Sustainable Energy and Climate Action Plan for Monastir Municipality

December 2019

This Sustainable Energy and Climate Action Plan has been developed by Royal Scientific Society (RSS) /National Energy Research Center (NERC) through The MENA Region Initiative As a Model of NEXUS Approach and Renewable Energy Technologies (MINARET) project.

RSS/NERC and MinaRET project would like to deeply thank the Municipality of Monastir for their continuous support and contribution.

Table of Contents

List of Tables

List of Figures

List of Abbreviations

BAU: Business As Usual

BEI: Baseline Emissions Inventory

CoM: Covenant of Mayors

EF: Emission Factor

HDD: Heating Degree Days

ICCS: Institute of Communications and Computer Systems

IEA: International Energy Agency

IPCC: Intergovernmental Panel on Climate Change

LPG: Liquefied Petroleum Gas

MEW: Ministry of Energy and Water

NERC: National Energy Research Center of Jordan

RSS: Royal Scientific Society.

SECAP: Sustainable Energy and Climate Action Plan

ME: Ministry of Environment.

ANME: National Energy Control Agency (Agence nationale pour la maîtrise de l'énergie)

Executive Summary

Monastir is a city on the central coast of Tunisia, in the Sahel area. It is 20 kilometers (12 miles) south of Sousse and 162 kilometers (101 miles) south of Tunis, the capital. Traditionally a fishing port, Monastir is now a major tourist resort. Its population is about 101,934. It is the capital of Monastir Governorate. [1]

Monastir municipality has committed to a 40% reduction of the municipality's GHG emissions as well as to an adaptation in climate change for 2030. The involvement of all citizens and stakeholders of the municipality is considered crucial for achieving the set targets. The citizens are the most important resource for the city, especially in the GHG saving targets. Within the framework of potential participation in the Covenant of Mayors for Climate and Energy Initiative, the scenario of mitigation actions has been developed for Monastir, reaching up to 40% against the calculated 2030 emissions (379,998 tn CO_2). The achievement of this scenario is conditional upon the funding availability from grants, international donors and financing institutions.

Regarding the total budget for the SECAP's implementation (40%) the total cost for the Municipality is calculated at 43 million USD, while for the private sector has been estimated at 230 million USD approximately, resulting in an overall budget of 273 million USD.

The energy balance for Monastir Municipality (Baseline Emissions Inventory) has been developed for 2016, in line with the CoM guidelines and utilizing the IPCC emission factor approach, for all the compulsory sectors and one optional, namely:

A. Buildings, Equipment & Facilities
   - Municipal Buildings, Equipment and Facilities
   - Public lighting
   - Residential buildings
   - Tertiary buildings, equipment and facilities (non municipal)
   - Water and wastewater facilities.

B. Transport
   - Municipal fleet
   - Public transport
   - Private and Commercial transport

C. Solid waste management.

D. Livestock breeding.

Although the agricultural sector is a significant contributor in the municipality's economy, it wasn't possible to identify separately reliable data on its energy consumptions, so as to include it in the Baseline Emission Inventory (BEI). To this end, it has been studied as part of the tertiary sector.

The highest energy consumer is the Transportation followed by Residential sector and Tertiary sector, while the municipal sector consumptions are the lowest. The total energy consumption in Monastir Municipality is presented in the following spider chart:

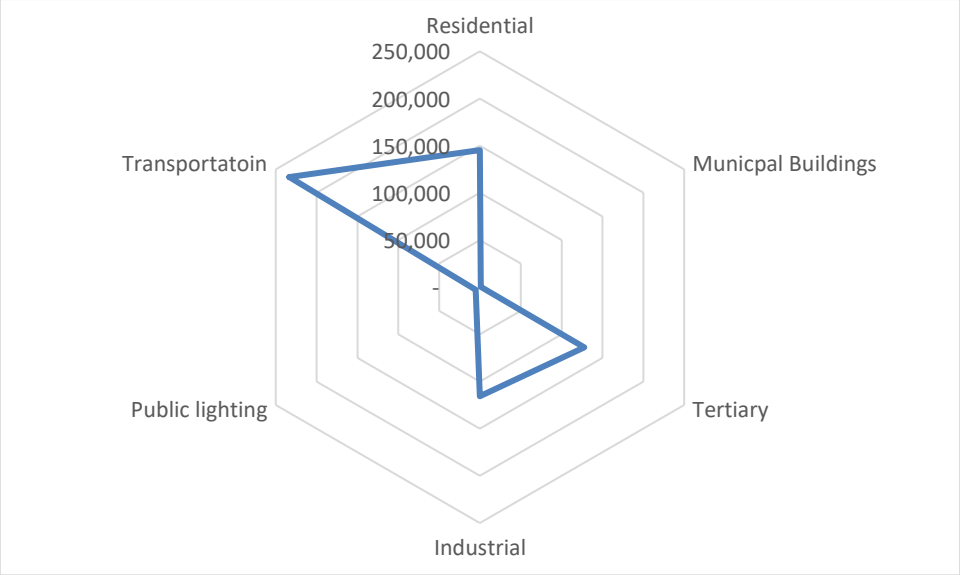


Figure 1: Energy consumption per sector in Monastir Municipality

A more detailed allocation of the calculated energy consumption in Monastir Municipality (All sectors) is presented in the next figure per sector and per fuel.

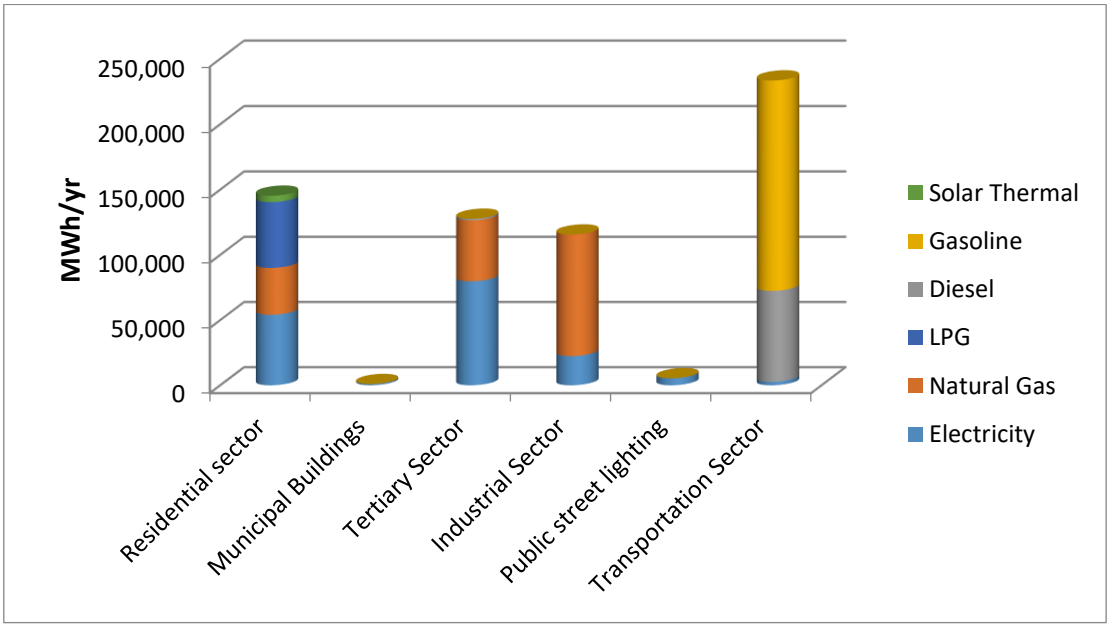


Figure 2: Energy consumption per sector and per fuel

The respective total emissions for the baseline year, including emissions from waste management, equal 258,502tn CO_2 and they are presented in the following chart.

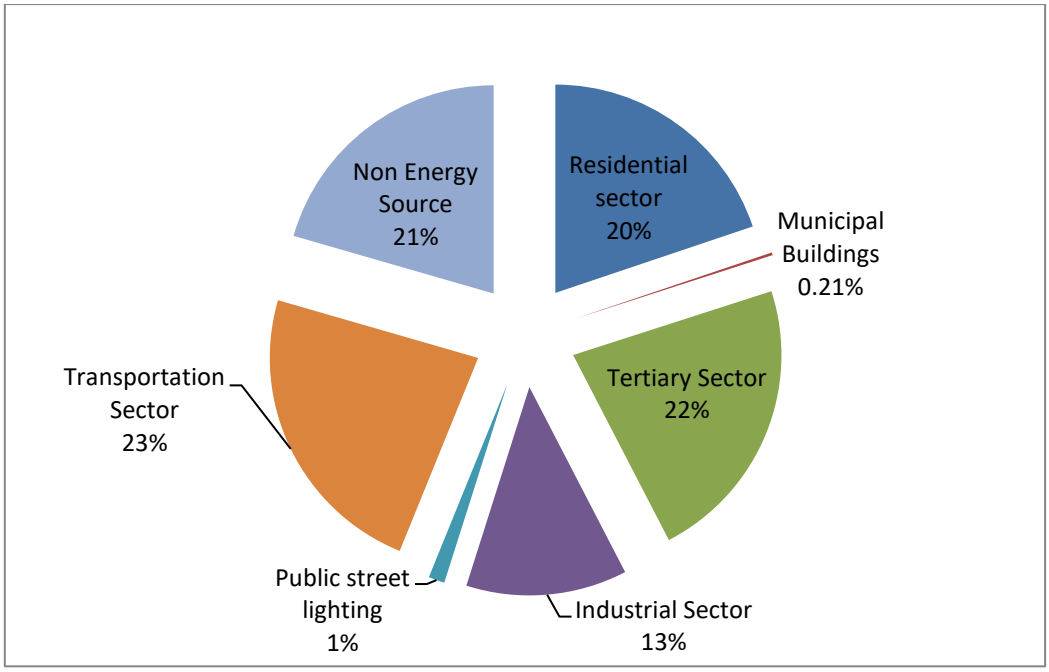


Figure 3: Total CO_2 emissions per sector

In order to set the emission reduction targets, they have to be calculated against the Business as Usual (BAU) scenario, in line with the JRC guidelines for South Municipalities, considering that Tunisia, as a country with developing economy, will face an increase in its energy demand due to the expected economic and population growth. Thus, the forecasted emissions under the BAU scenario for 2030 have been calculated to be 379,998 tn CO_2. As mentioned above.

An overview table of the actions per sector, as well as the calculated emission reductions per action for both scenarios, is presented below.

Table 1: summary of the mitigation actions

Action No.	Action	Emission Reduction Co2
Municipal Buildings and facilities		
1.1	Green procurement procedures for municipal buildings	39.7
1.2	Energy manager appointment in the municipality	2.4
1.3	Awareness raising activities for municipal employees	7.6
1.4	Adoption of bioclimatic principles in new municipal buildings /Strict application of green building codes in new municipal buildings	96.3
1.5	Efficient municipal buildings including Photovoltaic Systems on the Municipal buildings Rooftop 187 kWp	420.1
1.6	Promotion of recycling	1,165.7
1.7	Waste management	38,078.7
1.8	3 MW PV plant	3,250.8
1.9	Creation of Energy Saving Department	-

1.10	Web portal creation	-
Sub-total		**43,061.11**
Public Lighting		
2.1	Street lighting upgrade	1,297.16
2.2	Astronomical timers	420.86
2.3	Green procurement procedures for future lighting equipment	998.91
Sub-total		**2,716.92**
Residential Sector		
3.1	Awareness raising activities for modification of the residents' consumption behavior and energy saving	6,389
3.2	Promotion of Green Buildings' concept / Strict application of the building code	3,768
3.3	1. Campaign for promoting high-energy label home appliances and other awareness activities 2. Implement the PROMO-FRIGO action plan locally ANME: replacing old refrigerators with new ones performing.	1,729
3.4	Replacement of existing lamps with LEDs	2,196
3.5	Replacement of existing air-conditioners with more efficient ones	1,242
3.6	1. Replacement of single glazing with double glaze windows 2. Implement locally the PROMO-ISOL action plan of the ANME: installation of thermal insulation on the roofs of houses individual.	2,896
3.7	Replacing 10% of inefficient Boilers with efficient condensing boilers	121
3.8	Installing 6.6 MW Photovoltaics in residential rooftops 2. Implementing locally the PROSOL ELEC programme of ANME: Installing Photovoltaic systems for residential	7,178
3.9	1. Replacing existing water heaters with solar water heaters 2. Implementing Locally the PROSOL programe of the ANME: installation solar thermal systems instead of the existing water heaters.	6,148
Sub-total		**31,668**
Tertiary Sector		
4.1	Put in place the recommendations of the audits and contracts programs in the tertiary sector.	12,403
4.2	7.5 MWp Photovoltaics in rooftops	8,068
	2.0 MW Photovoltaics for water facilities and agricultural sector	1,937
4.3	Replacing existing water heaters with solar collectors	792
4.4	Upgrade water facilities	2,920

4.5	Develop eco-tourism.	911
Sub-total		**27,031**
Industrial Sector		
5.1	Implement the recommendations of audits and contract programs ANME for industrial units.	12,098
5.2	Install photovoltaic systems in the industrial sector.	4,947
Sub-total		**17,045**
transportation Sector		
6.1	Carry out an audit of the municipality's fleet of vehicles and implement the actions recommended through a program contract.	97.27
6.2	Set up a management unit for the fleet of vehicles of the municipality.	97.27
6.3	Restructuring and strengthening vehicle maintenance.	48.63
6.4	Train drivers in eco driving	72.95
6.5	Improve the process of acquiring new vehicles.	48.63
6.6	Carry out an Urban Mobility Plan and set up the actions recommended by the PDU.	6,880.86
6.7	Transfer of taxi stations and regulation of taxi traffic	429.61
6.8	Improve the city bus network.	1,698.98
6.9	Implement the recommendations of audits and contract programs ANME for the STS.	102.19
6.10	Raise public awareness of public transport.	2,802.79
6.11	Improve and secure pedestrian routes and paths.	1,051.05
6.12	Improve and secure bike paths.	5,605.59
6.13	Improvement / development of parking infrastructure	2,802.79
6.14	Transfer all government departments and institutions to one complex near to the population centers in the city	3,503.49
6.15	Building vehicle crossing lines with the railway to facilitate local transportation	2,802.79
6.16	Establishing central markets near dense residential areas	2,802.79
6.17	Using buses instead of private cars to transport students to the schools and universities	700.7
6.18	Regulating Cargo vehicles work in the City	849.49
6.19	Replacing 5% of the existing Taxi vehicles with electric vehicles	238.06
6.20	Information events on the new vehicle technologies	700.7
Sub-total		**33336.63**
Agriculture sector		
7.1	Planting trees (Increasing Green Areas)	1,085
Total		**155,942.56**

The fourth Chapter of the SECAP concerns the Adaptation to climate change. The last 20 years significant changes in the global climate have occurred which negatively affect life in many aspects. This section presents the current situation in Monastir and the expected problems due to the climate change impacts. Subsequently a set of actions are proposed towards the

city protection against the forecasted extreme weather events. Tunisia has already launched the “Tunisia’s Third National Communication on Climate Change” report in 2016, which is dealing with the above mentioned topic. The national targets presented on this report are consistent with the SECAP actions.

Chapter 1: Introduction

1.1 Monastir 2030 Targets

The overall target that has been set for 2030 is 41% CO_2 emissions reduction (according to the Intended Nationally Determined Contributions - INDCs). Which matches the required reduction percentage 40% according to CoM requirements, emphasis is placed on working closely with all community actors. The municipality will take all necessary measures on its facilities, establishing a good example for the community, while it will put efforts on collaborating with the public and achieving significant reductions from the residential, tertiary and transport sectors, with waste being also a priority for the local administration. The target of 40% has big challenge and there will be need of more intensive efforts from the Municipality and the Governmental Bodies while it is of utmost importance to attract more donors and funds.

1.2 Current status

1.2.1 Geographical location

Monastir is a city on the central coast of Tunisia, in the Sahel area. It is 20 kilometers (12 miles) south of Monastir and 162 kilometers (101 miles) south of Tunis, the capital. Traditionally a fishing port, Monastir is now a major tourist resort. Its population is about 101,934. It is the capital of Monastir Governorate. [1]

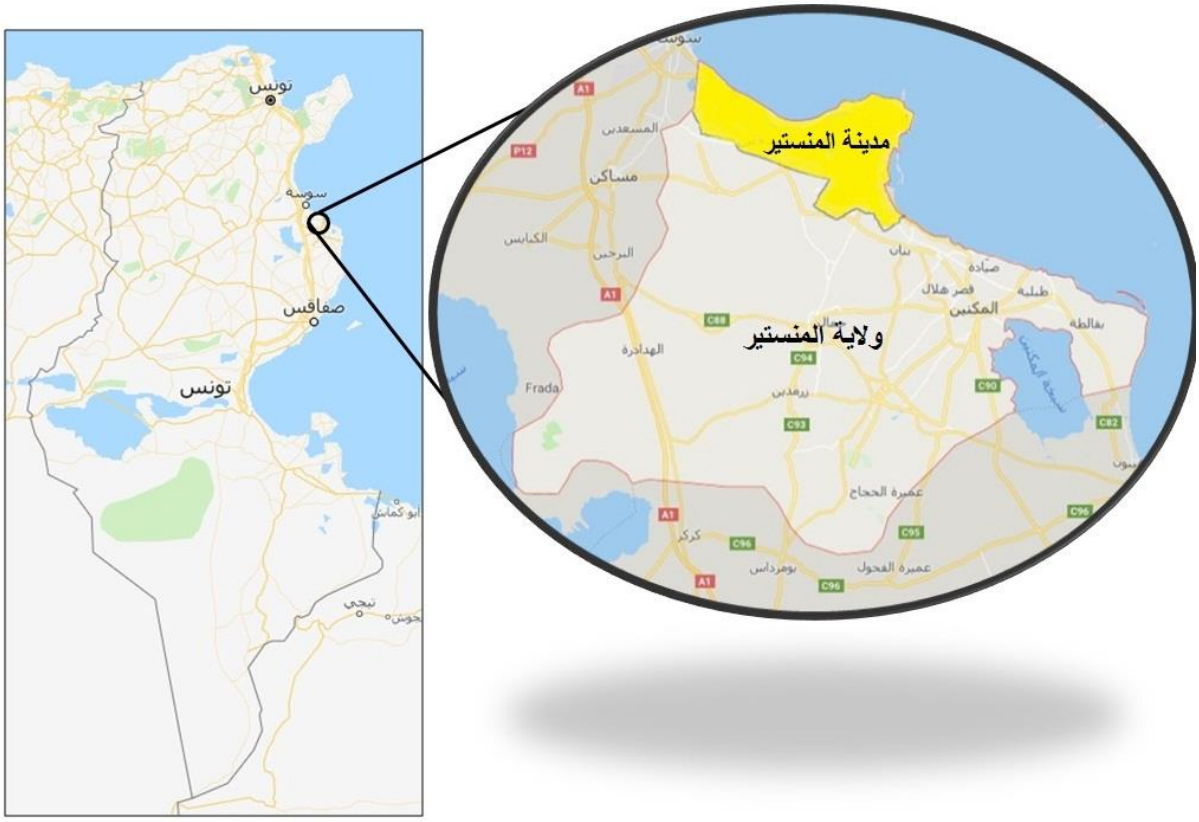


Figure 4: Monastir Map

The city is known for its castle which called "Ribat of Monastir". It is a ribat, an Islamic defensive structure, located in Monastir, Tunisia. It is the oldest ribat built by the Arab conquerors during the Muslim conquest of the Maghreb [2]. It is Founded in 796 by the Abbasid leader and the governor of Ifriqiya, Harthama ibn A'yan, several improvements and changes were introduced to the building throughout the medieval times, including the expansion carried out by Abu al-Qasim ibn Tammam in. It contains a maze of corridors and chambers [2]. A characteristic picture of the castle is presented in Figure 5.

Figure 5**: **Ribat of Monastir

1.2.1 Climate characteristics

In Monastir, the summers are hot, muggy, dry, and clear and the winters are long, cool, windy, and mostly clear. Over the course of the year, the temperature typically varies from 9°C to 32°C and is rarely below 5.5°C or above 36°C.

The hot season lasts for 2.9 months, from June 21 to September 19, with an average daily high temperature above 28°C. The hottest day of the year is August 6, with an average high of 31.6°C and low of 23.8°C. The cool season lasts for 3.9 months, from November 29 to March 27, with an average daily high temperature below 67°F. The coldest day of the year is January 19, with an average low of 8.9°C and high of 16°C. [1]

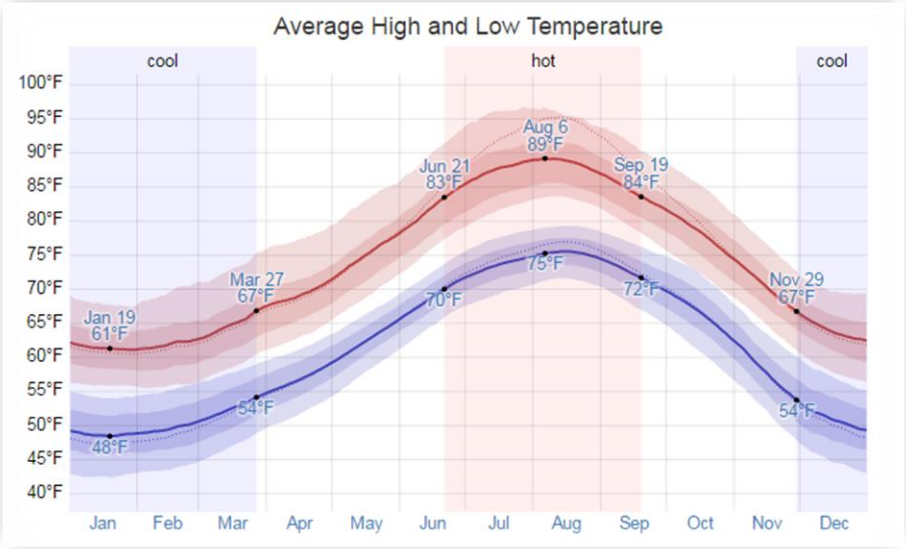


Figure 6

The figure below shows a compact characterization of the entire year of hourly average temperatures. The horizontal axis is the day of the year, the vertical axis is the hour of the day, and the color is the average temperature for that hour and day.[1]

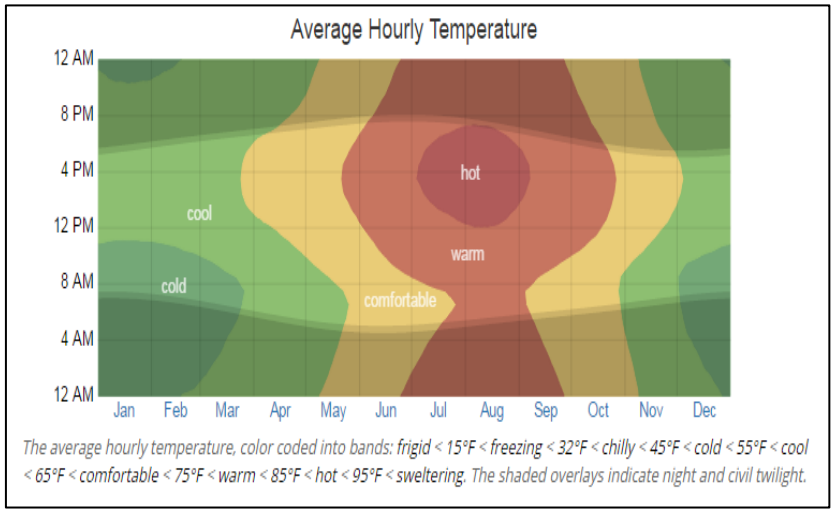


Figure 7

Clouds

In Monastir, the average percentage of the sky covered by clouds experiences significant seasonal variation over the course of the year.

The clearer part of the year in Monastir begins around June 14 and lasts for 2.9 months, ending around September 12. On July 27, the clearest day of the year, the sky is clear, mostly clear, or partly cloudy 97% of the time, and overcast or mostly cloudy 3% of the time. The cloudier part of the year begins around September 12 and lasts for 9.1 months, ending around June 14. On October 26, the cloudiest day of the year, the sky is overcast or mostly cloudy 39% of the time, and clear, mostly clear, or partly cloudy 61% of the time. [1]

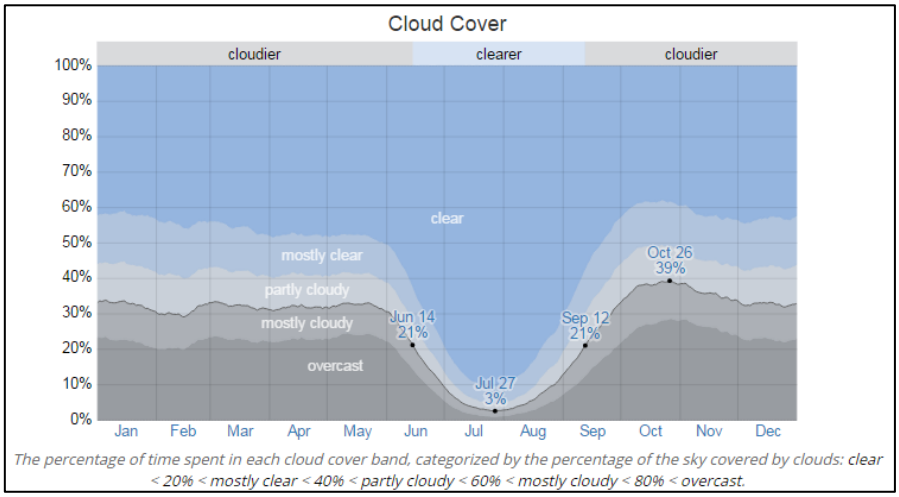


Figure 8

Precipitation

A wet day is one with at least 0.04 inches of liquid or liquid-equivalent precipitation. The chance of wet days in Monastir varies throughout the year.

The wetter season lasts 8.5 months, from August 30 to May 15, with a greater than 10% chance of a given day being a wet day. The chance of a wet day peaks at 18% on October 9.The drier season lasts 3.5 months, from May 15 to August 30. The smallest chance of a wet day is 2% on July 5.

Among wet days, it can be distinguished between those that experience rain alone, snow alone, or a mixture of the two. Based on this categorization, the most common form of precipitation throughout the year is rain alone, with a peak probability of 18% on October 9.[1]

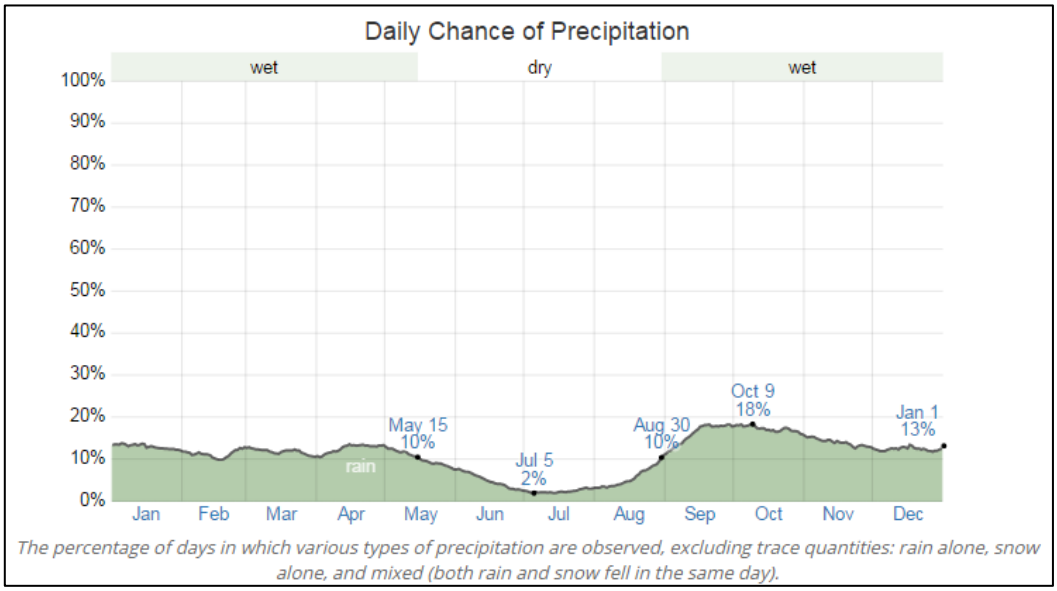


Figure 9

Rainfall

To show variation within the months and not just the monthly totals, the rainfall accumulated over a sliding 31-day period centered around each day of the year. Monastir experiences some seasonal variation in monthly rainfall.

The rainy period of the year lasts for 9.2 months, from August 23 to May 30, with a sliding 31-day rainfall of at least 0.5 inches. The most rain falls during the 31 days centered around October 1, with an average total accumulation of 1.5 inches. The rainless period of the year lasts for 2.8 months, from May 30 to August 23. The least rain falls around July 10, with and average total accumulation of 0.1 inches. [1]

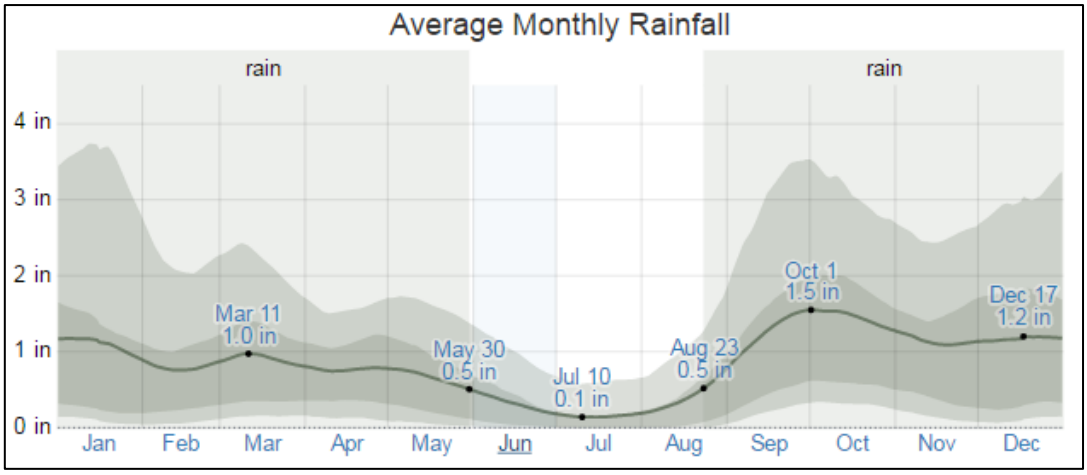


Figure 10

Humidity

We base the humidity comfort level on the dew point, as it determines whether perspiration will evaporate from the skin, thereby cooling the body.

Lower dew points feel drier and higher dew points feel more humid. Unlike temperature, which typically varies significantly between night and day, dew point tends to change more slowly, so while the temperature may drop at night, a muggy day is typically followed by a muggy night.

Monastir experiences extreme seasonal variation in the perceived humidity. The muggier period of the year lasts for 4.9 months, from June 1 to October 28, during which time the comfort level is muggy, oppressive, or miserable at least 22% of the time. The muggiest day of the year is August 17, with muggy conditions 85% of the time. The least muggy day of the year is February 4, when muggy conditions are essentially unheard of. [1]

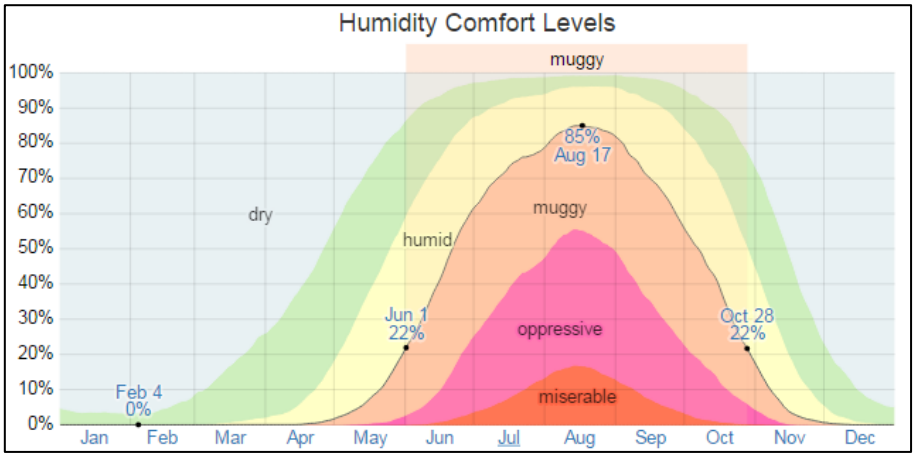


Figure 11

Wind

This section discusses the wide-area hourly average wind vector (speed and direction) at 10 meters above the ground. The wind experienced at any given location is highly dependent on local topography and other factors, and instantaneous wind speed and direction vary more widely than hourly averages.

The average hourly wind speed in Monastir experiences mild seasonal variation over the course of the year. The windier part of the year lasts for 6.0 months, from November 3 to May 2, with average wind speeds of more than 5.8 miles per hour. The windiest day of the year is December 19, with an average hourly wind speed of 6.8 miles per hour. The calmer time of year lasts for 6.0 months, from May 2 to November 3. The calmest day of the year is August 12, with an average hourly wind speed of 4.8 miles per hour. [1]

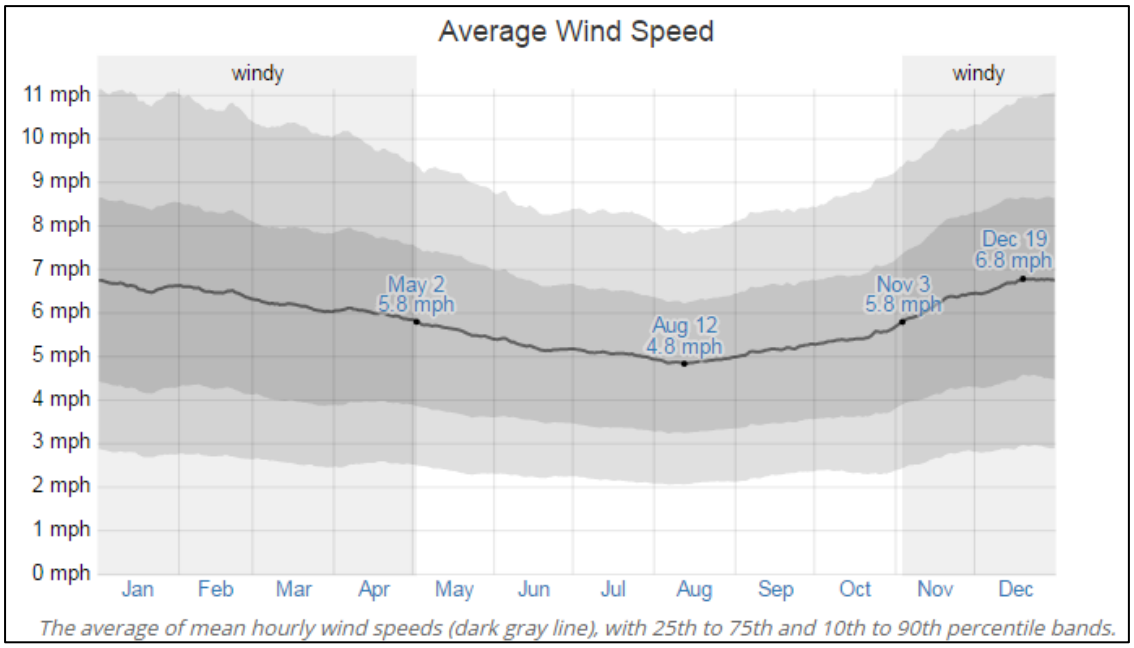


Figure 12

The predominant average hourly wind direction in Monastir varies throughout the year. The wind is most often from the north for 9.4 months, from February 6 to November 18, with a peak percentage of 43% on July 22. The wind is most often from the west for 2.6 months, from November 18 to February 6, with a peak percentage of 38% on January 1. [1]

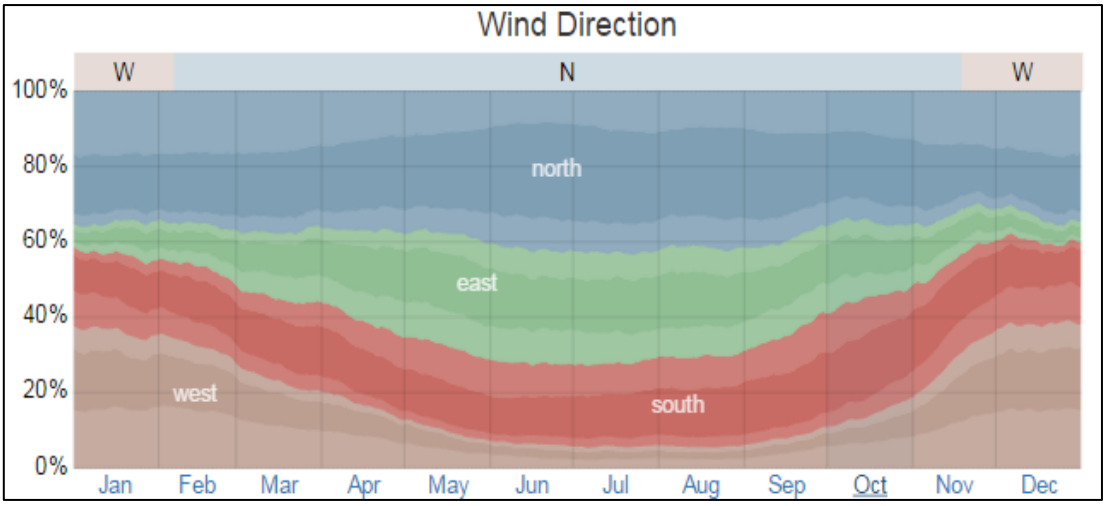


Figure 13

Water Temperature

Monastir is located near a large body of water (e.g., ocean, sea, or large lake). This section reports on the wide-area average surface temperature of that water.

The average water temperature experiences significant seasonal variation over the course of the year. The time of year with warmer water lasts for 3.1 months, from July 7 to October 11, with an average temperature above 24°C. The day of the year with the warmest water is August 20, with an average temperature of 26.6°C. The time of year with cooler water lasts for 4.1 months, from December 26 to April 30, with an average temperature below 17.2°C. The day of the year with the coolest water is February 26, with an average temperature of 14.5°C. [1]

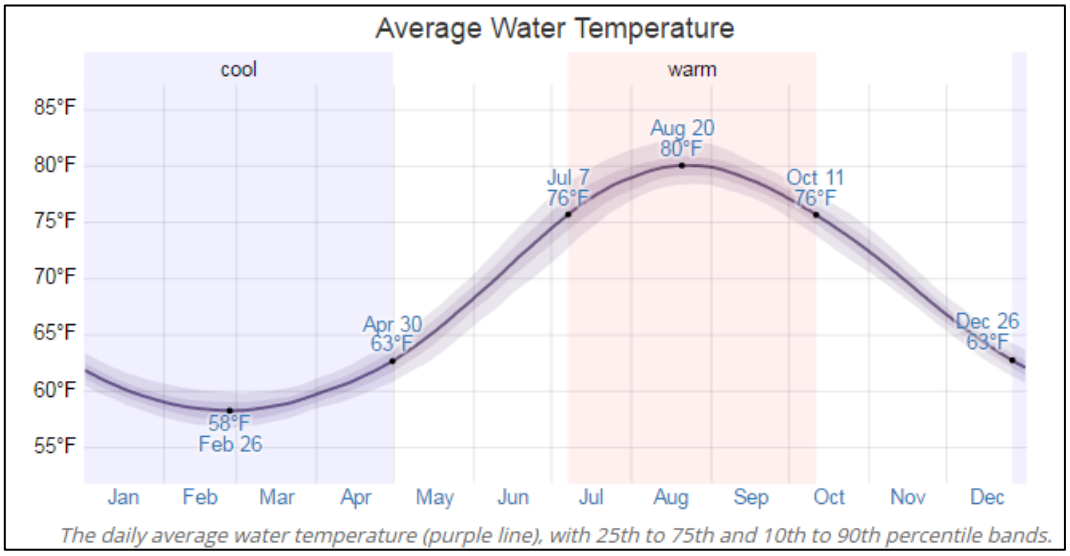


Figure 14

Solar Energy

This section discusses the total daily incident shortwave solar energy reaching the surface of the ground over a wide area, taking full account of seasonal variations in the length of the day, the elevation of the Sun above the horizon, and absorption by clouds and other atmospheric constituents. Shortwave radiation includes visible light and ultraviolet radiation.

The average daily incident shortwave solar energy experiences extreme seasonal variation over the course of the year. The brighter period of the year lasts for 3.5 months, from May 3 to August 20, with an average daily incident shortwave energy per square meter above 6.9 kWh. The brightest day of the year is July 7, with an average of 8.0 kWh.

The darker period of the year lasts for 3.4 months, from October 28 to February 10, with an average daily incident shortwave energy per square meter below 3.7 kWh. The darkest day of the year is December 18, with an average of 2.6 kWh. [1]

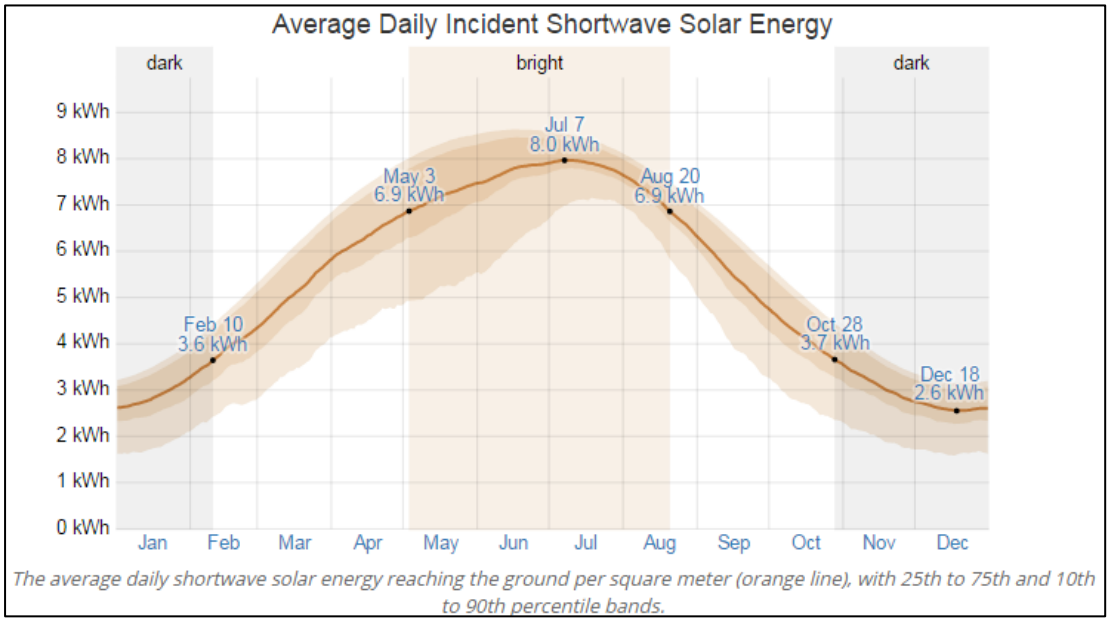


Figure 15

1.2.2 Demographic tendencies

According to the last population census of 2017, the population living in Monastir governorate has 585,283 inhabitants. Whereas the population for Monastir municipality in 2017 was 101,934 citizens. [3]

1.2.3 Employment

Based on the statistics that was done in 2018, The employees in Monastir District comprise approximately 48.9% of its population, 4.7% of them work in agricultural sector, while 37% of them work in technical field, and 44.8% work in services. In the

part of economically active citizens there is a 6.1% percentage that is currently unemployed and looking for a job. [3]

1.2.4 Education

Regarding the educational status of Monastir citizens. Monastir is a prominent educational center in Tunisia, a percentage of 17.1% of the total population was enrolled in the education in 2017. The number of first primary schools has reached 20 schools in the latest statistics in 2017, where the number of second primary and secondary schools and study rooms reached 13 schools and 403 general and specialized study rooms. Total number of teachers and students in the first primary schools reached 516 teachers and 9247 students, with 17.92 average number of students per teacher.[3].

As for higher education where there is The University of Monastir which includes 16 university institutions. The total number of students of the University of Monastir is 18,876 students with 969 administrative staff for the academic year 2017/2018, where 31.5% of them are males and 68.5% are female. The largest colleges are the Faculty of Science, followed by the Faculty of Economic Sciences and Management and the Higher Institute of Biotechnology. [4]

1.2.5 Infrastructures

The Governorate provides a public network for access in water and drinking water. 100% of the housing units have access in the water network. In addition, it seems that there isn't a fully developed public sewage system and thus there is 85% of the population has access in the public network. The rest of the housing units are been served by cesspools. (2017) [2]

The road network in Monastir Municipality consists of 45 Km of paved and unpaved roads, of which 49.3% are regional roads, 19.3% local roads, and a final 31.4% farm tracks. [3]

1.2.6 Economy

The economy of Monastir depends mainly on tourism, sea fishing and industry. Monastir industrial zone includes 51 factories, 34 of them are textile factories with total number of employees reached 4,767 in 2017.

Also Monastir is characterized by Sea fishing, where Number of fishing boats are 261 with total Sea fishing production of 3,241 tons per year. Whereas the total number of manpower in sea fishing is around 900 in 2017. [3]

As for tourism in Monastir, it contains many monuments, archaeological sites and museums, in addition to Monastir beaches, where the total number of hotels and hostels are 89, where 46% of them are classified hotels with total Housing Capacity of 24,264 guests.[3]

1.2.7 Complementarity with municipal and national plans and other related actions

Monastir's decision for the implementation of a SECAP study is in line with national legal framework, targets, and priority actions set. Abiding with the 41% emission reduction target by 2030 is consistent with the national target for that period, as expressed through the Intended Nationally Determined Contributions (INDCs) submitted to the UNFCCC.

Under the current legal framework, the municipalities are entitled to the development of their energy policy plans, such as the current study on Sustainable Energy and Climate Action Plan for Monastir. In addition, they can influence the energy consumptions related to their own use (buildings, vehicles, street lighting, solid waste and waste water management, water pumping etc.), as well as promote legislative measures for the adoption of the building codes in place, or the use of Solar Water Heaters (SWH).

The National Energy Efficiency Action Plan (NEEAP) is the umbrella regarding energy efficiency at the national level. Some of the most relevant actions for local authorities, as addressed in the NEEAP, include use of efficient equipment and replacement of compact fluorescent lamps (CFLs) with LED lighting.

1.3 Vision for the future

Monastir is a growing city that has significantly increased its population over the past years. This trend is expected to continue in the future, even at a lower rate. This population increase trend poses significant pressures on the existing and future infrastructures and the further development of the city.

Monastir municipal authority is deeply committed to a sustainable future for the city, in order to make it prosperous for its citizens and sophisticated. This objective is expressed through the actions selected in this SECAP, focusing not only in reducing the energy consumption through energy efficiency, or producing more clean energy, but also on improving the existing infrastructures at the municipal, as well as the city level.

1.4 Organizational and financial aspects

1.4.1 Coordination with national and local authorities

During the SECAP implementation, Monastir Municipality is going to coordinate closely with the affiliated ministries and national institutions, namely the Ministry of Environment, especially with regards to the Climate Adaptation actions, as well as the Ministry of Energy and Water and ANME, as relate to the energy efficiency and renewable energy projects and initiatives.

At the same time, Monastir will exchange experience with the other two regional cities that have benefitted from Minaret for the development of their SECAPs, namely Karak in Jordan and Jdaidat Al-Chouf in Tunisia, while it will share best practices and experience gained with other municipalities interested in realizing similar activities.

1.4.2 Adaptation of administrative structures

The departments that will be engaged with the SECAP are the Task force committee, which will be responsible for the energy and climate issues in Municipality.

1.4.3 Involvement of stakeholders and citizens

Having conducted the analysis of the energy consumption patterns in the territory, it should be highlighted that the municipality is responsible for less than 1% of the consumptions realized at the city level. Thus, it is evident that the involvement of all citizens and stakeholders of the private sector is considered crucial for achieving the 40% reduction target. A high level collaboration is expected with private investors interesting to realize small or larger scale RES investments in the city, while efforts for close contacts with associations from the tertiary and residential sector will be placed and several programs for GHG emission reduction shall be incorporated.

1.4.4 Budget – SECAP financing sources

Regarding the total budget for the SECAP's implementation, the total cost for the Municipality is calculated at 43 million USD, while for the private sector has been estimated at 230 million USD approximately, resulting in an overall budget of 273 million USD.

Any action to be implemented will have a clear budget and implementation plan and will be executed pending the approval of the yearly budget, as required by the municipal regulations.

Chapter 2: Baseline Emission Inventory (BEI)

2.1 BEI Methodology

2.1.1 Baseline Year

According to the Covenant of Mayors Guidelines for South Signatories, in order to develop the energy balance sheet and consequently specify the CO_2 emissions, the year 1990 should be considered as the baseline year. In case where there aren't adequate data for this year, as a baseline year should be considered the nearest year to 1990 for which there are complete and reliable data. Thus, for the Monastir Municipality the baseline year has been set to 2016, since it was the year with the most sufficient and reliable data available. [5]

2.1.2 SECAP administrative body

Following a meeting of the consultant Royal Scientific Society/National energy Research Center (RSS/NERC) with the Monastir representatives, it was made clear that their wish for the BEI is to cover the administrative boundaries of Monastir municipality.

2.1.3 Sectors to be included in the BEI

The sectors for which the appropriate data were gathered and calculations for the total energy consumption and CO_2 emissions are presented below:

A. Buildings, Equipment & Facilities
   - Municipal Buildings, Equipment and Facilities
   - Public lighting
   - Residential buildings
   - Tertiary buildings, equipment and facilities (non-municipal)
   - Water and Waste water facilities.
   - Industrial Sector

B. Transport
   - Municipal fleet
   - Urbain Rail transport
   - Urbain Public transport
   - Urbain Private and Commercial transport
   - Local Ferries transport

C. Solid waste management.

D. Livestock breeding.

As regards agriculture, although there is agricultural activity in the region, it has not been possible to separate the consumptions for the specific sector from the tertiary one, and especially the water pumping for irrigation.

2.1.4 Emission factors and Conversion rates

The emission factors which are used in this BEI were derived from the Covenant of Mayors Guidebook in table 2. With the only exception of the electricity emission factor which is characteristic for the country. The emission factor was calculated based on the Tunisian energy mix and the electricity consumption. According to the National Agency for Energy Conservation "Agence Nationale pour la Maîtrise de l'Énergie" (ANME), the electricity emission factor in Tunisia is 0.602 $tnCO_{2equivalent}$/MWh.

Table 2: Emission Factors & Conversion Rates

	Emission Factor (tn Co2/MWh) Factors (tn CO_2/MWh)	Conversion Factors
Electricity	0.602	Not applicable
LPG	0.227	13,1 MWh/tn
Natural Gas	0.202	11.6 MWh/tn
Diesel	0.267	10 KWh/lt
Gasoline	0.249	9,2 KWh/lt
Solar (thermal/ PV)	0	Not applicable

Furthermore, emissions from the biomass were calculated according to the IPCC method. Waste separation process, Sewadge Sludge and livestock breeding create methane emissions (CH_4) which are converted to CO_2 emissions according to the equivalence "1 tn CH_4 = 25 tn CO_2".

2.2 Energy Consumption

The total amount of energy consumed in Monastir Municipality is **628.31 GWh**. The allocation of this energy consumption among the different sectors, by fuel type, is presented in the next table. Further analysis of the consumptions per sector is provided in the following sections.

Table 3: Total Energy consumption per sector

MWh Sector	Electricity	Natural Gas	LPG	Diesel	Gasoline	Solar Thermal	Total
Residential sector	54,080	35,936	50,446			4,856	145,318
Municipal Buildings	898	19					917
Tertiary Sector	79,792	46,707		1,186			127,685
Industrial Sector	22,360	93,257					115,617
Public street lighting	5,378						5,378
Transportation Sector	2,630			69,819	160,949		233,398
Total	**165,137**	**175,919**	**50,446**	**71,005**	**160,949**	**4,856**	**628,310**

2.2.1 Municipal Buildings & Facilities

Tunisian Electricity & Gas Company provided electricity and NG consumptions for the year 2016 for municipal buildings, organized by building category: Administration, Markets and Slaughterhouses, Culture, Gardens, Sport. The total electricity and NG consumption of buildings and facilities in the municipality amounts to **917 MWh** (excluding municipal lighting). (See Appendix A).

2.2.2 Municipal public lighting

As far as the municipal public lighting is concerned, this sector is related to the street lighting and public areas' lighting. The electricity consumption for this sector is **5,377.6 MWh** according to prepared study by the municipality in 2016. (See Appendix B).

2.2.3 Residential Buildings

Electricity

Monastir's households consume electricity for lighting and electrical appliances such as refrigerator, air conditions and others, as well as in water heating. The consumed electricity in this sector is **54,080 MWh** in 2016 according to statistics prepared by Ministry of Development, Investment and International Cooperation (MDIIC) [3].

Natural Gas (NG)

The only source for space heating and cooking in the houses is the natural gas fuel. Estimations for NG consumption (Low pressure) were realized according to the data given from STEG and statistics by MDIIC. The percentage of share for residential sector was considered as same as for electricity with share percentage of 36.92% of overall NG consumption (except for agricultural, water pumping and waster sector since they do not depend on the population). The annual NG consumption in Monastir district was given for 2016 by the municipality with total value of (23 ktoe) for 33 municipalities within Monastir district. The percentage of consumption for Monastir delegation was calculated by knowing the total subscribers number for each involved municipality as shown in the table below [3]. Based on that, the annual NG consumption in Monastir Delegation for all sectors was calculated to be 9.5 ktoe. Since Monastir delegation has two municipalities (Monastir and Khaniss Municipalities), the NG consumption was projected based on the population ratio between the two municipalities, which is 88.25% for Munastir municipality with overall NG consumption of 8.38 ktoe. After excluding Agriculture, water pumping and waste water sectors from the overall natural gas consumption, the remaining overall NG consumption is 8.369 ktoe. Finally, by using the calculated share percentage of residential sector, the annual NG consumption for residential sector was calculated to be 3.09 ktoe (35,936 MWh) for Monastir municipality.

Table 4: *Annual NG (Low-pressure) consumption for Monaster district 2016*

Delegations within Monastir district	Number of Subscribers	Percentage of subscription	Annual NG Consumption (ktoe)
Monastir	**22575**	**41.31%**	**9.50**
Wardanin	3	0.01%	0.00
Sahlin	2976	5.45%	1.25
Zarmadin	874	1.60%	0.37
Bani Hassan	6	0.01%	0.00
Jammal	4267	7.81%	1.80
Banbalah	3354	6.14%	1.41
Maknin	4868	8.91%	2.05
Baqaltah	1179	2.16%	0.50
Tablabah	1984	3.63%	0.84
Qasr Hilal	7388	13.52%	3.11
Qasibat Almadyony	1277	2.34%	0.54
Sayyadah-lamtah-bo hajar	3894	7.13%	1.64
Total	**54645**	**100.00%**	**23**

Liquefied Petroleum Gas (LPG)

LPG is mainly used as portable bottles for cooking and space /water heating for the households that not connected to the NG network. The annual LPG consumption at municipal level was calculated based on the population ratio between the national and municipal levels, which the total LPG consumption given by IEA statistics at national level was reflected on the Municipal level, with total annual consumption of 50,445 MWh.

Solar thermal

In addition, a great number of households own solar water heaters, thus they consume solar power in order to heat water. In order to determine this quantity, IEA gave data at a national level (558,240 MWh) [8], and subsequently the solar thermal energy was calculated by knowing the population ratio between municipal and national levels. The total population at national level was 11,229,700 in 2016, whereas the population at municipal level was 98,084 (according statistics by MDIIC [3]) with population ratio of 0.87%. Based on that, the annual solar thermal consumption at the municipal level is calculated to be 4,856 MWh.

Summary

Gathering all the data of the residential sector, it seems that residents consume 3 distinct energy sources. In table and figure below, the final consumption per fuel type for this sector is presented.

Table 5: *Total energy consumption in the residential sector*

MWh/year	Residential Sector
Electricity (MWh)	54,080

Natural Gas (MWh)	35,936
LPG (MWh)	50,446
Solar Thermal (MWh)	4,856
Total (MWh)	**145,318**

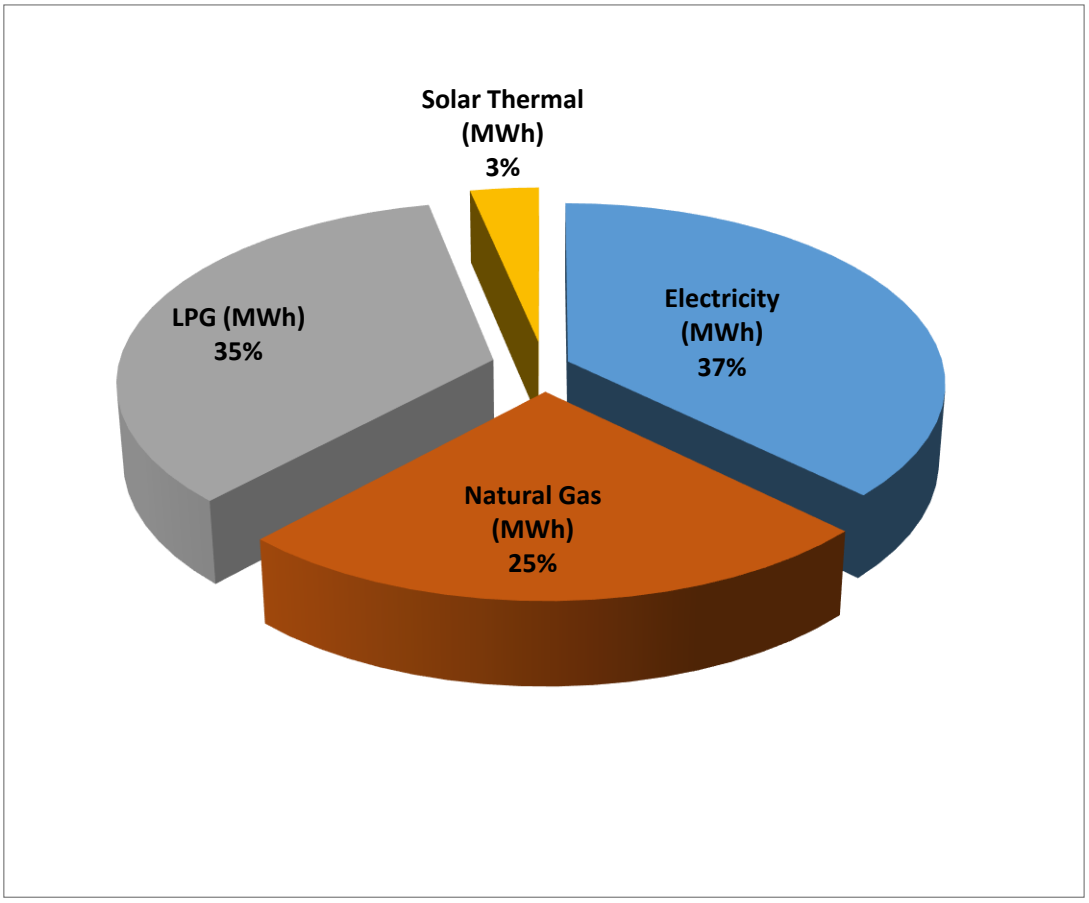


***Figure 16**: Energy consumption per fuel in Residential Sector*

2.2.4Tertiary Buildings, Equipment & Facilities

Tertiary sector includes all buildings that not referred to the municipal and industrial sectors, which includes the commercial buildings such as shops, restaurants, hotels, offices, hospitals. Also this sector includes the educational buildings (Schools and Universities), public buildings and water management facilities as well, which provide services to Monastir's citizens. It should be noted that water management facilities include facilities for water pumping and waste water treatment. In case of commercial buildings, the approach used to calculate the annual NG consumption is same one used for residential sector. Based on that, the annual NG consumption at municipal level is calculated to be (46,707 MWh). The annual electricity

consumption was given by MDIIC statistics and bills with total value of (79,792 MWh). The collected data are presented in the table below.

Table 6: *Energy consumption in tertiary sector per type of sub-sector*

Types of Buildings in the Tertiary Sector	Electricity (MWh)	Natural Gas (MWh)	Diesel (MWh)	Total (MWh)
Commercial buildings	17,678	11,747	0	29,425
Public & Governmental buildings	18,686	12,417	0	31,103
Tourism	33,670	22,374	0	56,044
Agricultural	1,455	68	1,186	2,709
Water & Waste Management Facilities	8,302	102	0	8,404
Total	79,792	46,707	1,186	127,685

In the next charts, it is obvious that the consumption's allocation in the tertiary sector is dominated by Tourism and commercial & public buildings.

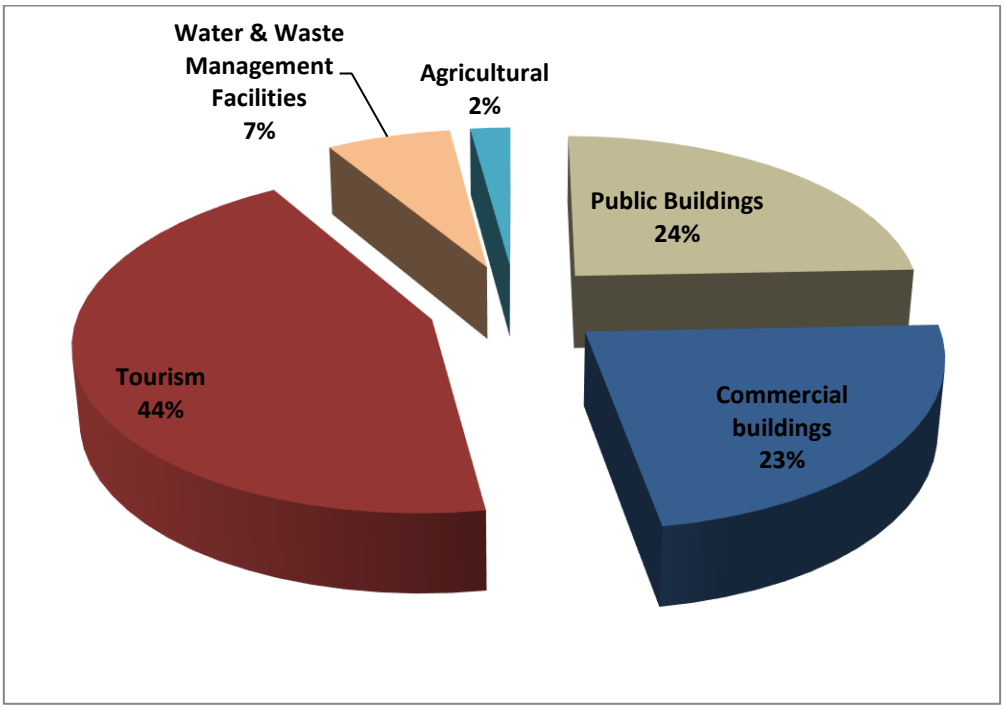


Figure 17: *Energy consumption in tertiary sector per type of building*

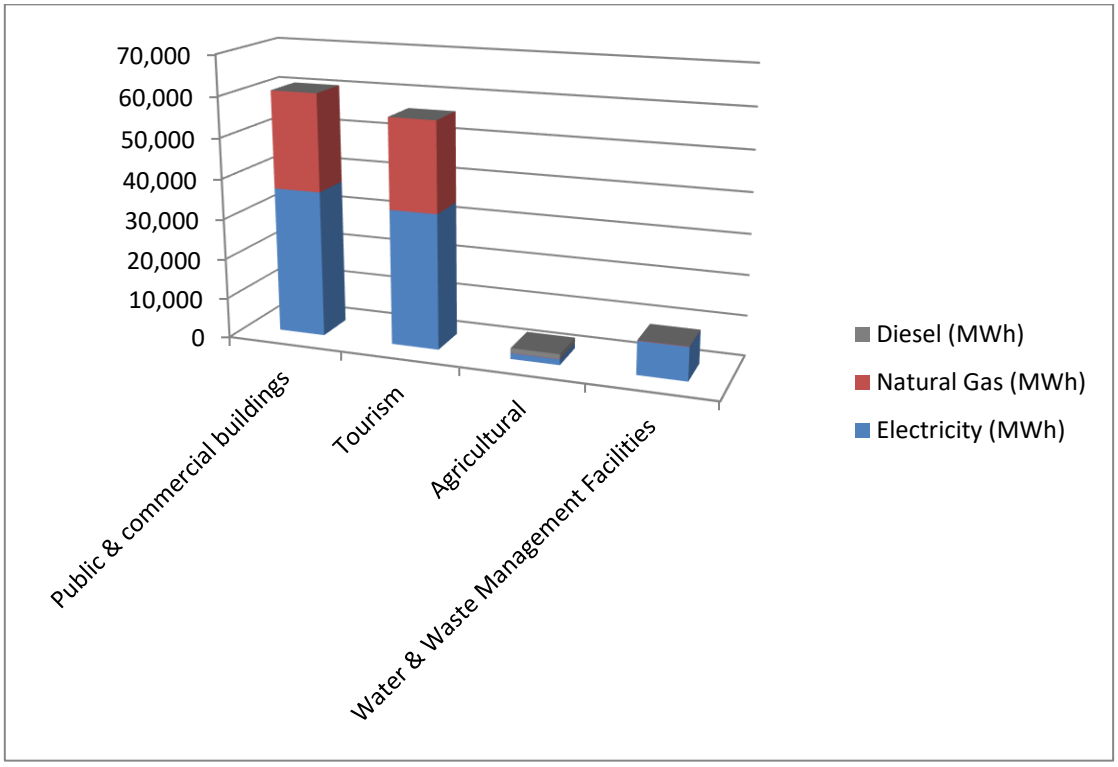


Figure 18: *Energy consumption in tertiary sector per type of building and fuel*

2.2.5 Buildings' & facilities Synopsis

The consumed energy allocation for all the buildings and facilities in Monastir Municipality is presented in the next figure.

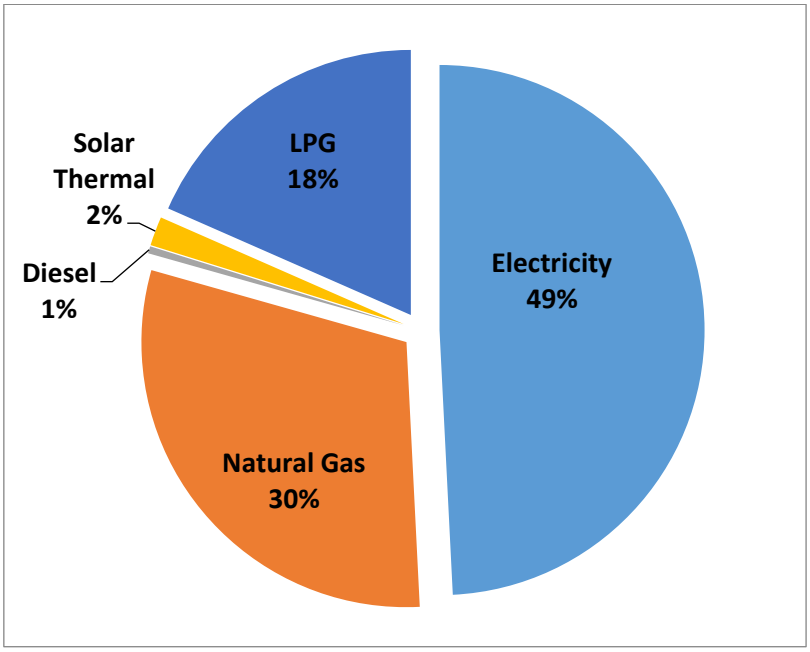


Figure 19: Energy consumption in buildings and facilities per fuel

2.2.6 Industrial Sector

Electricity consumption for industrial sector was given according to MDIIC statistics with total amount of (22,360 MWh/yr) [3].

Natural gas consumption was calculated using the data from STEG and statistics, which the same approach done for the previous sectors was adopted for the industrial sector. The percentage of consumption for Monastir municipality was calculated by knowing the total NG (Medium pressure) consumption for each involved municipality in Monastir for 2015 year (as provided by MDIIC statistics [3]), which can be reflected on the provided annual NG (Medium pressure) for 2016 (110.5 ktoe) as shown in the table below, which the annual NG (MP) consumption is 78,399 MWh after taking the pop ratio for Munastir delegation in consideration.

Table 7: *Annual NG (Medium pressure) consumption for Monastir district 2015/2016*

Delegations within Monastir district	NG (MP) consumption (MThermie) 2015	Weight (%)	NG (MP) Consumption (Ktoe) (2016)
Monastir	**146**	**6.91%**	**7.64**
Wardanin	0	0.00%	0.00
Sahlin	37	1.75%	1.94
Zarmadin	820	38.83%	42.90
bani hassan	0	0.00%	0.00
Jamal	523	24.76%	27.36
Banbalah	264	12.50%	13.81
Maknin	63	2.98%	3.30
Baqaltah	3	0.14%	0.16
Tablabah	107	5.07%	5.60
Qasr hilal	92	4.36%	4.81
Qasibat almadyony	0	0.00%	0.00
Sayyadah-lamtah-bo hajar	57	2.70%	2.98
Total	**2,112**	**100.00%**	**110.5**

On the other hand the Low pressure NG consumption can be simply computed by subtract the Annual NG consumption by residential and tertiary sectors from the total annual NG (Low pressure) consumption. Thus, the total NG consumption (LP & MP) was calculated to be 93,257 MWh/yr

2.2.7Transport Sector

2.2.7.1 Municipal fleet

As far as the consumption of the municipal vehicles is concerned, the available data, followed by the vehicles' type, was collected and is presented in the next table. Monastir's municipal fleet has 71 vehicles which use diesel and gasoline.

***Table 8*: Annual Energy Consumption in Municipal fleet of Monastir**

Type of Municipal vehicles	Number of vehicles	Diesel		Gasoline		Total
		Lit	(MWh)	Lit	(MWh)	(MWh)
Waste transportation Vehicles and heavy vehicles	33	181,532	1,815	5,160	47	1,863
Passengers Vehicles	38	16,851	169	52,460	483	651
Total	71	198,383	1,984	57,620	530	2,514

2.2.6.2 Urban Rail Transportation

One of the most important transportation ways in Monastir is by the rail transport, where there are 22 Electric trains and other Gasoil trains serve the travelers which controlled by the National Railway Company of Tunisia (NRCT).

The annual electrical energy consumption for this sector can be calculated by knowing the annual traveled distance (km) within Monastir boundaries and the specific energy consumption per distance (kWh/km). based on data received from (NRCT), the annual travelled distance by the rail transport along the line (end to end) for 2016 is **998,063 km** with total traveled strokes of (**14,607 strokes**), Knowing that one complete stroke (end to end) has a distance of **68.3 km**, whereas the length of the rail line crossing Monastir borders is **16.8 km** (according to NRCT responsible). Also the specific electricity consumption (kWh/km) for the line was given by NRCT for each month with the traveled distance. Thus, by considering all the above numbers, the estimated annual energy consumption in the rail transport within Monastir borders is **2,630 MWh.** Further analysis is presented in Table 9.

Also there are some Gasoil trains which consume 330,931 Liters per year (according to NRCT responsible). Which fuel consumption within Monastir municipality borders can be estimated using the same above approach to be 81,367 Liters per year (813.6 MWh/yr).

***Table 9:** Energy Consumption in Rail transportation within Monastir Municipality borders 2016*

2016	Total traveled distance (end to end)(km)	Total Traveled distance within Monastir Borders (km)	Specific electricity consumption (kWh/km)	Energy consumed within Monastir Municipality borders (kWh)

Jan	84,574	20,795	9.47	196,924
Feb	82,565	20,301	11.14	226,148
Mar	87,888	21,609	10.37	224,089
Apr	84,172	20,696	10.26	212,338
May	87,512	21,517	10.9	234,534
Jun	66,400	16,326	11.38	185,790
Jul	75,856	18,651	10.8	201,431
Aug	78,368	19,269	12.08	232,765
Sep	85,033	20,907	11.26	235,417
Oct	89,747	22,066	10.4	229,491
Nov	87,888	21,609	10.25	221,496
Dec	88,060	21,652	10.59	229,291
Total	**998,063**	**245,398**	Avg. = 10.74	**2,629,715**

2.2.6.3 Urban Road Public Transport

Urban Public transport refers to buses and taxies that serve Monastir's citizens. The data for fuel consumption are available for buses only, whereas the taxies and Louage taxies consumptions were calculated based on the data given for the total taxies number and daily fuel consumption within Monastir municipality limits. The energy consumption results are summarized in table 10 (see appendix C).

Table 10: *Energy consumption in Public Transport within Monastir municipality borders*

Vehicle Type	Number of vehicles passing the Monastir municipality borders	Daily Fuel consumption per vehicle (Lit/day)	Diesel (MWh)	Gasoline (MWh)	Total (MWH)
Buses			8,740	0	39,631
Taxis	600	12	0	25,544	
Louage (within the district borders)	28	25	2,555	0	
Louage (outside the district borders)	51	15	2,792	0	
Total			14,087	25,544	

2.2.6.3 Urban Road Private and Commercial Transport

The previous methodological approach and assumptions was used in this sector too. In Appendix C shows the detailed analysis per vehicle category. The total number of registered private and commercial vehicles for 2016 year was not available, thus, a published statistic study was used to estimate the vehicles types and numbers in Tunisia [10]. Then the total number for each vehicle category was reflected to municipal level based on the population ratio and the activity ratio in the municipality. The total estimated vehicles number in Monastir

municipality is 17,365 and the total consumption regarding Diesel and Gasoline is 187,619 MWh. Table 11 shows the analysis results and outputs regarding the diesel and gasoline consumptions.

Table 11: *Energy consumption in Private and Commercial Transport*

Vehicle Type	Number of vehicles	Diesel (MWh)	Gasoline (MWh)	Total (MWh)
Passengers Vehicles	13,642	122	134,875	**187,619**
Commercial Vehicles	3,589	51,029	0	
Heavy and construction Vehicles	114	1,572	0	
Agricultural Vehicles	20	21	0	
Total	**17,365**	**52,744**	**134,875**	

Figure 16 presents the proportion between Diesel and Gasoline consumption in the Private and Commercial vehicles.

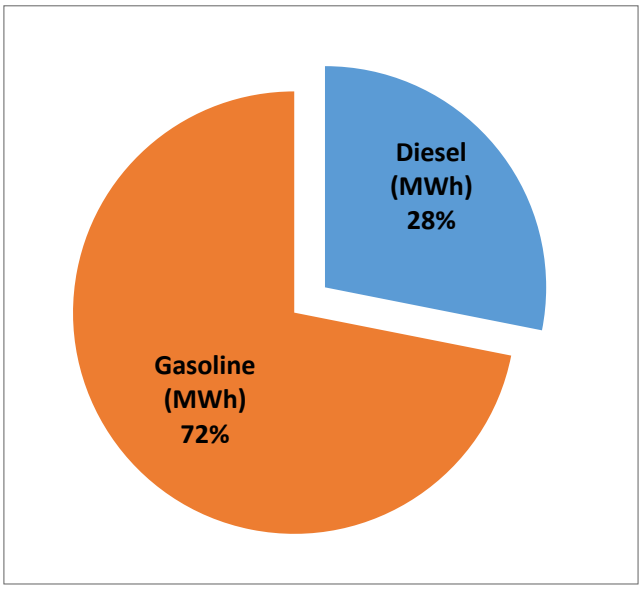


Figure 20: *Energy consumption in Private and Commercial vehicles per fuel*

2.2.6.4 Local Ferries Transport

Due to existing of Marina Monastir within Monastir Municipality borders, the energy consumption for Local Ferries will be considered. The fuel consumption for the local ferries was calculated based on the data given for the total ferries number and daily fuel consumption within Monastir municipality boundaries as well as the number of days per year that have ferries travels. The energy consumption results are summarized in table 12.

Table 12**:** *Energy consumption in Local Ferries Transport*

No.	Name of ferry	Passengers Capacity	No of days that have ferries travels (Days/yr)	fuel cons. Per day as per municipality data	Annual fuel consumption for one ferry (Lit/yr)	MWh/yr
1	Barbaros	120	30	80.0	2,400	24
2	AlBasha	76	50	40.0	2,000	20
3	Lac majeur 2	56	60	80.0	4,800	48
4	Hanba'l	72	50	40.0	2,000	20
5	AlQursan	75	60	60.0	3,600	36
6	Sultan	90	50	80.0	4,000	40
Total					**18,800**	**188**

Table 13 and figure 21 summarize the overall energy consumption and share for each transportation sector, which show that the overall energy consumption is 319,184 MWh/yr, whereas urban road private transportation take the largest share with percentage of 35%.

Table 13: *Total energy consumption for transportation sector within Monastir municipality borders*

Vehicle Type	Number of vehicles	Electricity (MWh/yr)	Diesel (MWh/yr)	Gasoline (MWh/yr)	Total MWh
Municipal Fleets	71	0	1,984	530	2,514
Urban rail transport	> 22	2,630	814	0	3,443
Urban Public Transport	> 600	0	14,087	25,544	39,631
Urban Private and Commercial Transport	17,365	0	52,744	134,875	187,619
Local Ferries Transport	6	0	188	0	188
Total		**2,630**	**69,817**	**160,949**	**233,396**

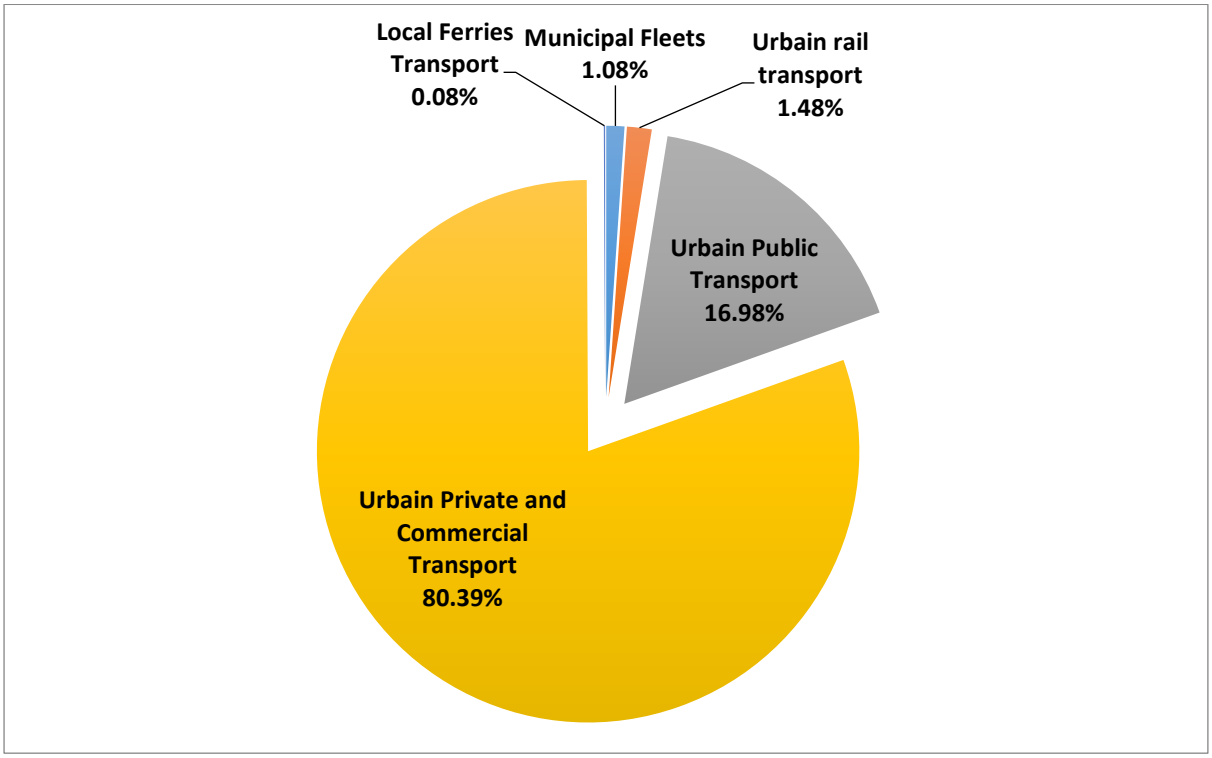


Figure 21: *Energy consumption distribution in transportation sector*

2.2.7 Final Energy Consumption

In the next table all the energy consumptions within Monastir municipality are presented, with total energy consumption of 628.31 GWh

Table 14: Total Energy Consumption in Monastir municipality

Sector			FINAL ENERGY CONSUMPTION [MWh]								
			Electricity	Heat/cold	Fossil fuels					Renewable energies	Total
					Natural Gas (Low Pressure)	Natural Gas (Medium Pressure)	LPG	Diesel	Gasoline	Solar thermal	
Residential sector			54,080		35,936		50,445.66			4,856	**145,318**
Municipal Buildings			898		19						**917**
Tertiary Sector			79,792		46,707			1,186			**127,685**
Industrial Sector			22,360		14,858	78,399					**115,617**
Public street lighting			5,378								**5,378**
Transportation Sector	Urban Road Transportation	Municipal Fleets						1,982	530		**2,514**
		Public Transportation						14,087	25,544		**39,631**
		Private Transportation						52,744	134,875		**187,619**
	Urban Rail Transportation		2,630					813.67			**3,443**
	Local Ferries							188.00			**188**
Total			**165,137**	**0**	**97,521**	**78,399**	**50,446**	**71,003**	**160,949**	**4,856**	**628,310**

Chart below shows the energy consumption distribution for all Monastir's sectors, which can be noted that the energy consumption is almost distributed equally for residential, industrial and tertiary sectors with percentage of around 20%, whereas the transportation sector took the largest share of energy consumption between all sectors with percentage of 40 %.

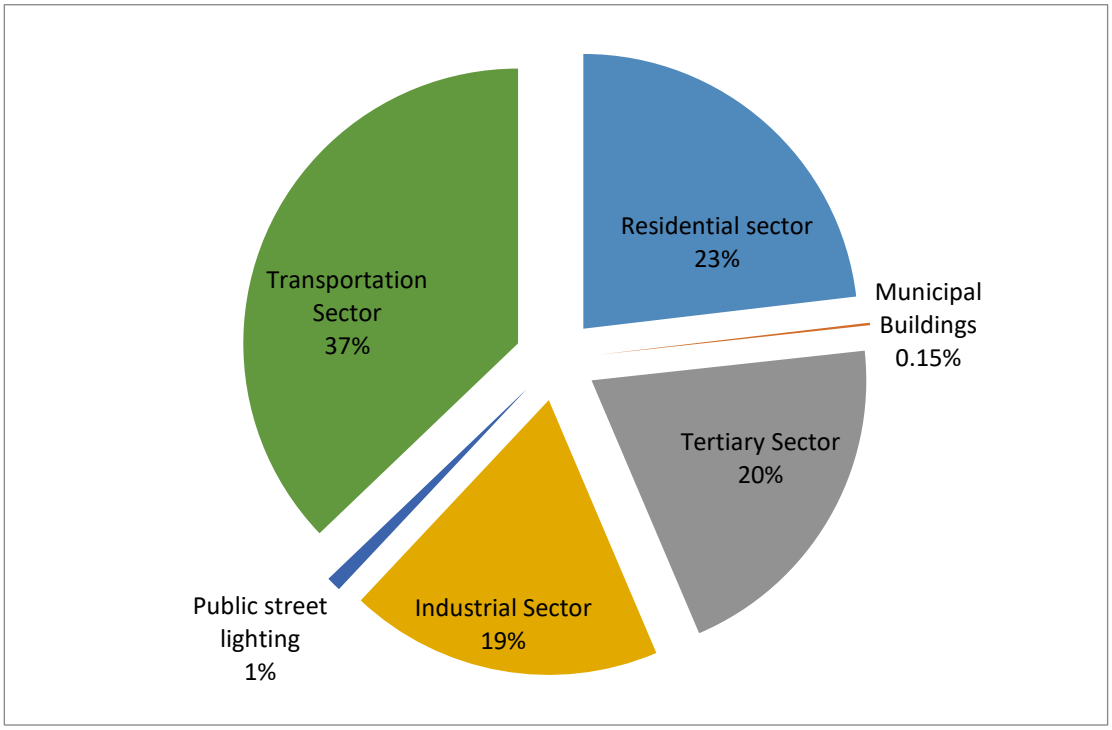


Figure 22: *Energy consumption distribution for all sectors in Monastir Municipality*

2.3 Local electricity production

There is no local electricity production in the Municipality of Monastir except for few small rooftop PV systems. The total capacity for these systems is not available.

2.4 CO_2 emissions

2.4.1 Energy related emissions

In the previous sections, the energy related consumptions in Monastir municipality were described and the CO_2 emissions can be calculated using the IPCC emission factors. [9]

Electricity

In order to calculate the local emission factor for electricity, the following equation is used:

$$EFE = \frac{(TCE - LPE - GEP) * NEEFE + CO_2LPE + CO_2GEP}{TCE}$$

Where:

EFE: Local emission factor for electricity (tn/MWh)
TCE: Total electricity consumption in the local authority (MWhe)
LPE: Local electricity production (MWhe)
GEP: Green electricity purchased by the local authority (MWhe)
NEEFE: National or European emission factor for electricity (tn/MWh_e)
CO2LPE: CO_2 emissions due to the local production of electricity (tn)
CO2GEP: CO_2 emissions due to production of certified green electricity purchased by the local authority (tn) [9]

$$EFE = \frac{(165137 - 0 - 0) * 0.602 + 0 + 0}{165137} = 0.602 \text{ tn } CO_2/\text{MWh}$$

Diesel

According to the SECAP guidelines the CO_2 emission factor for the diesel used in vehicles is 0.267 tn/MWh. No biodiesel is being blended.

Gasoline

According to the SECAP guidelines the CO_2 emission factor for gasoline is 0.249 tn/MWh.

Natural Gas

According to the SECAP guidelines the CO_2 emission factor for NG is 0,202 tn/MWh.

LPG

According to the SECAP guidelines, the CO_2 emission factor for liquefied petroleum gas is 0.226 tn/MWh.

Solar thermal

The solar thermal power hasn't emissions thus its emission factor is zero according to the guidelines.

2.4.2 Non energy related emissions

Apart from the CO_2 emissions released from the daily activities, also there is a significant amount of Greenhouse Gases derived from waste management and waste water treatment plants.

In the Monastir municipality there is a wastewater treatment plant treat the waste water which produced from the municipality, in addition to the municipal solid waste production in the municipality.

Here is the CO_2 emission contribution of the biomass in the municipality:

A- Municipal solid waste

In order to calculate the emissions from municipal solid waste, the IPCC default method was used as it appears below [14] :

Methane emissions (Gg/yr) = (MSWT ● MSWF ● MCF ● DOC ● DOCF ● F ● 16/12-R) ● (1-OX)..... (1)

Where:

- MSWT : total MSW generated (Gg/yr)
- MSWF: fraction of MSW disposed to solid waste disposal sites
- MCF: methane correction factor (fraction)
- DOC: degradable organic carbon (fraction) (kg C/ kg SW)
- DOCF: fraction DOC dissimilated
- F: fraction of CH4 in landfill gas (IPCC default is 0.5)
- 16/12: conversion of C to CH4
- R: recovered CH4 (Gg/yr)
- OX: oxidation factor (fraction – IPCC default is 0)

The IPCC default method assumes that all the potential of CH4 emissions releases during the same year the waste is disposed of. The method introduces various specific default values and recommendations, for use in countries with lack of statistical data for Solid Waste.

The calculation of the degradable correction factor (DOC) is based on the following equation.

DOC=0,4*A+0,17*B+0,15*C+0,3*D.....(2)

Where:

- A Percentage of paper and textiles in SW
- By Percentage of garden and park waste and other organic putrescible in SW
- C Percentage of Food waste in SW
- D Percentage of wood and straw waste in SW

The form of this suggested equation wasn't followed directly because in the case of a Monastir municipality there was a different composition of solid waste. New factors were found in order to calculate the DOC.

The total quantity of solid waste for 2016 was 43,800 tn. The entire amount is thrown in landfill. Waste composition, as well as the results from the calculations is presented in the next two tables.

Table 15: *Solid waste composition in Monastir, 2016*

Solid waste composition	Percentage	tn/a
garden waste	3%	1,314.0
paper	10%	4,380.0
wood	1%	438.0
glass	2%	876.0
Organic Waste	64%	28,032.0
metal	4%	1,752.0
plastic	11%	4,818.0
Textiles	1%	438.0
others	4%	1,752.0
Total annual waste in tn	**100%**	**43,800**

Table 16: *Waste Emissions Calculation factors*

Variables	Values
MSW_t:	44
MSW_f:	1
MCF:	0.4
DOC:	0.2791
DOC_f:	0.648
F:	0.5
16/12:	1.3333
R:	0
OX:	0

Where DOC_f=0,014*T+0,28 (T: average temperature in Monastir, 26.3◦C)

All things considered, 2,115tn of methane are released due to the waste management. This quantity equals to 52,864tn of equivalent CO_2. (According to the guidelines the factor which was used for the conversion is 25)

B- Waste Water Treatment Plant (WWTP)

In order to calculate the emissions from WWTP, the IPCC default method was used as it appears below:

CH4 emissions = $(U_i * T_{i,j} * EF_j) * (TOW-S) - R$

Where:

- Ui : fraction of population in income in inventory year
- Ti,j : degree of utilization of treatment pathways or system
- EFi : Emission factor
- R : amount of CH4 recovery in inventory year.
- S : organic component removed in inventory year as sludge
- TOW : total organics in waste water during inventory year

The calculation of the emission factor factor (EFi) is based on the following equation.

EFi =B◦*MCFj

where:

- B◦ : Maximum CH_4 production Capacity
- MCFj : methane correction factor

The following equation was used to calculate the total organics in waste water in inventory year (TOW).

TOW= P*BOD*0.001*I*365

where:

- P : country population
- BOD : Biochemical Oxygen Demand (BOD)
- I : correction factor for additional industrial BOD discharged into sewers

The plant treats daily about 4,174,738 m^3 of waste water, and the total quantity of sewage sludge for 2016 was 521.2 tn from the Monastir municipality. Waste composition, as well as the results from the calculations is presented in the next table:

Table 17: *sewage Emissions Calculation factors*

Ui	0.09
Ti,j	0.7
EFi	0.06
R	0
S	1,428
TOW	5,073

All things considered, 6.99 tn of methane are released due to the waste management. This quantity equals to 174.84 tn of equivalent CO2. (According to the guidelines the factor which was used for the conversion is 25).

c- Livestock breeding

In Monastir Municipality there is a small livestock breeding sector. There are cows, camels and sheep breeding in the Municipality.

The table below shows the number of head from each type of livestock in addition to the annual emission factor:

Table 18: Number of heads and emission factor for livestock breeding in Monastir Municipality.

Type of livestock	Number of heads	Emission factor (Kg CH4/year)
Cows	655	1
Camels	15	2.56
Sheep	2350	0.2

All things considered, 1.16 tn of methane are released due to the livestock breeding. This quantity equals to 29.08 tn of equivalent CO_2. (According to the guidelines the factor which was used for the conversion is 25).

2.1.5 Final CO_2 emissions

The emissions of CO_2 for the sectors that have been described in the previous sections are available, in total, in the following table.

Table 19: *Total CO_{2eq} emissions for Monastir Municipality*

Sector			Total CO2 emissions [tnCO2/year]									
			Electricity	Heat/cold	Fossil fuels					Renewable energies		Total
					Natural Gas (Low Pressure)	Natural Gas (Medium Pressure)	LPG	Diesel	Gasoline	Other biomass	Solar thermal	
Residential sector			32,556		7,259	0	11,451	0	0		0	**51,266**
Municipal Buildings			541		4	0		0	0		0	**544**
Tertiary Sector			48,035		9,435	0		317	0		0	**57,786**
Industrial Sector			13,461		3,001	15,837		0	0		0	**32,299**
Public street lighting			3,238		0	0		0	0		0	**3,238**
Transportation Sector	Urban Road Transportation	Municipal Fleets	0		0	0		530	132		0	**662**
		Public Transportation	0		0	0		3,761	6,360		0	**10,122**
		Private Transportation	0		0	0		14,083	33,584		0	**47,667**
	Urban Rail Transportation		1,583		0	0		217	0		0	**1,800**
	Local Ferries		0		0	0		50	0		0	**50**
Sub-Total			**99,413**	**0**	**19,699**	**15,837**	**11,451**	**18,958**	**40,076**	**0**	**0**	**205,434**
Non Energy Sources												
Waste water treatment Plant										175		175
Livestock breeders										29		29
Municipal Solid waste										52,865		52,865
Sub-Total										**53,068**		**53,068**
Total			**99,413**	**0**	**19,699**	**15,837**	**11,451**	**18,958**	**40,076**	**53,068**	**0**	**258,502**

2.2 Results' Graphical Analysis

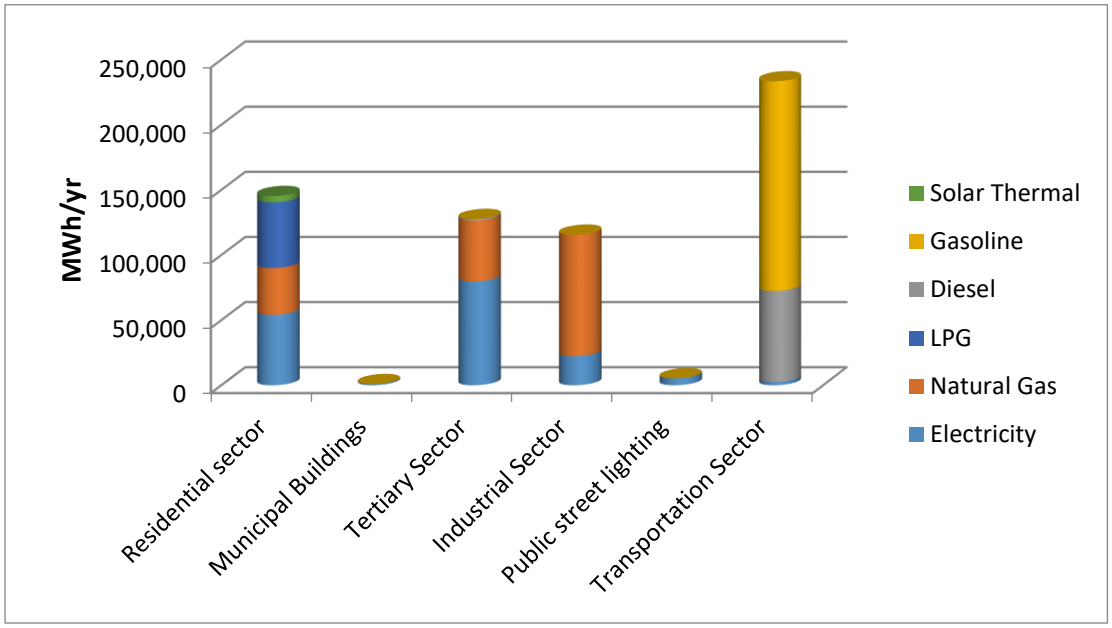


Figure 23: Final Energy consumption per sevtor and per fuel.

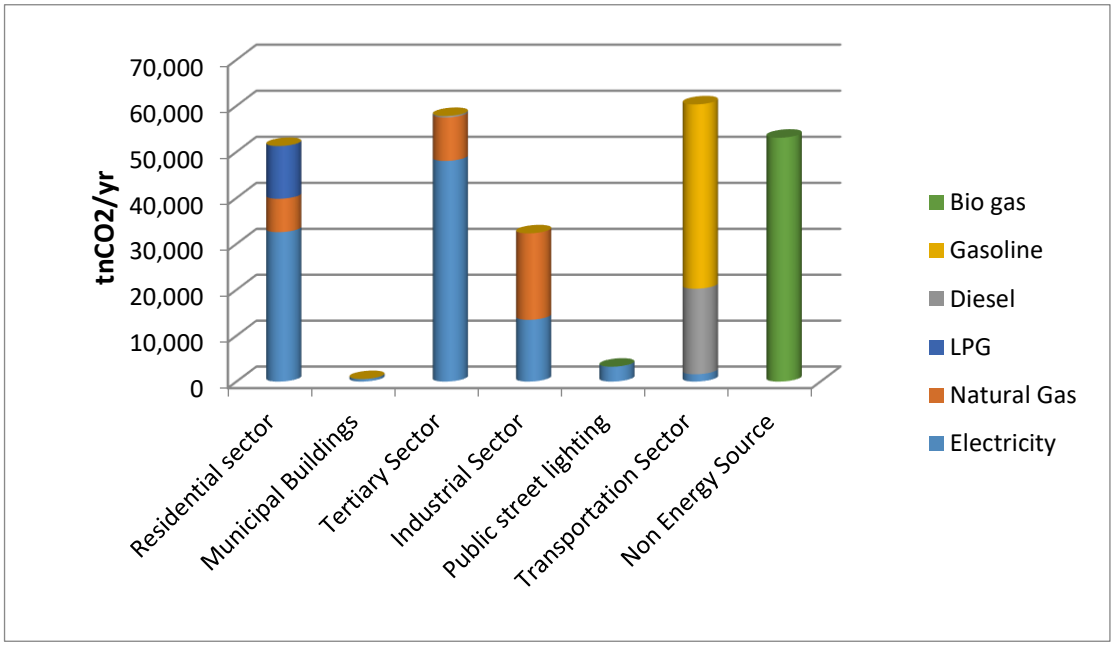


Figure 24: Total CO2 emissions per sector and per fuel.

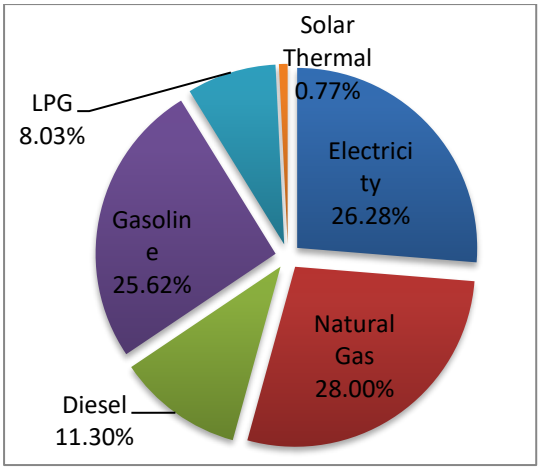


Figure 25: Final Energy Consumption per fuel.

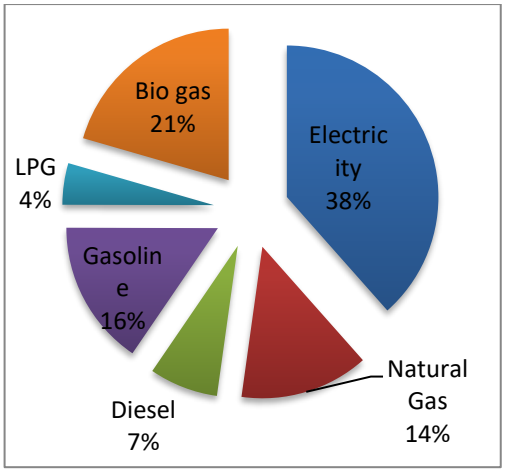


Figure 26: Total CO2 emissions per fuel

Chapter 3: SECAP Actions

3.1 Target for 2030

The Municipality of Monastir is called upon to take double role in the efforts towards CO_2 reduction, both as a demonstrator giving the good example to its citizens, as well as a triggering power and coordinator for all activities in the area. The first role, giving the good example, should be realized through the adoption of actions to reduce the emissions resulting from the buildings/ facilities / vehicles etc. under its direct responsibility. Emissions from waste are another sector under the direct responsibility of Monastir Municipality. Nevertheless, the municipal direct related emissions are only a relatively low percentage of the total. Therefore, it should act as a triggering power and coordinator of the activities to be realized by the private sector in a series of activity fields. According to the BEI, the sectors contributing the most to the carbon footprint are the transport (23%), the Tertiary (22%), the residential (20%) and the Bio waste (21%). Thus the Municipality should focus on the actions through which the citizens will be encouraged and take the appropriate measures in order to reduce the CO_2 emissions from their activities. At the same time, actions in the other sectors will be suggested as well.

In this respect, the first step is the calculation of the Business as Usual (BAU) scenario, in line with the JRC guidelines for South Municipalities, considering that Tunisia, as a country with its economy under development, will face an increase in its energy demand due to the expected economic and population growth. Considering the use of the BAU scenario for the calculation of the 2030 emission levels and in turn the respective reduction target, the following calculations are realized according to the guidelines.

$$Emissions_{CO_2}^{2030} = Emissions_{CO_2}^{Baseline\ year} \times k$$

In Monastir, the emissions for the baseline year, 2016, were 258,502 tn $CO_{2\ eq}$. The national coefficient k for the baseline year of 2016 in Tunisia is 1.47. Therefore, the forecasted emissions for 2030 are

$$Emissions_{CO_2}^{2030} = 258502 \times 1.47 = 379{,}998\ tn\ CO_{2\ eq}$$

The emission reduction target for Monastir Municipality according to Covenant of Mayors the target should be at least 40% (151,999 tn $CO_{2\ eq}$) against the calculated 2030 emissions compared with the BAU scenario.

On the other hand, in order for the 40% target to be achieved, strict measures are needed which should be enforced through the development and implementation of the respective legislative framework.

Calculations for 40% reduction have been realized based on the suggested actions. In the next sections a more detailed analysis per action for each sector is provided. It should be noted that for awareness raising activities conducted by the municipality, besides the implementation cost born by the municipality and its potential funding sources, the amount

of the private funds mobilized is reported as well where relevant. This cost doesn't participate in the calculation of the NPV value. Moreover, it should be clarified that externalities costs are not considered in the calculation of the NPV; this results sometimes in actions with a negative NPV from the strict economic calculation, although their overall impact could be considered positive if additional benefits were considered.

3.2 Municipal Buildings, Equipment/Facilities

This sector contributes in the carbon footprint less than 1%. Nevertheless the possible actions to be implemented in the Municipal Buildings could set an example for the citizens and the employees. Municipality acknowledged the measures which best fit its needs so as to achieve energy savings and emission reductions. In the following sections, a comprehensive set of actions is being analyzed.

The suggested actions for this sector consist of energy conservation and green energy production measures. Focus has been placed on energy saving activities and PVs on building's roof, since these are considered to be easily implemented, unlike the bigger RES facilities requiring more time and more free spaces available.

Apart from these categories of actions, there are also some envisaged actions which target the user through awareness raising activities. These actions aim to make the inhabitants' behavior environmental friendly, as well as to properly educate the new generations in environmental and energy related issues.

An overview of this sector's actions and achieved reductions is presented on the table below.

Table 20: Actions in Municipal Buildings, Equipment/Facilities

Action No.	Action	Emission Reductions (tn CO_2)
1.1	Green procurement procedures for municipal buildings	39.7
1.2	Energy manager appointment in the municipality	2.4
1.3	Awareness raising activities for municipal employees	7.6
1.4	Adoption of bioclimatic principles in new municipal buildings /Strict application of green building codes in new municipal buildings	96.3
1.5	Efficient municipal buildings including Photovoltaic Systems on the Municipal buildings Rooftop 187 kWp	420.1
1.6	Promotion of recycling	1,165.7
1.7	Waste management	38,078.7
1.8	3 MW PV plant	3,251
1.9	Creation of Energy Saving Department	-
1.10	Web portal creation	-
Total		**43,061.1**

3.2.1 Green procurement procedures for municipal buildings

Green procurement is the procedure where the municipality seeks to purchase goods and services with a reduced environmental impact throughout their life cycle. Selecting products of high efficiency that minimize the environmental impacts, it is possible to consume less energy thus reduce the CO_2 emissions and achieve monetary savings. The action is envisaged to be applied in all new office equipment that the municipality plans to purchase for their increasing needs and for the gradual substitution of old, inefficient one. Especially for high energy consuming office equipment, high efficiency products will be targeted, while minimum efficiency standards and requirements will be set in all relevant municipal tenders. An average estimation of 5% savings achieved against the BAU consumptions is envisaged.

In the next table, calculations regarding the cost, the savings and the financial viability of the action are presented.

Table 21: Action 1.1 in numbers

Green procurement procedures	
Duration	2019 - 2030
Total Implementation Cost (USD)	28,000
Annual Energy Savings (MWh)	65.9
Annual Emission Reduction (tn CO_2)	39.7
Funding Source	Own funds + Sida Funds
Net Present Value (NPV)	>0

3.2.2 Energy manager appointment in the municipality

One of the prerequisites of the municipality's adhesion to the Covenant of Mayors is the creation of the municipal administrative structures, in order to establish the working team to implement and monitor the progress of the SECAP activities. In this respect, this action focuses not only on the satisfaction of the above mentioned prerequisite, but goes well beyond it.

The energy manager will not only be the responsible person to monitor the energy consumptions and provide the necessary solutions when a problem is identified, but will act proactively in order to ensure the good coordination of the whole municipal team for the proper implementation of the envisaged SECAP actions.

The benefits related to the energy manager's appointment are considered multi-dimensional since strong coordination of the overall initiative is required, although strictly economic indicators are not encouraging. In case a member of the existing municipality staff is appointed to this position, this will have a positive NPV for the municipality.

Table 22: Action 1.2 in numbers

Energy manager appointment in the municipality	
Duration	2020 - 2030
Total Implementation Cost (USD)	9000
Annual Energy Savings (MWh)	3.92

Annual Emission Reduction (tn CO_2)	2.4
Funding Source	Own funds
Net Present Value (NPV)	<0

3.2.3 Awareness raising activities for municipal employees

A significant step to achieve the planned targets is to have properly communicated the municipality's intentions to the people working within those building. In this respect, this action comprises of a set of targeted awareness raising activities towards the municipal employees. The aim of these activities is to encourage the municipal employees to change their behavior and habits in order to achieve the envisaged results.

The set of awareness raising and training actions to be realized for the municipal employees includes the following:

- Training workshops and seminars for the team members directly involved in the SECAP implementation and monitoring. This activity aims at the capacity building regarding SECAP development and project implementation of the employees directly involved in the SECAP implementation team. These workshops and seminars could be targeted on how to attract financing from international donors, to manage the project implementation or even focus on the exchange of best practices and ideas with other municipalities in Tunisia and abroad that face the same challenges. Workshops on the latest available know how in terms of energy efficiency and RES technologies are envisaged as well.
- Development and circulation of promotional material through the employees' e-mails on the benefits of energy efficiency and how simple behavior changes impact the total consumption.
- Municipal contest for the administrative building with the highest energy savings achieved (in terms of %) due to users' behavior change. This contest prize could be any incentive provided to the employees, such as two additional days off that year or the development of posters with the pictures and names of the employees that contributed to the goal. The aim would be to achieve energy savings through strictly behavioral change, such as turning off the lights, the air conditioners ACs and office equipment when leaving the office, not leaving open windows with the AC on etc. This measure could be used during the first couple of years, when the rest of the energy efficiency interventions will be gradually taking place.

Table 23: Action 1.3 in numbers

Awareness raising activities for municipal employees	
Duration	2019-2023
Total Implementation Cost (USD)	1000
Annual Energy Savings (MWh)	12.55
Annual Emission Reduction (tn CO_2)	7.6
Funding Source	Own funds + external fund
Net Present Value (NPV)	>0

3.2.4 Strict application of green building codes in new municipal buildings

Due to the expected economic and population growth in site of 2030 horizon, citizens' needs will be increased; therefore the municipality's services should be extended. As a result, new buildings will be constructed to meet city's needs and consequently there will be an increase in energy consumption, as envisaged in the BAU scenario. In order to mitigate this increase, the construction of new buildings should strictly abide with the Energy Efficient Building Codes.

These measures include the adoption of natural lighting and ventilation, insulation in exterior surfaces, as well as shading in the glazing. In addition to the above, the use of cool colors especially in roofs will also contribute significantly to the reduction of energy losses. Moreover the building's orientation should be taken into consideration.

All the above measures (plus other appropriate bioclimatic principles where it is possible), as well as strict application of the existing Energy Efficient Building Code will be implemented in all new buildings so as to reduce the expected increase in energy and CO_2 emissions.

Table 24: Action 1.4 in numbers

Strict application of green building codes in new municipal buildings	
Duration	2020-2023
Total Implementation Cost (USD)	1,150,000
Annual Energy Savings (MWh)	160.03
Annual Emission Reduction (tn CO_2)	96.3
Funding Source	Own and governmental funds
Net Present Value (NPV)	>0

3.2.5 Efficient Municipal Buildings

The current state of Monastir's existing municipal buildings includes almost LED lighting units and old ACs in all of them. On the other hand, none of the buildings' envelope is thermally insulated and the windows are of single glazing. Consequently there are thermal losses which increase the energy consumption. Thus, the Municipality envisages making these buildings efficient and green through actions in the building envelope, namely applying insulation of walls and roofs and use of double glaze windows. It is estimated that due to these measures the energy savings in the air conditioning systems will be 35%.

Moreover the Municipality wants to exploit the solar potential of the region via the installation of 187 KW PV panels in roofs and thus cover a part of the electricity consumption with renewable energy. The substitution of the electricity production source with alternative ones will contribute to the CO_2 reduction as well. The calculations are based in the BAU scenario.

Table 25: Action 1.5 in numbers

Efficient municipal buildings	
Duration	2020-2023
Total Implementation Cost (USD)	1,970,000
Annual Energy Savings (MWh)	1033
Annual Emission Reduction (tn CO_2)	420
Funding Source	Own funds, Donors & government
Net Present Value (NPV)	>0

3.2.6 Promotion of Recycling

As waste contributes with a 21% to the total municipal emissions, Monastir Municipality is dedicated to actively implement awareness activities to promote the recycling context. The target is to achieve 15% recycling rates by 2030. The promotional campaign will include info days, promotional material like leaflets and posters or even messages in local media (TV, radio, social media) regarding the benefits of recycling and instructions on how to do it.

The municipality will also ensure that the proper infrastructure (recycling bins and vehicles) is available for the waste sorting and collection on the streets, including recycling of electrical devices. Furthermore, in order to lead by example, the municipality will install recycling bins in all municipal buildings and facilities, promoting the use of recycled paper for the local administration.

Table 26: Action 1.6 in numbers

Promotion of recycling	
Duration	2020-2023
Total Implementation Cost (USD)	1,500,000
Annual Emission Reduction (tn CO_2)	1165.7
Funding Source	Own funds
Net Present Value (NPV)	<<0

3.2.7 Waste Management

The total amount of waste collected is 110 tn/day in the Monastir Municipality. The solid waste issue has gained significant attention in the recent years, not only due to its environmental impacts, but also for its social and economic consequences. The Municipality is committed to work on reducing waste to be collected as the major solution to reduce energy consumption generated by waste management. It is also planning to separate the biomass to produce bio-fertilizer. Biological treatment will be used to treat the biomass and produce bio-fertilizer. The bio-fertilizer plant of1.7 MWp will convert the bio organic waste to bio gas and fertilizer.

Short-term actions

The Municipality is committed to work on reducing waste to be collected as the major solution to reduce energy consumption generated by waste management.

The Municipality will continue developing public awareness to reduce waste generation, promote recycling and separation. The idea is to draw experience from the pilot project to then be extended to the entire city.

Long-term actions

The municipality is planning to separate the biomass to produce bio-fertilizer. Biological treatment will be used to treat the biomass and produce bio-fertilizer.

The bio-fertilizer plant will reduce about 38,078 tn Co2 eq annually by converting the bio organic waste to bio gas and fertilizer.

Also the municipality will separate the glass and sell it to be recycled.

The total investment for the plant, regarding costs for 1.7 MWp biogas plant for bio fertilizer (purification and filling) and solid waste separation plant, equals 11,000,000 USD ,with operational cost 1,850,000 USD. The expected income from electricity and fertilizer generation is 2,342,878 USD. More specifically, the income is calculated as follows:

Income from electricity=14258 MWh * 71 USD/MWh= 1,012,318 USD

Income from fertilizer=45% (fertilizer production rate from biomass)*70.4 tn of biomass daily*300days of operation*140 USD/tn of fertilizer= 1,330,560 USD

Table 27: Action 1.7 in numbers

Waste Management	
Duration	2020-2023
Total Implementation Cost (USD)	11,000,000
Annual Energy Production (MWh)	14,258
Annual Emission Reduction (tn CO_2)	38,078
Funding Source	Own and EU funds
Net Present Value (NPV)	>0

3.2.8 Install 3 MW PV plant

It is well known that Tunisia has a great solar potential. Municipality wants to take advantage of this benefit and install a PV plant of 3 MW to cover partially the electricity consumption from municipal building and public lighting. By doing so, its dependency on the grid will be reduced through a renewable source of energy, thus achieving CO_2 reductions as well.

The Key data on the investment are presented in the table below.

Table 28: Action 1.8 in numbers

PV plant 5 KW	
Duration	2023-2030
Total Implementation Cost (USD)	5,400,000
Annual Energy Production (MWh)	5,400,000
Annual Emission Reduction (tn CO_2)	3,251
Funding Source	Donor
Net Present Value (NPV)	>0

3.2.9 Establishment of Energy Saving Department

The creation of an Energy Saving Department is proposed, to be staffed with 1 person according to the municipality's needs. These employees should be technically qualified on energy related issues, so as to promote appropriate activities related to energy savings and support citizens. Citizens will turn to this department in order to be informed for new practices and to receive techno-economic advices regarding their energy related investments. In addition to the above, this department can support the activities of the energy manager and undertake the responsibility for monitoring the SECAP actions' progress, in close collaboration with the employees directly involved with their implementation. The implementation of this action is not considered to derive direct energy savings and CO_2 reduction benefits, but it is seen as a supplementary one to the rest of the actions in the sector.

Table 29: Action 1.9 in numbers

Establishment of Energy Saving Department	
Duration	2017 - 2030
Total Implementation Cost (USD)	Already implemented
Funding Source	Own funds

3.2.10 Social media portal creation

The creation of a social media portal regarding energy savings could be a tool for the Energy Saving Department so as to interact with the citizens. The aim is to inform inhabitants about the municipality's actions and events related to the SECAP implementation, new measures for energy savings as well as funding sources. Moreover the social media will host a discussion forum where they could exchange their opinions, find out solutions to their questions and keep in touch with the Energy Saving Department's staff. No direct energy savings have been allocated to this action, but it is considered to be a significant contribution in encouraging citizens to adopt the "green" practices and as a major tool in the promotion of all related awareness raising activities by the municipality. This website can be a dedicated site linked to the municipal one, or be integrated within it.

Table 30: Action 1.10 in numbers

Web portal creation	
Duration	2016
Total Implementation Cost (USD)	1,000
Funding Source	Own funds

3.3 Municipal Public Lighting

The municipal public lighting includes street lighting and public areas' lighting. It is estimated that with the appropriate upgrades of this system there will be significant energy savings and respective emission reductions.

An overview of this sector's actions is presented in table 31 , while a detailed analysis with calculations for each action follows in the next paragraphs.

Table 31: Actions in Municipal Public Lighting

Action No.	Action	Emission Reductions (tn CO_2)
2.1	Street lighting upgrade	1,297
2.2	Astronomical timers	420.8
2.3	Green procurement procedures for future lighting equipment	998.9
Total		**2,717**

3.3.1 Street lighting upgrade

Various types of lamps are used for street lighting, more specifically the High Pressure Sodium. The Municipality wants to replace all of the existing lamps with LEDs, which are more efficient and provide great luminosity quality. This action will ensure great monetary savings for Monastir and significant reduction in electricity consumption.

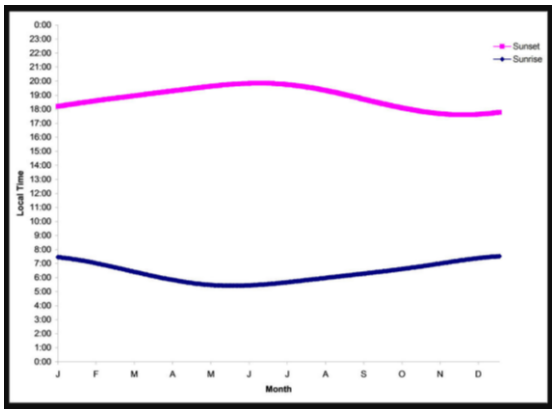
The key data on the action is presented in the below table.

Table 32: Action 2.1 in numbers

Street lighting upgrade	
Duration	2017- 2025
Total Implementation Cost (USD)	1,485,900
Annual Energy Savings (MWh)	2,154.7
Annual Emission Reduction (tn CO_2)	1,297.2
Funding Source	Own and Sida fund
Net Present Value (NPV)	>0

3.3.2 Astronomical timers

The operation of street lighting is controlled manually by the operators. This control method could be replaced with astronomical timers control, which are more accurate and precise compared to personal behavior. This action will reduce the electricity consumption by 15%, as explained in the following figure that shows the sunrise and sunset timing where the manual control acts little before/after timing and counts for loss of around 365 hours of operation per year.



Source: http://file.scirp.org/Html/4-6401175_24420.htm

Figure 27: Timing for sunset and sunrise in Tunisia

The astronomical timers' use would also help in precise timing for switching and programming the actual operation after 20 min of sunset and almost 30 min before sunrise, which is an acceptable trimming as light, will be still there.

Key data on the investment are presented in the table below.

Table 33: Action 2.2 in numbers

Astronomical timers	
Duration	2026-2030
Total Implementation Cost (USD)	37,000
Annual Energy Savings (MWh)	699
Annual Emission Reduction (tn CO_2)	420.8
Funding Source	Own funds
Net Present Value (NPV)	>0

3.3.3 Green procurement procedures for future lighting

Green procurement constitutes the procedure where the municipalities seek to procure goods with reduced environmental impact throughout their life cycle and high efficiency standards. In this way selection of products that minimize environmental impacts takes place, emphasizing on highly energy efficient equipment. This action is envisaged for the future lighting equipment purchases within the 2030 horizon, since it is expected that the network

will expand due to the city's growth. Key data on the action is presented in the table below and have been calculated against the BAU scenario.

Table 34: Action 2.3 in numbers

Astronomical timers	
Duration	2020-2030
Total Implementation Cost (USD)	700,000
Annual Energy Savings (MWh)	1,659
Annual Emission Reduction (tn CO_2)	998.9
Funding Source	Own funds
Net Present Value (NPV)	>0

3.4 Residential Buildings

This sector includes the energy consumption of all the private residents regarding the activities in each household (lighting, heating, use of electric appliances etc.). This consumption constitutes 47.69% of the total consumption with 51.31% contribution to the CO_2 emissions.

The initial actions are informational and they will be realized by Monastir Municipality. Since the Municipality does not have the possibility of direct interventions in terms of projects' realization, a series of actions will be planned aiming at encouraging the inhabitants to take the proposed measures in order to reduce their energy consumption and carbon emissions.

An overview of this sector's planned actions is presented in the next table.

Table 35: Actions in Residential Buildings

Action No.	Action	CO2 Reduction (tn)
3.1	Awareness raising activities for modification of the residents' consumption behavior and energy saving	6,389
3.2	Promotion of Green Buildings' concept / Strict application of the building code	1361
3.3	1. Campaign for promoting high-energy label home appliances and other awareness activities 2. Implement the PROMO-FRIGO action plan locally ANME: replacing old refrigerators with new ones performing.	1,729
3.4	Replacement of existing lamps with LEDs	2,196
3.5	Replacement of existing air-conditioners with more efficient ones	1,242
3.6	1. Replacement of single glazing with double glaze windows 2. Implement locally the PROMO-ISOL action plan of the ANME: installation of thermal insulation on the roofs of houses individual.	2,896

3.7	Replacing 10% of inefficient Boilers with efficient condensing boilers	121
3.8	1. Installing 6.6 MW Photovoltaics in residential rooftops 2. Implementing locally the PROSOL ELEC programme of ANME: Installing Photovoltaic systems for residential buildings.	7,178
3.9	1. Replacing existing water heaters with solar water heaters 2. Implementing Locally the PROSOL programe of the ANME: installation solar thermal systems instead of the existing water heaters.	3,689
	Total	26,802

3.4.1 Awareness raising activities for activities for the community about (RE &EE)

The initial step is that the municipality should organize frequently within the 2030 horizon, awareness raising campaigns for the residents of Monastir. Citizens' engagement is of utmost importance since almost the 23% of the total energy consumption is due to the residential sector. The aim is to enhance the environmental consciousness of the citizens through the following activities:

- Organization of "Energy days", in line with its participation in the Covenant of Mayors initiative. In these energy days the importance of energy saving and protecting the environment will be stressed, through simple actions such as modification of the energy behavior, changing inefficient lamps with LED lamps, importance of purchasing high energy class appliances, installation of solar panels for water heating in existing buildings etc.
- Projection of freely available environmental documentaries.
- Participation in "Earth hour" event by WWF, where people across the world turn their lights off for one hour on a designated day.

Related calculations on the action in terms of initial cost and emission savings are presented in Table 36 below. As an awareness raising activity, it is considered that the action is exponentially beneficial to the municipality against the related costs.

Table 36: Action 3.1 in numbers

Awareness raising activities for activities for the community about (RE &EE)	
Duration	2020 - 2030
Total Implementation Cost (USD)	10,000
Annual Energy Savings (MWh)	17,485
Annual Emission Reduction (tn CO_2)	6,389
Funding Source	Own funds, ANME, external funds
Net Present Value (NPV)	>>0

3.4.2 Promotion of Green Buildings' concept

The lack of mandatory application of the Energy Efficient Building Code in Tunisia is one of the key issues behind the moderate energy behavior of buildings in the country. This action is focusing new and old buildings.

The promotion of specific elements of the green buildings' concept that can be applied in around 10% of the buildings to be constructed. This 10% penetration level has been considered an average rate with which citizens adopt such types of measures, following the intensive awareness raising activities to be realized by Monastir Municipality. Also, the Municipality will proceed in consultations with the building constructors and try to establish voluntary agreements with them in order that they apply some minimum energy efficiency standards in the new constructions, to be commonly agreed. Customized sets of potential interventions and actions will be suggested to the citizens through info days and awareness activities in the local media (local newspapers, TV and radio), as well as distribution of dissemination material (flyers, brochures etc.), in line with the action described above. These interventions will be mainly focusing on the need to install shadings in the southern glazing and roof insulation. Low cost efficient technologies will be promoted as well, such as the use of energy efficient lamps (e.g. LEDs). The green municipal building will serve as a demonstration basis of these technologies and the existing potential for energy and cost reductions.

Related calculations on the action in terms of initial cost and emission savings are presented in the table below. As an awareness raising activity, it is considered that the action is exponentially beneficial to the municipality against the related costs.

Table 37: Action 3.2 in numbers

Promotion of Green Buildings' concept	
Duration	2020 - 2030
Total Implementation Cost (USD)	30,000
Private and Citizen Funds Mobilized (USD)	84,900,000
Annual Energy Savings (MWh)	6,259
Annual Emission Reduction (tn CO_2)	3,768
Funding Source	Own funds, ANME, Governmental funds, Private funds
Net Present Value (NPV)	<<0

3.4.3 Campaign for promoting high energy label equipment

Another important activity the municipality should organize is the campaign for promoting among the residents the purchase and use of high-energy label equipment. The old equipment (refrigerators, stoves, vacuum cleaners etc.) consumes greater amounts of energy compared to new, more technologically advanced. The aim is to inform the residents about the benefits of goods with a reduced environmental impact throughout their life cycle, emphasizing also on the monetary benefits for the users themselves, since when selecting energy efficient products this leads in less energy consumption as well. As presented in the previous sections,

dedicated awareness raising activities should also take place in order to disseminate the advantages of purchasing such electrical appliances. Indicative awareness raising campaigns include brief spots on the local TV and radio, posters, info days etc.

Key data on the action and its expected impact is presented in the table below.

Table 38: Action 3.3 in numbers

Campaign for promoting high energy label equipment	
Duration	2020 - 2027
Total Implementation Cost (USD)	17,500
Private and Citizen Funds Mobilized (USD)	8,560,152
Annual Energy Savings (MWh)	2,872
Annual Emission Reduction (tn CO_2)	1,729
Funding Source	Own funds, ANME, external, Private and residential funds
Net Present Value (NPV)	>0

3.4.4 Replacement of existing lamps with LED lamps

Currently, the use of LED lamps in the residential sector is relatively limited. The use of LED technology is suggested, since it can lead in energy and monetary savings on one hand, while these lamps provide great luminosity quality on the other. Their cost is higher from the conventional ones, but they have long life expectancy and a quite positive cost benefit ratio.

It is expected that through the awareness raising activities citizens will be encouraged to implement measures like this with a penetration level of 30%, thus contributing to the energy savings and CO_2 reduction in the region.

In addition, it is considered that Monastir will take upon legislative action to ban the use of mercury and low efficiency lamps in the area. Thus, the penetration level for high efficient lamps such as LEDs has been considered 100%.

Key data on the action are presented in the next table.

Table 39: Action 3.4 in numbers

Replacement of existing lamps with LED lamps	
Duration	2020 - 2030
Total Implementation Cost (USD)	370,800
Annual Energy Savings (MWh)	6,670
Annual Emission Reduction (tn CO_2)	4,015
Funding Source	ANME & external funds
Net Present Value (NPV)	>>0

3.4.5 Replacement of existing air – conditioners with more efficient ones

The hot climate in the region evokes the intense use of cooling systems in buildings and as a result a quite big percentage of electricity consumption is due to this need. In order to cut down the energy consumption the replacement of the existing A/Cs with units of higher energy class is suggested. Since A/Cs can constitute a significant part of the household's electricity bill, it is considered that within the 2030 horizon and following intensive awareness raising activities by the Municipality, the residents who are going to install/replace an A/C unit, will prefer one with relatively high performance standards.

Related calculations on the action in terms of initial cost and emission savings are presented in the table below.

Table 40: Action 3.5 in numbers

Replacement of existing air conditioners with more efficient ones	
Duration	2020 - 2028
Private Funds mobilized (USD)	4,876,848
Annual Energy Savings (MWh)	6,670
Annual Emission Reduction (tn CO_2)	1,729
Funding Source	ANME & external funds
Net Present Value (NPV)	>>0

3.4.6 Building envelope improvement for the existing buildings

A supplementary action with limited but not negligible savings is glazing replacement. In Monastir, although summers are very hot, in winter heating systems are required to achieve thermal comfort inside buildings. These heating systems consume LPG, Diesel and Kerosene and it is feasible to reduce their consumption by 15%, by reducing the building's heating losses via replacement of the single glazing with double. This action can also have impact in the electricity consumption, especially if it is to be combined with roof thermal insulation.

The PROMO-ISOL program, the idea of which was initiated by ANME in 2012, aims to produce and promote thermal insulation techniques for building roofs. This program mainly targets constructions individual. The program includes a financial mechanism to promote the thermal insulation of the roofs of new and existing housing through a subsidy of up to 30% of the cost of works and the purchase of equipment.

Table 41: Action 3.6 in numbers

Replacement of existing air conditioners with more efficient ones	
Duration	2020 - 2030
Private Funds mobilized (USD)	28,000,000
Annual Energy Savings (MWh)	8,761
Annual Emission Reduction (tn CO_2)	2,896
Funding Source	ANME & external funds
Net Present Value (NPV)	>0

3.4.7 Replacing 10% of inefficient NG boilers with efficient condensing boilers

Currently, the use of NG boilers for space heating in the residential sector is relatively limited. The use of condensing boilers is suggested, since it can lead in energy and monetary savings on one hand. Their cost is approximately higher from the conventional ones, but they have long life expectancy and a quite positive cost benefit ratio.

It is expected that through the awareness raising activities citizens will be encouraged to implement measures like this with a penetration level of 20%, thus contributing to the energy savings and CO_2 reduction in the region.

Also it is considered that Monastir will take upon legislative action to ban the use of traditional and old NG space heaters in the area. Thus, the penetration level for high efficient NG space heaters has been considered 15%.

Key data on the action are presented in the next table.

Table 42: Action 3.7 in numbers

Replacing 10% of inefficient NG boilers with efficient condensing boilers	
Duration	2020 - 2030
Private and Citizen Funds Mobilized (USD)	1,380,000
Annual Energy Savings (MWh)	586
Annual Emission Reduction (tn CO_2)	121
Funding Source	Private funds
Net Present Value (NPV)	>0

3.4.8 6.6 MW Photovoltaics in residential rooftops

As mentioned before, the solar energy potential is very high in the region. The households have the opportunity to install PV panels in the buildings' rooftops in order to substitute a part of the current electricity consumption with "green" energy from Renewable Energy Sources. Overall, 6.6 MW of PV panels respectively are expected to be installed within the 2030 horizon. In that way, and since electricity from solar energy has zero emission factor, the CO_2 emissions will be reduced. The municipality will conduct activities for the communities to ensure installing these target such as awareness activities on PV technology, Tax exemptions and others.

This action is part of the PROSOL ELEC program initiated by ANME. This allows access to a subsidy of 30% of the investment, with a ceiling of 1,500 TND / kWp, for installations of 1 kWp, and 2400 TND / kWp for installations of 2 kWp up to 4kWp. PROSOL ELEC also allows to access subsidized rate credit mechanisms, over a period of 7 years, via the STEG invoice.

We consider that the project would cover 15% of electrical consumption in the residential sector, or 6.6 MWp. Such a capacity would generate approximately 11,923 MWh of electricity in 2030 (taking an average of 1,800 kWh / kWp / year). Which estimated to cover 4676 households' consumption (considering 1.4 kWp per household).

This action consists in setting up, within the municipality, an incentive plan for the installation of systems solar photovoltaic in households by communicating on their economic benefits and aid available from ANME. The implementation of this plan will be carried out in collaboration with ANME and STEG which will be able to provide technical and economic data on photovoltaics.

Key data on the action are presented in the table below.

Table 43: Action 3.8 in numbers

6.6 MW Photovoltaics in residential rooftops	
Duration	2020 - 2030
Private and Citizen Funds Mobilized (USD)	11,923,200
Total Implementation Cost (USD)	20,000
Annual Energy Production (MWh)	11,923
Annual Emission Reduction (tn CO_2)	7,178
Funding Source	Private funds, ANME, Banks Loans
Net Present Value (NPV)	>>0

3.4.9 Replacing existing water heaters with solar water heaters

A standard permanent need in every household is the use of hot water for personal hygiene and house chores. Subsequently, currently a significant share of electricity and gas consumption is consumed for this activity. At the same time, although the use of solar water heaters in the country is quite extensive, it is considered that it could be further strengthened in the future. In order to mitigate the emissions derived from this activity's electricity and gas consumption the solution is to exploit the solar energy potential replacing the electric and gas water heaters with solar water heaters.

This action consists in setting up, within the municipality, an incentive plan for the installation of systems thermal solar panels for households, as part of the ANME PROSOL Residential program. The action would be to communicate on the economic benefits of solar water heaters (reduction of consumption of gas, fuel oil and electricity) and on the aid available from ANME. The realization of this plan will be carried out in collaboration with ANME which will be able to provide technical and economic data.

The amount of solar thermal systems that could be implemented through this action has been estimated in assuming that 50% of households would be equipped with solar thermal systems by 2030 (about 13,500 households), considering that Monastir will work towards this direction with its citizens through awareness raising activities and dedicated events.

Table 44: Action 3.9 in numbers

Replacing Existing Water Heaters with Solar heaters	
Duration	2020 - 2030
Private and Citizen Funds Mobilized (USD)	7,290,000
Total Implementation Cost (USD)	30,000
Annual Energy Production (MWh)	27,807

Annual Emission Reduction (tn CO_2)	6,148
Funding Source	ANME, Private funds
Net Present Value (NPV)	>>0

3.5 Tertiary Sector

This sector includes the energy consumption of public and commercial buildings, Water management facilities etc. regarding the activities in each one (lighting, cooling, heating, use of electric appliances etc.). This consumption constitutes the 20% of the total consumption, with 22% contribution to the CO_2 emissions.

The initial actions are informational and they will be realized by Monastir Municipality. Municipality does not have the possibility of direct interventions in terms of projects' realization, thus a series of actions will be planned aiming at encourage building managers/owners to take the proposed measures in order to reduce their energy consumption and carbon emissions.

An overview of this sector's planned actions is presented in the next table.

Table 45: Actions in Tertiary Sector Buildings

Action No.	Action	Emission Reductions (tn CO_2)
4.1	Put in place the recommendations of the audits and contracts programs in the tertiary sector.	12,403
4.2	7.5 MWp Photovoltaics in rooftops	8,068
4.3	Upgrade water facilities	4,857
4.4	Replacing existing water heaters with solar collectors	792
4.5	Develop eco-tourism.	911
Total		27,031

3.5.1 Put in place the recommendations of the audits and contracts programs in the tertiary sector

Since 2005, Tunisia has opted for an acceleration of the national energy efficiency policy with a program based on multiple actions: carrying out energy audits and program contracts, prior consultation concerning energy consuming projects, cogeneration, energy labeling of household appliances, etc.

One of ANME's flagship actions relates to program contracts. Indeed, at the end of the energy audit, establishments belonging to the industry, transport and tertiary sectors can sign a contract to carry out the energy saving actions recommended by the energy audit, thus committing them to reduce their consumption in return for financial aid. Indeed, the establishments involved benefit from a bonus of 70% of the cost of the audit and a grant which covers 20% of the cost of carrying out the action plan recommended by the energy audit.

The National Rational Energy Use Action Plan (ANME, 2013) suggests strengthening of this program, in particular via the establishment by the ANME of a specific assistance program and

to support establishments engaged in program contracts and which have not fulfilled the goals set. In addition, ANME undertakes communication and outreach efforts to intensify the pace of adherence to this program, and for the adoption of the Energy Management System (EMS) by the maximum number of establishments.

Furthermore, the Rational Energy Use action plan suggests the launch of more pointed on utilities. This measure allows establishments of all sizes, with the same activity, to have recourse to "standard" operations through the acquisition of high-performance equipment energetically without having to carry out a full audit of the establishment.

This action consists of supporting measures targeting the main utilities in use in the sector; in in this case heat pumps and air conditioning systems. It should be remembered that about 75% of the demand for primary energy in the tertiary sector comes from electrical uses, 2 / 5th of which are intended for thermal comfort.

For Monastir city case, there are some main significant consumers in the public and commercial sectors that have a high share in the energy consumption and CO2 emissions, such as Monastir Hotels (44 hotels), Monastir hospital, Monastir University, Habib bo Rqibah Airport, Marina Port, and the fishing ports. These main consumers have a share of 64% of CO2 emissions in the tertiary sector, which the energy audit should be conducted as a first step to define the energy saving measures and it financial analysis.

Table 46: Action 4.1 in numbers

Put in place the recommendations of the audits and contracts programs in the tertiary sector.	
Duration	2020 - 2030
Private and Citizen Funds Mobilized (USD)	45,000,000
Total Implementation Cost (USD)	50,000
Annual Energy Savings (MWh)	23,552
Annual Emission Reduction (tn CO_2)	12,403
Funding Source	Own funds, ANME & external funds

3.5.2 7.5 MWp Photovoltaics in rooftops

The solar energy potential for the country and Monastir region is very high. Thus, businesses will be encouraged to exploit this opportunity and install PVs in order to curtail a part of their electricity consumption. The utilization of rooftops is proposed for the installation of a total capacity of 7.5 MW of PVs. The produced electricity from Renewable Energy Sources like sun has zero emission factor. Consequently, the substitution of electricity production source with alternative ones will contribute to the CO_2 reduction.

ANME launched in 2010 the PROSOL ELEC program aimed at promoting photovoltaic installations targeting the residential sector in Tunisia. This program does not cover the tertiary sector, but the regulations allows tertiary establishments to benefit from a 20% investment subsidy. The conjunction such an incentive and the significant drop in photovoltaic costs could represent important opportunities for the tertiary sector.

This action therefore consists in setting up, within the municipality, a communication plan to relay ANME in the promotion of renewables, and more particularly the photovoltaics targeted by this action.

This plan will endeavor to communicate on the existing incentive program for the tertiary sector by putting emphasis on economic benefits (reduction in electricity consumption) and on available aid with ANME to reduce the investment cost of these systems. This plan will be carried out in collaboration with ANME, which can provide technical and economic data.

The quantity of photovoltaic solar systems that could be implemented thanks to this action and the gains associated emissions have been estimated. To make this calculation, the following assumptions were made:

• Average production in Tunisia is 1,800 kWh / kWp per year;

• 13% of the electrical energy consumption of the tertiary sector (except water facilities and agriculture sector) in the city of Monastir would be replaced by solar, which corresponds to the installation of around 7.5 MWp and to production more than 13,350 MWh per year;

• An average cost of 4000 TND / kWp in Tunisia.

Table 47: Action 4.2 in numbers

Photovoltaics in rooftops 7.5 MWp	
Duration	2020 - 2030
Private Funds Mobilized (USD)	10,800,000
Total Implementation Cost (USD)	45,000
Annual Energy Production (MWh)	13,403
Annual Emission Reduction (tn CO_2)	8,068
Funding Source	Private funds, ANME, External funds
Net Present Value (NPV)	>>0

3.5.3 Upgrade Water Facilities

In addition to the previous action, energy audits for the water pumping stations PSs and waste water treatment plants WWTPs (15 PSs and 1 WWTP) are needed to conducted, because the share of these stations in CO2 emissions is about 10.4% of the total tertiary sector. In the other hand, energy assessment for the irrigation systems in the agriculture sector should be conducted.

Also installing 2 MW of PV systems will to cover 25% of the electricity consumption in the water facilities and irrigation systems in the city, and partially avoid using fuel source for irrigation and pumping. Which a support by ANME can reach 45% of PV systems cost for the irrigation systems that work by diesel pumps.

Table 48: Action 4.3 in numbers

Photovoltaics in rooftops 2.0 MWp	
Duration	2020 - 2030
Private Funds Mobilized (USD)	3,000,000

Total Implementation Cost (USD)	45,000
Annual Energy saving (MWh)	5,672
Annual Energy Production (MWh)	3,218
Annual Emission Reduction (tn CO_2)	4,857
Funding Source	Private funds, ANME, External funds
Net Present Value (NPV)	>0

3.5.4 Using of Solar Water Heaters

Several businesses activated in the tertiary sector, such as schools and hotels, utilize extensively water heating for covering theirs and their customers' needs. Since the penetration of SWH in the sector in the baseline year was negligible, there is a significant potential for electricity savings through the adoption of SWH.

ANME launched in 2010 the tertiary PROSOL program aimed at promoting solar installations thermal in the tertiary sector in Tunisia. Thermal solar, like photovoltaics, has its place in the national plan to reduce greenhouse gases (GHG) since the Tunisian solar plan (TSP) provides a significant increase in installed capacity (from 2 MW in 2010 and 253 MW in 2016). This action therefore consists in setting up, within the municipality, a communication plan to relay the ANME Tertiary PROSOL program. This plan will focus on communicating on the existing program incentive to install solar thermal systems for the tertiary sector by emphasizing their economic benefits (reduction in the consumption of gas, fuel oil and electricity) and on the aid available with ANME to reduce the investment cost of these systems. The realization of this plan can be carried out in collaboration with ANME which can provide technical and economic data.

The quantity of solar thermal systems that could be implemented thanks to this action and the gains in associated emissions have been estimated. To make this calculation, it was considered that 5% of consumption of the tertiary sector of the city of Monastir would be replaced by solar (taking into account system yields and additional heat).

Key data on the action are presented in the following table.

Table 49: Action 4.4 in numbers

Using of Solar Water Heaters	
Duration	2020 - 2030
Private Funds Mobilized (USD)	1,000,000
Total Implementation cost (USD)	35,000
Annual Energy Production (MWh)	555
Annual Emission Reduction (tn CO_2)	792
Funding Source	ANME and External funds
Net Present Value (NPV)	>0

3.5.5 Develop eco-tourism

This action would consist of the municipality of Sousse working with the hotel sector to develop an eco-tourism offer. Mass bathing tourism on which Tunisia relies is no longer so profitable only in the 90s and reflections are underway to restructure this sector. Eco-tourism could present interesting opportunities for the sector.

For the costing of this action, the following working hypotheses were used:

- An average number of tourists to Monastir is 379,506 per year [3];
- It is assumed that each tourist emits around 20 kg CO2 / day and that the average length of stay is 6 days [3];
- This therefore represents approximately 7,590 tCO2 / year;
- If 10% of tourists turn to eco-tourism by 2030 and this mode of tourism allows reduce GHG emissions by 20%, this would reduce GHG emissions by 911 tCO2 / year by 2030 mainly on the tertiary sector but also on transport (for reasons of presentation, these gains are presented under the tertiary sector)

Table 50: Action 4.5 in numbers

Develop eco-tourism	
Duration	2020-2030
Private Funds Mobilized (USD)	35,000
Annual Emission Reduction (tn CO_2)	911
Funding Source	Private funds
Net Present Value (NPV)	>0

3.6 Industrial Sector

The share of the industrial sector is 18% out of the total energy consumption in Monastir Municipality, with 12% contribution in CO2 emissions. The proposed actions are presented in the next table and a more detailed analysis for each one is following.

Action No.	Action	Emission Reductions (tn CO_2)
5.1	Implement the recommendations of audits and contract programs ANME for industrial units	12,098
5.2	Install photovoltaic systems in the industrial sector	4,947
Total		17,045

3.6.1 Implement the recommendations of audits and contract programs ANME for industrial units.

In the framework of program contracts, establishments in industry sectors may be subject to energy audit and sign a contract to carry out the energy saving actions recommended by the audit. This thus commits them to reduce their consumption in return for financial aid.

Committed establishments receive a premium of 70% of the cost of the audit and a subsidy, which covers 20% of the cost of the actions recommended by the energy audit, capped according to the consumption levels of the establishment concerned. The National Rational Energy Use Action Plan (ANME, 2013) suggests strengthening of this program, in particular via the establishment, by ANME, of a specific assistance program and to support establishments engaged in program contracts but also through efforts to communication and proximity to intensify the pace of adherence to this program and for the adoption of the

Energy Management System (EMS) by the maximum number of establishments. The URE action plan recommends also the signing of voluntary agreements with the most energy-intensive industries. ANME and

The Rational Energy Use action plan suggests the launch of more pointed on utilities. This measure allows establishments of all sizes to have recourse to "standard" operations through the acquisition of energy efficient equipment without having to carry out a full audit of the establishment.

This action consists of supporting measures targeting the main utilities in use in the industrial sector (steam, compressed air, cold, engines, etc.).

Table 51: Action 5.1 in numbers

Implement the recommendations of audits and contract programs ANME for industrial units.	
Duration	2020-2030
Total Implementation Cost (USD)	13,000,000
Annual Energy Saving (MWh)	52,888
Annual Emission Reduction (tn CO_2)	12,098
Funding Source	Private, ANME and external funds
Net Present Value (NPV)	>0

3.6.2 Install 4.6 MW photovoltaic systems in the industrial sector.

ANME launched in 2010 the PROSOL ELEC program aimed at promoting photovoltaic installations targeting the residential sector in Tunisia. This program does not cover the industrial sector, but the regulations allow industrial establishments to benefit from a 20% investment subsidy.

The combination of such an incentive and the significant drop in photovoltaic costs can represent significant opportunities for the industrial sector.

This action therefore consists in setting up, within the municipality, a communication plan to relay ANME in promoting renewable energy in the industrial sector, and more particularly photovoltaics that this action targets. This plan will focus on communicating the existing incentive program for the industrial sector by emphasizing economic benefits (reduction of

electricity consumption) and on the aid available from ANME to reduce the investment cost of the PV systems. The realization of this plan can be carried out in collaboration with ANME, which can provide technical and economic data.

The quantity of photovoltaic solar systems that could be implemented thanks to this action and the gains associated emissions have been estimated. To make this calculation, it was considered that 25% of consumption of electricity from the industrial sector of the city of Monastir would be replaced by solar). The solar capacity to install is around 4.6 MW.

Table 52: Action 5.2 in numbers

Install 4.6 MW photovoltaic systems in the industrial sector.	
Duration	2020-2030
Total Implementation Cost (USD)	8,500,000
Annual Energy Production (MWh)	8,217
Annual Emission Reduction (tn CO_2)	4,947
Funding Source	Private, ANME and external funds
Net Present Value (NPV)	>0

3.7 Transport

The share of the Transportation sector, including the municipal fleet, private and commercial transport and public transport is 37% out of the total energy consumption in Monastir Municipality, with 23% contribution in CO_2 emissions. The proposed actions are presented in the next table and a more detailed analysis for each one is following.

Table 53: Actions in Transport

Action No.		Action	Emission Reductions (tn CO_2)
6.1	Municipal fleet	Carry out an audit of the municipality's fleet of vehicles and implement the actions recommended through a program contract.	97.27
6.2		Set up a management unit for the fleet of vehicles of the municipality.	97.27
6.3		Restructuring and strengthening vehicle maintenance.	48.63
6.4		Train drivers in eco driving	72.95
6.5		Improve the process of acquiring new vehicles.	48.63
6.6	Public & Private transport	Carry out an Urban Mobility Plan and set up the actions recommended by the PDU.	6,880.86
6.7		Transfer of taxi stations and regulation of taxi traffic	429.61
6.8		Improve the city bus network.	1,698.98
6.9		Implement the recommendations of audits and contract programs ANME for the STS.	102.19
6.10		Raise public awareness of public transport.	2,802.79

6.11	Improve and secure pedestrian routes and paths.	1,051.05
6.12	Improve and secure bike paths.	5,605.59
6.13	Improvement / development of parking infrastructure	2,802.79
6.14	Transfer all government departments and institutions to one complex near to the population centers in the city	3,503.49
6.15	Building vehicle crossing lines with the railway to facilitate local transportation	2,802.79
6.16	Establishing central markets near dense residential areas	2,802.79
6.17	Using buses instead of private cars to transport students to the schools and universities	700.70
6.18	Regulating Cargo vehicles work in the City	849.49
6.19	Replacing 5% of the existing Taxi vehicles with electric vehicles	238.06
6.20	Information events on the new vehicle technologies	700.7
Total		**33,336.64**

3.7.1 Carry out an audit of the municipality's fleet of vehicles and implement the actions recommended through a program contract.

This action aims to carry out an audit on the energy consumption of the fleet of vehicles of the municipality. This audit will serve to define an action plan for reducing consumption, but also to optimize overall expenses related to maintenance, oil change, etc. ANME finances 70% of this type and also supports the implementation of the actions recommended by the audits, through a premium from the Fund of energy transition up to 20% of the investment cost, capped according to the levels of consumption. The gains linked to this action are generated by the implementation of the recommended action plan. The audit as well as the action plan covers the entire fleet of vehicles. Taking conservative targets, we consider savings of about 25% of the total fleet consumption (i.e. around 97.2 tCO2).

The gains presented below take into account the fact that some of the following actions result from the audit and therefore realize part of the expected 25% gain. The gains from these shares have therefore been cut off with a total potential of 97.27 tCO2. This leaves only the gains achievable by additional actions, which would be identified by the audit.

Table 54: Action 6.1 in numbers

Carry out an audit of the municipality's fleet of vehicles and implement the actions recommended through a program contract.	
Duration	2020
Total Implementation Cost (USD)	20,000
Annual Emission Reduction (tn CO_2)	97.27
Funding Source	Own funds, ANME
Net Present Value (NPV)	<0

3.7.2 Set up a management unit for the fleet of vehicles of the municipality.

This action must be undertaken in conjunction with the previous action (Audit and program contract of the municipal fleet). It consists of the establishment, within the municipality of

Monastir, of a "unit of rolling stock management ". The responsibilities of this unit may include:

- The implementation of optimized working procedures and methods;

- Monitoring of administrative documents of vehicles;

- Control of the use of vehicles using the information provided by the GPS systems to edge;

- Mileage tracking;

- Monitoring consumption;

- Monitoring of operating expenses;

- Monitoring the implementation of performance improvement and energy saving actions.

This project requires the acquisition of fleet management software and computer hardware. The vehicles must also be equipped with GPS tracking systems. The municipality can be assisted by an IT expert and / or fleet management. The reduction in fuel consumption linked to this action comes mainly from improving vehicle performance by quickly identifying the problems as well as the optimization of the use of the equipment (in particular the journeys made).

This action should also generate additional financial gains linked to the reduction in consumption, oil, spare parts, etc. This action would result from the energy audit; thus, the GHG impacts of this action has been subtracted from the total potential of 25%, which would result from the implementation of the actions recommended by the audit.

Table 55: Action 6.2 in numbers

Municipal fleet maintenance (for the existing & the new ones)	
Duration	2020 - 2030
Total Implementation Cost (USD)	80,000
Annual Emission Reduction (tn CO_2)	97.27
Funding Source	Own funds, ANME
Net Present Value (NPV)	>0

3.7.3 Restructuring and strengthening vehicle maintenance.

This action must be an integral part of the "Audit and contract program of the municipal fleet" action, and supported by the action "setting up a management unit for the municipality's vehicle fleet". The objective of this project is to improve the performance of the rolling stock maintenance units of the municipality in through the following sub-actions:

- Implementation of a preventive maintenance unit triggered and managed by the fleet management unit;

- Establishment of procedures relating to maintenance management;

- Implementation of an IT maintenance management solution;

- Reinforcement of the material means of these units;

- Improvement of the skills of technical staff.

Carrying out this action can reduce fuel consumption by 5%. By improving the mechanical state of the vehicles and the control tire pressure. This action would result from the energy audit; this action has been subtracted from the total potential of 25%, which would result from the implementation of the actions. thus, the GHG impacts of recommended by the audit.

Table 56: Action 6.3 in numbers

Restructuring and strengthening vehicle maintenance	
Duration	2020-2030
Total Implementation Cost (USD)	17,000
Annual Emission Reduction (tn CO_2)	48.6
Funding Source	Own funds, ANME
Net Present Value (NPV)	>0

3.7.4 Train drivers in eco driving

This action consists in sensitizing the drivers of the municipality to economical driving techniques and to road safety through training courses. These training courses are generally provided by a specialized organization. The necessary investment is considered immaterial and the municipality can benefit from a ANME subsidy up to 70% of the cost of training. The energy gains expected by this action would amount to 10% of the total consumption of the fleet. This action must be associated with that relative the installation of on-board systems for monitoring the performance of vehicles communicating via GPRS.

Table 57: Action 6.4 in numbers

Train drivers in eco driving	
Duration	2020 – 2022
Total Implementation Cost (USD)	125,000
Annual Emission Reduction (tn CO_2)	72.95
Funding Source	Own Funds , ANME
Net Present Value (NPV)	>0

3.7.5 Improve the process of acquiring new vehicles.

This action focuses on two essential tasks for optimizing economic performance and energy of the municipal fleet, namely the reform of used vehicles and the acquisition of new vehicles.

- Vehicle reform: this operation initially allows the municipality to know the state of the vehicle fleet. This then facilitates the identification of the need for reform or renewal cars. These tasks may be carried out by a committee whose task would be to define the criteria for purchasing new vehicles and periodically reviewing proposals for reforming worn vehicles.
- The acquisition of new vehicles: in order to have a fleet of suitable and sober vehicles in fuel, the municipality may adopt minimum performance criteria for new vehicles purchased.

These two actions result in optimizing the quality of the municipality's vehicle fleet and therefore reduce fuel consumption in the long term. However, the purchase of vehicles is

rather at a national level, and therefore there should be regulations imposing performance levels on the markets public. This action would therefore be difficult to operationalize for the Municipality of Monastir alone, in the absence of a national initiative, which should logically be launched by ANME. It will therefore be a question of initiating a concertation process between cities and with ANME to achieve such action. Although it is an effective action to be taken, its potential impacts are not integrated into the action plan without having more than certainty about its outcome.

Table 58: Action 6.5 in numbers

Improve the process of acquiring new vehicles.	
Duration	2020-2030
Total Implementation Cost (USD)	4,000
Annual Emission Reduction (tn CO_2)	48.63
Funding Source	Own Funds , ANME
Net Present Value (NPV)	>0

3.7.6 Carry out an Urban Mobility Plan and set up the actions recommended by the PDU

The transport sector is one of the largest emitter of GHGs in the territory of the commune of Monastir. Therefore, this is the strategic focus of the plan Action.

This action consists in carrying out a concomitant revision of the urban development plan (PAU) and plan of urban travel (PDU) and to carry out urban projects (incentive to use public transport, development of public spaces, development of high-level bus lines, eco neighborhoods, ...)

An urban transport plan is a planning document, which determines the organization of the transport of people and goods, traffic and parking in the city. All modes of transport are concerned, which results in the implementation of actions in favor of alternative modes of transport to the private car: public transport, two wheels, walking, etc. PDU responds to action plan, which aims to optimize transport in the city. The implementation of the action plan generates gains in terms of city shows.

The development and urban plan is the main planning document for the city. This one details main axes of strategic planning of the city and its articulation with the PDU is therefore essential.

Certain actions that can be envisaged within the framework of the PAU / PDU are described on the following pages. A PDU could make it possible to specify the nature of these actions and to supplement them with other adapted actions.

As an illustration, here is an example of some measures that may arise from a PAU / PDU:

• Simple and low-cost measures: clearing sidewalks, reducing wild parking, development of pedestrian spaces, redevelopment of intersections with markings on the ground, implementation consistency of timetables for different modes of public transport, optimization of traffic lights;

• Achievements: crossroads layout, layout of relay parking, implementation of a parking plan, development of multimodal platforms, development public spaces.

To implement this action, it is recommended to form an executive committee with legitimacy to decide to implement the recommendations of the PAU / PDU. The Ministry of Transport responsible for the STS is notably a key player.

According to estimates made by the URE study (ANME, 2013), an executed PDU can save more 15% of vehicle consumption in a city.

The gains presented below correspond to the total potential of the PDU minus the gains made by some actions described below which would be undertaken within the framework of the PDU. Therefore, this is the potential additional linked to additional actions, which would be identified within the framework of the PDU.

Table 59: Action 6.6 in numbers

Carry out an Urban Mobility Plan and set up the actions recommended by the PDU	
Duration	2020-2030
Total Implementation Cost (USD)	
Annual Emission Reduction (tn CO_2)	6880.8
Funding Source	ANME, Governmental Funds

3.7.7 Transfer of taxi stations and regulation of taxi traffic

As the supply of transport companies is often insufficient in Tunisia, the taxi and rental activity has experienced an important development and often badly framed. The lack of organization of this sector is reflected in the traffic problems and is amplified by an increase in the use of the private car.

The STS notes in particular that bus exits are hampered by taxi traffic and recommend thinking about organizing taxi stands to relieve congestion in the city center.

In order to relieve the streets of the commune of Monastir, this action therefore aims to study the layout of the taxis stations and to relocate and organize the supply of taxis and hire more generally. This action could be carried out by the technical services of the municipality with the support of a transport expert if necessary.

Optimizing this offer could relieve the overall traffic in the city and reduce travel time and therefore the quantity of fuel, the emissions generated and the fuel bill paid by the transport sector and taxis / rentals.

Encrypting this action precisely is difficult at this stage, in particular because of the many options that can be envisaged for the implementation of this measure. In the context of this SECAP, it was however considered that the reduction of congestion in the city following the implementation of this measure could lead to a reduction overall energy consumption in the transportation sector by 0.5%. This action would be carried out within the framework of the PDU but its gains are recorded here separately.

Table 60: Action 6.7 in numbers

Transfer of taxi stations and regulation of taxi traffic	
Duration	2020-2030
Total Implementation Cost (USD)	115,000
Annual Emission Reduction (tn CO_2)	429.6
Funding Source	Own and external funds

3.7.8 Improve the city bus network

This action consists of working with the STS to improve the offer of bus transport in the city. This action can be linked to the TCSP development action and / or be part of the realization of a PDU. Various actions can be taken to improve the city's public transport offer:

- Improve the timing of buses and extend schedules;
- Create, extend or modify bus lines;
- Improve connections between lines, and synchronization of crossing times;
- Offer attractive pricing for users;
- Modernize the bus fleet;
- Inform citizens about the public transport offer;
- …

This action can be carried out through a study carried out by a company expert in transport and be complementary to the energy audit of the company STS.

Improving the bus network would increase the number of trips by public transport by 20% common on the perimeter of the commune (due to the modal shift from the private car to the bus) compared to the baseline scenario.

This action would be carried out within the framework of the PDU but its gains are recorded here separately (and withdrawn from the total potential of the PDU)

Table 61: Action 6.8 in numbers

Improve the city bus network	
Duration	2020-2030
Total Implementation Cost (USD)	-
Annual Emission Reduction (tn CO_2)	1698.9
Funding Source	Private & external funds

3.7.9 Implement the recommendations of audits and contract programs ANME for the STS.

As part of the mandatory and periodic energy audits of energy-consuming companies, STS has recently performed an energy diagnosis. The audit followed up on an action plan to reduce

fuel consumption of the company's bus fleet and therefore its emissions. The plan of action is made up of five actions presented below:

- Service reorganization energy control and strengthening of its resources material and human.
- Tire inflation generalization of tires tubeless.
- Driver training in rational driving.
- Improvement of services maintenance.
- Network restructuring of the STS.

CO2 reduction by implementing the action plan will be around 4.4% of STS emission within Monastir city borders.

Table 62: Action 6.9 in numbers

Implement the recommendations of audits and contract programs ANME for the STS.	
Duration	2020-2030
Total Implementation Cost (USD)	500,000
Annual Emission Reduction (tn CO_2)	102.19
Funding Source	Private & external funds

3.7.10 Raise public awareness of public transport

This action consists in communicating on the offer of public transport in the city and the modes of transport soft to encourage residents to reduce their travel by private car. This project can be undertaken by the transport and / or communication services of the municipality in collaboration with the ANME and the STS. An increase in the use rate of soft transport decreases the emissions of the transport sector thanks to the modal shift from the private car to these less emitting modes of transport.

Various communication and awareness-raising actions can be envisaged, a few examples of which are cited below:

• A day promoting cycling trips with events, demonstrations, races, etc.
• A day without a car to promote alternative modes of transport to the car (bus, bikes, walking…) ;
• Poster or information campaigns for public transport;
•…
To evaluate this action, it was assumed that a modal shift of 5% from private transport to the bus and the cycling following these events (assuming a reduction of 4 / 5th of the carbon intensity of travel affected), an overall emission reduction of 4%. This action is considered independent of the PDU.

Table 63: Action 6.10 in numbers

promotion of using schools buses rather than private cars	
Duration	2020-2023
Total Implementation Cost (USD)	23,000
Annual Emission Reduction (tn CO_2)	2,802.8
Funding Source	Own funds, ANME

3.7.11 Improve and secure pedestrian routes and paths

To encourage residents to use their cars less and to encourage modal shift towards modes of transport gentle as walking, the streets must be safe and pleasant. This action aims to launch a dynamic improving and securing pedestrian routes to encourage people to move on foot whenever is possible. Several initiatives can promote walking:

- Secure and develop pedestrian routes: sidewalks, pedestrian routes, etc.
- Informing city dwellers about the times and routes for walking,
- Launch communication campaigns encouraging people to move for health reasons,
- Reduce vehicle traffic speeds in certain areas (using retarders, etc.)
- …

For the calculation of avoided emissions, it was considered that 1.5% of journeys made by private vehicle in the city are replaced by walking.

This action is considered independent of the PDU and is therefore quantified below.

Table 64: Action 6.11 in numbers

Improve and secure pedestrian routes and paths	
Duration	2022-2030
Total Implementation Cost (USD)	3,000,000
Annual Emission Reduction (tn CO_2)	1051
Funding Source	Own, governmental and external funds

3.7.12 Improve and secure bike paths

The bicycle is, in some cities, one of the most efficient and most used means of transport. In Tunisia, its potential is generally under-exploited. This action consists in setting up an action plan, linked with the pedestrian action plan, in order to promote transport by bicycle. The following actions can be envisaged:

- Raise awareness of the fact that cycling is an efficient means of transport;
- Develop / improve cycle facilities as well as bicycle-car cohabitation;
- Connect the bicycle and public transport;
- Offer self-service bike offers;

- Subsidize the purchase of bicycles by individuals;
- Install bicycle parking lots.

The implementation of this action can help encourage the modal shift from the private car to the bicycle and therefore reduce emissions linked to the transport sector in the city.

For the calculation of avoided emissions, it was considered that 8% of journeys made by private vehicle in the city are replaced by the bicycle and that the network of cycle track makes a distance of 20 km (for a cost of 115,000 USD per km).

Table 65: Action 6.12 in numbers

Improve and secure bike paths	
Duration	2020-2030
Total Implementation Cost (USD)	2,300,000
Annual Emission Reduction (tn CO_2)	5605.6
Funding Source	Own, governmental and external funds

3.7.13 Improvement / development of parking infrastructure

Traffic congestion is a problem within Monastir Municipality especially near to the central markets and center of the city. Therefore, in order to decrease the time and fuel spent by the drivers in their attempt to find a parking space, the Municipality intends to improve/extend the existing parking infrastructure and develop new ones where required. More specifically, the plan is to develop large parking lots (300 cars capacity) in the outskirts of the center, and have municipal shuttles to the city center and the other main centers and complexes.

Table 66: Action 6.13 in numbers

Improvement / development of parking infrastructure	
Duration	2020-2030
Total Implementation Cost (USD)	500,000
Annual Emission Reduction (tn CO_2)	2,802.8
Funding Source	Own, governmental and external funds

3.7.14 Transfer all government departments and institutions to one complex near to the population centers in the city

One of the main transportation and traffic problems in Monastir city is the locations of the government departments and institutions and the distance between each other, which the people need to drive or take public transport to move from one to another in order to complete their Governmental and civil transactions. This problem will lead to drive more and create a traffic jams in the connecting road. One of the best solutions is to transfer all related

government departments and institutions to one complex near to the population centers in the city in order to avoid take transportation in the movement.

For the calculation of avoided emissions, it was considered that 5% of journeys made by private and public vehicles in the city could be avoided after bringing these institutions together and easy to reach them by walking.

Table 67: Action 6.14 in numbers

Transfer all government departments and institutions to one complex near to the population centers in the city	
Duration	2020-2030
Total Implementation Cost (USD)	1,000,000
Annual Emission Reduction (tn CO_2)	3503.5
Funding Source	Own, governmental and external funds

3.7.15 Building vehicle crossing lines with the railway to facilitate local transportation

Another transportation problem in Monastir City is locating of railway crossing the city without existing enough crossing lines along the railway. This leads to make the passengers drive around the rail way and stopping at a traffic jam near to the city center in order to reach to other side of the railway, which make more driving time and then more GHG emissions.

By establishing vehicles crossing lines along the railway, traffic jams and transportation distance will be reduced. Then the C2 emission will be reduced.

For the calculation of avoided emissions, it was considered that 4% of CO2 emissions can be avoided (2,802.8 tn CO2) by solving this problem.

Table 68: Action 6.15 in numbers

Building vehicle crossing lines with the railway to facilitate local transportation	
Duration	2020-2030
Total Implementation Cost (USD)	10,000,000
Annual Emission Reduction (tn CO_2)	2802.8
Funding Source	Own, Governmental, Private and external funds

3.7.16 Establishing central markets near dense residential areas

Duo to the far location of the Central market from the most of city households, the people need to drive or take a public transportation to reach the central market and shopping.

By establishing new similar central markets near to the dense residential areas, the people can make shopping without taking a transport way, which leads to reduce the emissions from passengers vehicles.

For the calculation of avoided emissions, it was considered that 4% of CO2 emissions can be avoided (2,802.8 tn CO2) by solving this problem.

Table 69: Action 6.16 in numbers

Establishing central markets near dense residential areas	
Duration	2020-2030
Total Implementation Cost (USD)	3,000,000
Annual Emission Reduction (tn CO_2)	2,802.8
Funding Source	Own, Private and external funds

3.7.17 Promotion of using schools buses rather than private cars

The principles of support using school's buses are a measure that can lead in considerable decrease of fuel consumption. The role of the municipality here is to organize awareness raising activities and regular trainings for the citizens to be aware for its environmental and economic benefits.

Table 70: Action 6.17 in numbers

promotion of using schools buses rather than private cars	
Duration	2020-2026
Total Implementation Cost (USD)	15,000
Annual Emission Reduction (tn CO_2)	700
Funding Source	Own and external funds

3.7.18 Regulating Cargo vehicles work in the City

Some traffic jams in the Markets complexes happens due to Cargo vehicles works. Regulating their works by requiring them to load and unload goods at late time, not during peak times, will lead to avoid these jams and then avoid additional Co2 emissions.

For the calculation of avoided emissions, it was considered that 1% of CO2 emissions can be avoided (849.5 tn CO2) by solving this problem.

Table 71: Action 6.18 in numbers

Regulating Cargo vehicles work in the City	
Duration	2020-2025
Total Implementation Cost (USD)	-
Annual Emission Reduction (tn CO_2)	849.5
Funding Source	-

3.7.19 Replacing 5% of the existing Taxi vehicles with electric vehicles

The inefficiencies of today's transportation systems can translate into deteriorating service, excess cost, energy use and environmental impact. As mentioned in the public transportation section, there are 600 Taxi cars move within Monastir city, which most of them are old. If 5% of them (30 Taxi car) were replaced with Hybrid cars, then a higher energy efficiency and thus fuel and monetary savings will be achieved. This action is envisaged through the provision of the respective legislative framework that supports exemptions for replacing taxis with electric cars.

For the calculation of avoided emissions, it was considered that 1.6% of CO2 emissions by public transportation can be avoided (238 tn CO2) by solving this problem.

Table 72: Action 6.19 in numbers

Replacing 5% of the existing Taxi vehicles with electric vehicles	
Duration	2020-2025
Total Implementation Cost (USD)	170,000
Annual Emission Reduction (tn CO_2)	238
Funding Source	Private Funds

3.7.20 Information events on the new vehicle technologies

Private and commercial vehicles have the larger share in energy consumption between the other transports. It is proposed that the Municipality will organize awareness raising activities in order to inform the citizens about new technology's cars and the double fuel cars followed by their economic and environmental benefits. The next step will be citizens purchasing these cars instead of conventional ones, for instance replacing gasoline cars with hybrid or electric and diesel vehicles with more efficient ones.

For the calculation of avoided emissions, it was considered that 5% of passengers' cars would be replaced with Hybrid/electric cars, with estimated CO2 emission reduction of 1% from emissions by private transportation (700 tn CO2).

Table 73: Action 6.20 in numbers

Information events on the new vehicle technologies	
Duration	2020-2025
Total Implementation Cost (USD)	100,000
Annual Emission Reduction (tn CO_2)	700.7
Funding Source	Own and Governmental Funds

3.8 Agriculture Sector

3.8.1 Planting trees (increasing green areas)

Planting forest trees will contribute in reducing the GHG through absorbing the CO2 emission. The forest trees absorb the co2 through the photosynthesis. The municipality will plant forest trees and support planting such trees by the local community to contribute in reducing the CO2 emissions.

Table below illustrates the information that present the action.

Table 74: Action 7.1 in numbers

Planting Trees (increasing green areas)	
Duration	2020-2030
Total Implementation Cost (USD)	500,000
Number of Trees	50,000
CO2 Captured (Tn CO2)	1085
Funding Source	Own and external funds

3.9 Actions' Overview

In the next table, the complete list of the SECAP Actions is presented followed by the respective energy savings/production and the CO2 reduction.

Table 75: Summary of the mitigation actions

Action No.	Action	Emission Reduction Co2
Municipal Buildings and facilities		
1.1	Green procurement procedures for municipal buildings	39.7
1.2	Energy manager appointment in the municipality	2.4
1.3	Awareness raising activities for municipal employees	7.6
1.4	Adoption of bioclimatic principles in new municipal buildings /Strict application of green building codes in new municipal buildings	96.3
1.5	Efficient municipal buildings including Photovoltaic Systems on the Municipal buildings Rooftop 187 kWp	420.1
1.6	Promotion of recycling	1,165.7
1.7	Waste management	38,078.7
1.8	3 MW PV plant	3,250.8
1.9	Creation of Energy Saving Department	-
1.10	Web portal creation	-
Sub-total		**43,061.11**
Public Lighting		

2.1	Street lighting upgrade	1,297.16
2.2	Astronomical timers	420.86
2.3	Green procurement procedures for future lighting equipment	998.91
Sub-total		**2,716.92**
Residential Sector		
3.1	Awareness raising activities for modification of the residents' consumption behavior and energy saving	6,389
3.2	Promotion of Green Buildings' concept / Strict application of the building code	3,768
3.3	1. Campaign for promoting high-energy label home appliances and other awareness activities 2. Implement the PROMO-FRIGO action plan locally ANME: replacing old refrigerators with new ones performing.	1,729
3.4	Replacement of existing lamps with LEDs	2,196
3.5	Replacement of existing air-conditioners with more efficient ones	1,242
3.6	1. Replacement of single glazing with double glaze windows 2. Implement locally the PROMO-ISOL action plan of the ANME: installation of thermal insulation on the roofs of houses individual.	2,896
3.7	Replacing 10% of inefficient Boilers with efficient condensing boilers	121
3.8	Installing 6.6 MW Photovoltaics in residential rooftops 2. Implementing locally the PROSOL ELEC programme of ANME: Installing Photovoltaic systems for residential	7,178
3.9	1. Replacing existing water heaters with solar water heaters 2. Implementing Locally the PROSOL programe of the ANME: installation solar thermal systems instead of the existing water heaters.	6,148
Sub-total		**31,668**
Tertiary Sector		
4.1	Put in place the recommendations of the audits and contracts programs in the tertiary sector.	12,403
4.2	7.5 MWp Photovoltaics in rooftops	8,068
	2.0 MW Photovoltaics for water facilities and agricultural sector	1,937
4.3	Replacing existing water heaters with solar collectors	792
4.4	Upgrade water facilities	2,920

4.5	Develop eco-tourism.	911
Sub-total		**27,031**
Industrial Sector		
5.1	Implement the recommendations of audits and contract programs ANME for industrial units.	12,098
5.2	Install photovoltaic systems in the industrial sector.	4,947
Sub-total		**17,045**
transportation Sector		
6.1	Carry out an audit of the municipality's fleet of vehicles and implement the actions recommended through a program contract.	97.27
6.2	Set up a management unit for the fleet of vehicles of the municipality.	97.27
6.3	Restructuring and strengthening vehicle maintenance.	48.63
6.4	Train drivers in eco driving	72.95
6.5	Improve the process of acquiring new vehicles.	48.63
6.6	Carry out an Urban Mobility Plan and set up the actions recommended by the PDU.	6,880.86
6.7	Transfer of taxi stations and regulation of taxi traffic	429.61
6.8	Improve the city bus network.	1,698.98
6.9	Implement the recommendations of audits and contract programs ANME for the STS.	102.19
6.10	Raise public awareness of public transport.	2,802.79
6.11	Improve and secure pedestrian routes and paths.	1,051.05
6.12	Improve and secure bike paths.	5,605.59
6.13	Improvement / development of parking infrastructure	2,802.79
6.14	Transfer all government departments and institutions to one complex near to the population centers in the city	3,503.49
6.15	Building vehicle crossing lines with the railway to facilitate local transportation	2,802.79
6.16	Establishing central markets near dense residential areas	2,802.79
6.17	Using buses instead of private cars to transport students to the schools and universities	700.7
6.18	Regulating Cargo vehicles work in the City	849.49
6.19	Replacing 5% of the existing Taxi vehicles with electric vehicles	238.06
6.20	Information events on the new vehicle technologies	700.7
Sub-total		**33336.63**
Agriculture sector		
7.1	Planting trees (Increasing Green Areas)	1,085
Total		**155,942.56**

Regarding the costs, for Monastir Municipality will derives 43 million USD approximately whereas for the private sector is 230 million USD approximately.

In order to achieve the 40% target, the Monastir Municipality and the Government should place intensive and consecutive efforts towards the strict implementation of the SECAP and seek for agreements and grants with national and international organizations.

3.10 Monitoring

Monitoring of the Municipality's progress against the set targets is very significant, especially since it has to be realized in a frequent basis. The following table includes the suggested indicators to monitor each action's progress against the initial objectives, in order any deviations from the target to be noticed quickly, and appropriate correction measures to be taken.

These indicators will be also utilized during the production of the actions' monitoring report in line with the Covenant of Mayors requirements, as well as common practice, in order to demonstrate the achieved progress and results.

Table 76: suggested indicators to monitor each action's progress

Action No.	Action	Key Performance Indicators	Measurement units
Municipal Buildings and facilities			
1.1	Green procurement procedures for municipal buildings	· Number of equipment bought with green procurement procedures	· Equipment number/year
1.2	Energy manager appointment in the municipality	· Years that the Energy Manager is appointed and active · Quantity of municipal infrastructure under his supervision · Energy savings under his supervision	· Number of years · Number and % of municipal infrastructure being supervised · KWh
1.3	Awareness raising activities for municipal employees	· Number of training seminars that were implemented · Municipal employees that were trained	· Number of seminars Number of employees
1.4	Adoption of bioclimatic principles in new municipal buildings /Strict application of green building codes in new municipal buildings	Number of new buildings with bioclimatic principles	Number of buildings
1.5	Efficient municipal buildings including Photovoltaic Systems on the Municipal buildings Rooftop 187 kWp	Installed capacity of PVs - Percentage of Installed capacity compared to the initial target	· Number of LED units installed. Kwp % out of 187kWp

		Insulation **Double glaze** **Percentage of installed capacity compared to the initial target**	**m2 of roof insulation** **m2 of wall insulation** **m2 of windows**
1.6	**Promotion of recycling**	**· Total amount of recycled waste in the Municipality** **· Number of implemented actions to promote recycling** **· Available infrastructure in terms of recycle bins coverage**	**· tn/year** **· Number of seminars, leaflets and other actions** **· Number of recycle bins per square km area**
1.7	**Waste management**	**· Construction completion state** **· Total amount of solid waste deposited in landfill** **· Electricity Production** **· Biofertilizer Production**	**· %** **· tn** **· MWh** **· tn**
1.8	**3 MW PV plant**	**· Installed PV capacity** **· Percentage of installed capacity against the initial target**	**· KWp** **· % out of 3 MWp**
1.9	**Creation of Energy Saving Department**	**· Number of people served by the Energy Department** **· Employees in the Energy Saving Department**	**· Number of people** **· Number of employees**
1.10	**Web portal creation**	**· Number of visits in the site** **· Average time a user spent in the site**	**· Number of visits** **· Min/visit**
Public Lighting			
2.1	Street lighting upgrade	**Lamps that were replaced with energy efficient ones**	**Number of lamps**
2.2	Astronomical timers	Percentage of astronomical timers against initial target	%
2.3	Green procurement procedures for future lighting equipment	Number of devices that were bought with green procurement procedures	· Device number/year

Residential Sector			
3.1	Awareness raising activities for modification of the residents' consumption behavior and energy saving	· Number of seminars & information days · Attendants in each event	· Number of activities · Number of people attending each event
3.2	Promotion of Green Buildings' concept / Strict application of the building code	· Number of promotion actions · Average attendance · Share of new Green buildings in total new buildings · Average energy savings of green building/m2	· Number of seminars, leaflets etc. · People attended each action · % · KWh/m2
3.3	1. Campaign for promoting high energy label home appliances and other awareness activities 2. Implement the PROMO-FRIGO action plan locally ANME: replacing old refrigerators with new ones performing.	· Number of promotion actions · Average attendance	· Number of seminars, leaflets etc. · Number of people attending each event
3.4	Replacement of existing lamps with LEDs	· Number of lamps replaced with LEDs	· Number of lamps replaced each year
3.5	Replacement of existing air-conditioners with more efficient ones	Number of A/Cs replaced with new ones	Number of A/Cs
3.6	1. Replacement of single glazing with double glaze windows 2. Implement locally the PROMO-ISOL action plan of the ANME: installation of thermal insulation on the roofs of houses individual.	· Surface of double glazing insulation	m2 of replaced windows m2 of installed insulation
3.7	Replacing 10% of inefficient Boilers with efficient condensing boilers	Number of boilers replaced with new ones	Number of boilers
3.8	Installing 6.6 MW Photovoltaics in residential rooftops 2. Implementing locally the PROSOL ELEC programme of ANME: Installing Photovoltaic systems for residential	· Installed PV capacity on roofs · Percentage of installed capacity against the initial target	· MWp · % out of 2MWp or 10MWp

3.9	1. Replacing existing water heaters with solar water heaters 2. Implementing Locally the PROSOL programe of the ANME: installation solar thermal systems instead of the existing water heaters.	· Increase of solar water heaters installation	· Number of solar water heaters
Tertiary Sector			
4.1	Put in place the recommendations of the audits and contracts programs in the tertiary sector.	Number of audits and program contracts engaged	annual consumption electricity and gas in kWh / year - Consumption in kWh / m²
4.2	7.5 MWp Photovoltaics in rooftops	· Installed PV capacity on roofs · Percentage of installed capacity against the initial target	· MWp · % out of 2MWp or 10MWp
4.3	2.0 MW Photovoltaics for water facilities and agricultural sector	· Installed PV capacity on roofs · Percentage of installed capacity against the initial target	· MWp · % out of 2MWp or 10MWp
4.4	Replacing existing water heaters with solar collectors	· Increase of solar water heaters installation	· Number of solar water heaters
4.5	Upgrade water facilities	Number of SCADA systems installed	· Number of systems
4.6	Develop eco-tourism.	Number of hotels engaged	Number of tourists in these hotels / year - Consumption annual energy in kWh / year
Industrial Sector			
5.1	Implement the recommendations of audits and contract programs ANME for industrial units.	Number of audits and program contracts engaged	Consumption annual energy in kWh / year
5.2	Install photovoltaic systems in the industrial sector.	· Installed PV capacity on roofs · Percentage of installed capacity against the initial target	· MWp · % out of 2MWp or 10MWp
transportation Sector			

6.1	Carry out an audit of the municipality's fleet of vehicles and implement the actions recommended through a program contract.	Human resources, technical, financial) available	Number of km traveled - Number of liters consommé
6.2	Set up a management unit for the fleet of vehicles of the municipality.	Human resources, technical, financial) available	Number of km traveled - Number of liters consommé
6.3	Restructuring and strengthening vehicle maintenance.	Human resources, technical, financial) available	Number of km traveled - Number of liters consommé
6.4	Train drivers in eco driving	Number of driver trained - Number of trainings business	Number of km traveled - Number of liters consommé
6.5	Improve the process of acquiring new vehicles.	Establishing of procedures and monitoring characteristics park techniques vehicles	Average performance of the vehicle fleet new and existing in l / 100 km
6.6	Carry out an Urban Mobility Plan and set up the actions recommended by the PDU.	Advancement of carrying out the study - Action tracking implemented	Number of vehicles / km - Number of passagers.km - Number of tons / km
6.7	Transfer of taxi stations and regulation of taxi traffic	Number of stations relocated	Number of vehicles.km of taxi

6.8	Improve the city bus network.	Number of actions business	Number of passengers
6.9	Implement the recommendations of audits and contract programs ANME for the STS.	Number of actions efficiency achieved	Consumption in l / year - Distance traveled in km / year
6.1	Raise public awareness of public transport.	Number of persons sensitized	Number of passenger / year
6.11	Improve and secure pedestrian routes and paths.	Number of km from landscaped pedestrian path	Number of journeys pedestrian per year
6.12	Improve and secure bike paths.	Number of km from bike path Finished	Number of km cycled
6.13	Improvement / development of parking infrastructure	Number of parking lots constructed	Number of parking lots
6.14	Transfer all government departments and institutions to one complex near to the population centers in the city	number of institutions transferred	No. of visitors for each institution
6.15	Building vehicle crossing lines with the railway to facilitate local transportation	Number of lines constructed	No of daily vehicles use these lines
6.16	Establishing central markets near dense residential areas	Number of central markets constructed	No of daily visitors
6.17	Using buses instead of private cars to transport students to the schools and universities	• Number of student that are use schools buses.	• Number of student
6.18	Regulating Cargo vehicles work in the City	Number of remaining cargos still work at peak times	no. of hours per day that the markets complexes have traffic jams
6.19	Replacing 5% of the existing Taxi vehicles with electric vehicles	Number of Hybrid Taxis	Number of Hybrid Taxis
6.20	Information events on the new vehicle technologies	Number of Hybrid/electric cars	Number of Hybrid/electric cars
Agriculture sector			
7.1	Planting trees	• **Number of planted trees**	• **Number of trees**

Chapter 4: Adaptation to climate change

4.1 Introduction on climate change impact

During the last 20 years studies and observations have shown significant changes in the global climate which negatively affect life in many aspects. Indicatively in the next two figures the rise in the temperature and sea level are presented.

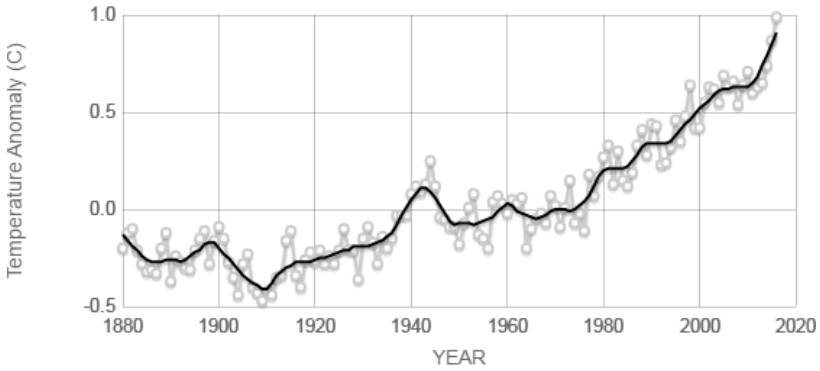


Figure 28: Land-ocean temperature variation

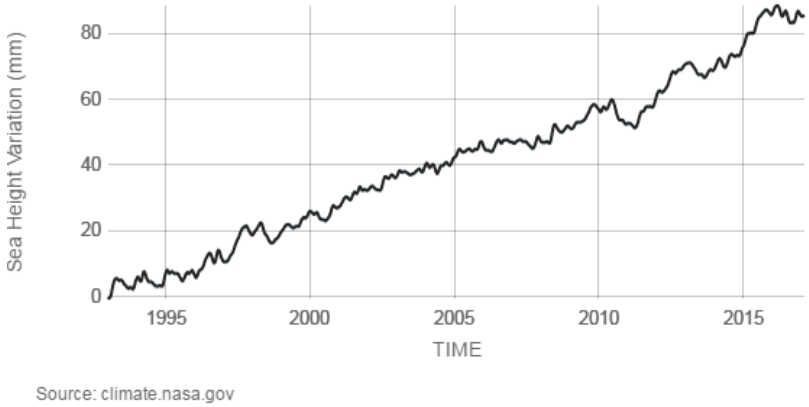


Figure 29: See level variation

In addition in the next figure the global temperature variation is presented from 1884 to 2018 in a worldwide map. [13]

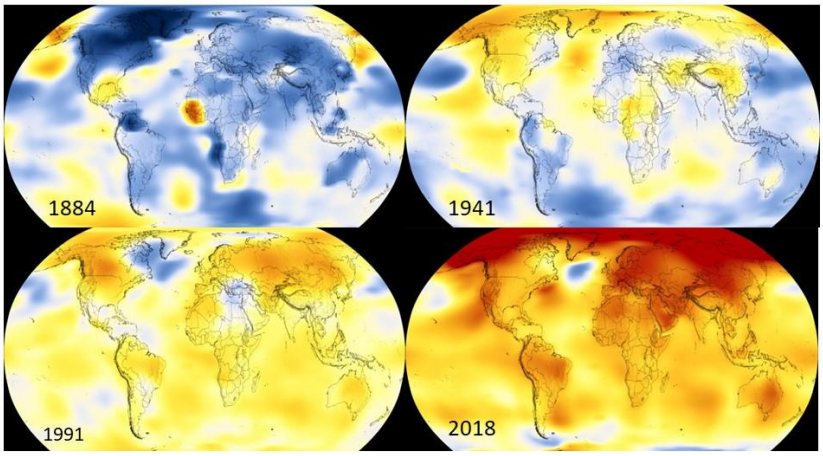


Figure 30: Global temperature variation

More specifically, the Mediterranean region is rich in a large variety of complex climatic phenomena, caused by its morphology and its geographical location. The location of the Mediterranean Sea in a transitional band between subtropical and multitude regimes produces a large climate variability at multiple timescales and a strong seasonal variability of precipitation in many areas [14]. The Mediterranean has been identified as one of the most prominent “Hot-Spots” in future climate change projections [15]. The water cycle and its extremes are one of the major concerns, since there are many countries that are over exploiting the water resources, a problem that is expected to deteriorate in the future. Episodes of extreme precipitation are also taking place and disastrous floods are a major threat for the region and especially the coastal areas. In addition to the above, phenomena taking place especially in the Southern Mediterranean Countries, such as cultivation of marginal land, overgrazing and firewood harvesting, put more pressure on the environment [14].

The Mediterranean region has experienced drastic changes in its climate over the years and according to Luterbacher et al. [16], has shown large climate shifts in the past. Twenty thousand years ago, cold steppes (with sparse forests) extended from the south of Spain to Caucasus. In the northern part of the Mediterranean basin, the temperature of the coldest month was 15°C lower than it is today (Peyron et al., 1998). Less water was available for vegetation. Over the last 2000 years, the climate over the Mediterranean has experienced a sequence of humid/dry and warm/cold periods that have produced effects on environmental conditions.

In the Figure 31 presented below, the seasonal mean temperature for the period 1961-1990 is being depicted in panels A-D, while the total precipitation maps for the same period are depicted in panels E-H.

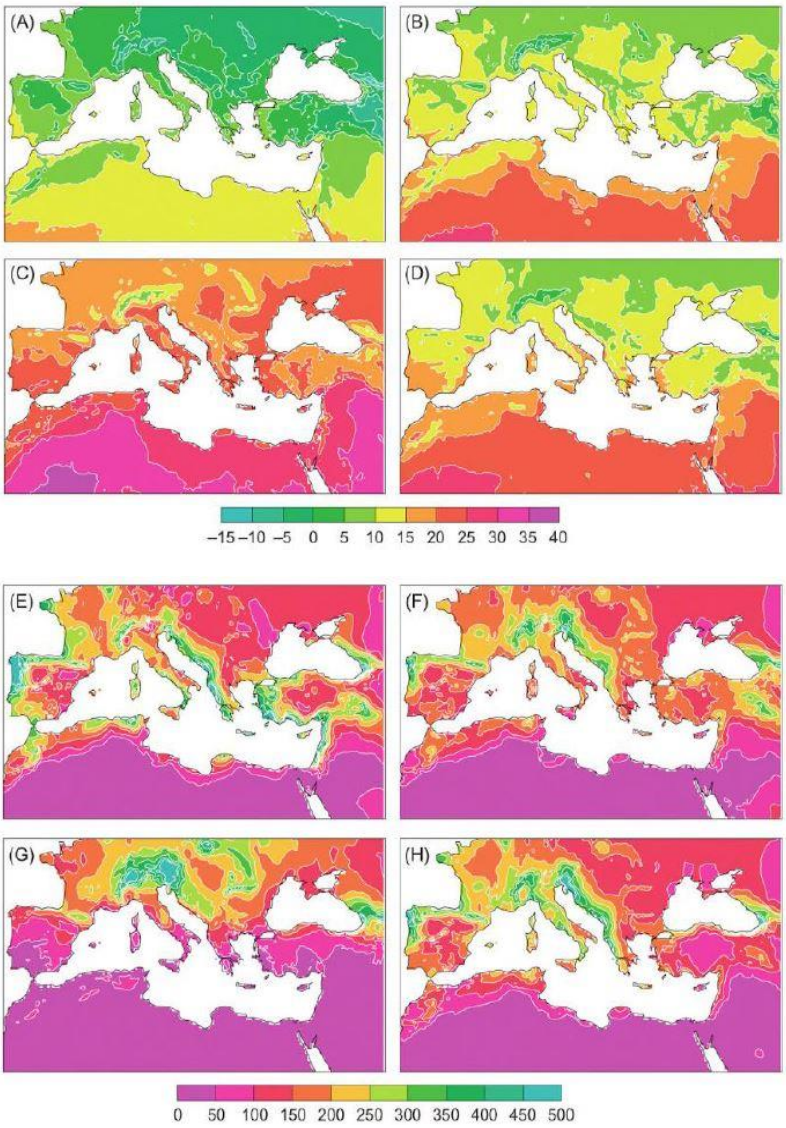


Figure 31: Seasonal (winter: December – January – February; sping: March – April – May; summer: June – July – August; autumn: September – Octomber – November) mean temperature (oC, panels A-D) and total precipitation (mm per season, panels E-H) maps for the period 1961 -1990 based on CRU data

Source: Lionello, 2012

The increase of the projected temperatures in the Mediterranean region in the period 2071 - 2100 compared to 1961-1990 is at least 3 degrees in the South countries and could be even higher, depending the season, as presented in the figure 32 below [14].

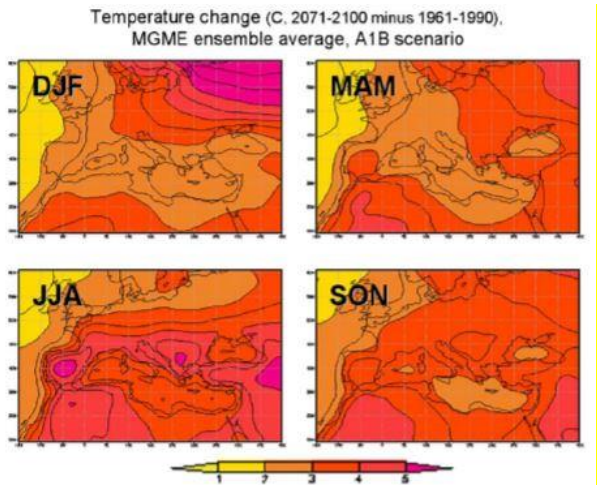


Figure 32: Multi Global Model Ensemble (MGME) average change in surface air temperature for the four seasons, 2071–2100 minus 1961–1990. Units are °C. DJF is December–January–February, MAM is March–April–May, JJA is June–July–August, SON is September–October–November

According to an EIB report of 2008, for the Mediterranean region, climate experts anticipate during the 21st century:

- An increase in air temperature in the range of 2.2 C° to 5.1 C° for the countries of Southern Europe and the Mediterranean region over the period 2080 – 2099 with respect to the period 1980 – 1999;
- A significant decrease in rainfall, ranging between -4 and -27 % for the countries of Southern Europe and the Mediterranean region (while the countries of Northern Europe will report a rise between 0 and 16 %);
- Increase in drought periods manifested by a high frequency of days during which the temperature would exceed 30 °C. Extreme events, such as heat waves, droughts or floods, are likely to be more frequent and violent.
- An increase of the sea level which, according to some specific studies, could be around 35 cm up to the end of the century.

Giannakopoulos et al. (2005) underlines that in line with the results of the projection scenarios, the most significant temperature increases in the 21st century are expected in Eastern Egypt and especially the Nile Delta, Tunisia and the Maghreb. It is therefore evident that the more vulnerable Mediterranean areas will be those of North Africa adjacent to desert areas, the major deltas (such the Nile one), the coastal areas (Northern rim and Southern rim of the Mediterranean basin), as well as the high-demographic growth and socially vulnerable areas (Southern and Eastern rim, densely populated cities and suburbs).

In the Mediterranean region, 50% of the urban population lives in an altitude of less than 10 meters from the sea level, in areas which are vulnerable to sea level rise. In addition to the above, tourist destinations in these areas are vulnerable not only due to the sea level rise, but also due to the temperature increase encountered [17].

The impacts of climate change on the Mediterranean environment will relate particularly to [18]:

- Water, via a change of its cycle due to a rise in evaporation and a decrease in rainfall. This water problem will be of crucial importance with regard to the issue of sustainable development in the region;
- Soil, via the acceleration of already existing desertification phenomena;
- Land and marine biological diversity (animal and plant), via a displacement northward and in altitude of certain species, extinction of less mobile or more climate sensitive species, and emergence of new species;
- Forests, via a rise in fire hazards and parasite risks.

These impacts will exacerbate already existing pressures on the natural environment connected with anthropogenic activities, such as agriculture and fishery (reduction of yields), tourism attractiveness (heat waves, water scarcity), coastal areas and infrastructures (significant exposure to the action of waves, coastal storms and other extreme weather events, rise in sea level), human health (heat waves), the energy sector (water needs for power plants, hydropower and increased consumption).

In line to the above, the Southern and Eastern Mediterranean Countries (SEMCs) appear to be more vulnerable to climate change than the Northern Mediterranean Countries (NMCs).

Indeed, they are, on the one hand, more exposed to accelerated desertification, soil aridity and water scarcity and, on the other hand, presenting economic structures that are more strongly dependent on natural resources, as well as technical and financial capacities that are too limited to help implement large-scale adaptation options [18].

The Mediterranean, and more especially the Southern and Eastern rim, is and will be more affected by climate change than most other regions of the world in the course of the 21st century. The impacts of the rise in temperatures, the decrease in rainfall, the multiplication of the number and intensity of extreme events and the possible rise in sea level overlap and amplify the already existing pressures of anthropogenic origin on the natural environment.

Through the crucial issue of scarcity of water resources, their impacts are fraught with consequences in the 21st century for human activities, in particular agriculture, fishery, tourism, infrastructures, urbanized coastal areas and hydropower production. In order to minimize as much as possible the economic losses and damages, several adaptation options must be thought out and implemented.

Energy lies at the heart of the climate change issue. On the one hand, it is the main GHG emitting sector, and CO2 emissions in the future are likely to increase much more rapidly than the global average. On the other hand, hydropower production—relatively significant in certain countries (13% of power production in the SEMCs)—is affected by the climate as well as by the plant cooling constraints. Lastly, the energy demand (in particular, electricity) which is growing at a very high pace in the region, is likely to be further accelerated by the additional demand necessary to lessen the impacts of climate change (water desalination, air-conditioning of buildings, etc).

4.2 Climate data for Tunisia

Current situation

typically temperate in north with mild, rainy winters and hot, dry summers; desert in south. The terrain: mountains in north; hot, dry central plain; semiarid south merges into the Sahara. For Tunis in January the daily average maximum temperatures is 16°C with the average minimum 8°C, while in June the average maximum is 31°C with a minimum of 19°C. The wettest month for Tunis is December with an average of 80.7mm of precipitation falling while the driest month is July with 4.0mm falling

Table 77: Climate data for Tunis, Tunisia.

Month	Average Max temperature(°C)	Mean total rainfall (mm)
January	16	62
February	17	47
March	19	38
April	22	34
May	26	29
June	31	16
July	34	4
August	34	11
September	30	52
October	27	42
November	21	64
December	17	81

As far as The average daily wind speed in December has been around 14 km/h, that's the equivalent to about 9 mph, or 8 knots. In recent years the maximum sustained wind speed has reached 80 km/h, that's the equivalent of around 49 mph, or 43 knots.

Table 78: Tunis – Tunisia region - Average wind speed

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Max Recorded wind speed (Km/h)	80	69	78	85	93	81	61	74	56	69	74	80

Source: http://dev.myweather2.com/City-Town/Tunisia/Tunis/climate-profile.aspx

4.3 Expected Climate Changes for Tunisia

According to the third communication report for FCCU the climate Projections show an increase in annual temperature at the 2050 and 2100 horizons for both scenarios. This increase ranges between 1° C and 1.8° C by 2050 on average for the set of studied models and between 2° C and 3° C at the end of the century, with the RCP 4.5 scenario. For the RCP 8.5 scenario, this increase ranges between 2° C and 2.3° C by 2050 on average for the set of studied models and between 4.1° C and 5.2° C at the end of the century. The coast in the North and the East of Tunisia would warm up less quickly than the West and the extreme South.

In Tunisia, under the RCP 4.5 scenario, the seasonal rainfall projections show a much more pronounced variability by 2100 with significant rainfall decreases in summer in southern Tunisia (- 35 %) and a slight increase in rainfall in autumn in the north-west of the country (+ 5 %).

Regarding climate extremes, Tunisia could experience more frequent and longer heat waves by 2100 under the scenario RCP 8.5. On the other hand, the cold waves would decrease as well as the episodes of extreme rainfall.

The decrease in average rainfall and the increase in the intensity and frequency of dry periods, combined to the increase in temperature, should reduce soil moisture and surface and underground water stocks. These impacts of climate change are likely to be worsened by the increasing water needs, notably for human use, but more particularly for agriculture, given the increase in evapotranspiration and the decrease in soil humidity. Groundwater forms 44.5% of Tunisia's water potential, with 226 shallow water tables and 340 deep aquifers. [19]

4.4 Adaptation Scoreboard

The adaptation scoreboard is part of the SECAP template developed by the JRC. The municipality is intended to realize a self-assessment of its adaptation status, putting a grade from A to D, in line with its progress.

More specifically:

- "A", corresponds to completion level of 75 - 100%.
- "B", corresponds to completion level of 50-75%.
- "C", corresponds to completion level of 25-50%. Finally,
- "D", corresponds to completion level of 0-25%.

The municipality will put one of these four grades to each one of the adaptation cycle specific steps, as presented in the following table.

Table 79: Municipality's score in the Adaptation Cycle Specific Steps (SECAP template)

Adaptation Cycle Steps	Actions	Grade
Step 1: Preparing the ground for Adaptation	Adaptation commitments defined/integrated into the local climate policy	**B**
	Human, technical and financial resources identified	**C**
	Adaptation team (officer) appointed within the municipal administration and clear responsibilities assigned	**C**
	Horizontal (e.g. across departments) coordination mechanisms in place	**D**
	Vertical (e.g. across governance levels) coordination mechanisms in place	**C**
	Consultative and participatory mechanisms set up, fostering the multi stakeholder engagement in the adaptation process	**A**
	Continuous communication process in place	**C**

Step 2: Assessing risks and vulnerabilities to climate change	Mapping of the possible methods and data sources for carrying out a Risk &Vulnerability Assessment conducted	**C**
	Assessment of climate risks and vulnerabilities undertaken	**B**
	Possible sectors of actions identified and prioritized	**B**
	Available knowledge periodically reviewed and new finding integrated	**B**
Steps 3 and 4 – Identifying, assessing and selecting adaptation options	Full portfolio of adaptation actions compiled, documented and assessed	**C**
	Possibilities of mainstreaming adaptation in existing policies and plans assessed, possible synergies and conflicts identified	**D**
	Adaptation actions developed and adopted	**D**
Step 5: Implementing	Implementation framework set with clear milestones	**C**
	Adaptation actions implemented and mainstreamed as defined in the SECAP document	**C**
	Coordinated action between adaptation and mitigation set	**D**
Step 6: Monitoring and evaluation	Monitoring framework in place for adaptation actions	**D**
	Appropriate monitoring and evaluation indicators identified	**D**
	Regular monitoring of the progress and reporting to the relevant decision makers	**D**
	Adaptation strategy and/or Action Plan updated, revised and readjusted according to the findings of the monitoring and evaluation procedure	**D**

4.5 Risk Assessment and Vulnerability Analysis

In order to conduct a risk assessment and vulnerability analysis, as a first step, the climate hazard types should be identified. These hazard types in general and for the Maghreb and Mashreq countries in particular, are presented in the Table below, while those applicable for Monastir have been identified.

Table 80: Climate Hazard Types

General Climate Hazard Types	Applicable for Monastir region
Extreme heat	√
Extreme cold	
Landslides	
Storms	√
Droughts	√
Sea level rise	√
Floods	√
Extreme precipitation	
Forest fires	
Ice and snow	

The municipalities are called in to assess the impact that each climate hazard type has on a series of Vulnerable/ Impacted sectors, such as:

- Health

- Infrastructure (Energy, Water, Transport)
- Built environment
- Economy (Tourism, Agriculture and Forestry)
- Biodiversity (Coastal areas, Green zones/ forests)

These sectors have been identified as the most relevant for the Maghreb / Mashreq region, utilizing info from Future Cities Adaptation Compass Tool, Mayors' Adapt, as well as the European Climate Adaptation Platform website.

Monastir Municipality has filled in Table 82 below, in order to conduct the vulnerability analysis, based on sources such as the Future Cities Adaptation Compass Tool and UNFCCC.

Table 81: Suggested template for the Vulnerability analysis (based on the Future Cities Adaptation Compass tool)

	Receptors	Extreme weather event	Potential effects	Who/What is affected
Population	Public Health	Extreme heat	- Heat stress - Deaths due to cardiovascular diseases - Spread of vector born and infectious diseases - Altered allergic pattern	Everyone, but especially workers in outdoor environments, elderly people, babies, children, and sensitive groups of people
		Droughts	- Asthma and cardiovascular diseases - Accumulation of trace elements	All people living or working in the area
		Sea level Rise	- Damages and causalities - Injuries and deaths - Water-borne diseases - Asthma and respiratory allergies	All people living or working in the area mainly in the coastal area especially Fishermen.
		Storms	Casualties and deaths	All people living or working in the area
		Floods	- Damages and causalities - Injuries and deaths - Water-borne diseases - Asthma and respiratory allergies	All people living or working in the area
Infrastructure	Transport	Extreme heat	- Higher maintenance costs - Road and (Rail)* network damages - Change in behaviour patterns - Air quality problems	Roads, rail roads, public transport, people mobility

	Droughts	- Difficult transport of bulk material	Waterways, water management
	Sea level Rise	- Damages - Mobility difficulties in afflicted areas	Roads, rail roads, public transport, people mobility
	Storms	- Damages - Mobility difficulties in afflicted areas	Roads, rail roads, public transport, people mobility
	Floods	- Damages - Mobility difficulties in afflicted areas	Roads, rail roads, public transport, people mobility
Energy	Extreme heat	- Altered electricity peaks/demand - Damages - Cooling problems - Reduction of efficiency yield from conventional power plants and distribution grid - Higher maintenance costs	Conventional power plants, electricity providers and consumers
	Droughts	- Higher maintenance costs - No/lower production from hydro power plants - Energy supply and demand patterns' shift - Cooling problems	Conventional power plants, electricity providers and consumers
	Sea level Rise	- Higher maintenance cost - Damages - Operational difficulties	All facilities in the electricity generation and distribution grid in the affected areas
	Storms	- Damages and losses	All facilities in the electricity generation and distribution grid in the affected areas
	Floods	- Damages - Operational difficulties	All facilities in the electricity generation and distribution grid in the affected areas
Water	Extreme heat	- Higher water demand - Water quality issues - Higher maintenance costs	Public health, water infrastructures

	Droughts	- Water scarcity - Water quality issues - Higher maintenance costs	Public health, water infrastructures
	Sea level Rise	- Water management issues - Damages - Water quality issues - Higher maintenance costs - Increased salinity of underground water	Public health, water infrastructures
	Storms	- Water management issues - Water quality issues	Public health, water infrastructures
	Floods	- Water quality issues - Water management issues - Damages - Higher maintenance costs	Public health, water infrastructures
Social	Extreme heat	- Higher electricity demand to cover cooling needs - Changes in behaviour patterns, e.g. living outdoors - Burdening of the health care facilities due to the increased number of patients in hospitals	Hospitals, schools, public places, municipal facilities/infrastructure, athletic facilities
	Droughts	- Difficulties in meeting water demand for athletic facilities (e.g. swimming pools) and green public spaces	Hospitals, schools, public places, municipal facilities/infrastructure, athletic facilities
	Sea level Rise	- Impacts on public spaces (e.g. loss of beaches) - Damages on coastal facilities	Hospitals, schools, public places, municipal facilities/infrastructure, athletic facilities
	Storms	- Damages in social facilities in afflicted areas - Burdening of the health care facilities due to the increased number of patients in hospitals	Hospitals, schools, public places, municipal facilities/infrastructure, athletic facilities

		Floods	- Flooding of social facilities in afflicted areas. - Burdening of the health care facilities due to the increased number of patients in hospitals	Hospitals, schools, public places, municipal facilities/infrastructure, athletic facilities
Built Environment	Building stock and material	Extreme heat	- Concrete's damages - Increased cooling demands - Higher maintenance costs - Urban heat island effect	All building infrastructure
		Droughts	- Higher water demand	All building infrastructure, road network etc
		Sea level Rise	- Sinkholes collapse - Extensive damages - Flooding at the city level of all building infrastructure	All building infrastructure
		Storms	- Damages - Higher maintenance costs	All building infrastructure
		Floods	- Damages - Higher maintenance costs	All building infrastructure
Economy	Tourist	Extreme heat	- Increased demand for cooling - Lower touristic flows during the impacted seasons - Higher water demand	Tourists, tourist infrastructure, tourist related economy
		Droughts	- Increased pressure on water resources, escalating water scarcity issues - Increased water supply costs	Tourists, tourist infrastructure, tourist related economy
		Sea level Rise	- Damages in touristic infrastructure, which are located at coastal areas	Tourists, tourist infrastructure
		Storms	- Damages in touristic infrastructure and related costs for repairs	Tourists, tourist infrastructure, tourist related economy
		Floods	- Damages in touristic infrastructure and related costs for repairs	Tourists, tourist infrastructure, tourist related economy

	Agriculture	Extreme heat	- Changes in growth cycle - Damages / loss of harvest - Livestock loss and impacts on health - Lower crop yields	Farmers, food industry, consumers
		Droughts	- Damages / loss of harvest - Lower crop yields - Livestock loss and impacts on health - Land degradation	Farmers, food industry, consumers
		Sea level Rise	- Damages / loss of harvest in coastal areas - Increased water salinity will result in existing crops' long-term destruction - Loss of fertile grounds near coastal areas and especially the deltas	Farmers, food industry, consumers
		Storms	- Damages / loss of harvest in afflicted areas / loss of livestock	Farmers, food industry, consumers
		Floods	- Damages / loss of harvest in afflicted areas / loss of livestock	Farmers, food industry, consumers
Biodiversity	Costal zones ecosystems	Extreme heat	- Increased coral bleaching - Migration of coastal species towards higher altitudes - Reduction of vulnerable fishing stock - Altered flora and fauna, new and invasive species*	Ecosystem, fish industry, consumers
		Droughts	- Increase of coastal water salinity - Loss of species - Altered flora and fauna, new and invasive species	Ecosystem
		Sea level Rise	- Increased coastal erosion - Salinization of surface and ground waters	Ecosystem, fish industry, consumers

		- Displacement of coastal lowland and wetlands and reduction of certain fish species	
	Storms	- Pollution of natural resources	Ecosystem
	Floods	- Loss of species	Ecosystem

Table 82: Suggested template for the risk assessment

	Receptors	Weather Sensitivity	Future Risk	Impact
Population	Public Health	Extreme heat	- Increased number of deaths - Reinforcement of heat stress - Increased infectious diseases - Altered allergic patterns	Medium
		Droughts	- Increased allergic incidents - Decreased air quality - More respiratory problems	Medium
		Sea level Rise	- Increased incidents of asthma and pneumonia - Increased water-borne diseases - Limitations to the healthcare access	Low
		Storms	- Limitations to the healthcare access - Increased numbers of injuries and deaths	Low
		Floods	- Limitations to the healthcare access - Increased numbers of injuries and deaths	Low
Infrastructure	Transport	Extreme heat	- Damages on roads - Modification of transport frequency and means - Air quality problems - Higher maintenance costs	Low
		Droughts	- Difficult transport of bulk material	Low
		Sea level Rise	- Damages	Low
		Storms	- Damages - Mobility problems	Low
		Floods	- Damages - Mobility problems	Medium
	Energy	Extreme heat	- Blackouts and inability to cover demand load - Damages, especially in the thermal power plants	Low
		Droughts	- Blackouts and inability to cover demand load - Higher maintenance costs - Cooling problems in power plants	Low
		Sea level Rise	- Damages	Low

		- Shut down of power plants near rivers, etc. - Operational difficulties - Higher maintenance cost	
	Storms	- Damages / Failures in the production facilities and distribution grid / power cuts	Low
	Floods	- Damages / power cuts	Low
Water	Extreme heat	- Water scarcity (Desalinated water) - Water quality issues (bottled water)	Medium
	Droughts	- Water scarcity (Desalinated water) - Water quality issues (bottled water)	Medium
	Sea level Rise	- Increased underground water salinity - Water management issues - Damages - Water quality issues - Higher maintenance costs	Medium
	Storms	- Increased damages and related maintenance costs - Water management issues	Medium
	Floods	- Increased damages and related maintenance costs - Water management issues - Water quality issues	Medium
Social	Extreme heat	- Increased need for air conditioned public spaces	Low
	Droughts	- Increased numbers of people presenting respiratory problems and burdening the health care facilities - Inability to cover the water demand - Difficulties in the operation of certain facilities due to lack of water (e.g., swimming pools)	Low
	Sea level Rise	- Potential damages in the coastal area facilities - Loss of coastal public spaces (beaches etc.)	Low
	Storms	- Damages - Increased maintenance costs	Low
	Floods	- Damages - Increased maintenance costs - Flooding at the city level of the afflicted public building	Low

			infrastructure (schools, hospitals, etc.) - Difficulties in providing the envisaged services	
Built Environment	Building stock and material	Extreme heat	- Concrete's damages - Increased cooling demands - Higher maintenance costs - Urban heat island effect	High
		Droughts	- Higher water demand	High
		Sea level Rise	- Sinkholes collapse - Extensive damages and loss of property - Impact on coastal zone economy	Medium
		Storms	- Damages - Increased maintenance costs	Low
		Floods	- Damages - Increased maintenance costs	Low
Economy	Tourist	Extreme heat	- Change of the tourism season - lower touristic flows - Reduction of the tourism related economy	Medium
		Droughts	- Increased water supply costs - Potential increase of indirect costs for the tourists (infrastructure related) & reduction of touristic flows	Low
		Sea level Rise	- Damages and even complete destruction of touristic infrastructure, nearby coastal areas and deltas	Medium
		Storms	- Damages to touristic facilities	Medium
		Floods	- Damages to touristic facilities - Potential effects on the touristic flows, in areas with flooding history	Medium
	Agriculture	Extreme heat	- Changes in growth cycle - Damages / loss of harvest - Livestock loss and impacts on health - Lower crop yields - Increased fire risks	Low
		Droughts	- Damages / loss of harvest - Lower crop yields - Livestock loss and impacts on health - Land degradation - Increased fire risks	Low
		Sea level Rise	- Damages / loss of harvest in areas near delta, sea etc.	Low

			- Increased water salinity will result in existing crops' long-term destruction.	
		Storms	- Damages/ loss of harvest in afflicted areas - Surface soil erosion	Low
		Floods	- Damages/ loss of harvest in afflicted areas - Livestock loss - Surface soil erosion	Low
Biodiversity	Costal Zones ecosystems	Extreme heat	- Loss of specific species (fish, etc.)	Medium
		Droughts	- Increase of coastal water salinity	Low
		Sea level Rise	- Loss of specific species (fish, etc.) - Soil erosion - Water salinization	Medium
		Storms	- Soil erosion	Medium
		Floods	- Soil erosion	Medium

4.6 Adaptation Actions

The municipality, having compiled the vulnerability analysis and risk assessment, needs to identify a specific set of actions that will allow it to adapt to the situation it faces. A list of adaptation actions, identified from the international literature and best practices available, are presented in the following tables, for each one of the five sectors studied above. Of course, these lists are not exhaustive and the consultants can look for additional measures, depending also on the local needs and situation; however, they are considered a good starting point.

For each one of the five sectors, a further distinction of the adaptation actions in four categories is realized:

- Strategic actions. Actions regarding the formulation of action plans, or strategic policy planning documents, that set the basis for all the actions to come in the specific sector.
- Alert /Communication actions. These are focusing on alerting the citizens on a situation, such as an extreme climate event or hazard (high temperatures, floods, tsunamis etc.).
- Educational actions. The focus in this case is given on increasing the awareness raising level of the citizens on a specific threat or situation that the municipality is faced and requires the citizens' collaboration in one way or another.
- Technical actions. Activities that are directly addressing in a technical the specific climate hazard.

4.6.1 Public Health

The first sector to be examined, Public Health is of utmost importance since it has direct impacts on population and their living. Table 83 below focuses on a set of suggested adaptation actions on the population and public health.

Table 83: Suggested adaptation actions for population and public health

Actions' characteristic	Adaptation Actions
Strategic	Health action plan for the extreme events that Monastir is facing e.g. heat etc. (heat health action plan) - Collaboration with the regional medical services to increase preparedness level
	Provide access to hated public buildings during heat waves or other extreme events, for those citizens that lack the infrastructure to protect themselves (people living in underground apartments during floods, or lacking AC during extreme temperatures etc.)
Alert / Communication	Developing an early warning system to alert citizens in the case of extreme weather events
Educational	Educational and awareness raising campaigns about health-related effects of extreme events
Technical	Regular cleaning and maintenance of the sewage and drainage system
	Frequent monitoring of water and air quality

Health action plan for the extreme events

Estimated Coat (USD)	110,000
Implementing Year/Period	2021

The health action plan should include the framework for the implementation, coordination and evaluation of extreme events response activities in order to reduce the health impacts. It aims to provide measures for a successful coordination between government departments, health care professionals such as emergency medical personnel, health center staff, and hospital staff, and community groups. The proposed effective actions will ensure that health care and social systems are ready to act and strengthen the health and well-being. Preventive measures for those high-risk target groups will be also considered, such as not working outside in high temperatures for workers/technicians, or modification of their working hours during heat waves etc.

Provide access to public buildings during extreme events

Estimated Coat (USD)	15,000
Implementing Year/Period	2020-2030

There is a part of the population which lacks the infrastructure to protect themselves during extreme weather events. The Municipality may provide air-conditioned spaces in public buildings for those who have not ACs in their residences so as to eliminate the health impacts due to high temperatures. Moreover, public buildings may be provided as well, to citizens living in underground apartments, in case of floods.

Developing an early warning system to alert citizens in the case of extreme weather events

Following the forecasting of an extreme event, immediate notification of the public and all those participating in the response is critical to ensure safety. The warning system should

include early meteorological announcements followed by protection and medical advices. The aim is to alert those citizens who are most at risk so as to take the appropriate precautions. These extreme weather events take into account heat waves, floods, droughts, as well as landslides in specific areas. This action should be realized in coordination to a national action at this level, or cooperation with other municipalities, as it is a high cost and difficulty activity for Monastir municipality.

Educational and awareness raising campaigns about health-related effects of extreme events

Estimated Coat (USD)	15,000
Implementing Year/Period	2021-2023

Campaigns should include information and advices for citizens on how they can protect themselves in case of extreme heats, floods, forest fires, landslides, vector born diseases etc. so as to prevent impacts and infections. The aim is to communicate the risks disseminating public messages through media, informational material and social media. Special efforts should be made to reach vulnerable population such as elderly people, children, citizens with chronic diseases and employees working outdoors.

Regular cleaning and maintenance of the sewage and drainage system

Estimated Coat (USD)	35,000
Implementing Year/Period	2020-2030

A rise in temperature due to climate change will increase microorganisms' growth. In addition, floods as a result of extreme rainfall leads to disruption of water purification and contamination with sewage disposal systems, leading to increase the probability of epidemics. Subsequently the regular cleaning and maintenance of the sewage and drainage system is vital in order to mitigate the health risks.

4.6.2 Infrastructure

The next section regards infrastructure and actions to mitigate the climate impacts on them are presented.

Table 84: Suggested adaptation actions for infrastructure

Actions' characteristic	Adaptation Actions
Strategic	Water management plan
	Modelling predicted supply changes in the electricity from the locally available RES
	Mapping of sites with landslides and flood risks
Educational	Developing guides and awareness raising campaigns for citizens on how to save water and energy, especially during crisis
Technical	Support rainwater harvesting systems
	Building desalination plants based on the best available technologies

	New or upgrade of (coastal) flood defense systems near affected facilities. Potential re-engineering to increase the height of quaysides.
	Development of controlled flood management zones near afflicted facilities

Water management plan

Estimated Coat (USD)	30,000
Implementing Year/Period	2020

The expected reduced precipitation, the temperature increase and the evaporation will result in less recharge and less replenishment of surface water and groundwater reserves. In addition the water demand is increased and contributes in reducing per capita shares. An important action is to develop a plan so as to manage the water supply systems in order for instance to detect leakages, organize regular maintenance and notify the Municipality when such incidents take place.

Modelling predicted supply changes in the electricity from the locally available RES

Estimated Coat (USD)	20,000
Implementing Year/Period	2021

A certain part of electricity consumption in Monastir, but also in all Tunisia, will depend on Renewable Energy Sources. The extreme weather events may cause malfunctions in the energy supply leading in major problems in the city (e.g. patients who lives in their homes under technical assistance). Subsequently, problems should be predicted via prediction models in order for Municipality to plan what actions should take to face the situation in each case.

Mapping of sites with landslides and flood risks

Estimated Coat (USD)	10,000
Implementing Year/Period	2020

Another strategic action is the systematic mapping of sites that face landslide or flood risk. Since prevention is the basic tool to avoid future destructions, Monastir Municipality will invest on the mapping of its whole territory, determining the areas with low, medium and high risk for phenomena such as the above. Basic aim of this exercise, depending on the extent of the afflicted areas, is potentially to ban the establishment of infrastructures in areas with high risk, or to require specific permits for building in these areas and only if certain high standards are to be followed in the construction.

Developing guides and awareness raising campaigns for citizens on how to save water and energy, especially during crisis

Implementing Year/Period	2020 -2030

As part of the mitigation actions envisaged in the previous chapter, Municipality is going to implement numerous awareness raising activities and campaigns for the citizens, in order to make them more aware on how to save energy. These actions could be further enhanced with water saving advice, especially during heat waves, droughts or other extreme weather events that require savings in these resources. The cost for this action can be covered through the dedicated amount in the mitigation actions, and is expected to have the same duration.

Support rainwater harvesting systems

Estimated Coat (USD)	60,000
Implementing Year/Period	2020 - 2030

The municipality will work on supporting store of rainwater for reuse on-site, rather than allowing it to run off. Rainwater can be collected from roads or roofs, and in many places, the water collected is redirected to a deep pit (well, shaft, or borehole), aquifer, a reservoir with percolation, or collected from dew or fog with nets or other tools. Its uses include water for gardens, livestock, irrigation, domestic use with proper treatment, indoor heating for houses, etc. The harvested water can also be used as drinking water, longer-term storage, and for other purposes such as groundwater recharge.

Building desalination plants based on the best available technologies

Estimated Coat (USD)	3,000,000
Implementing Year/Period	2020 - 2025

In order to increase the drinking water sources, the municipality has to build desalination plants. The water desalination technology will be chosen according to the cost and the efficiency of the available technologies.

New or upgrade of (coastal) flood defense systems near affected facilities. Potential re-engineering to increase the height of quaysides.

Estimated Coat (USD)	500,000
Implementing Year/Period	2022 - 2025

To protect the areas and lands beside the sea beach from rising the sea level the municipality will take actions to defense systems near affected facilities. The actions will cover all the coastal area of Monastir municipality.

Development of controlled flood management zones near affiliated facilities

Estimated Coat (USD)	500,000

Implementing Year/Period	2022 - 2025

The municipality will develop controlled flood areas beside the buildings and facilities that face increasing in accumulating the water beside these facilities.

4.6.3 Built Environment

The next section is about the actions to be implemented in order to enhance the built environment and protect it from the future climate repercussions.

Table 85: Suggested adaptation actions for built environment

Actions' characteristic	Adaptation Actions
Strategic	Integrated land use planning with zoning system depending on the different areas
Educational	Educational campaigns on informing the citizens on the benefits of adopting the suggested actions in their premises
Technical	Greening infrastructure such as buildings' roofs and walls
	Increasing the amount of shade and green areas in the city by planting trees and using green pavements to reduce the heat island effect
	White roofs (cool colors), shading and bioclimatic design
	Rainwater collection and use
	Adoption of methods to reduce water demand
	Using water resistant construction materials

Enforcement of building codes for more energy efficient and heat tolerant structures

Implementing Year/Period	2020 - 2030

In Monastir, as well as Tunisia in general, building codes are applicable for new structures; however, these codes are not strictly enforced, since their implementation remains somehow optional. Therefore, the legislative framework is there, and Municipality should work towards promoting its use or decide its strict enforcement. Moreover, techniques on how to protect infrastructure from floods (e.g. minimum floor heights, water proofing etc.) are also required. This action has been suggested as part of the mitigation actions across all building infrastructure in the territory. The estimated cost and duration for this action has been considered in the mitigation actions.

Integrated land use planning with zoning system depending on the different areas

Estimated Coat (USD)	300,000
Implementing Year/Period	2020 - 2024

This action is basically the integration in the land use planning of the mapping of the region conducted before, depending the high, medium and low risk for phenomena such as flooding and landslides for characterizing certain zones.

Educational campaigns on informing the citizens on the benefits of adopting the suggested actions in their premises

Implementing Year/Period	2020 - 2030

Monastir Municipality should organize educational campaigns in order to inform inhabitants about the risks and climate hazards on the region and propose the appropriate measures via guidebooks or other material. Thus citizens will be able to modify their residences and businesses and convert them to more safe places which could resist floods and heat. Since Monastir Municipality is going to implement a series of awareness activities in the mitigation and adaptation thematic fields, it is the Municipality's intention to group where possible these activities for better coordination.

Greening infrastructure such as buildings' roofs and walls

Estimated Coat (USD)	10,000
Implementing Year/Period	2023 - 2030

A green roof is covered with vegetation and between other purposes it serves to provide insulation and help to lower air temperatures. It also contributes in mitigating the heat island effect and in cleaning the air in parallel with decreasing stress of the inhabitants.

Increasing the amount of shade and green areas in the city by planting trees and using green pavements to reduce the heat island effect

In order to adapt to the high temperatures, the municipality could create shade and green areas in places where a lot of people gather or pass through their day. Trees and parks can contribute in reducing the heat island effect and provide outdoor thermal comfort as well as a shaded and breezy place for the people passing to rest. In addition, the chosen material for the construction of sidewalks should be heat absorbing so as to prevent the extra heating from the ground to be reflected. In that way, citizens will feel euphoria and will be partially protected by a heat stroke. This project is similar to the mitigation action section above.

White roofs (cool colors), shading and bioclimatic design

The main measures to adapt for a building are those which can prevent temperature increase. White roofs (cool colors), shading and bioclimatic on rooftops or even the external walls reflect a percentage of the absorbed heat, thus maintaining the inner temperature at lower levels. This action has already been suggested as a measure for the mitigation of energy consumption and related emissions.

Rainwater collection and use

Collecting rainwater is an excellent way to conserve the fresh water. Using rain barrels, rainwater collection systems with big tanks underground (to avoid evaporations) can lead to significant water savings. This water could be used for domestic purposes like gardening, washing vehicles and equipment, flushing toilets etc. This action envisages rainwater collection in selected municipal buildings at first, as a pilot study. This action repeated in section (1.6.2).

Adoption of methods to reduce water demand

Estimated Coat (USD)	10,000
Implementing Year/Period	2022 - 2024

Since water scarcity is a major problem for Tunisia in general, and Monastir especially, a solution is to adopt methods to reduce its use. Using proper showerheads, toilet flushes with adjustable flow, wash machines only when they are full are easy activities to follow in order to save water and adapt to the increasing problem of water scarcity.

Using Water Resistance Constriction Material

Estimated Coat (USD)	10,000
Implementing Year/Period	2022 - 2026

The municipality will support using water resistance material in the construction phase. The support will be through awareness campaign to present the importance of using water resistance material in the building.

4.6.4 Economy

Climate changes and extreme events affect the economy sector and create problems that have to be addressed promptly.

Table 86: Suggested adaptation actions for economy

Actions' characteristic	Adaptation Actions
Strategic	Elaboration of water and ground water management plan
	Adoption of integrated land use planning for the tertiary sector
Technical	Adoption of energy efficient, water conservation and using RE Technologies programs at resorts

Elaboration of water and ground water management plan

This action has been also considered above, in the infrastructure section. The water management plan to be developed should target the economic sectors in the region as well.

Adoption of integrated land use planning for the tertiary sector

Integrated land use planning is a strategy to prevent climate impacts such as flooding, drought, water scarcity and heat stress, as well as to avoid exposure of valuable elements to risks. The planning for the tertiary sector proposes that construction in flood areas should be

avoided if possible, urban development should be planned in low hazard areas, development of buildings, housing, economical values etc. in flood risk areas should be restricted and storm water services should be planned. This action is illustrated in section (1.6.3)

Adoption of energy efficient, water conservation and using RE Technologies programs at resorts

This action has been also considered above, in the mitigation actions chapter. This action will aims at reducing the energy and water bills for the resorts.

4.6.5 Biodiversity

Biodiversity – the variety of life on the planet – is essential for the economy and for people well-being, but one of the main environmental challenges facing the planet is the loss of it. Conserving biodiversity and maintaining nature's capacity to deliver the related goods and services is became a priority at global scale.

Table 87: Suggested adaptation actions for biodiversity

Actions' characteristic	Adaptation Actions
Strategic	Elaboration of water and ground water management plan
	Establishment of a fire management plan
Educational	Educating the citizens
Technical	Trees planting
	Establishment of controlled flooding zones
	Beach nourishment or replenishment

Establishment of a fire management plan

Estimated Coat (USD)	10,000
Implementing Year/Period	2022

The municipality will adapt a firefighting plan in order to prevent the negative effect of the fire and conduct a quick control on the fire.

Elaboration of water and ground water management plan

This action has been also considered above, in the economy section (1.6.4). This action prevent any change in the biodiversity.

Educating the citizens

A significant measure is citizens' education regarding the importance of biodiversity for their wellbeing. People have to realize that their actions and activities are connected directly with the state of the environment thus effecting their own living conditions. Campaigns should be organized so as to inform inhabitants how they can adopt an environmental friendly behavior

and protect their natural habitat. The estimated cost for this action is considered as part of other awareness raising activities to be conducted by the Municipality.

Trees planting

An important action towards the protection of biodiversity is the tree planting and the expansion of green areas with friendly drought-tolerant plants. Trees not only contribute to the preservation of the natural habitat of fauna but they can also prevent floods and soil erosion. Moreover, they are significant actors in air cleaning which means that more trees and plants will reduce more the greenhouse gasses. This action illustrated as an action in mitigation section.

Establishment of controlled flooding zones

This action has been also considered above, in the infrastructure section (1.6.2).

Beach nourishment or replenishment

Estimated Coat (USD)	30,000
Implementing Year/Period	2020-2030

It is the artificial placement of sand on an eroded shore to maintain the amount of sand present in the foundation of the coast, and this way to compensate for natural erosion and to a greater or lesser extent protect the area against storm surge (nourishment may also use gravel and small pebbles, in particular for the shores' face).

Beach nourishment also often aims at maintaining beaches (beach width for tourism and recreational purposes)

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