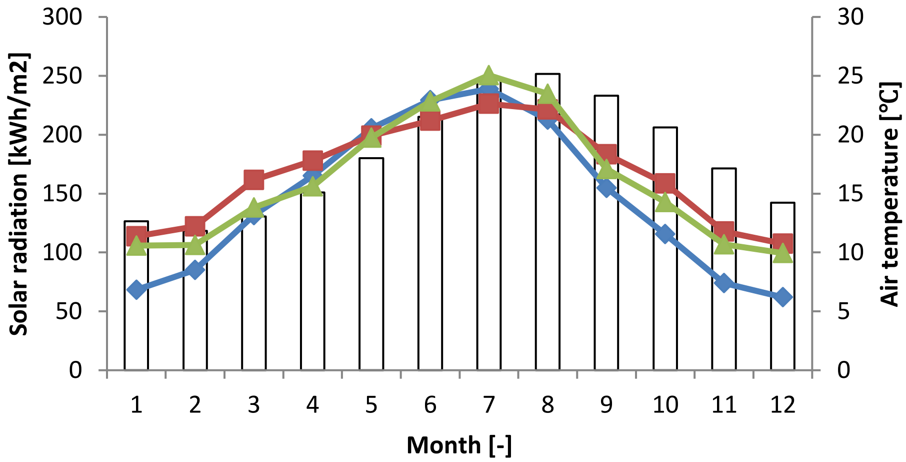


Figure 61: Cagliari

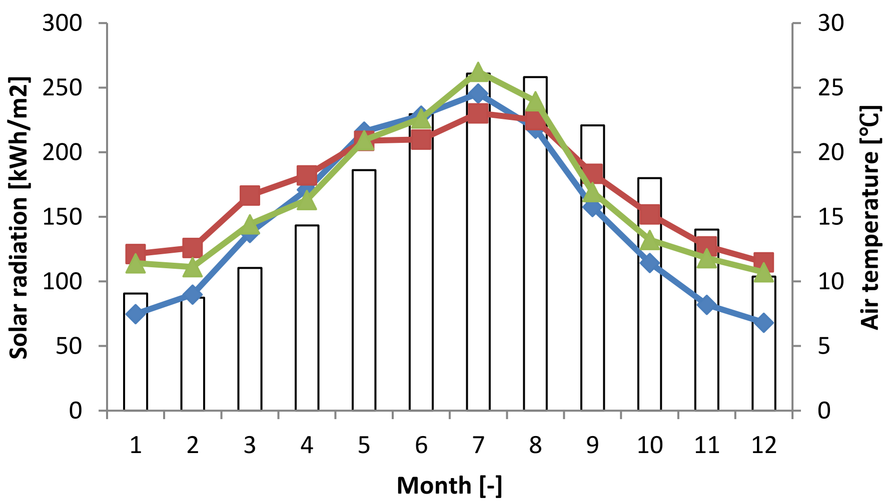


Figure 62: Catania

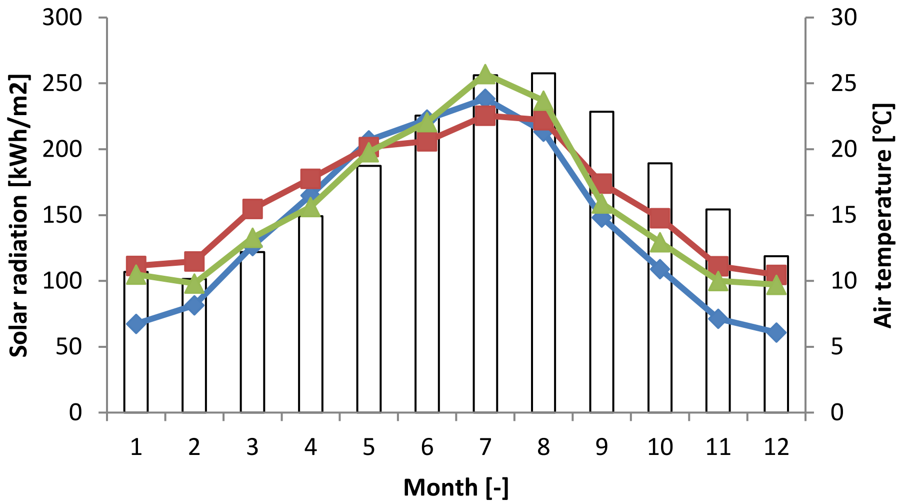


Figure 63: Crotone

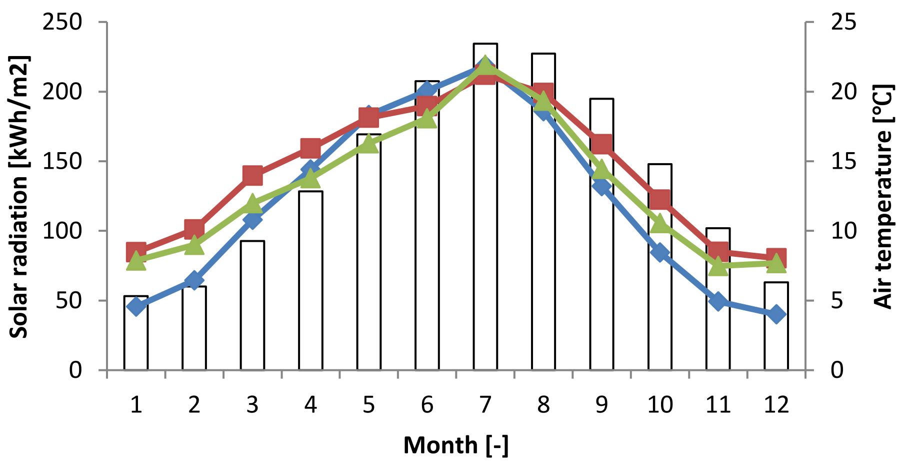


Figure 64: Genoa

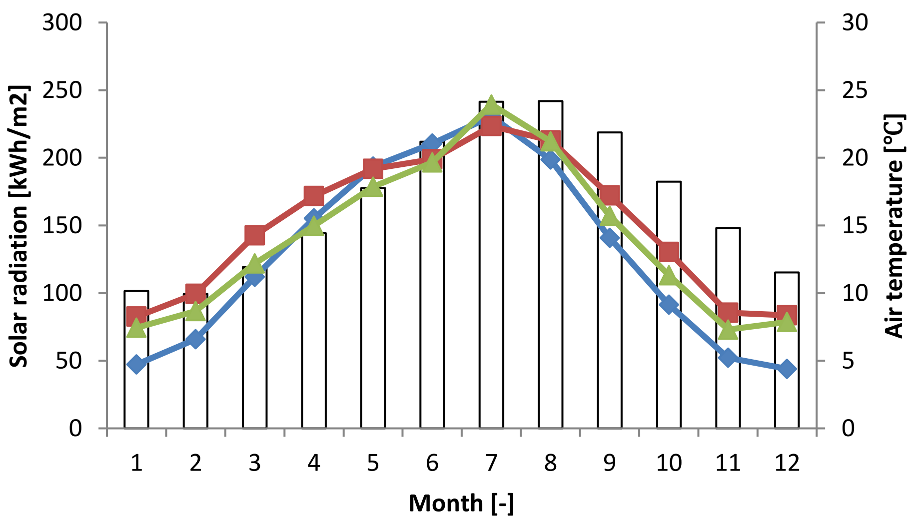


Figure 65: Livorno

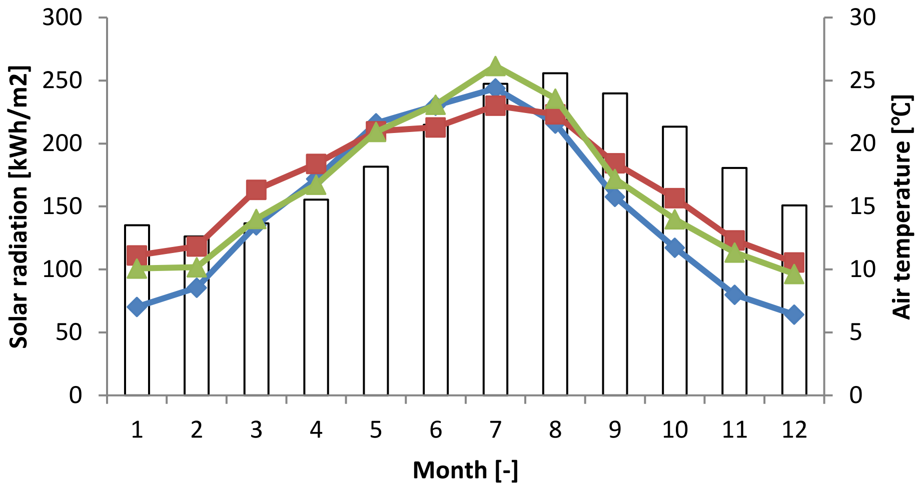


Figure 66: Marsala

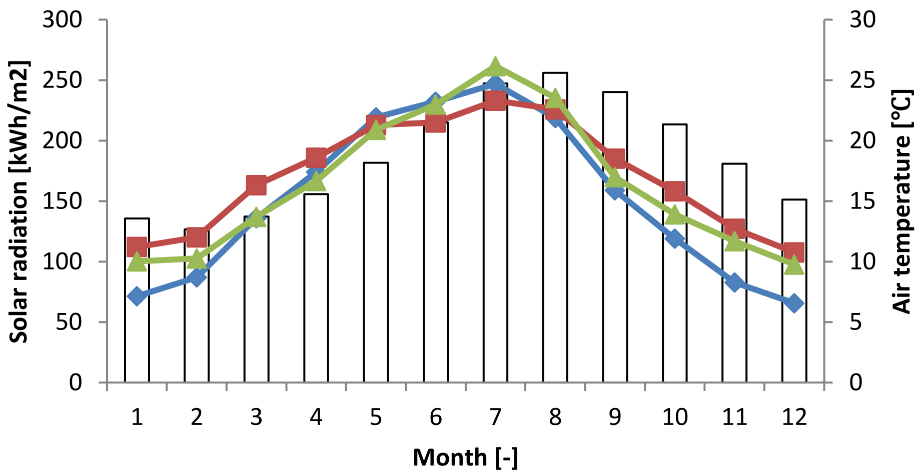


Figure 67: Mazara Del Vallo

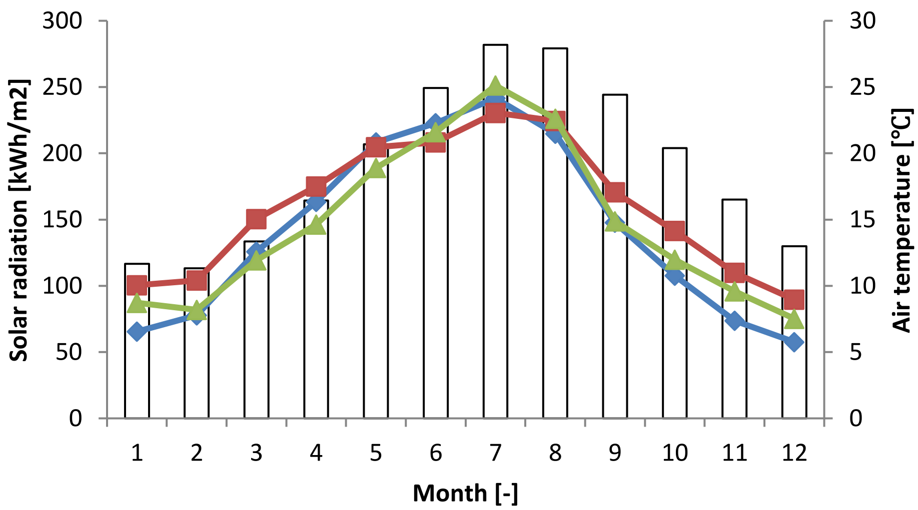


Figure 68: Messina

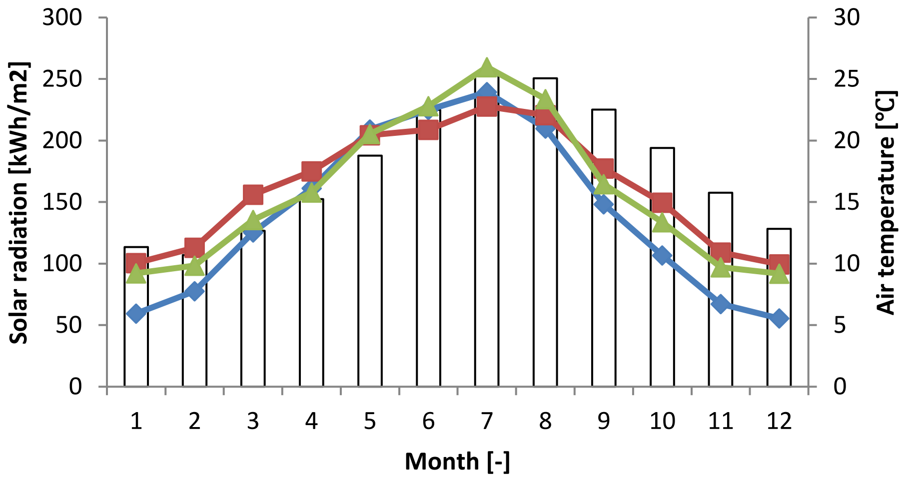


Figure 69: Olibia

3. Greece

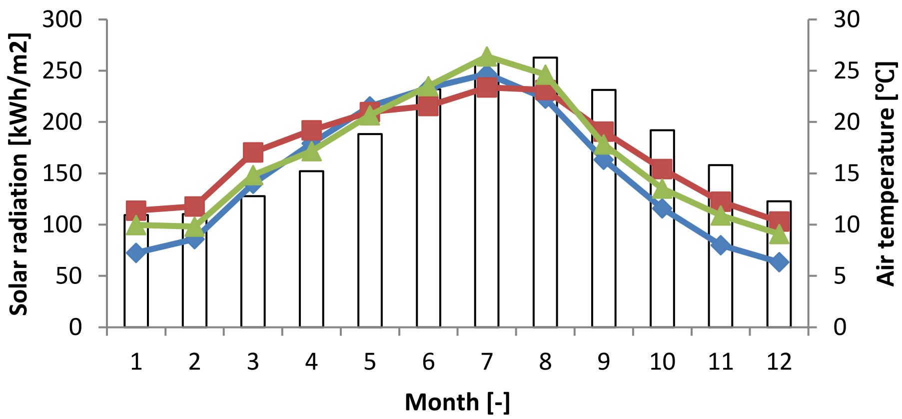


Figure 70: Athens

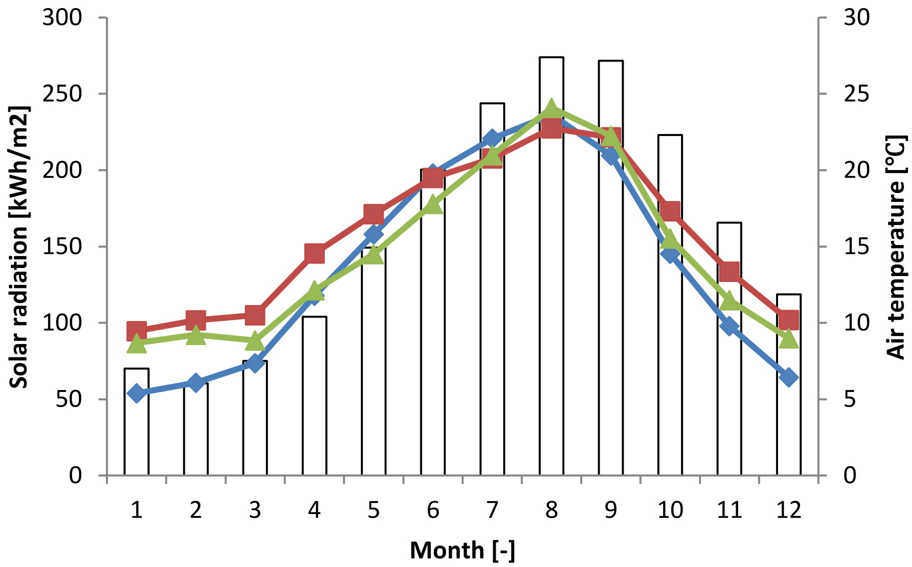


Figure 71: Thessaloniki

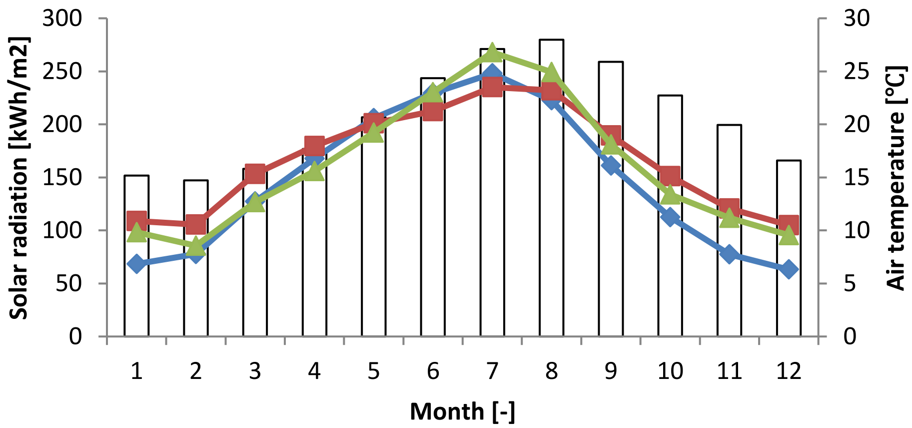


Figure 72: Patras

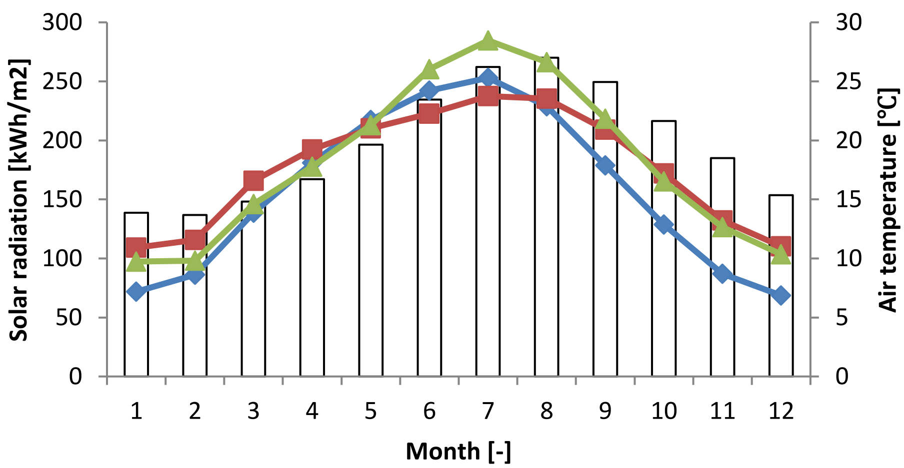


Figure 73: Rhodes

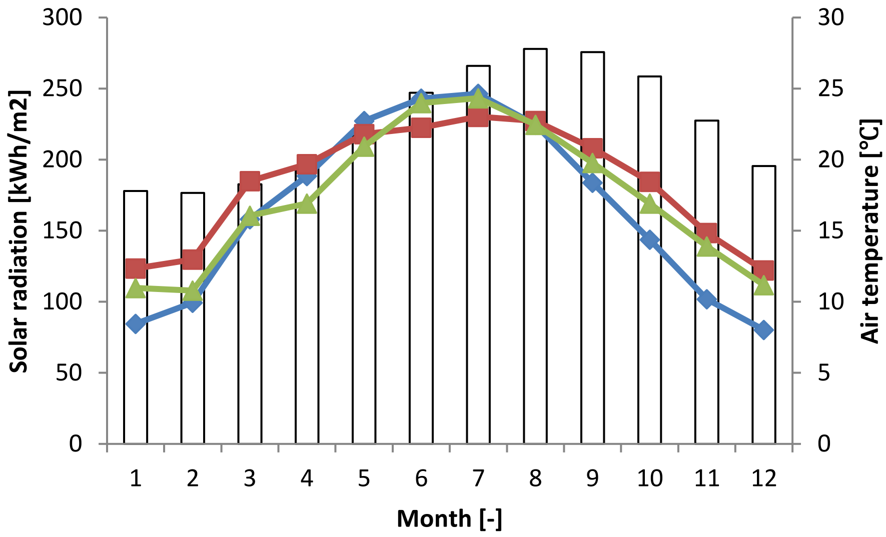


Figure 74: Tyras

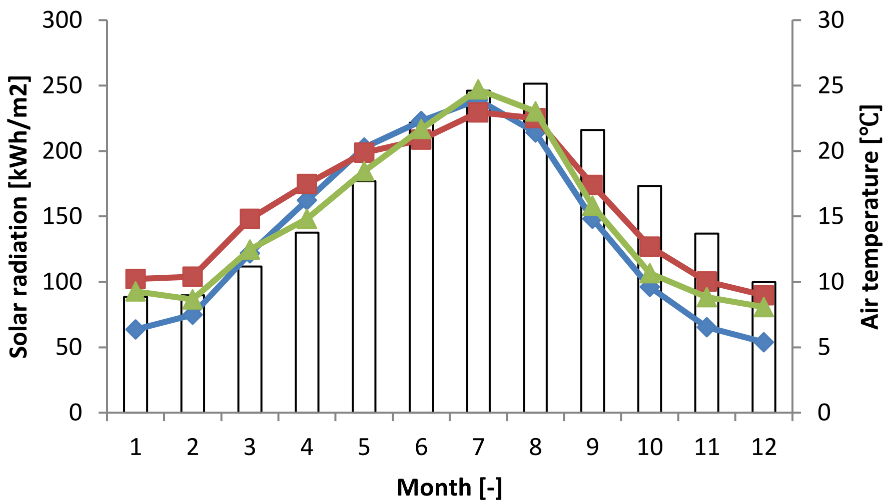


Figure 75: Volos

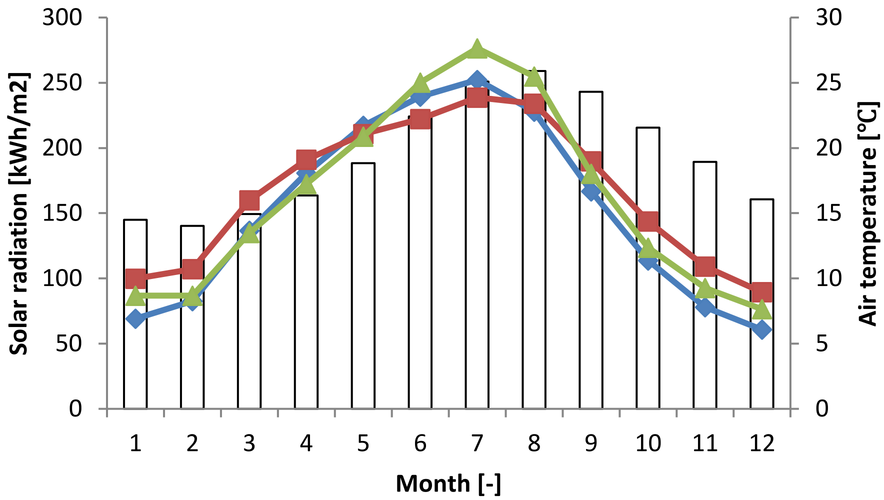


Figure 76: Chania

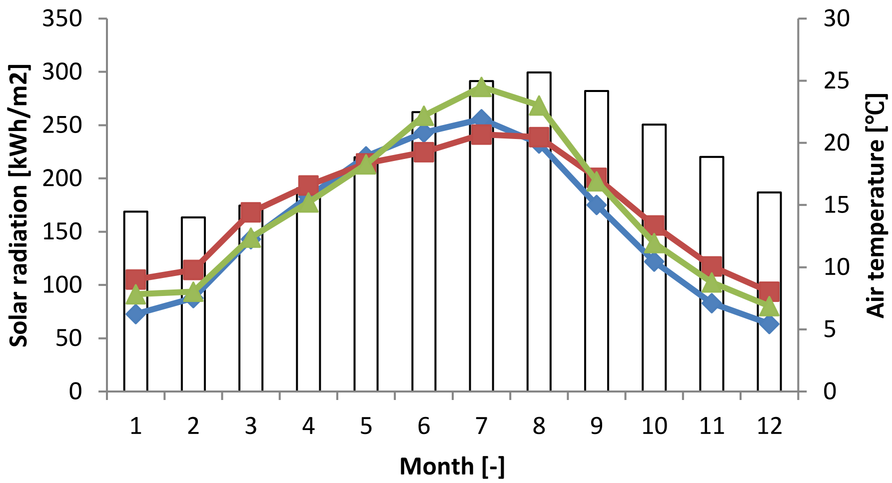


Figure 77: Heraklion

4. Croatia:

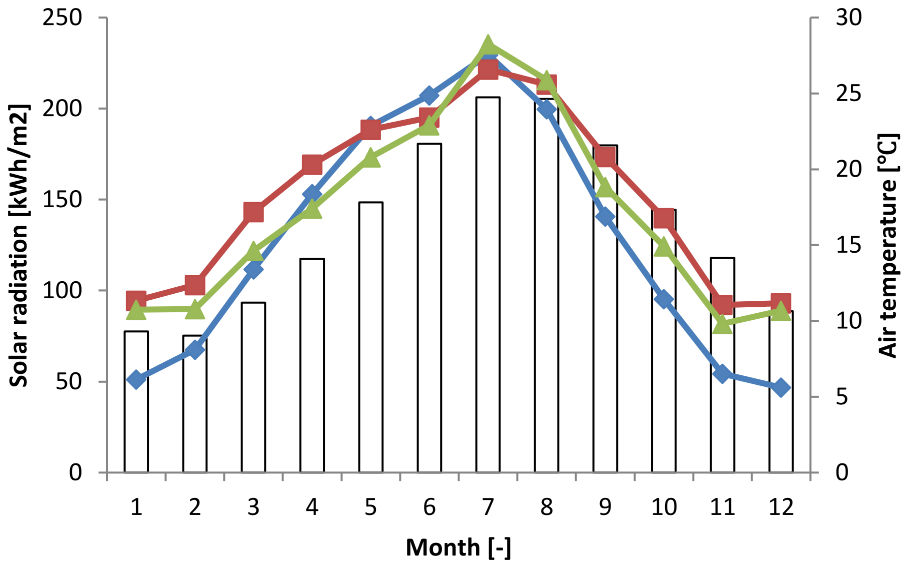


Figure 78: Solin

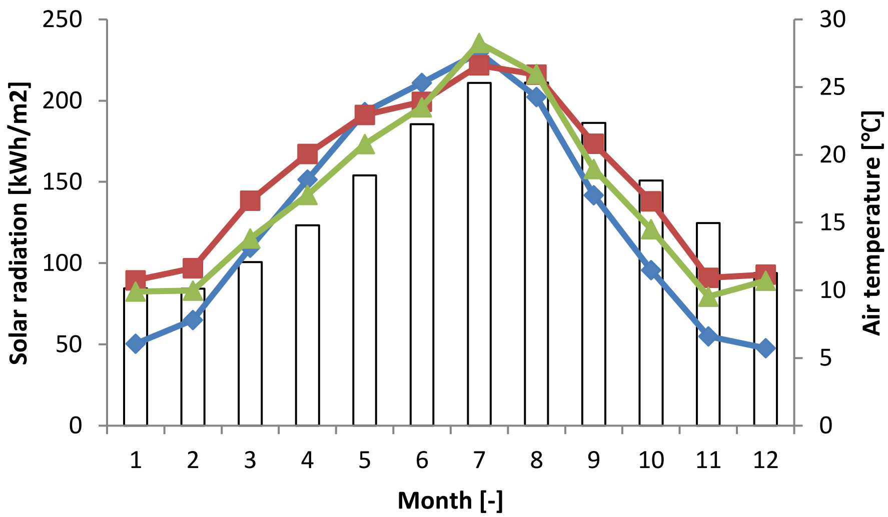


Figure 79: Ploce

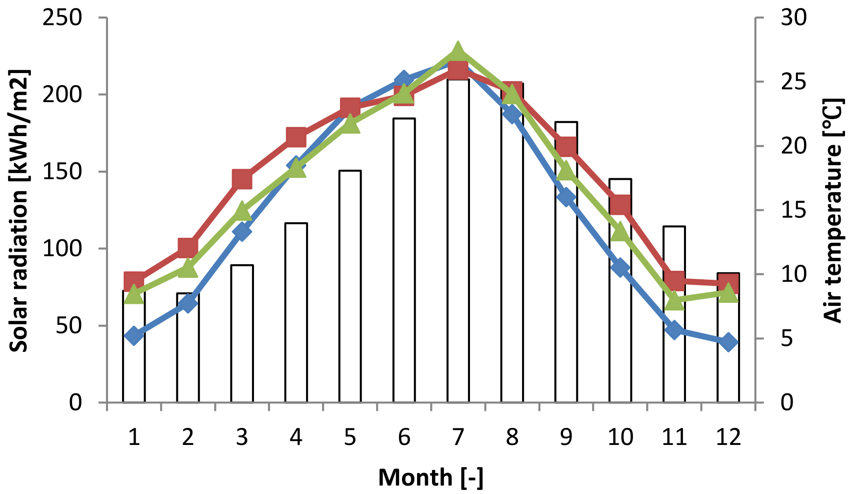


Figure 80: Pula

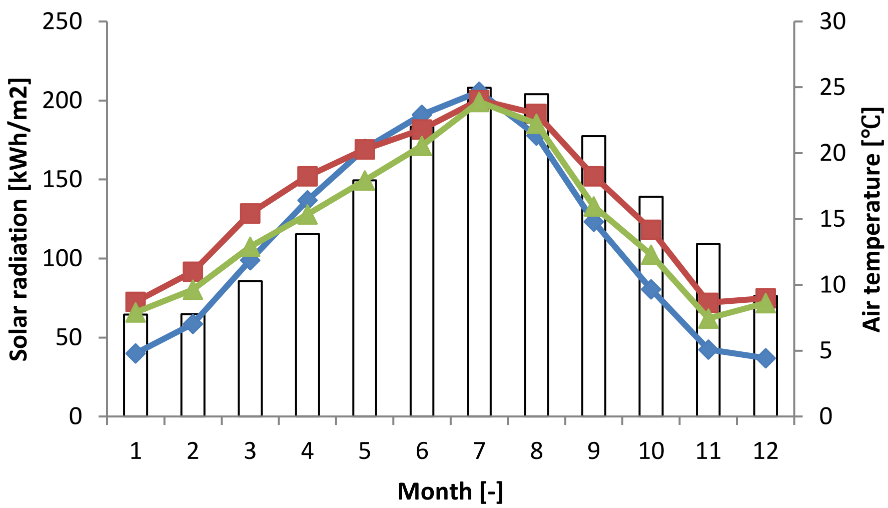


Figure 81: Rijeka

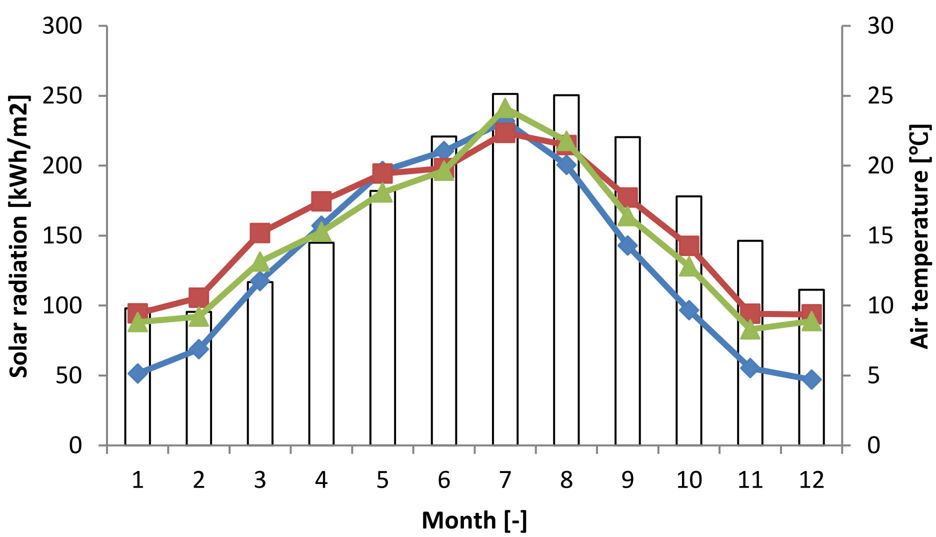


Figure 82: Sibenik

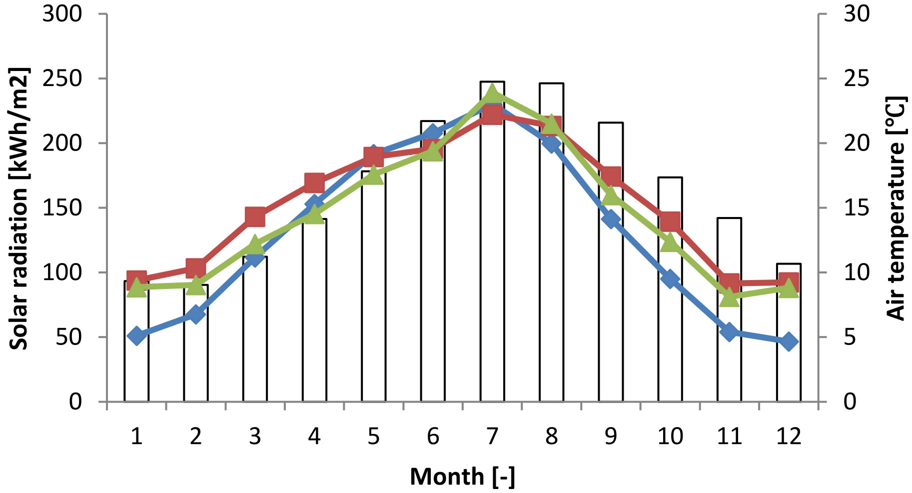


Figure 83: Split

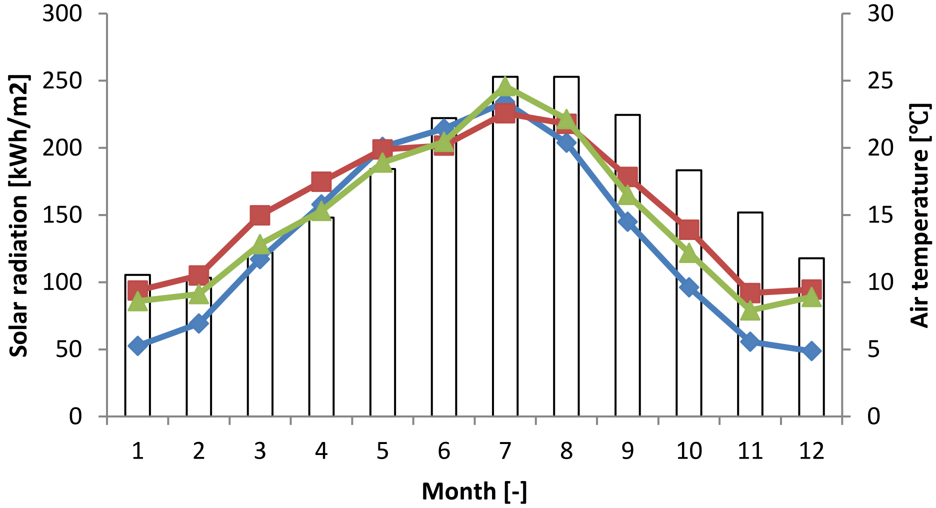


Figure 84: Stari Grad

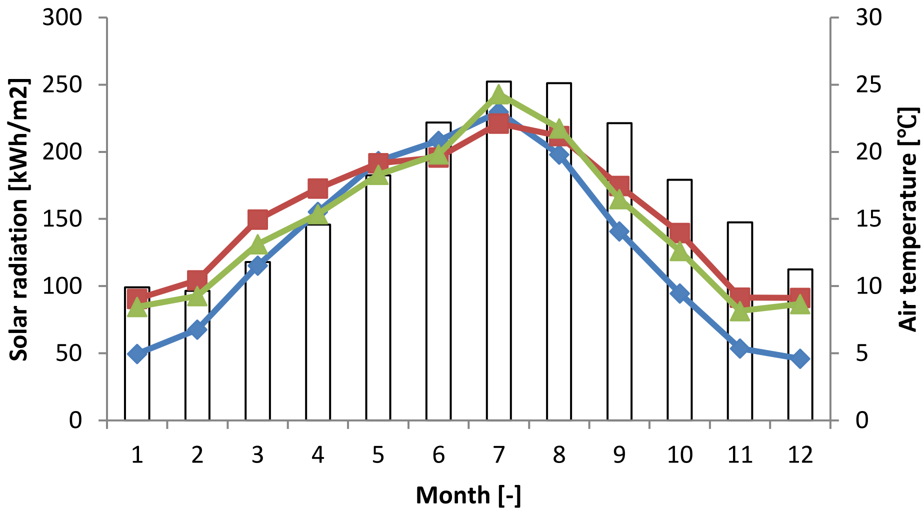


Figure 85: Vodice

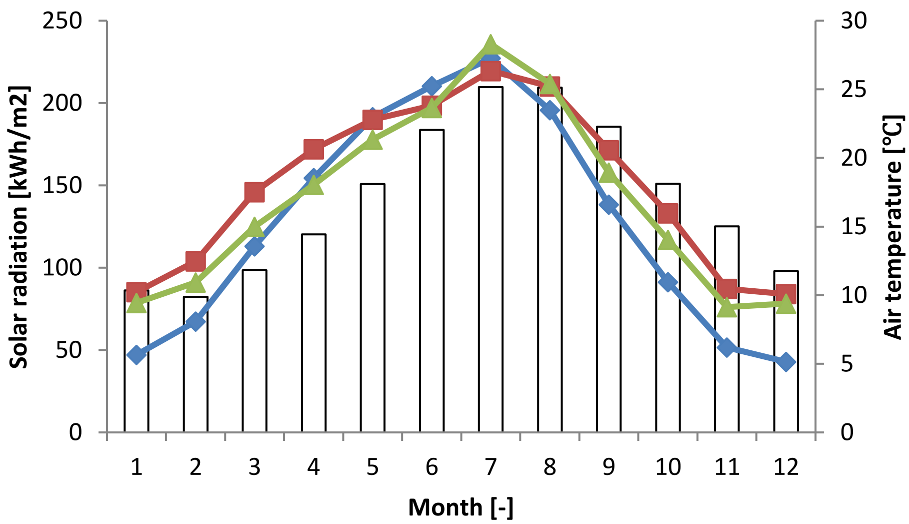


Figure 86: Zadar

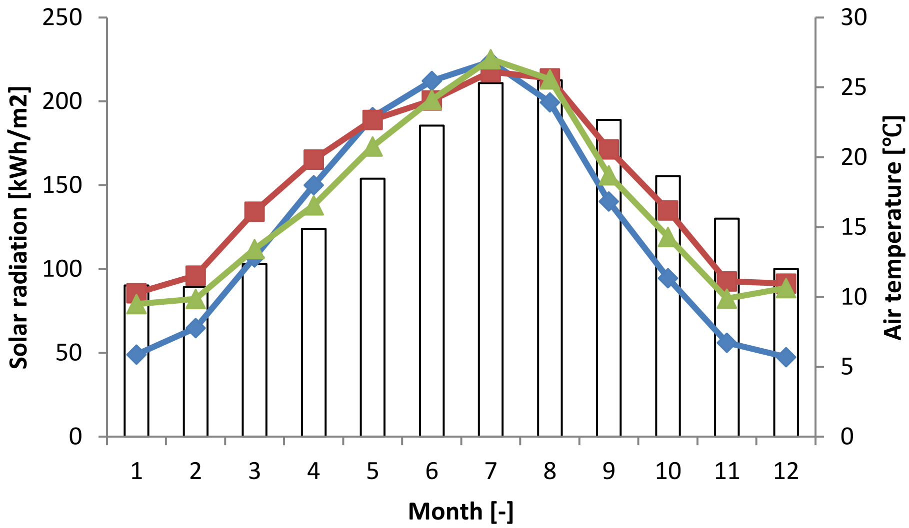


Figure 87: Dubrovnik

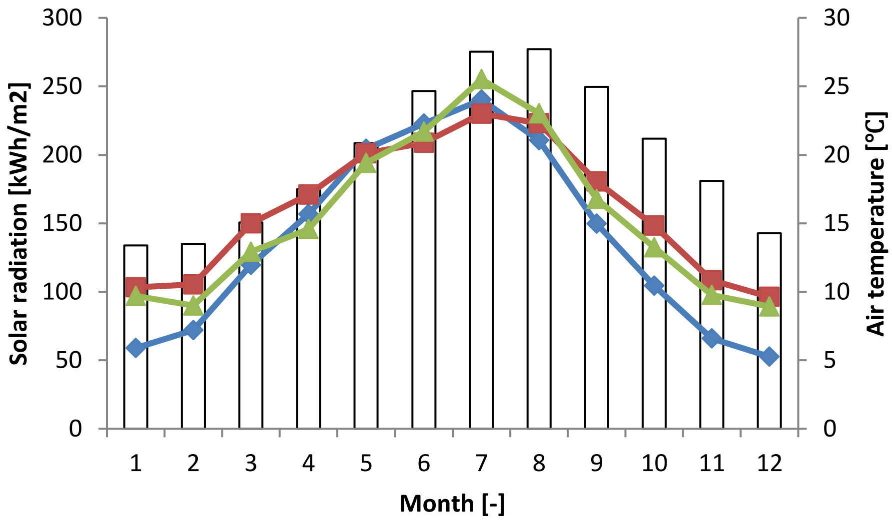


Figure 88: Durres

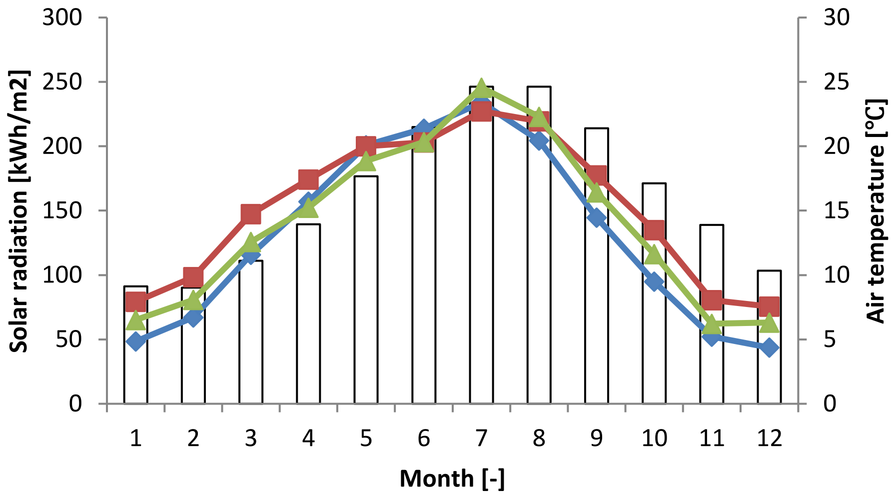


Figure 89: Hvar

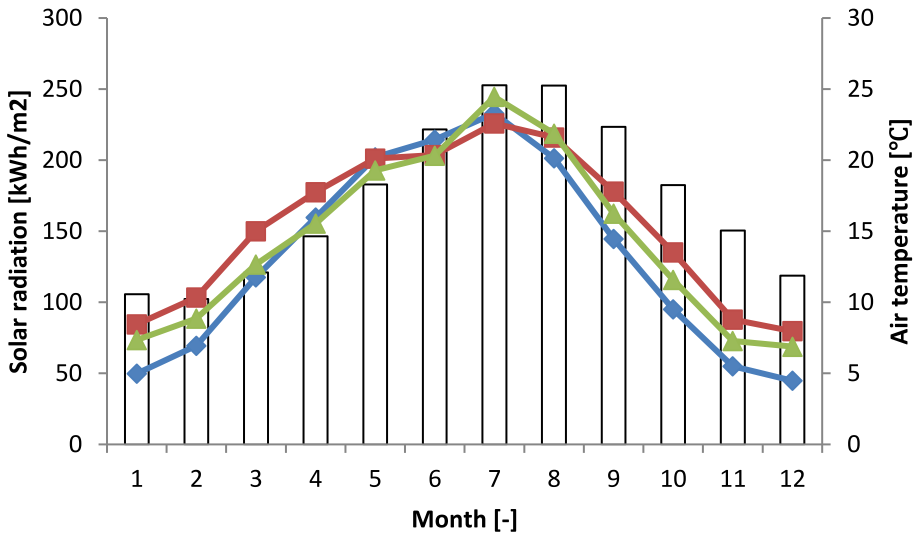


Figure 90: Komiza

North:

1. Ukraine:

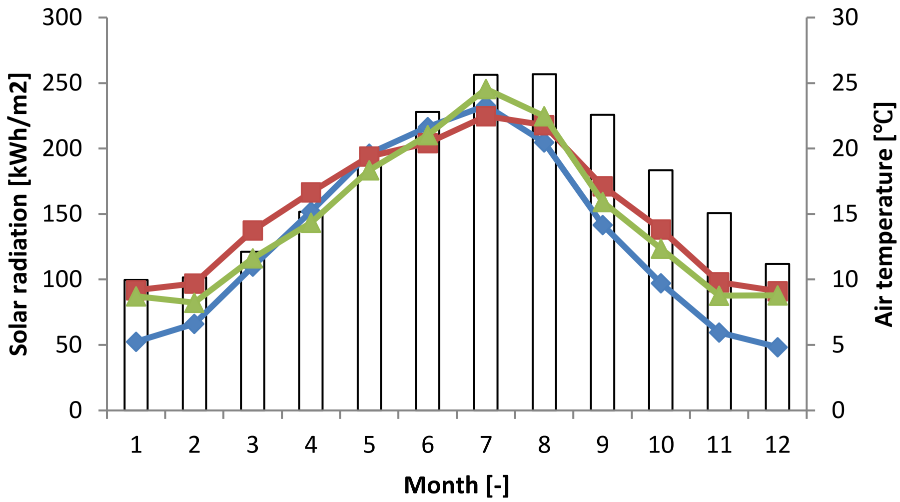


Figure 91: Bar

2. Tunisia

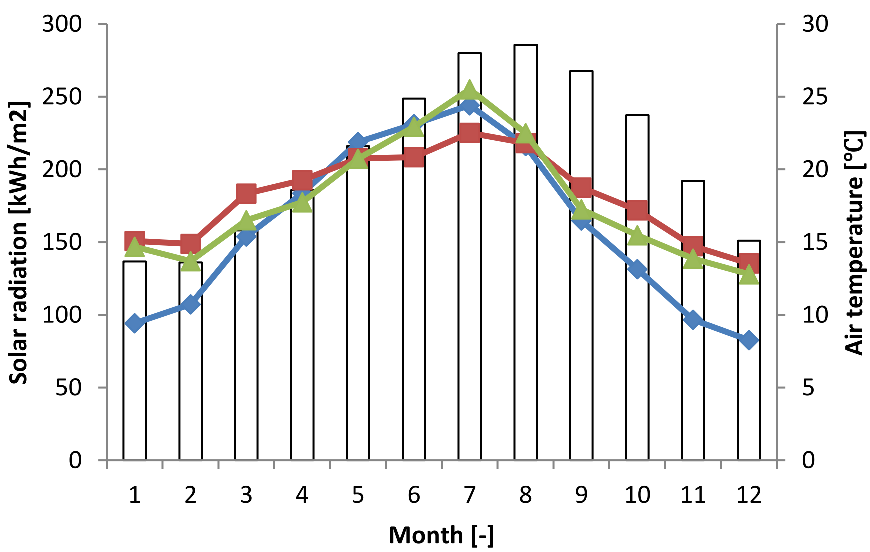


Figure 92: Sfax

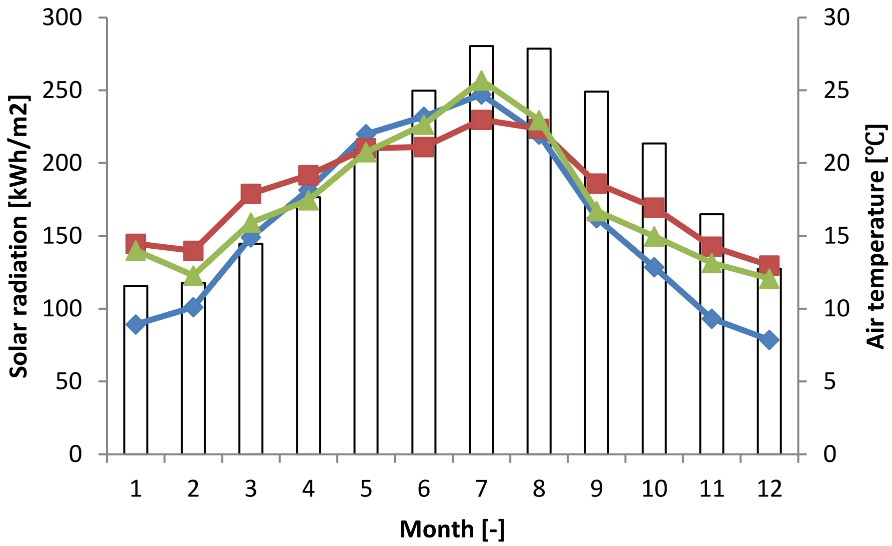


Figure 93: Sousse

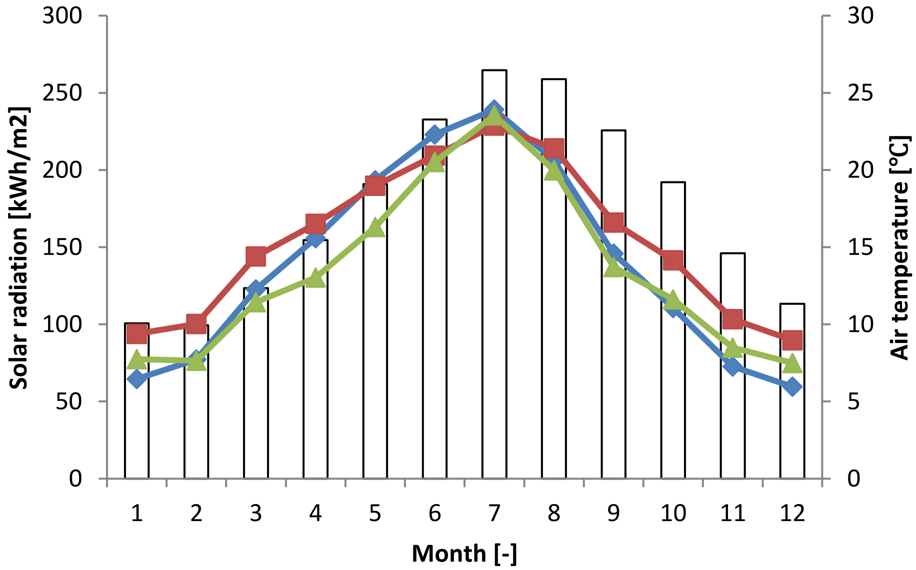


Figure 94: Tabarka

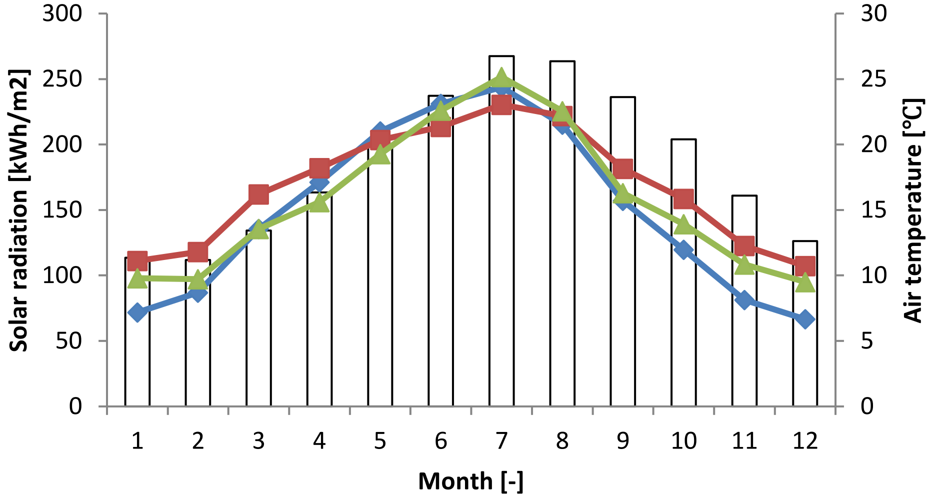


Figure 95: Bizerte

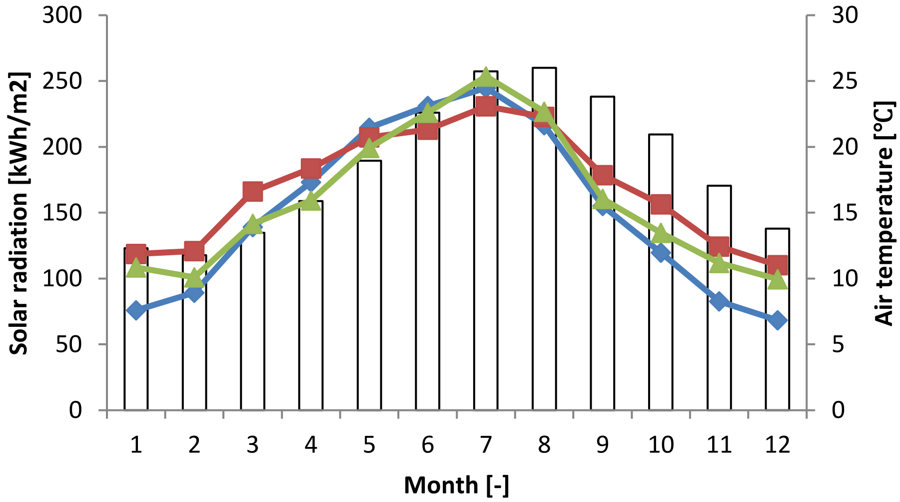


Figure 96: Kelibia

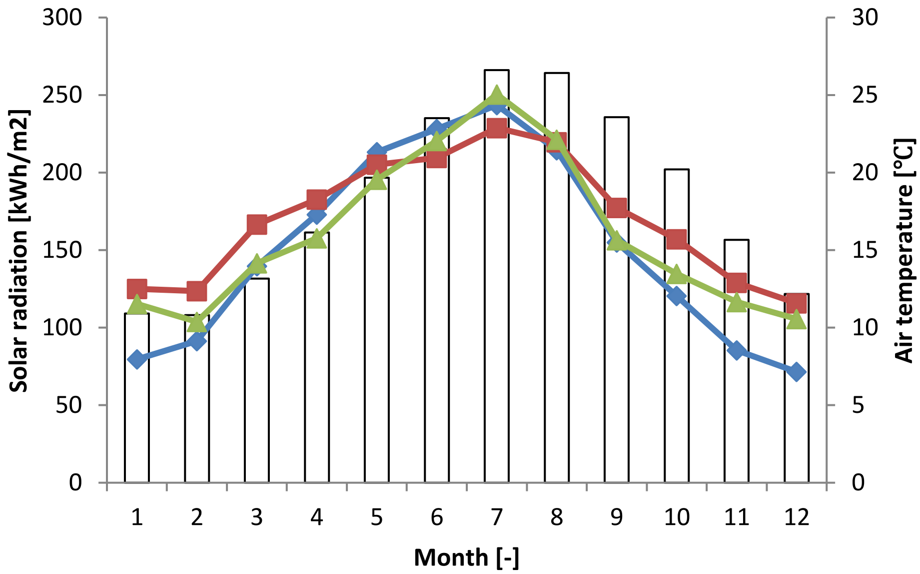


Figure 97: Nabeul

3. Morroco:

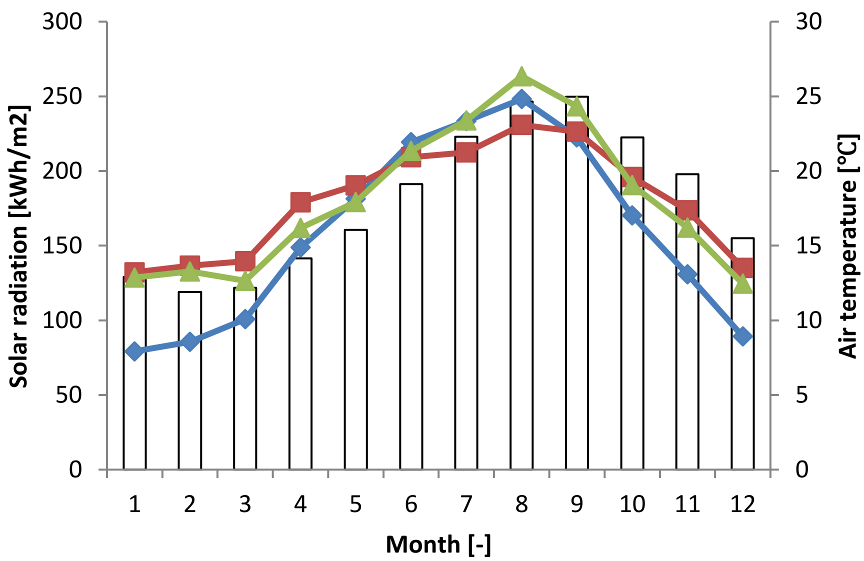


Figure 98: Tangiet

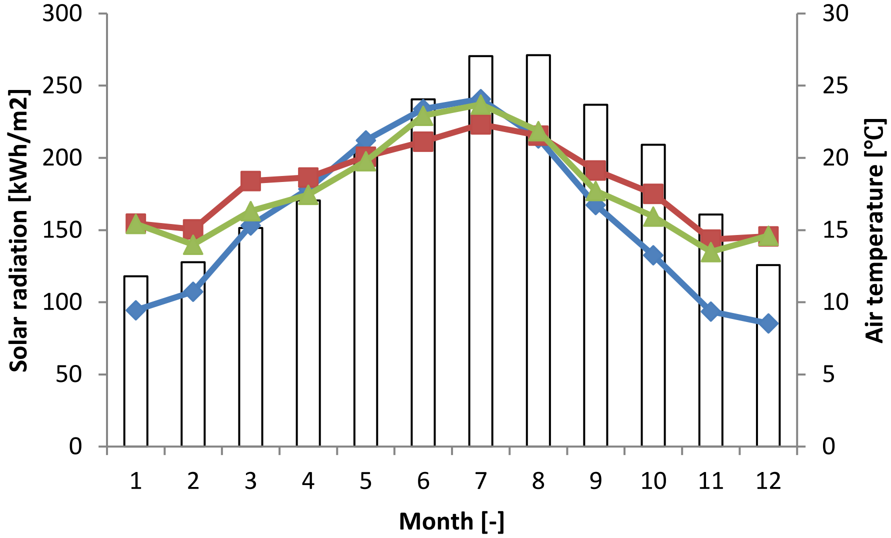


Figure 99: Al Hoceima

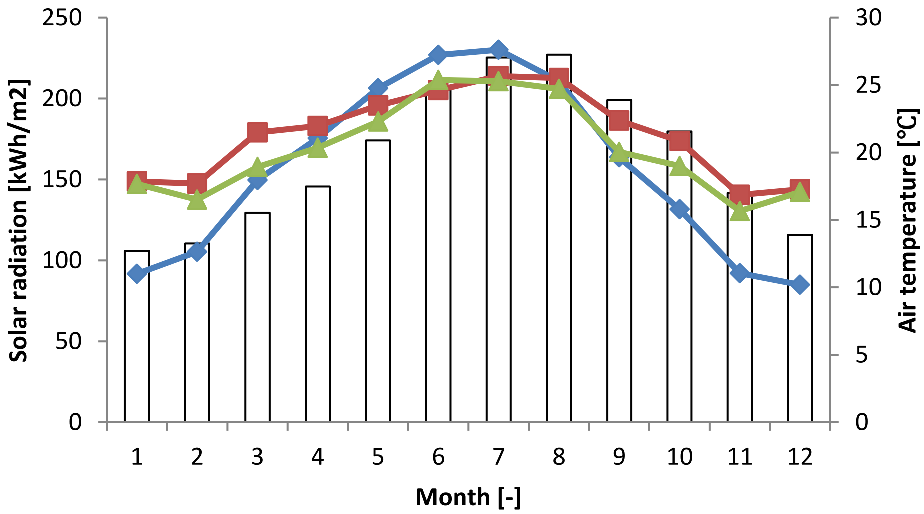


Figure 100: Nador

4. Libya

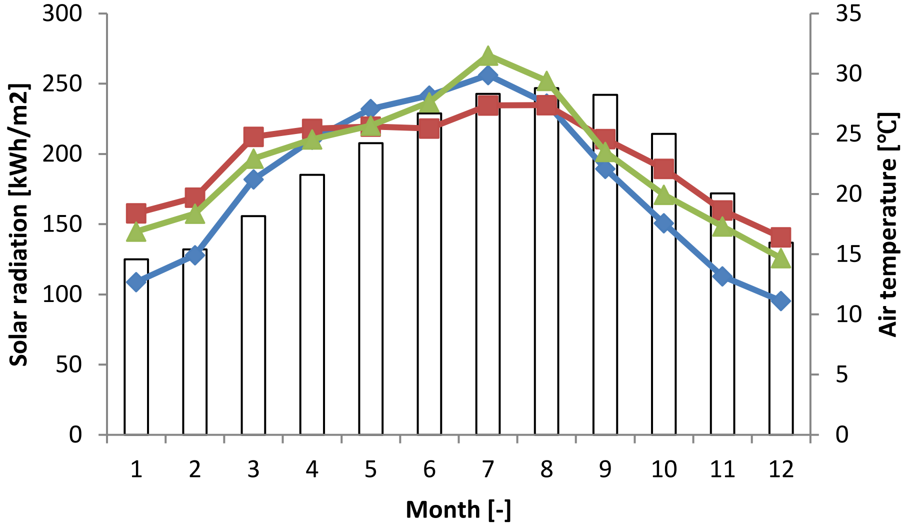


Figure 101: Sirte

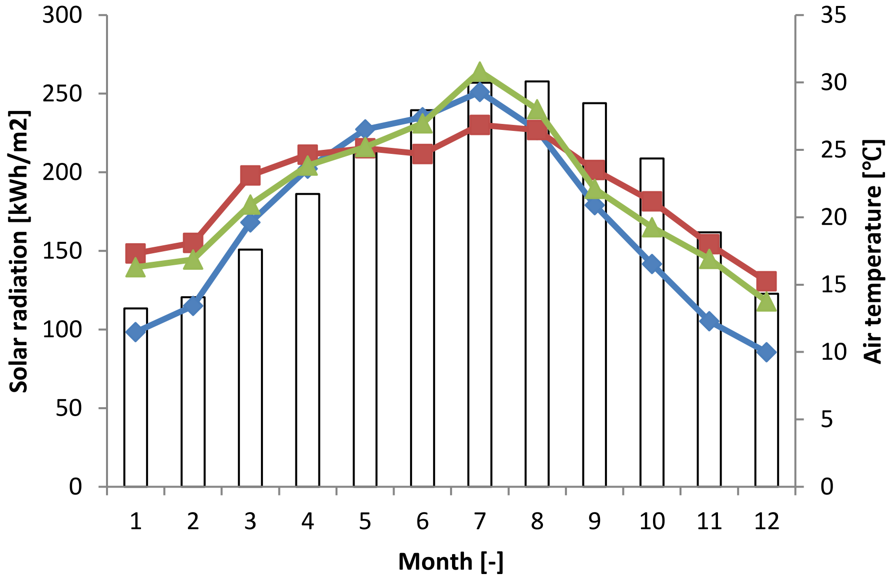


Figure102: Tripoli

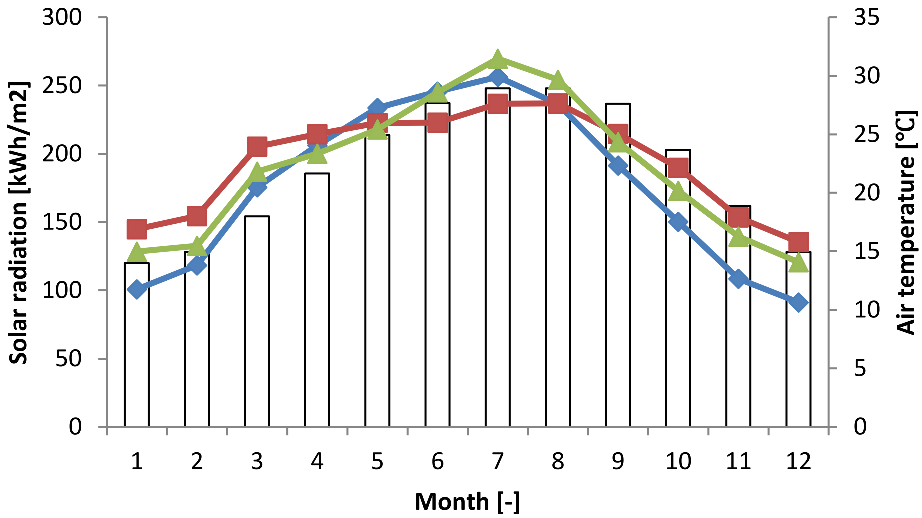


Figure 103: Tobruk

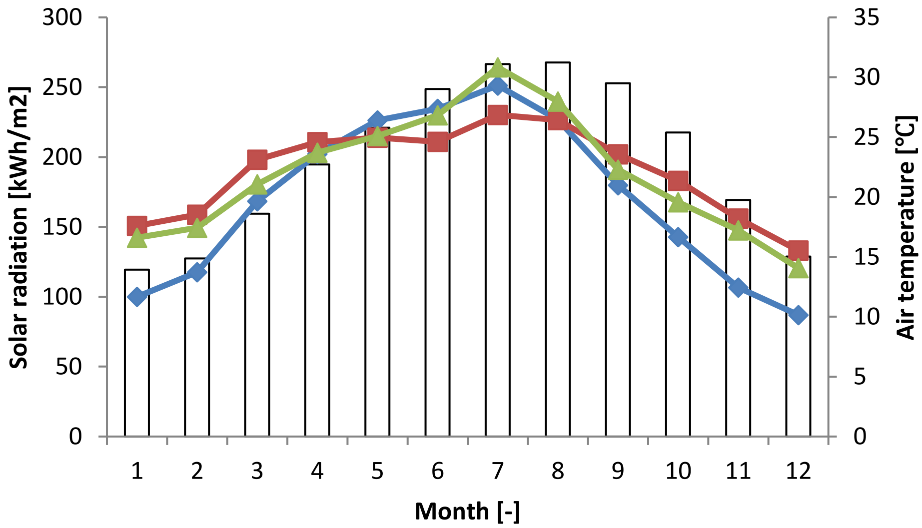


Figure 104: Zawiya

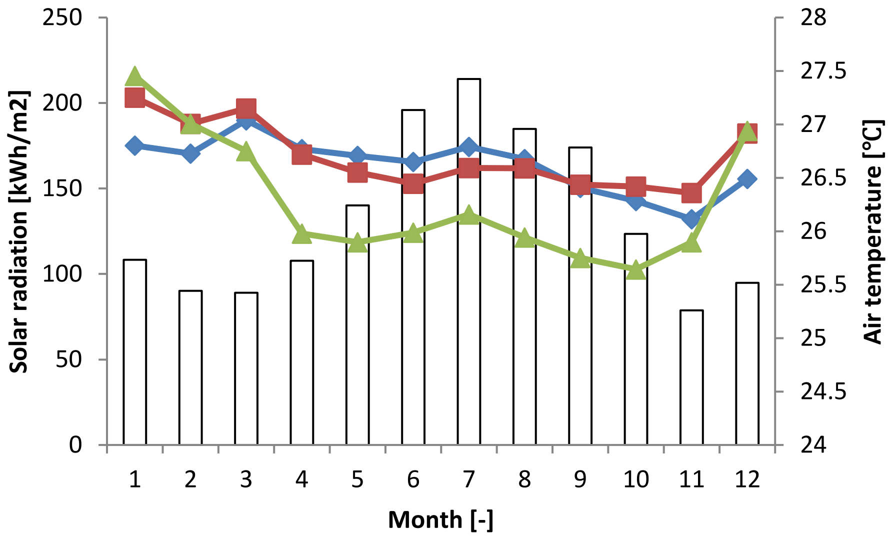


Figure105: Cartegena

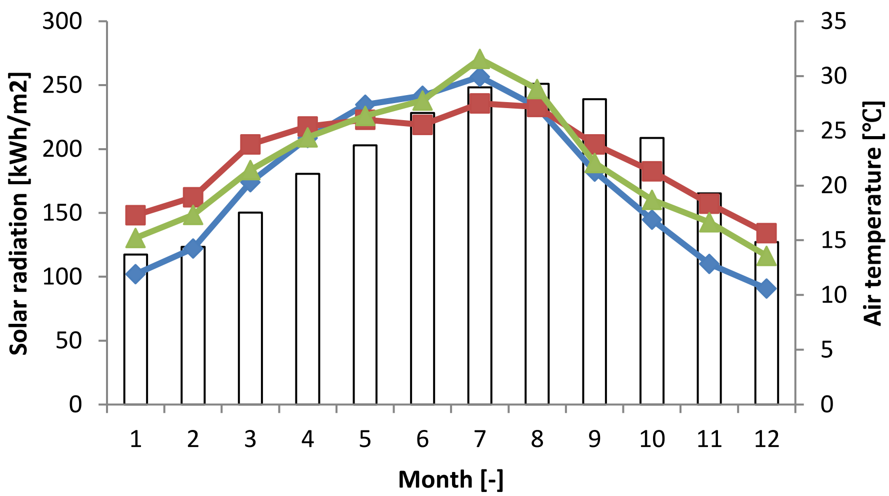


Figure 106: Zliten

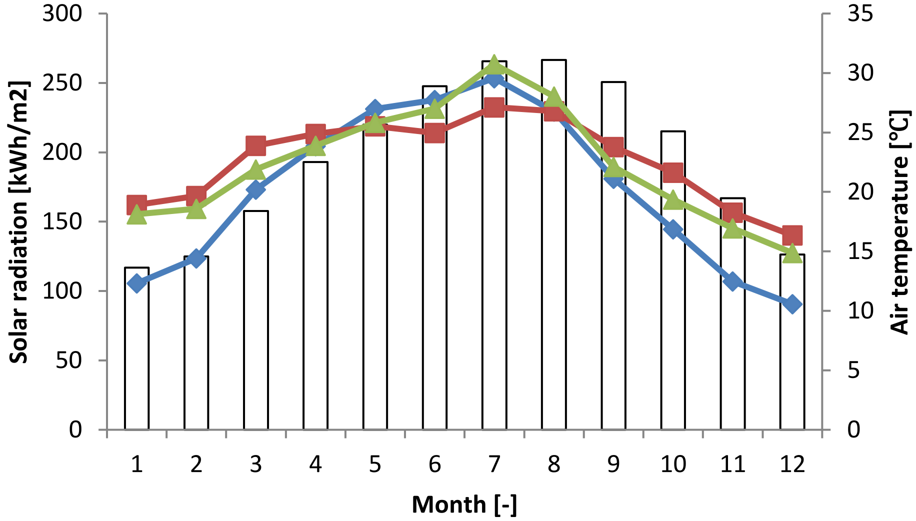


Figure 107: Zuwarah

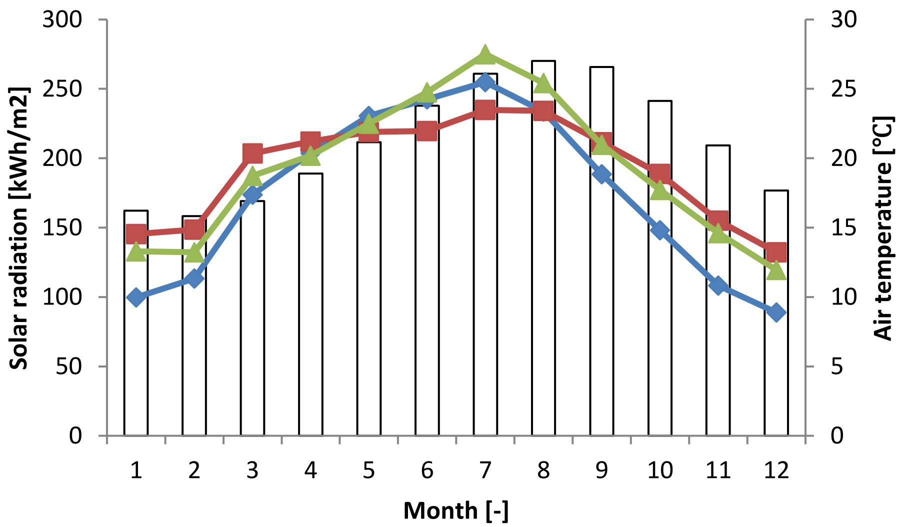


Figure 108: Benghazi

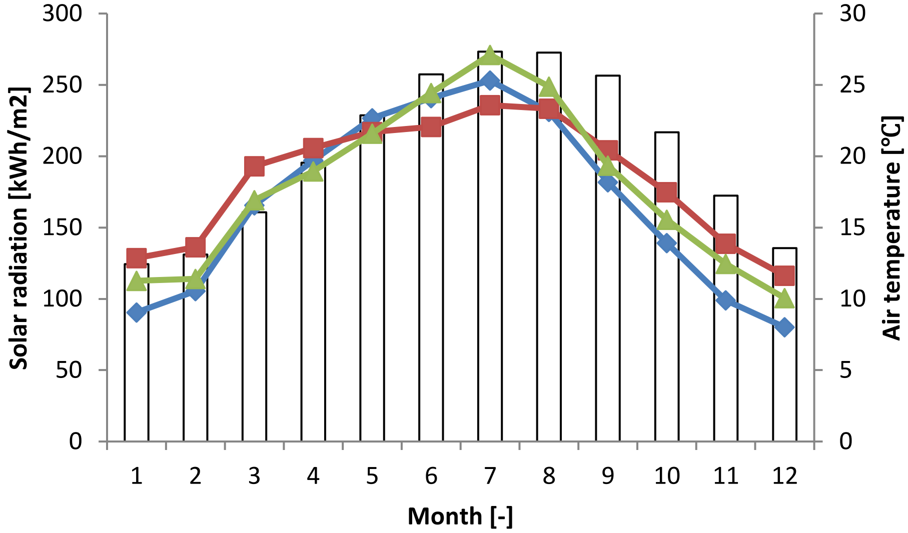


Figure 109: Derna

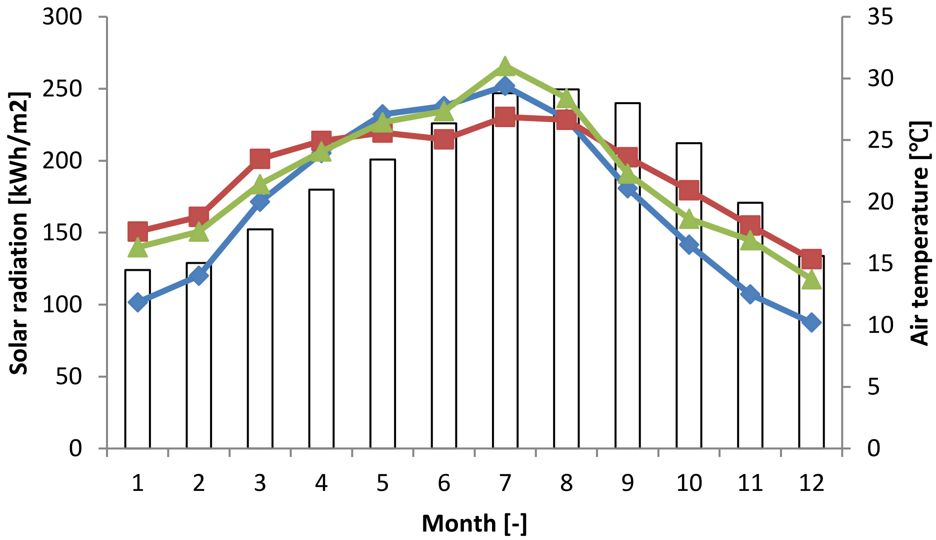


Figure 110: Misurata

5. Algeria

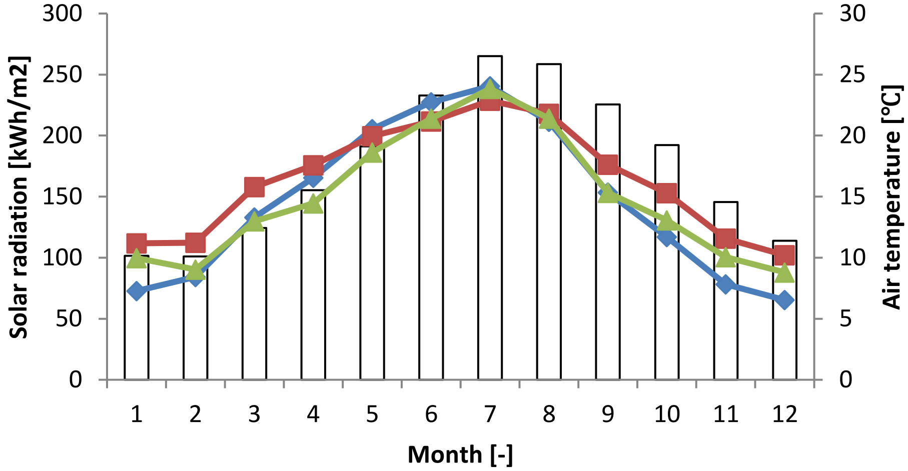


Figure 111: Annaba

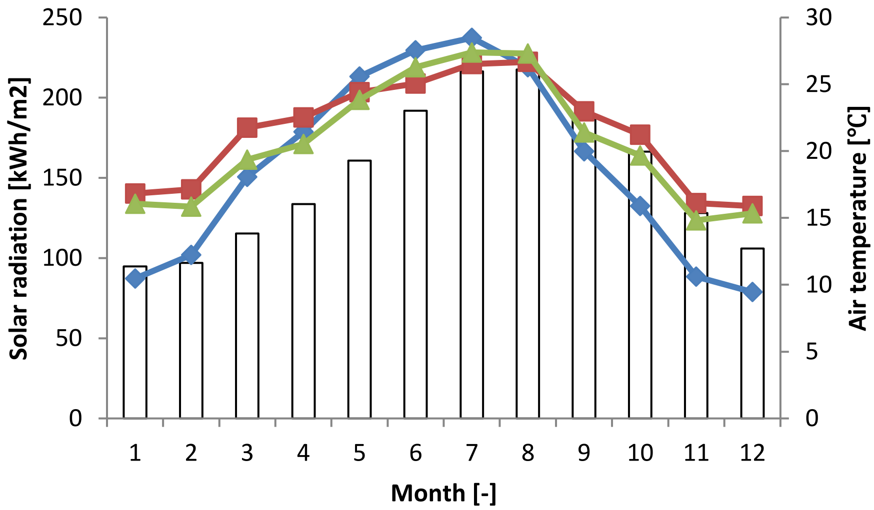


Figure 112: Oran

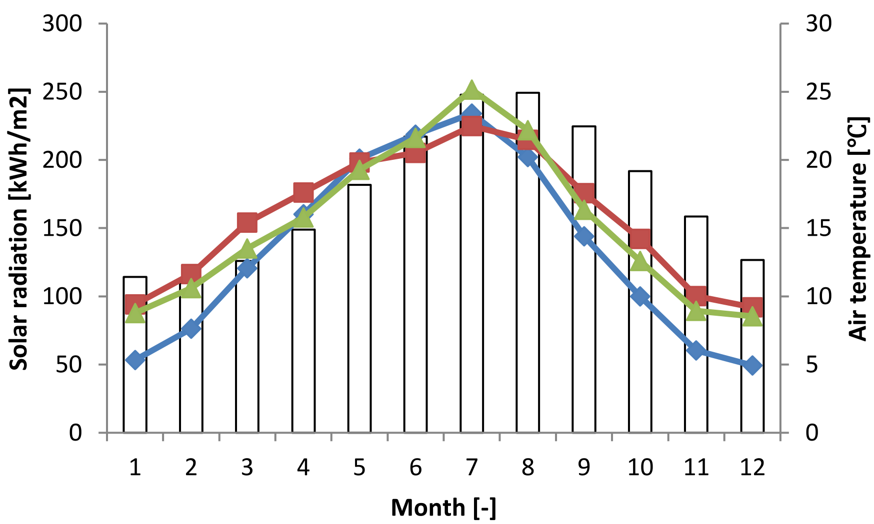


Figure 113: Orbetallo

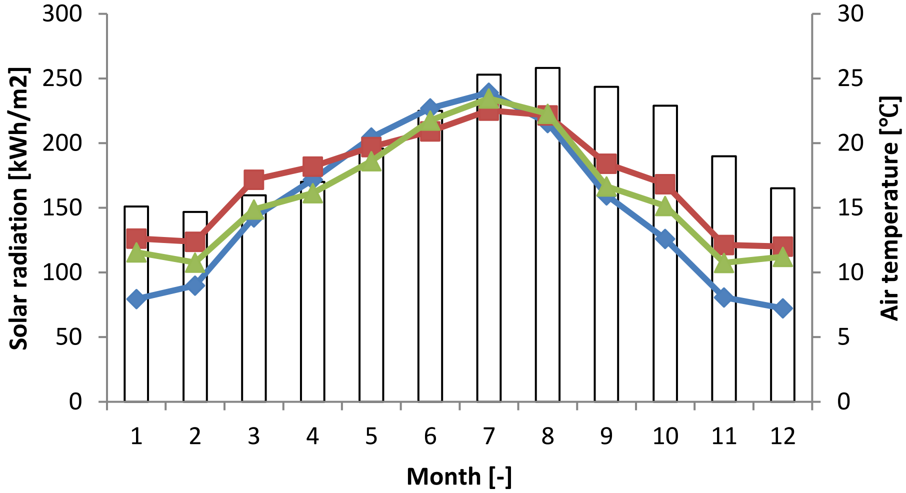


Figure 114: Algiers

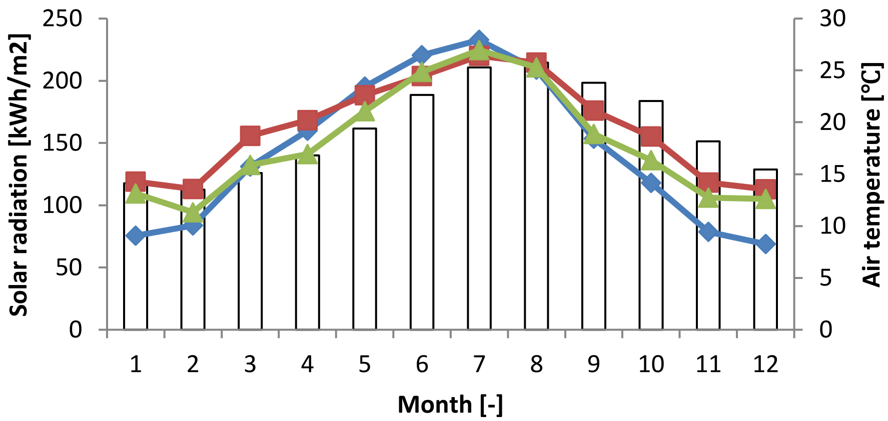


Figure 115: Bejaia

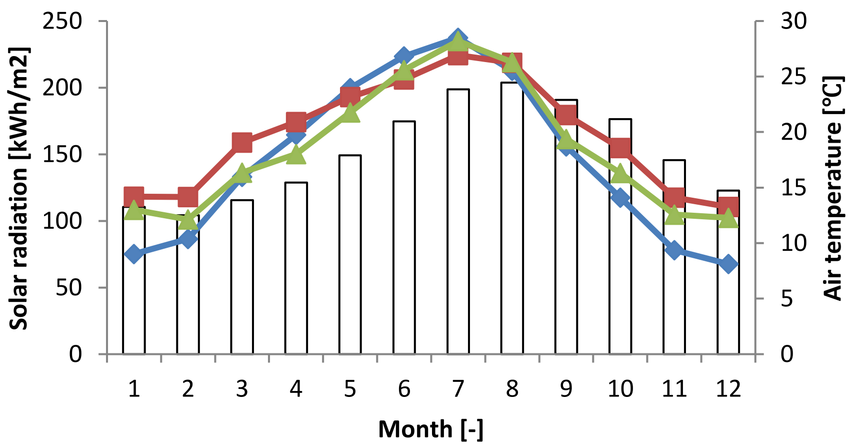


Figure 116: Jijel

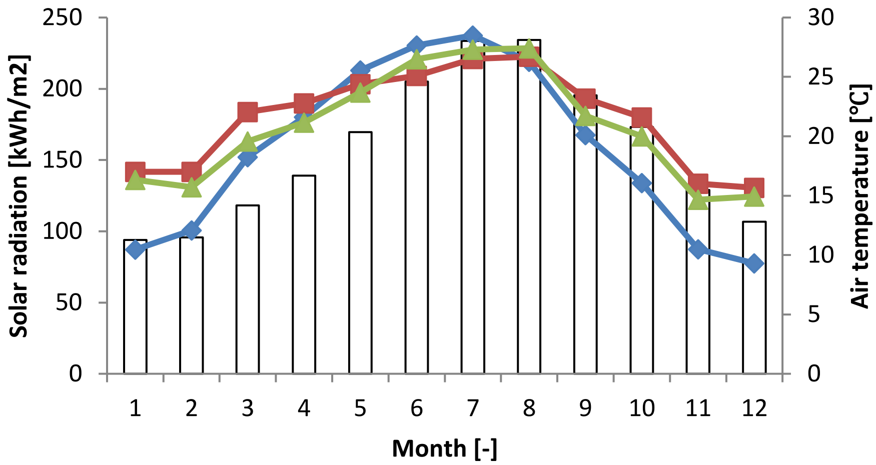


Figure 117: Mostaganem

6. Slovenia

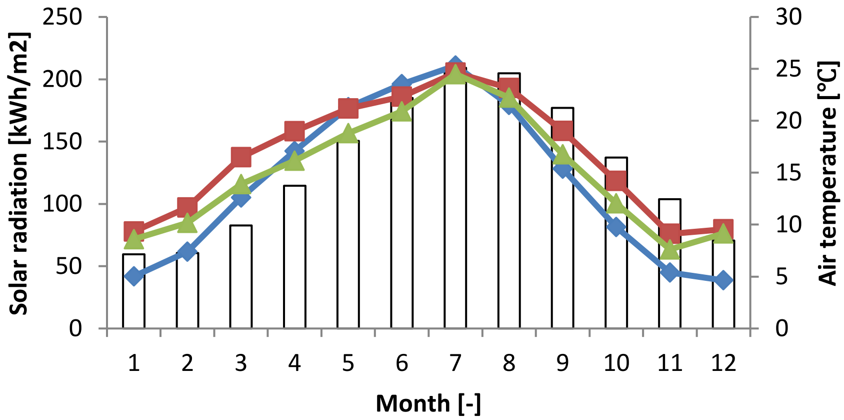


Figure 118: Koper

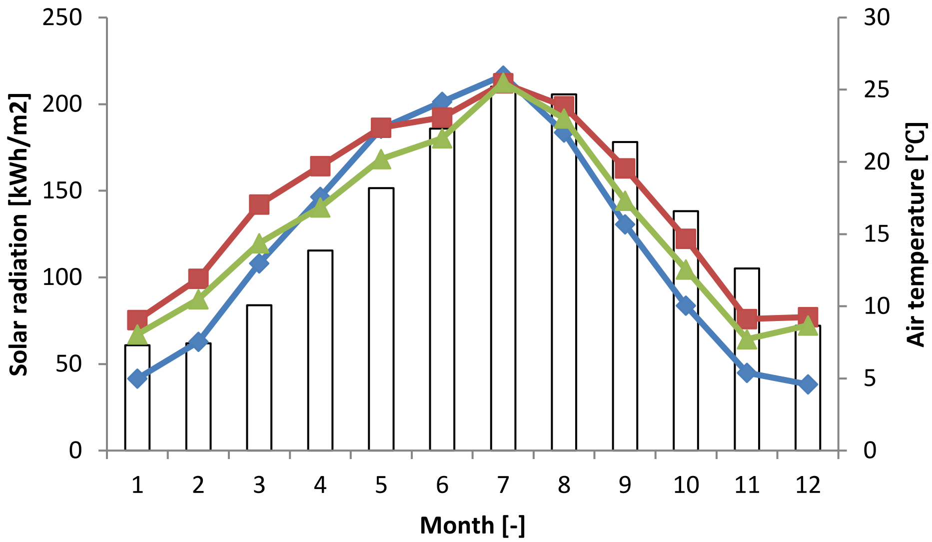


Figure 119: Piran

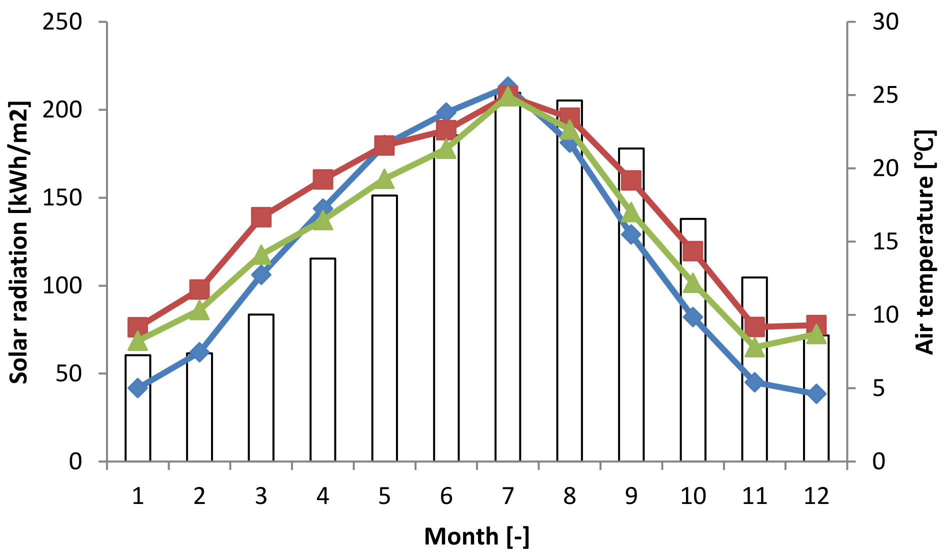


Figure 120: Izola

7. Egypt

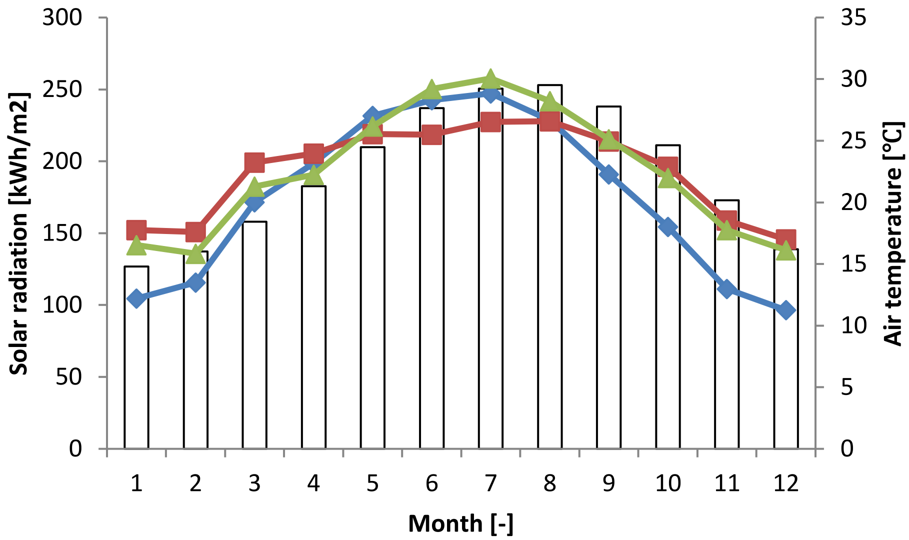


Figure 121: Port Said

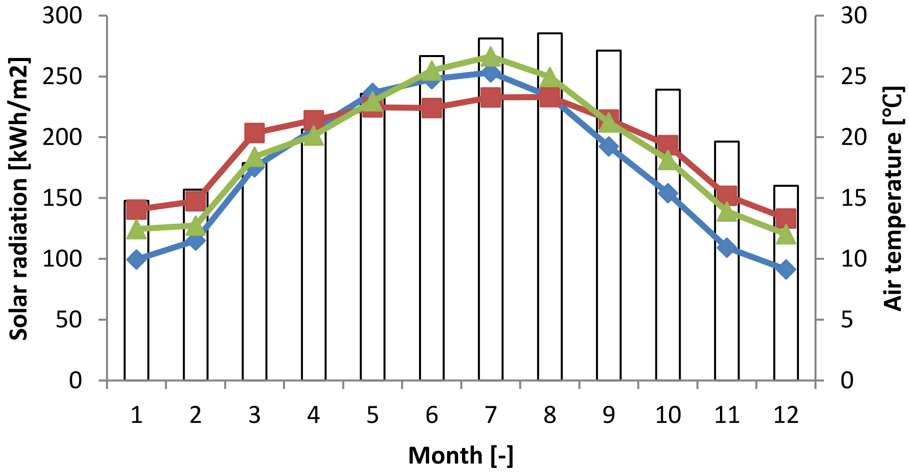


Figure 122: Alexandria

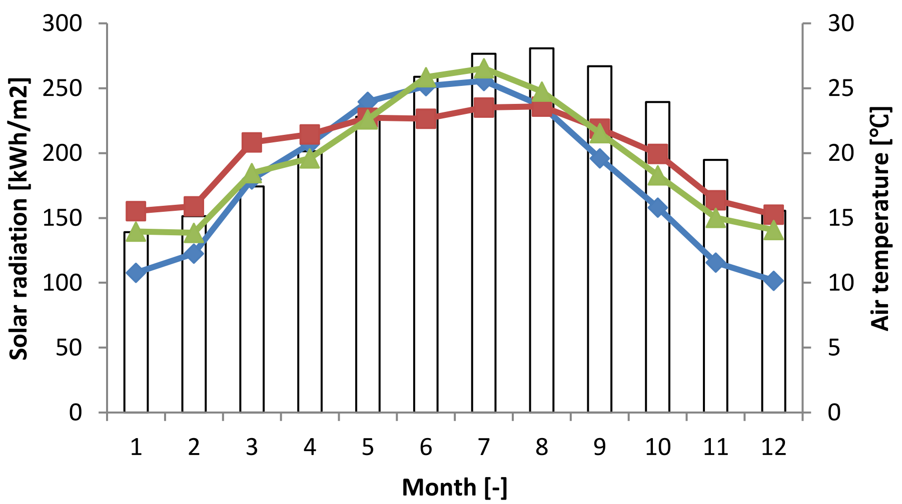


Figure 123: Arish

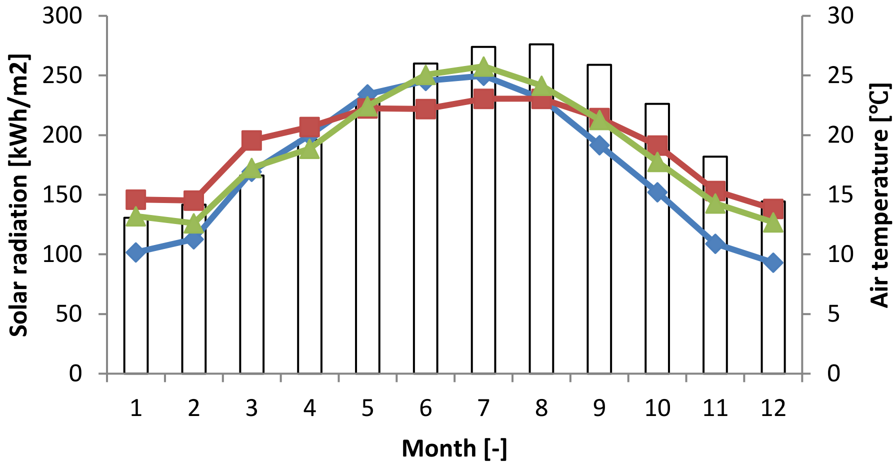


Figure 124: Damietta

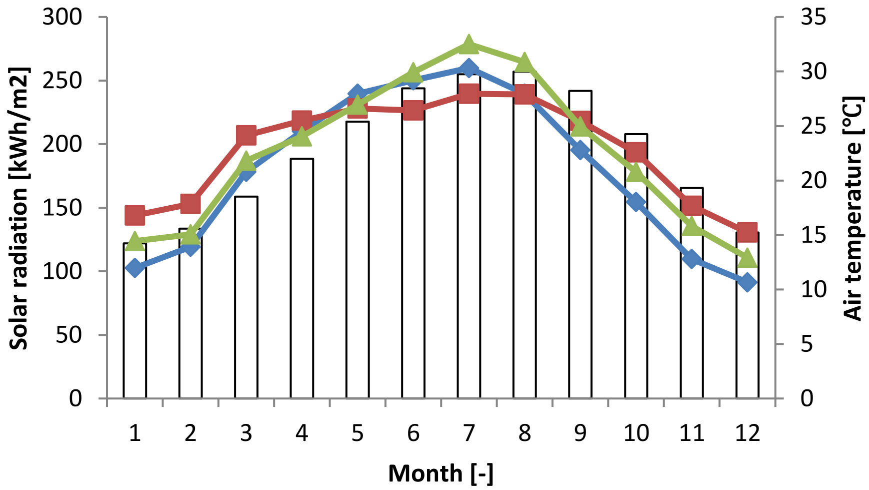


Figure 125: Mersa Matruh

8. Albania

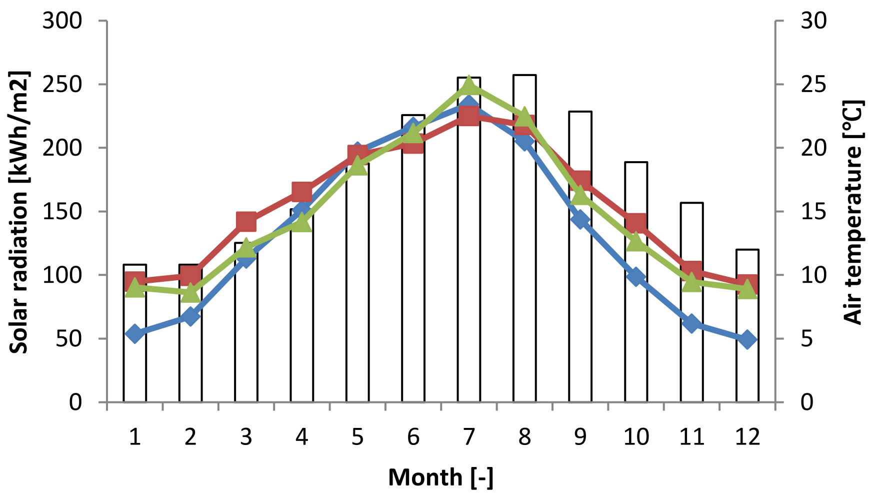


Figure 126: Velipoje

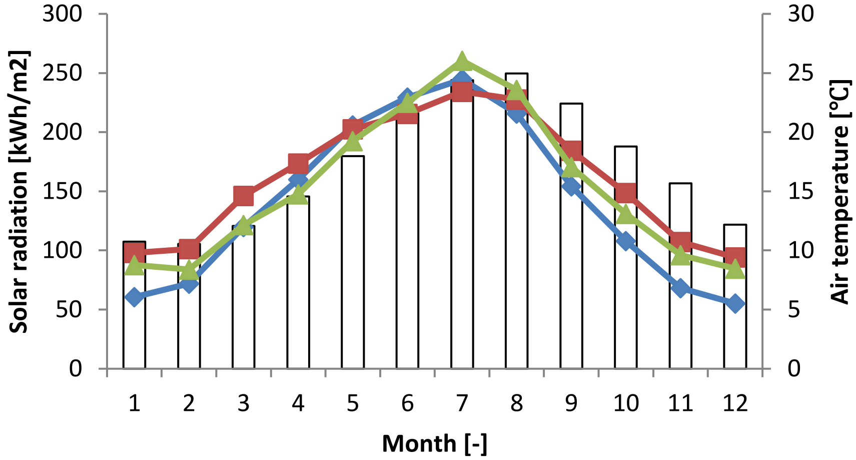


Figure 127: Saranda

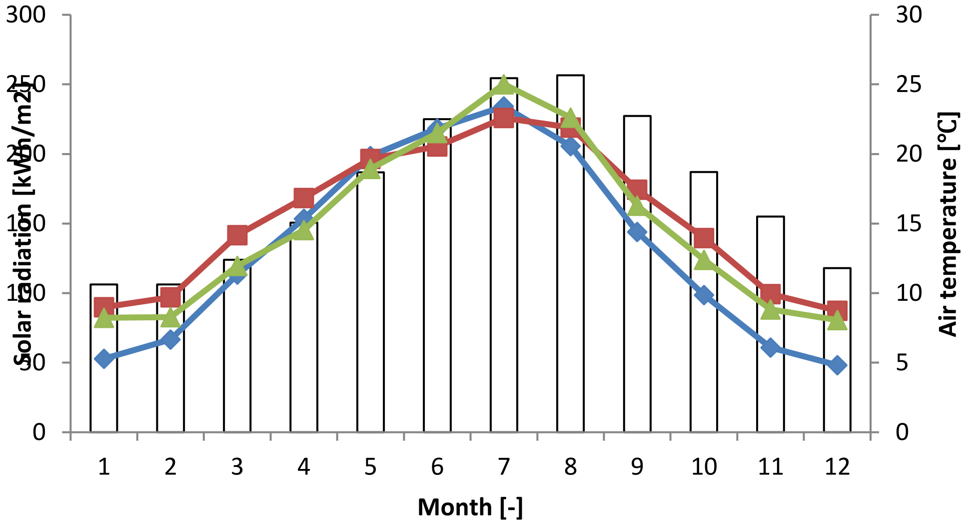


Figure 128: Ulcinj

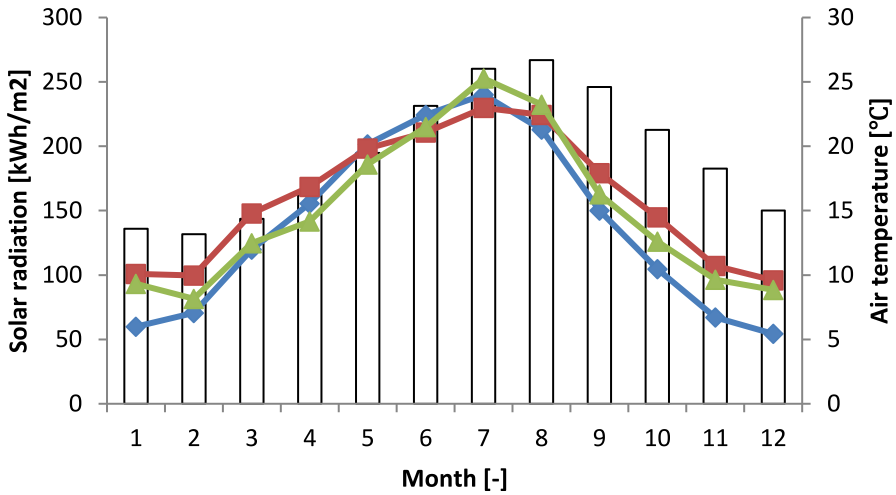


Figure 129: Vlore

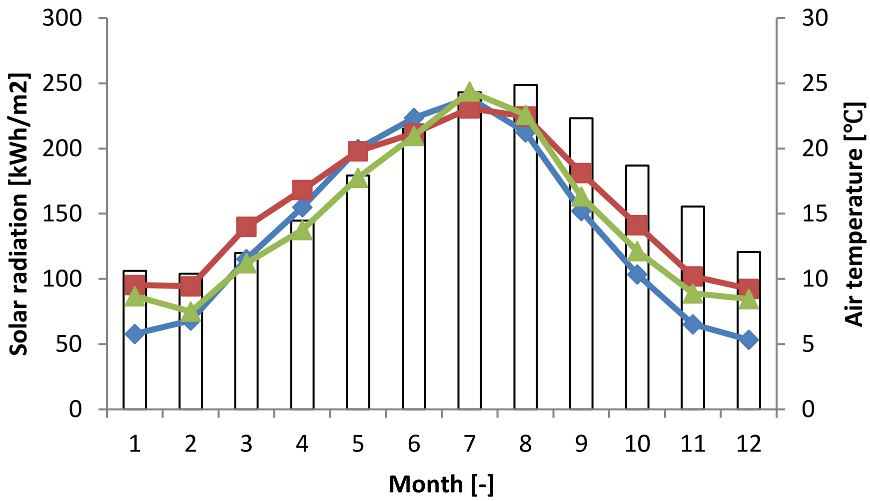


Figure 130: Dhermi

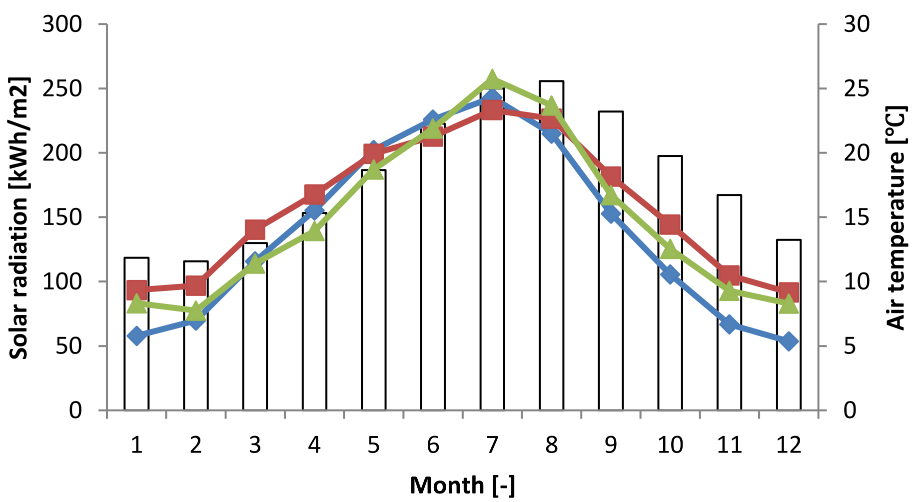


Figure 131: Himare

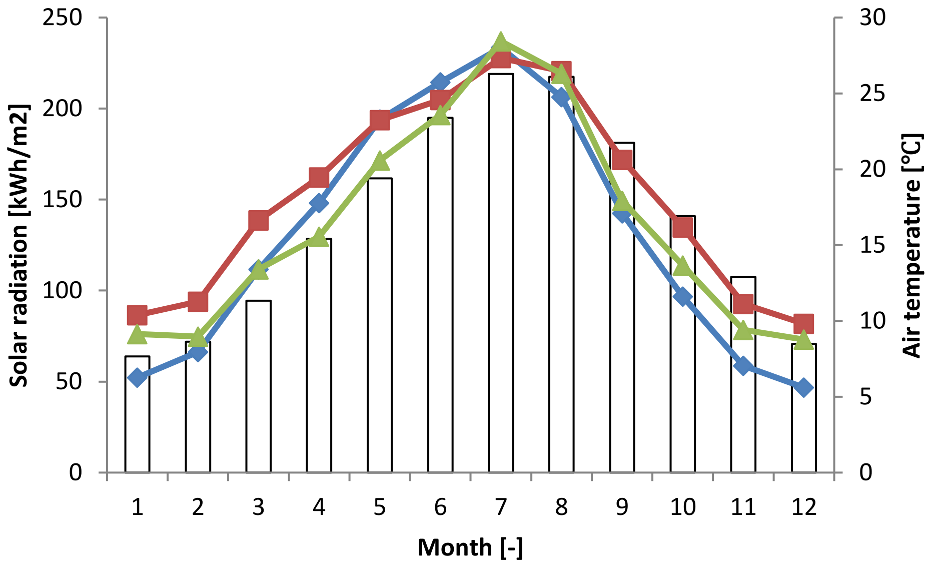


Figure 132: Lezhe

West:

1. France

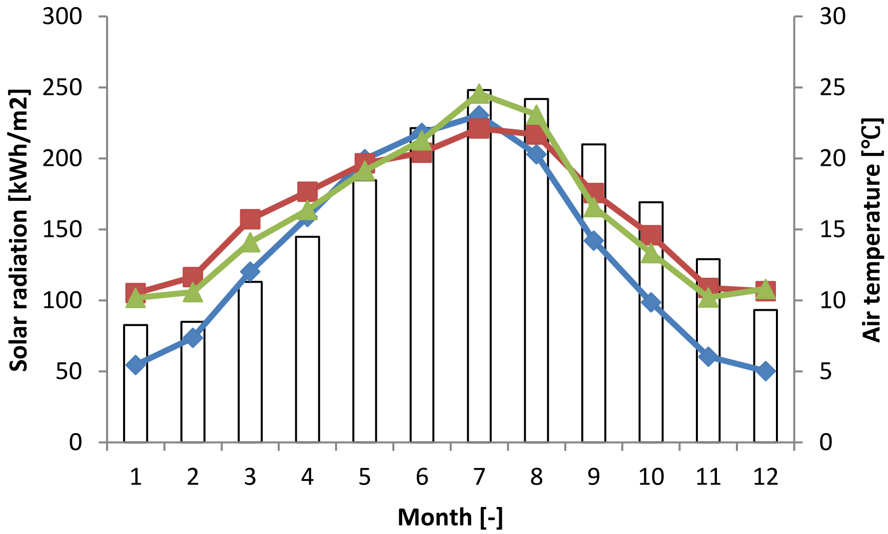


Figure 133: Antibes

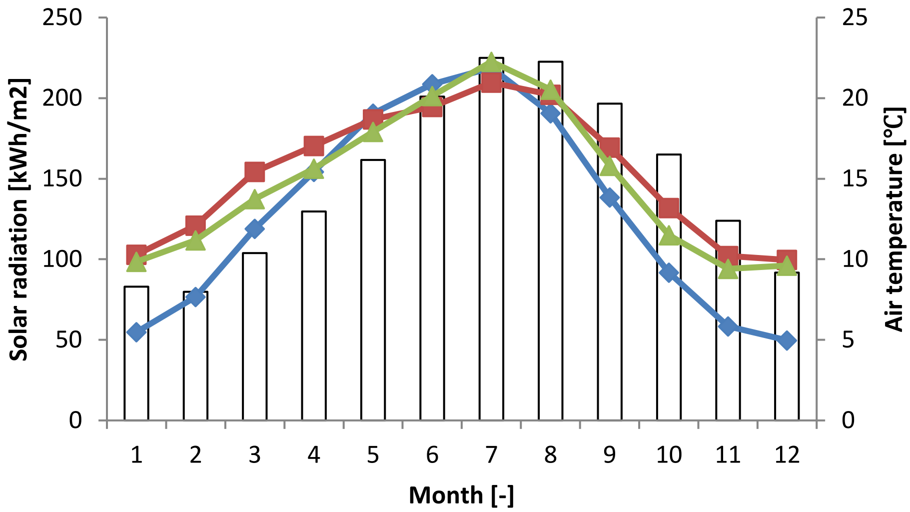


Figure 134: Agde

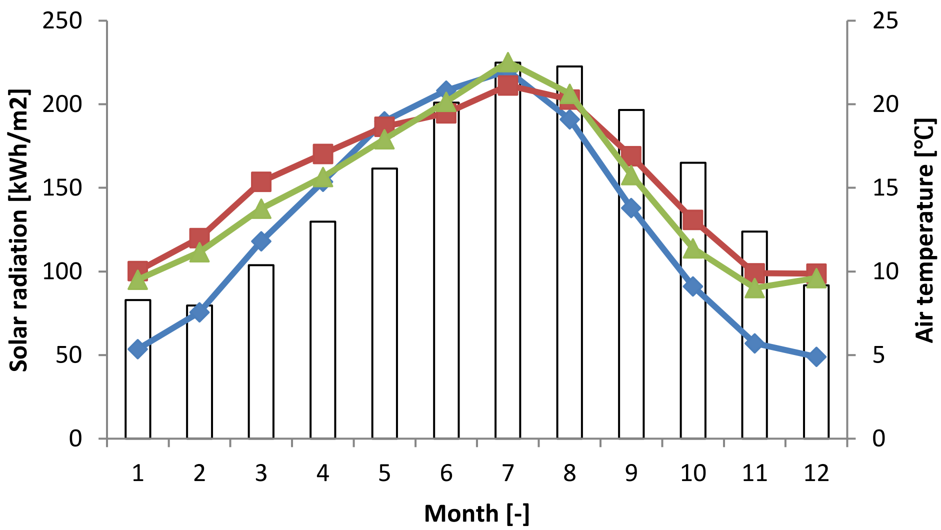


Figure 135: Sete

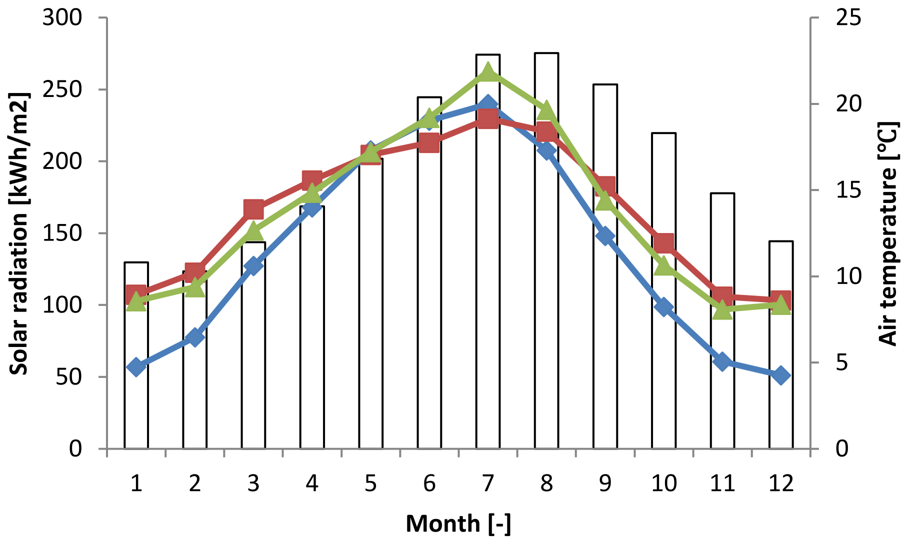


Figure 136: Toulon

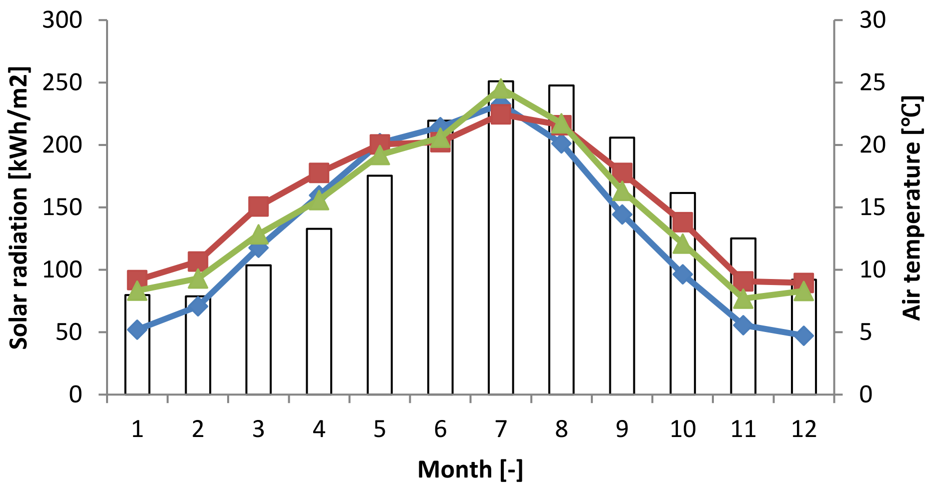


Figure 137: Vis

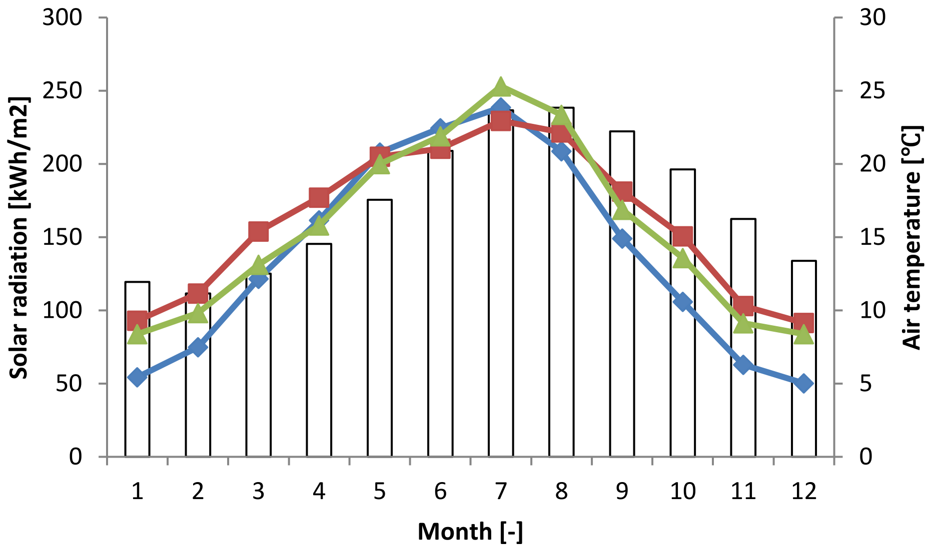


Figure 138: Ajaccio

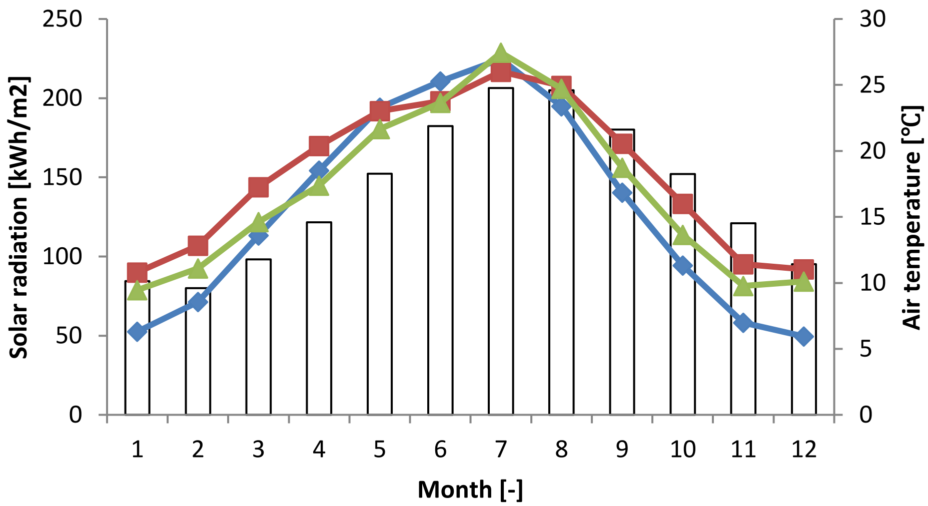


Figure 139: Bastia

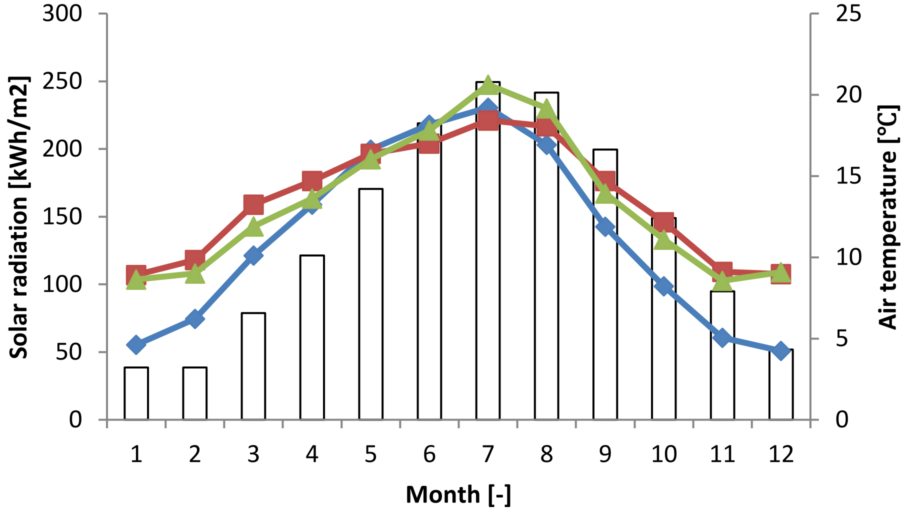


Figure 140: Cannes

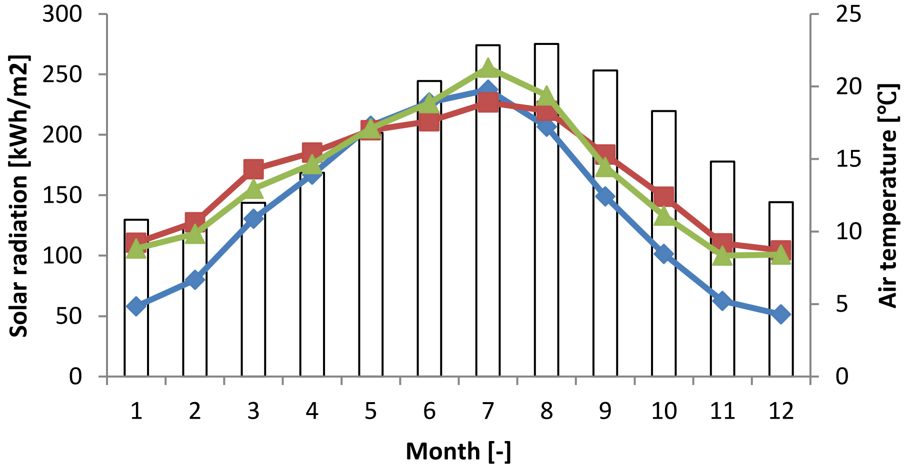


Figure 141: Marseille

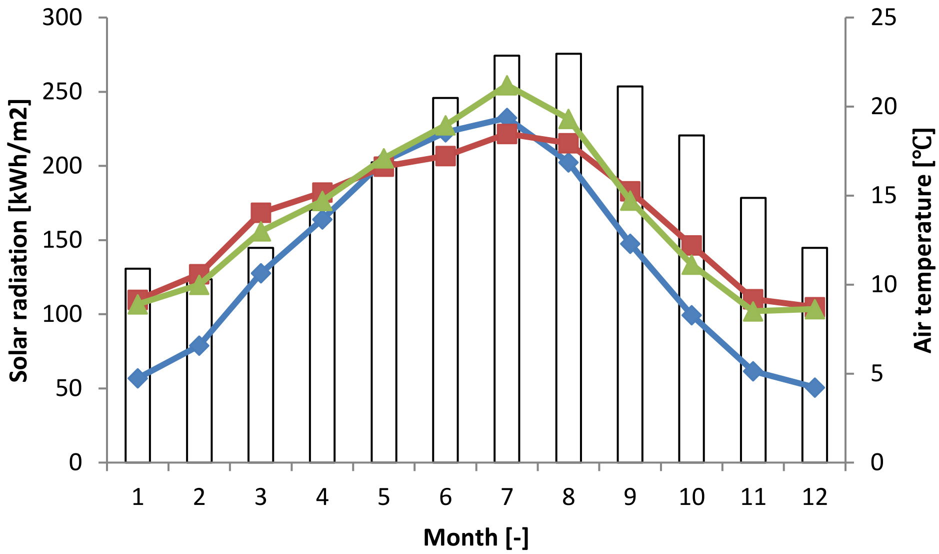


Figure 142: Martigues

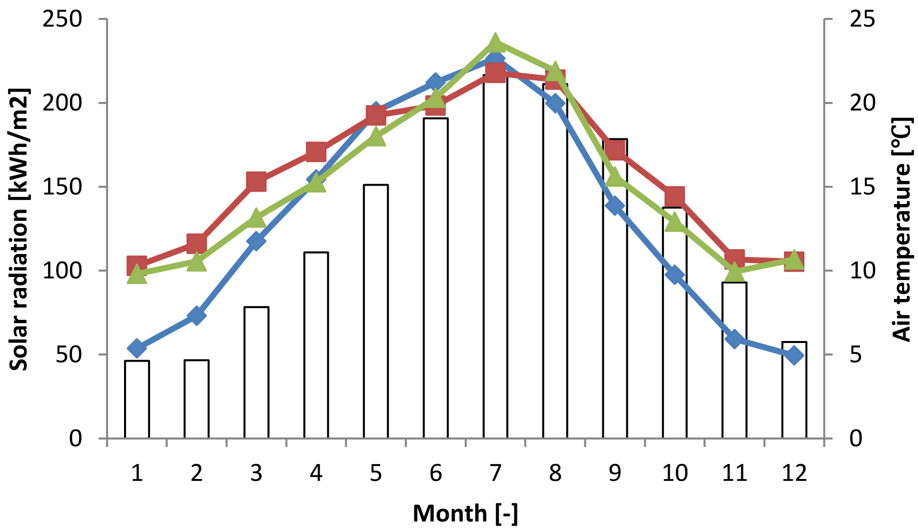


Figure 143: Menton

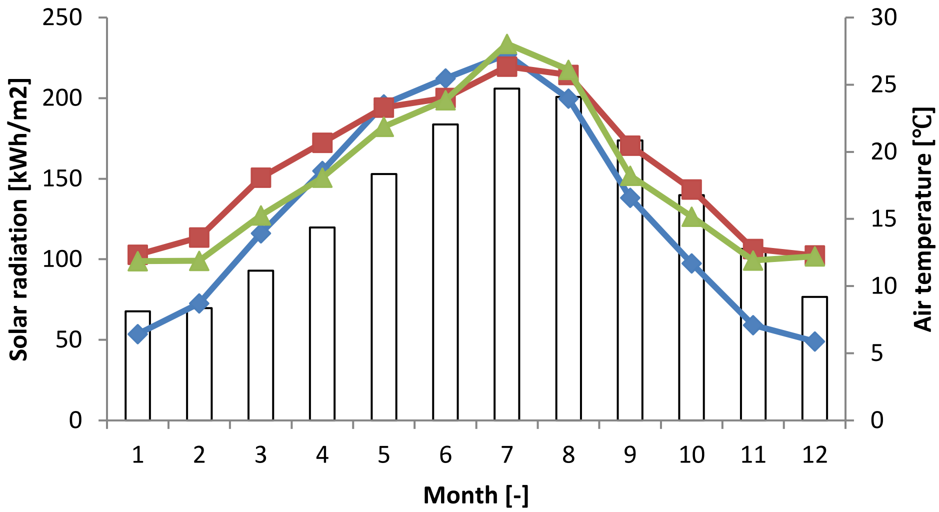


Figure 144: Monaco

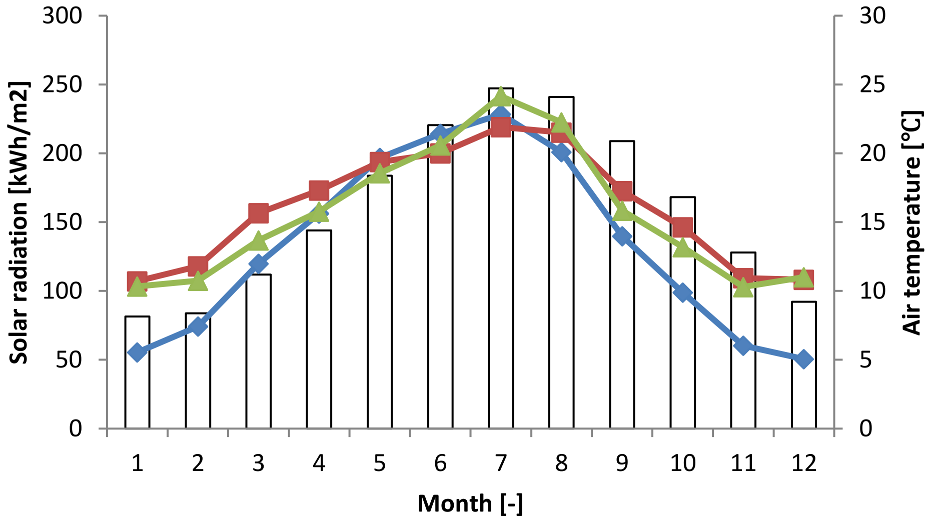


Figure 145: Nice

2. Montenegro

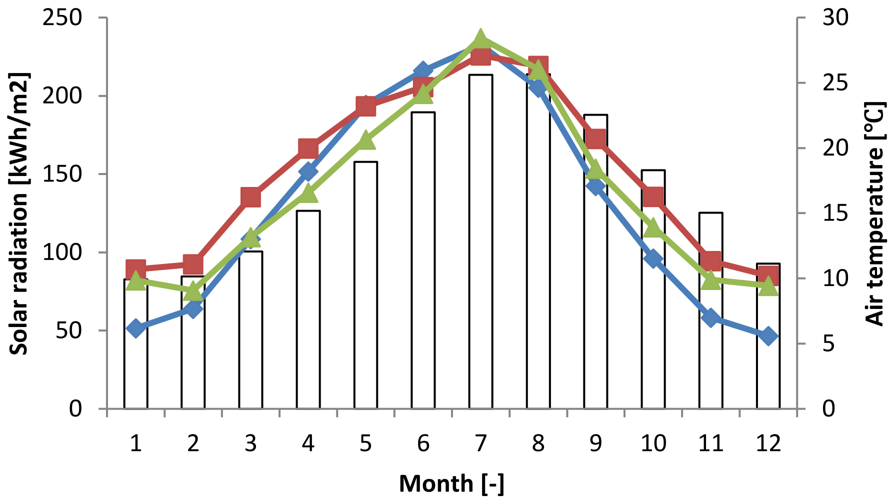


Figure 146: Budva

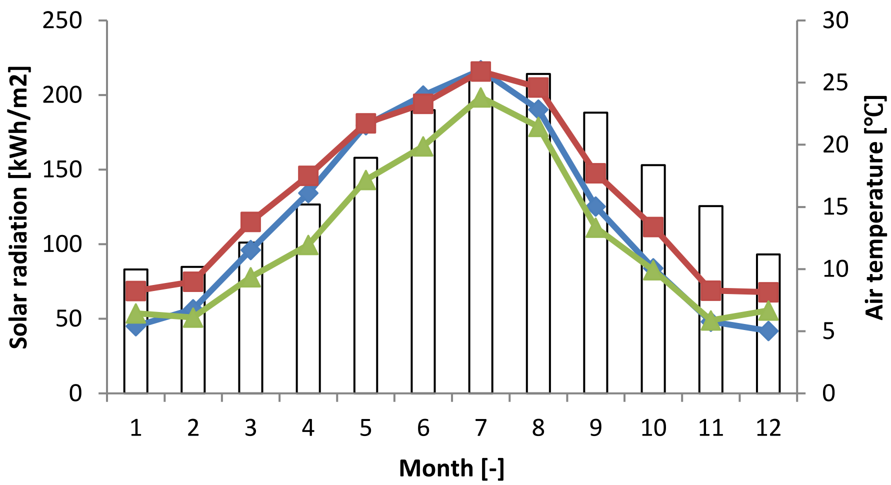


Figure 147: Kotor

3. Syria

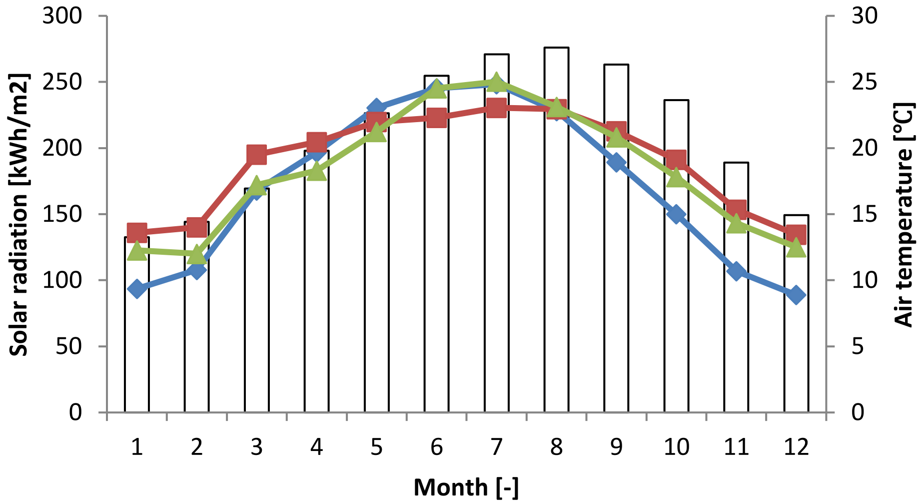


Figure 148: Tartus

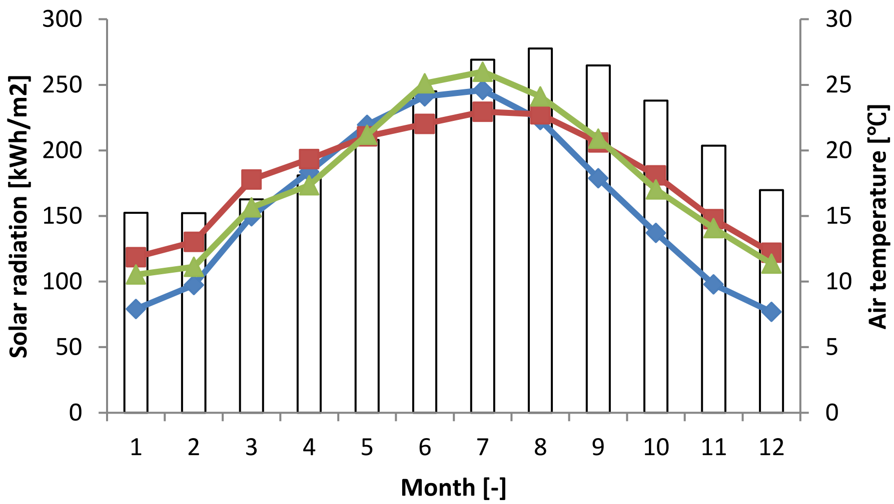


Figure149: Latakia

4. Lebanon

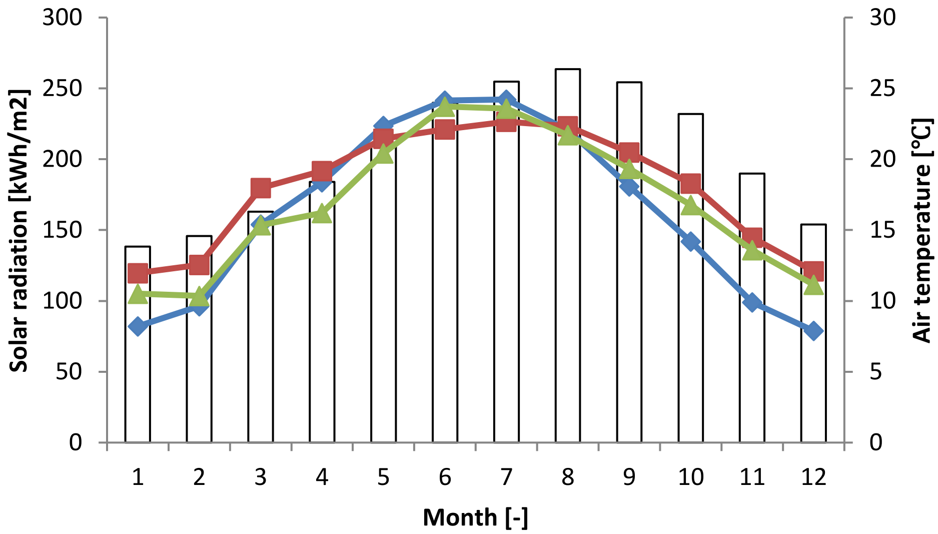


Figure 150: Sidon

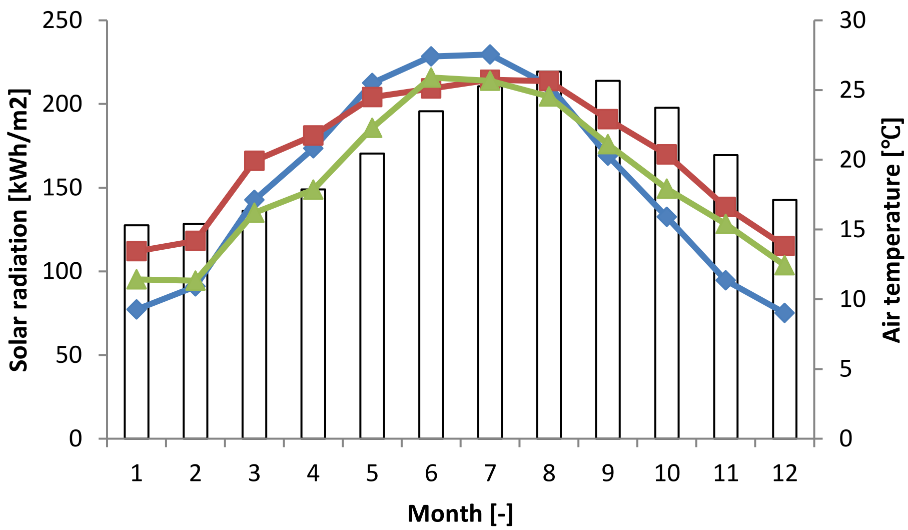


Figure 151: Batroun

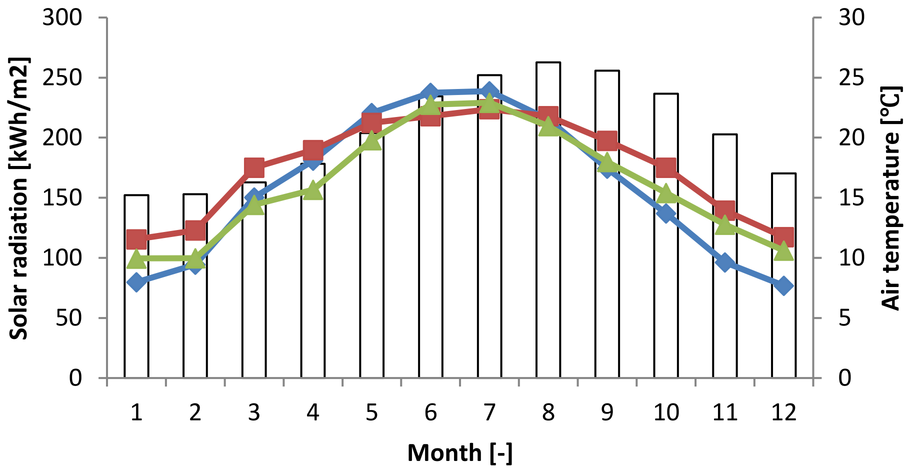


Figure152: Beirut

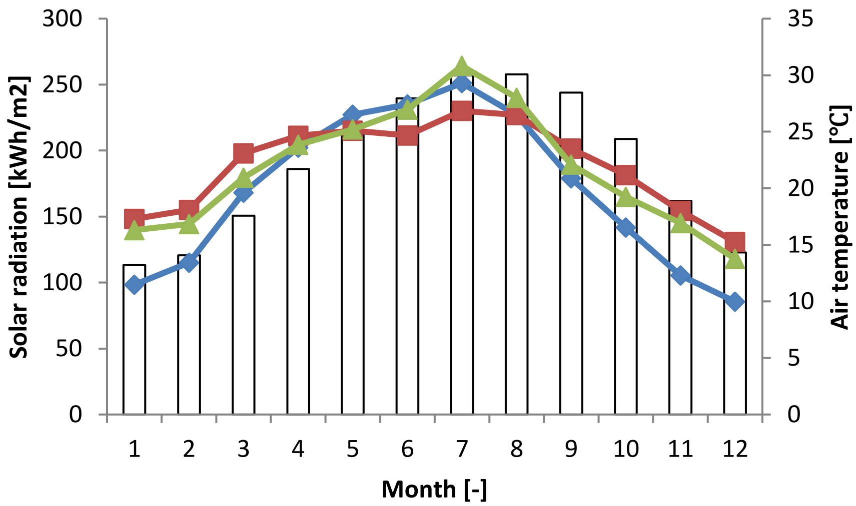


Figure153: Tripoli

5. Palestine

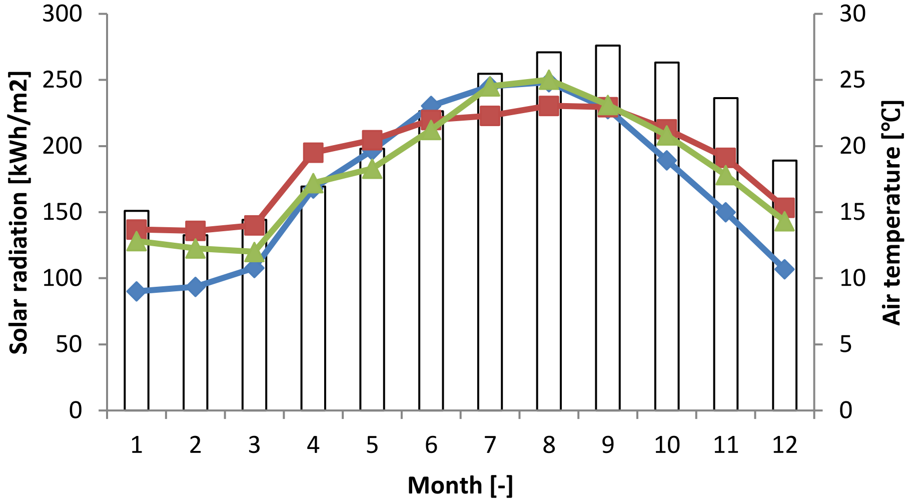


Figure 154: Tel Aviv

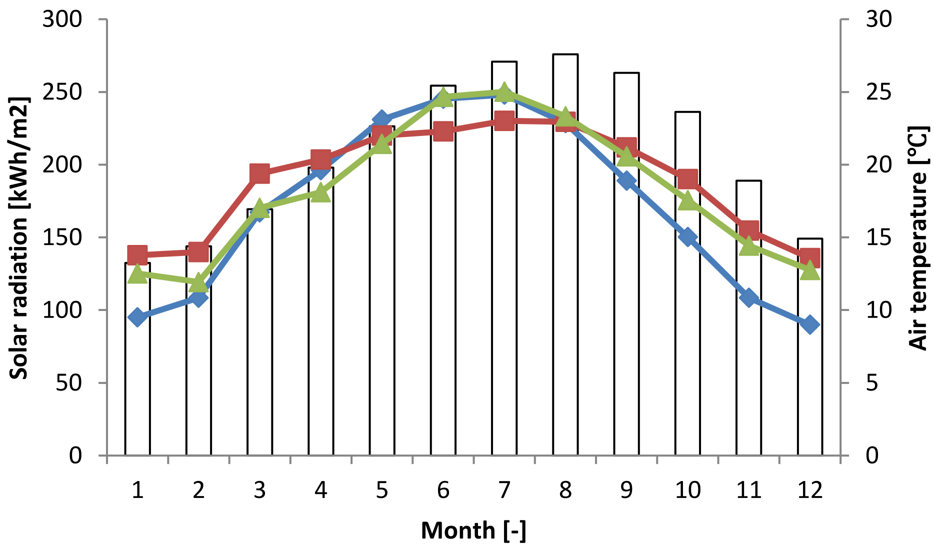


Figure 155: Ashdod

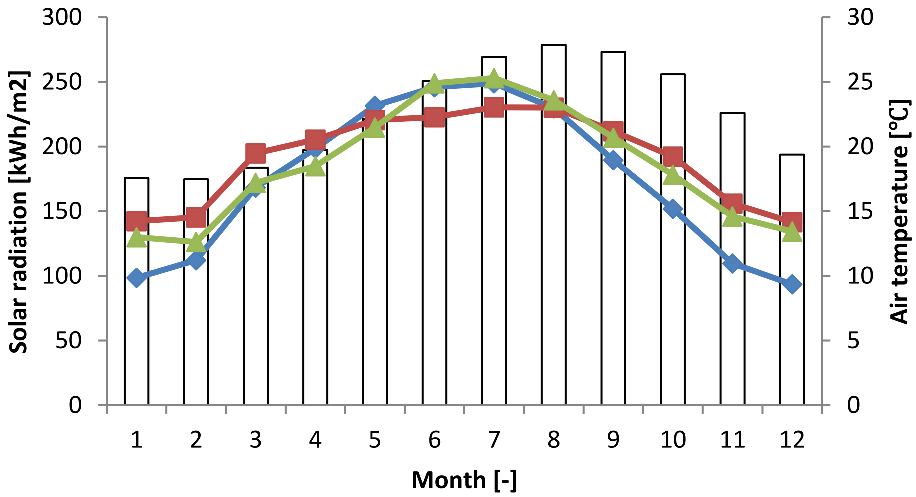


Figure 156: Gaza

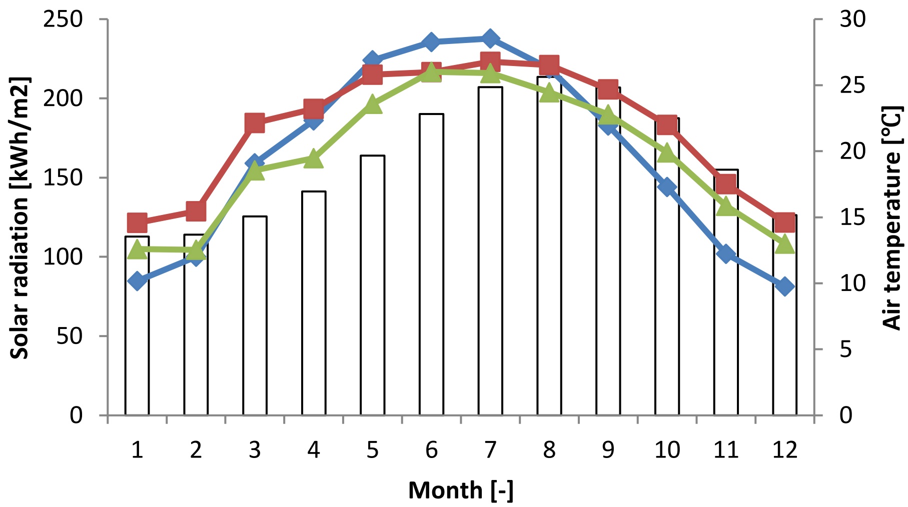


Figure157: Haifa

East:

1. Cyprus

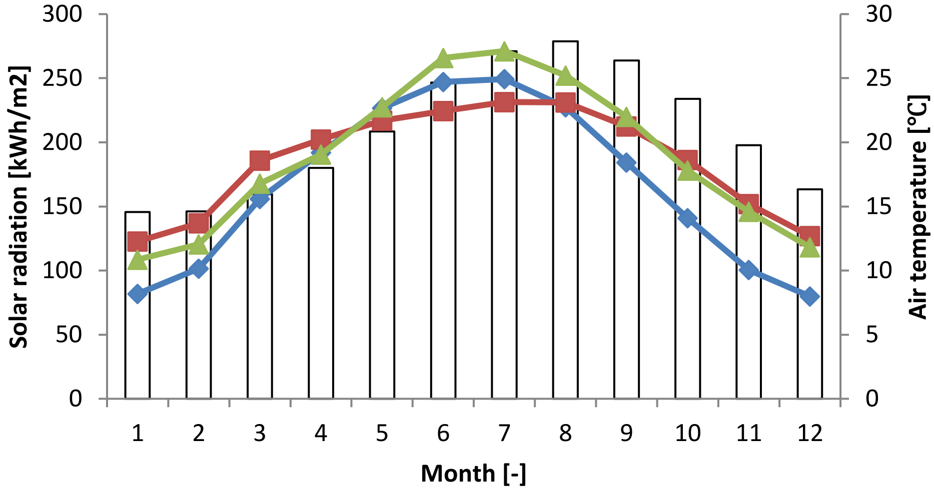


Figure 158: Limassol

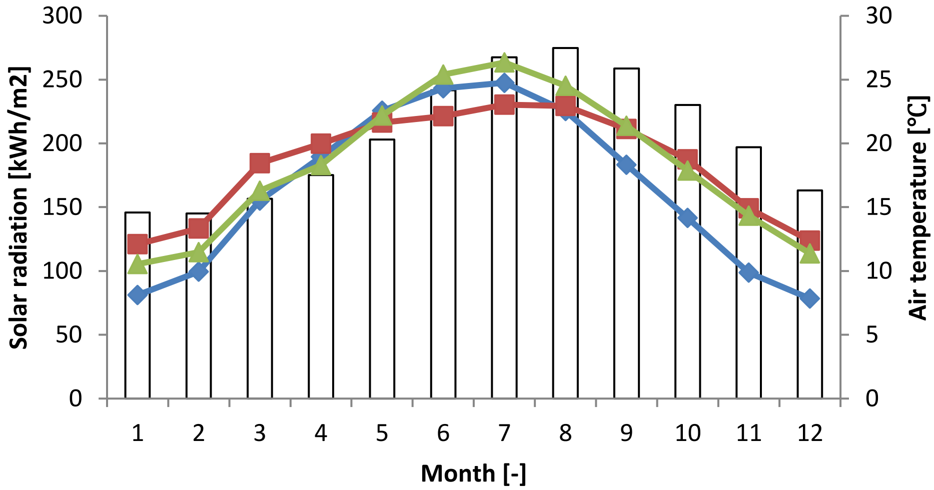


Figure 159: Paphos

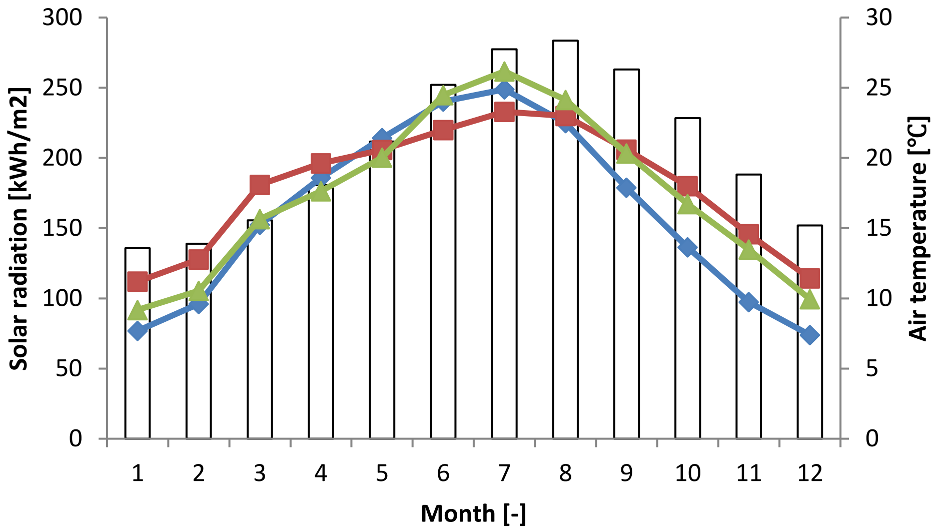


Figure 160: Kyrenia

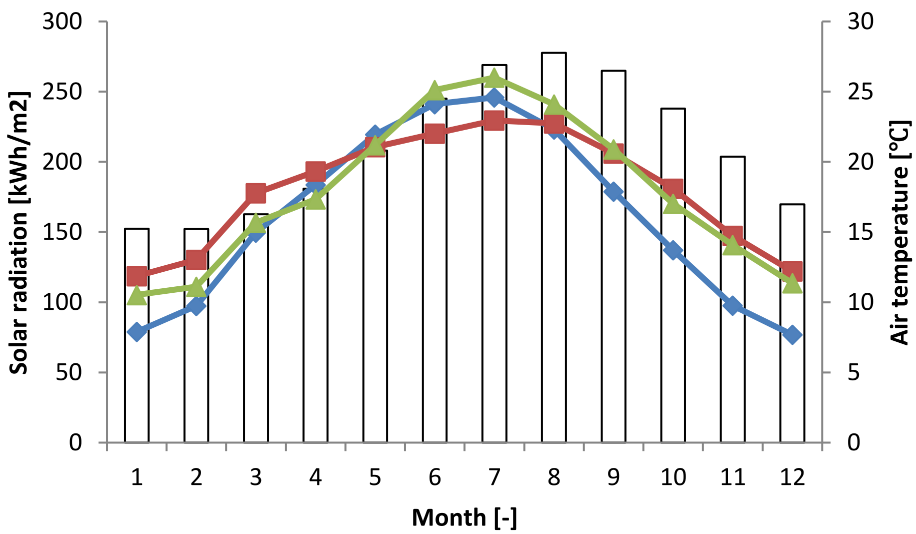


Figure 161: Larnaca

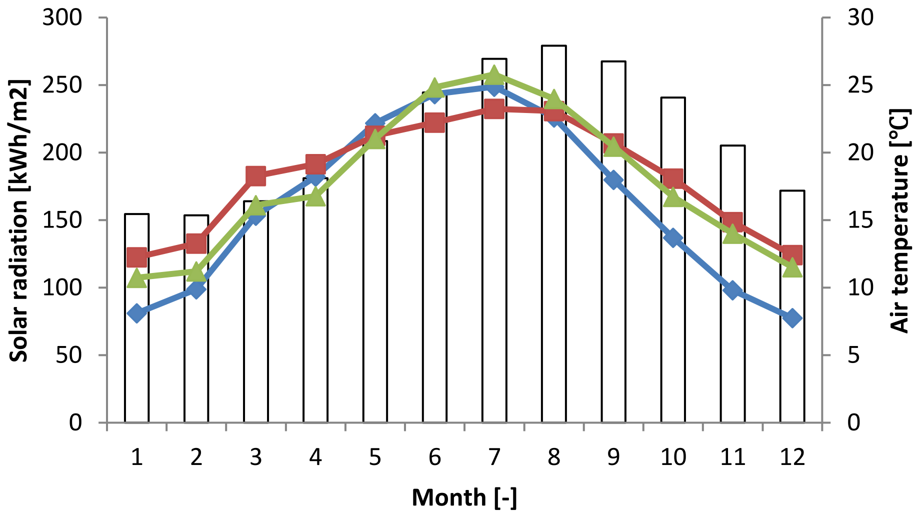


Figure 162: Famagusta

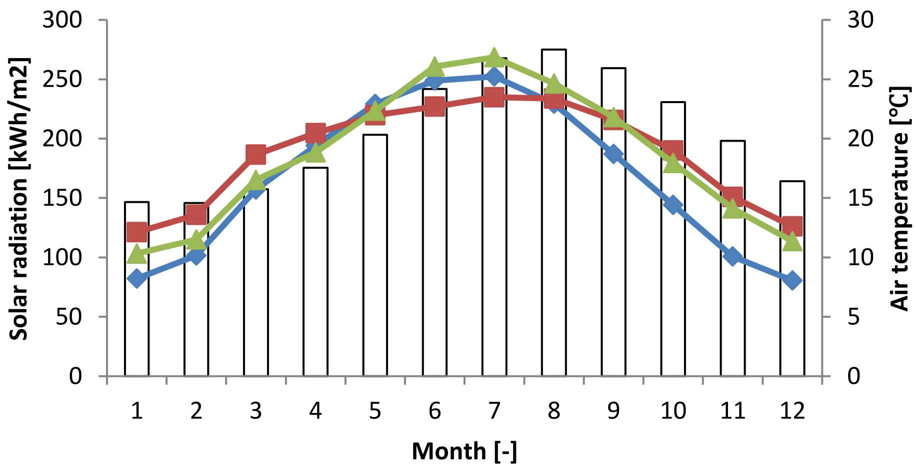


Figure 163: Episkopi

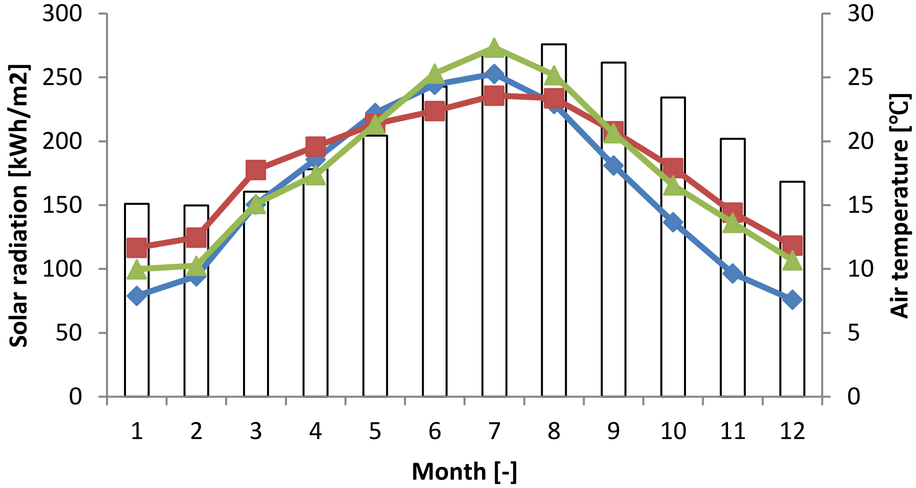


Figure 164: Polis Chrysochous

2. Turkey

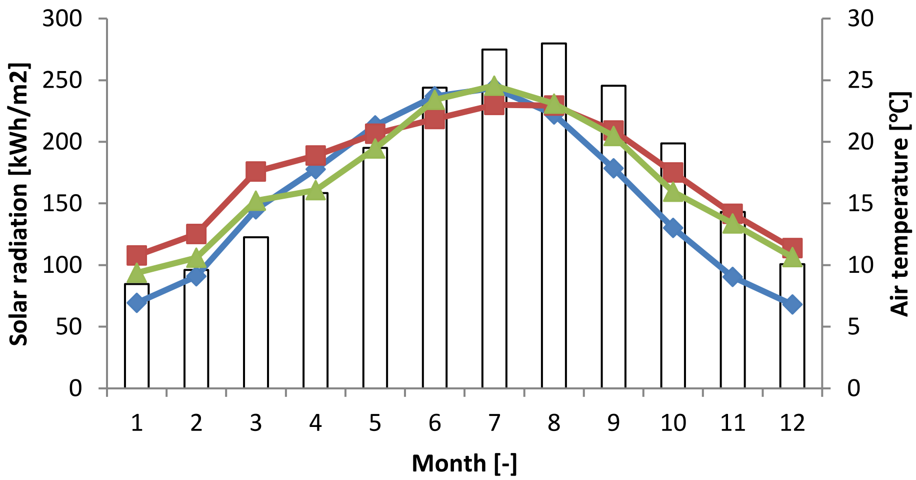


Figure 165: Mersin

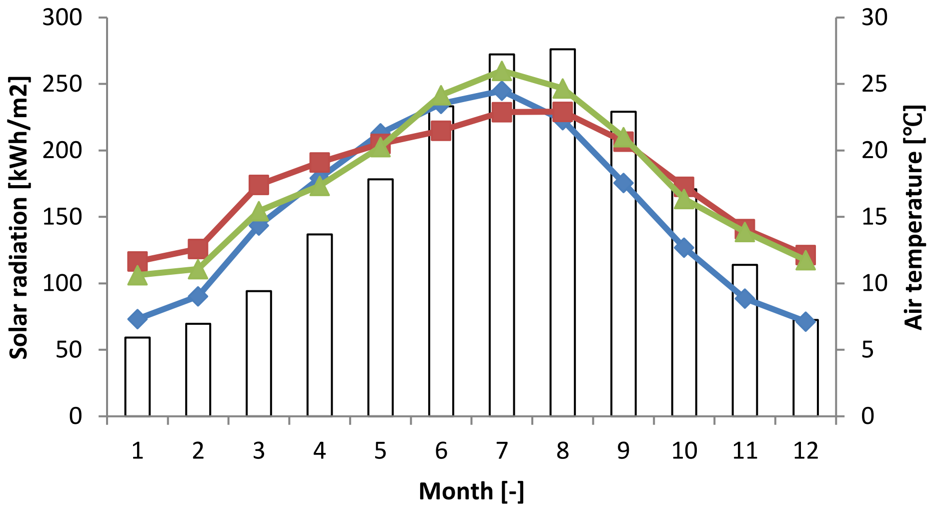


Figure 166: Antalya

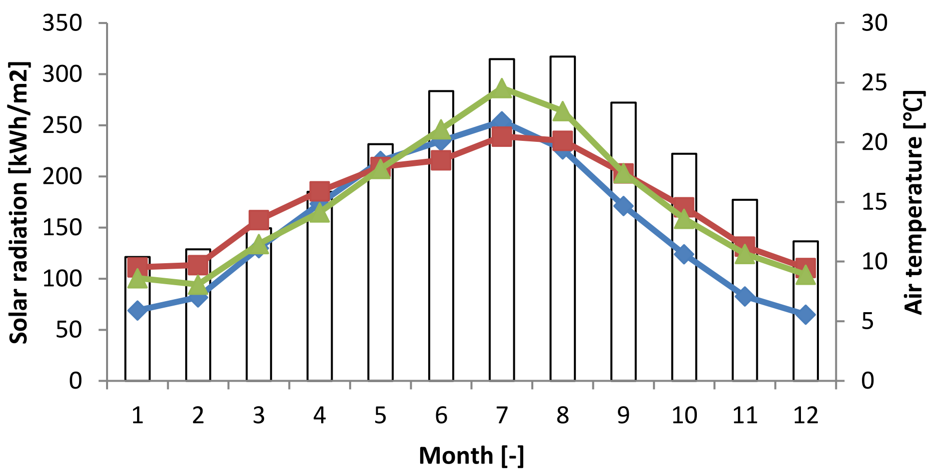


Figure 167: Izmir

CHAPTER V

Conclusion

Solar energy is undeniably a clean, pollution-free, and sustainable source of energy. The development of this source of energy necessitates a precise, long-term understanding of the potential, taking seasonal fluctuations into account. The region of the earth between the latitudes of 401N and 401S, also known as the solar belt, is a region with an abundant amount of solar radiation. Arish being located between latitudes 31.1321° N and 33.8033° E has a geographic position that favours the harvesting and development of solar energy. Arish receives global solar radiation in the range of 2171-2396 kWh/m2 with respective to irradiation on horizontal plane and irradiation on a plane. Global solar radiation during the season of monsoon is less compared to winters and summers due to the denser clouds. This study identifies that Arish appears to be ideally suited for harvesting solar energy. Some of the limitations that occurred in this research were as follows; solar panels require space, cost of placement, initial materials for construction of solar panel can lead to pollution and negative energy balance. The study has also demonstrated the potential of solar radiation near the coastal region of the Mediterranean and has successfully determined the most suitable location for the placement of solar energy.

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