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nexus

MINARET II

Empowering Municipal Governance for Climate Resilience Using WEF Nexus Approach

Sustainable Energy and Climate Action Plan (SECAP)

Manouba Municipality

MINARET II is supported by the Nexus Regional Dialogues Programme which is implemented by the GIZ and co-funded by the European Union (EU) and the German Federal Ministry for Economic Cooperation and Development (BMZ), and implemented by Royal Scientific Society/National Energy Research Centre. The project is implemented at municipal level targeting Jordan, Lebanon and Tunisia.

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Executive Summary

Manouba is a city in north-eastern Tunisia, and is part the metropolitan area of Tunis, also called "Grand Tunis". It is located at the west of Tunis city center at around 36°48′28″N 10°6′4″E. It is the capital city of Manouba Governorate. Manouba is well known for its university. t is also often viewed as a desirable place for family life because of its security, availability of various services and its high level of education.

Manouba 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 Manouba, reaching up to 40% against the calculated 2030 emissions (111,387 tn CO_2). The achievement of this scenario is conditional upon the funding availability from grants, international donors and financing institutions.

The energy balance for Manouba Municipality (Baseline Emissions Inventory) has been developed for 2018, in line with the Covenant of Mayors (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)
- Industrial Sector

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).
The highest energy consumer is the Transportation followed by Residential sector and Tertiary sector, while the municipal sector consumptions are the lowest. A more detailed allocation of the calculated energy consumption in Manouba Municipality (All sectors) is presented in the next figure per sector and per fuel.

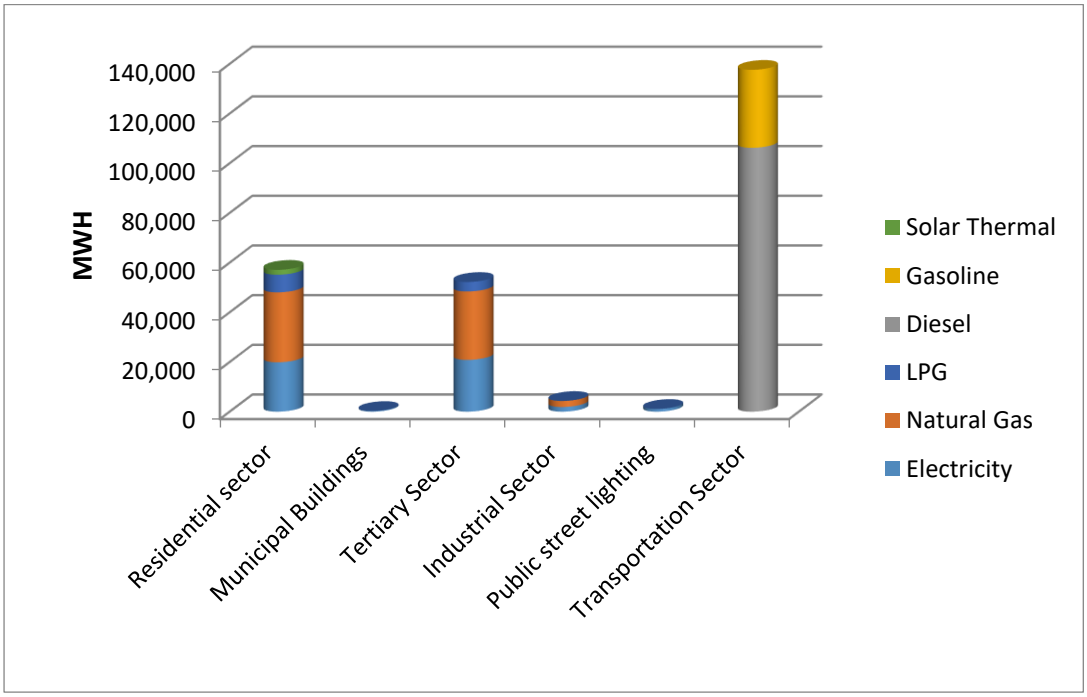

Figure 1: Energy consumption per sector and per fuel.

The respective total emissions for the baseline year, including emissions from waste management, equal 82,509 tn CO_2 and they are presented in the following chart.

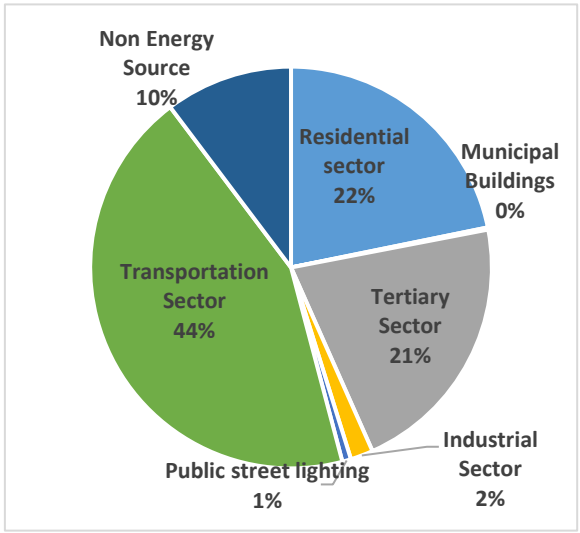

Figure 2: Total CO_2 emissions per sector.

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 111,387 tn CO_2. As mentioned above.

Table 1 shows an overview of the actions per sector, as well as the calculated emission reductions per action for both scenarios.

Table 1 : summary of the mitigation actions.

Action No.	Action	Emission Reductions (tn CO_2)
Municipal Buildings & Facilities		
3.2.1	Green procurement procedures for municipal buildings	9.65
3.2.2	Energy manager appointment in the municipality	0.59
3.2.3	Awareness raising activities for municipal employees	2.0
3.2.4	Strict application of green building codes in new municipal buildings	25.4
3.2.5	Efficient municipal buildings	26.9
3.2.6	Promotion of recycling	186.75
3.2.7	Install 0.89 MW PV plant	108
Municipal Public Lighting		
3.3.1	Street lighting upgrade	233.7
3.3.2	Astronomical timers	87.6
3.3.3	Green procurement procedures for future lighting equipment	357
Residential Buildings		
3.4.1	Awareness raising activities for modification of the residents' consumption behavior and energy saving	1,880
3.4.2	Promotion of Green Buildings' concept / Strict application of the building code	673
3.4.3	Campaign for promoting high-energy label home appliances and other awareness activities	309
3.4.4	Replacement of existing lamps with LEDs	715.5
3.4.5	Replacement of existing air-conditioners with more efficient ones	718
3.4.6	Building envelope improvement for the existing buildings	943
3.4.7	2.4 MW Photovoltaics on residential rooftops	20,332
3.4.8	Replacing existing water heaters with solar water heaters	4,986
Tertiary Sector		
3.5.1	1.96 MWp Photovoltaics on rooftops	1,875
3.5.2	Replacing existing water heaters with solar collectors	78
3.5.3	Replacement of existing lamps with LEDs	539
Industrial Sector		
3.6.1	Install 0.39 MW photovoltaic systems in the industrial sector	373
Transportation Sector		
3.7.1	Improve the process of car repair and purchasing new vehicles	34
3.7.2	Eco-driving seminars for the municipal fleet drivers	25.6

3.7.3	Improve the city bus network	595
3.7.4	Raise public awareness of public transport	980
3.7.5	Improve and secure pedestrian routes and paths	368
3.7.6	Improve and secure bike paths	1,960
3.7.7	Transfer all government departments and institutions to one complex near to the population centers in the city	1,226
3.7.8	Building vehicle crossing lines with the railway to facilitate local transportation	981
3.7.9	Establishing central markets near dense residential areas	981
3.7.10	Using buses instead of private cars to transport students to the schools and universities	245
3.7.11	Regulating Cargo vehicles work in the City	298
3.7.12	Replacing 5% of the existing Taxi vehicles with electric vehicles	642
Agricultural Sector		
3.8.1	Planting trees (increasing green areas)	1,085
Total		**43,878**

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.

1. Introduction

1.1. Current status

1.1.1. Geographical location

Manouba Governorate is one of the twenty-four governorates (provinces) of Tunisia and is in inland, northern Tunisia. It has a population of 379,518 (as at the 2014 census), and an area of 1,137 km^2. The capital is Manouba[1].

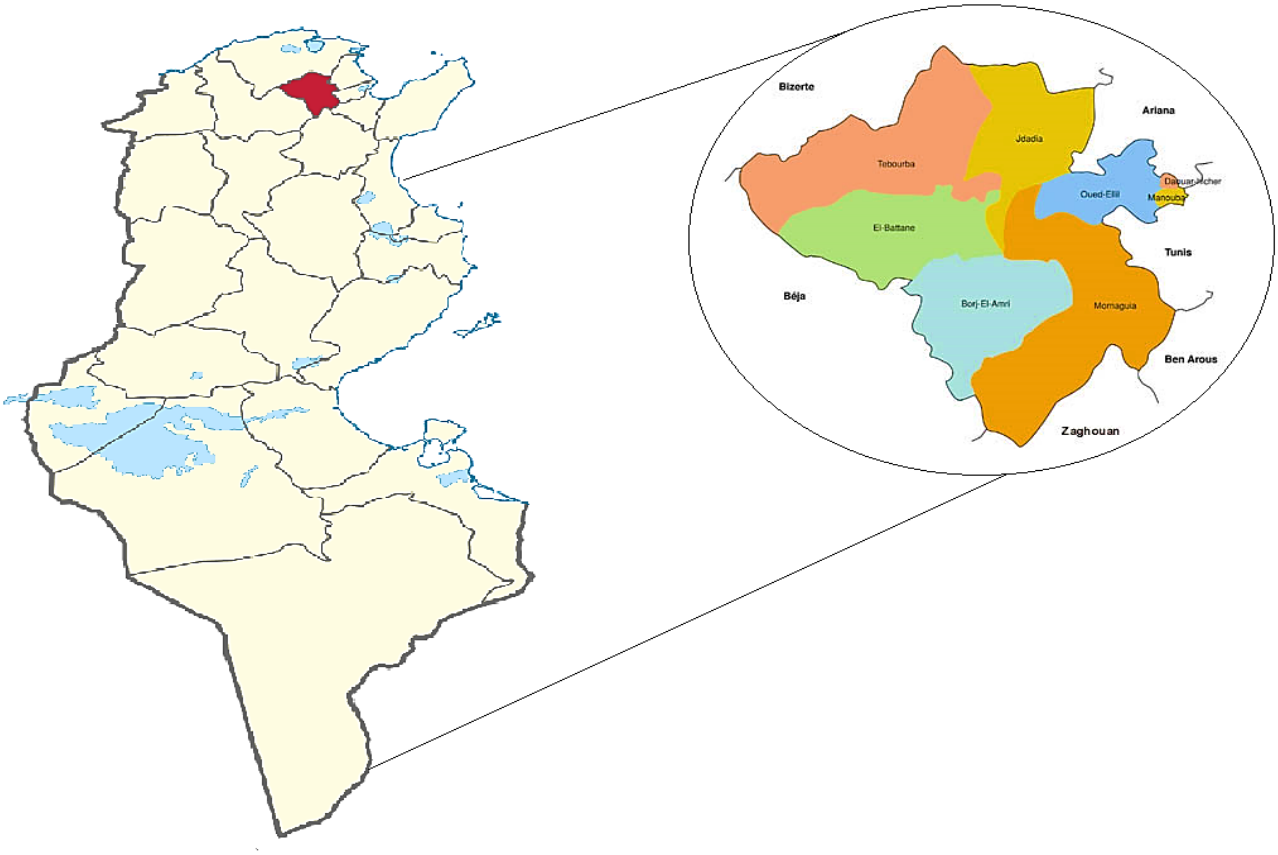

Figure 3: Manouba governorate geographical location [2].

The governorate is 5.5 kilometers (3.4 mi) from the capital, the east and west of the province have high foothills; from both ranges the three lakes of Tunis and the Bay of Tunis can be seen. The east part of the west range is named the Forest of Tebourba, one of its four largest settlements. The average temperature is 18.7 °C and annual rainfall is 450 millimeters [1].

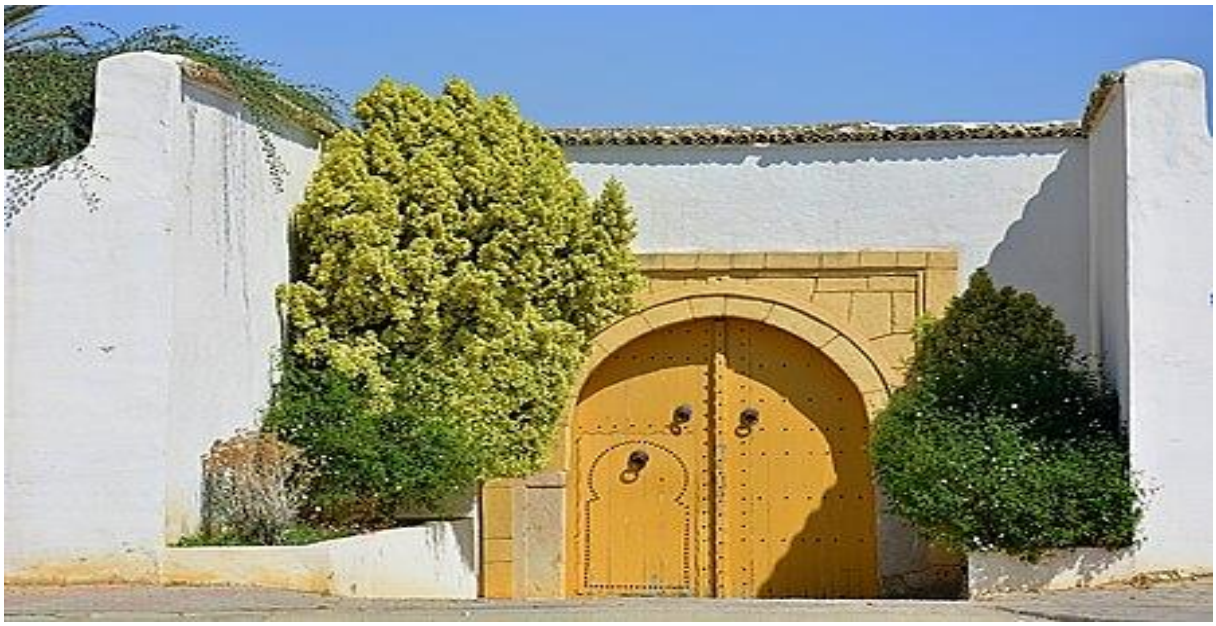

Figure 4: Mourad bey main palace gate in Manouba city [3].

Manouba is well known for its university. It is also often viewed as a desirable place for family life because of its security, availability of various services and its high level of education [1].

1.1.2. Climate characteristics

In Manouba, the summers are short, hot, humid, dry, and clear and the winters are long, cold, windy, and partly cloudy. Over the course of the year, the temperature typically varies from 7°C to 35°C and is rarely below 4°C or above 39°C.

The hot season lasts for 2.9 months, from June 17 to September 12, with an average daily high temperature above 31°C. The hottest month of the year in Manouba is August, with an average high of 34°C and low of 22°C. On the other hand, the cool season lasts for 4.0 months, from November 24 to March 23, with an average daily high temperature below 19°C. The coldest month of the year in Manouba is January, with an average low of 7°C and high of 16°C [4] .

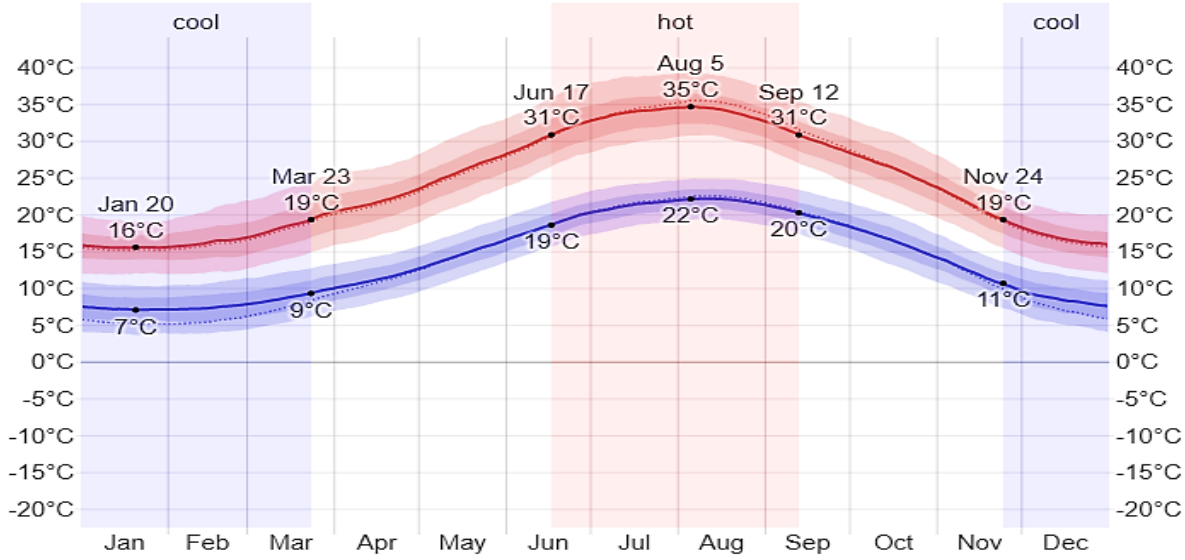

Figure 5: Minimum and Maximum average monthly temperature. [4]

The figure below shows you 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.

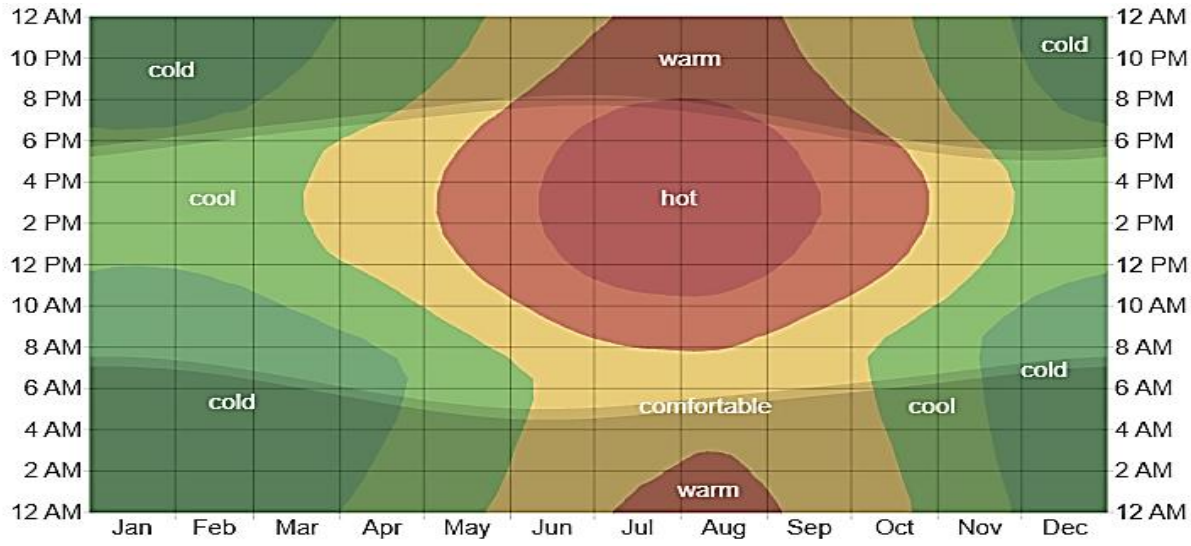

Figure 6: Hourly average temperatures. [4]

Clouds

In Manouba, 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 Manouba begins around June 13 and lasts for 2.9 months, ending around September 9. The clearest month of the year in Manouba is July, during which on average the sky is clear, mostly clear, or partly cloudy 94% of the time. The cloudier part of the year begins around September 9 and lasts

for 9.1 months, ending around June 13. The cloudiest month of the year in Manouba is October, during which on average the sky is overcast or mostly cloudy 41% of the time [4].

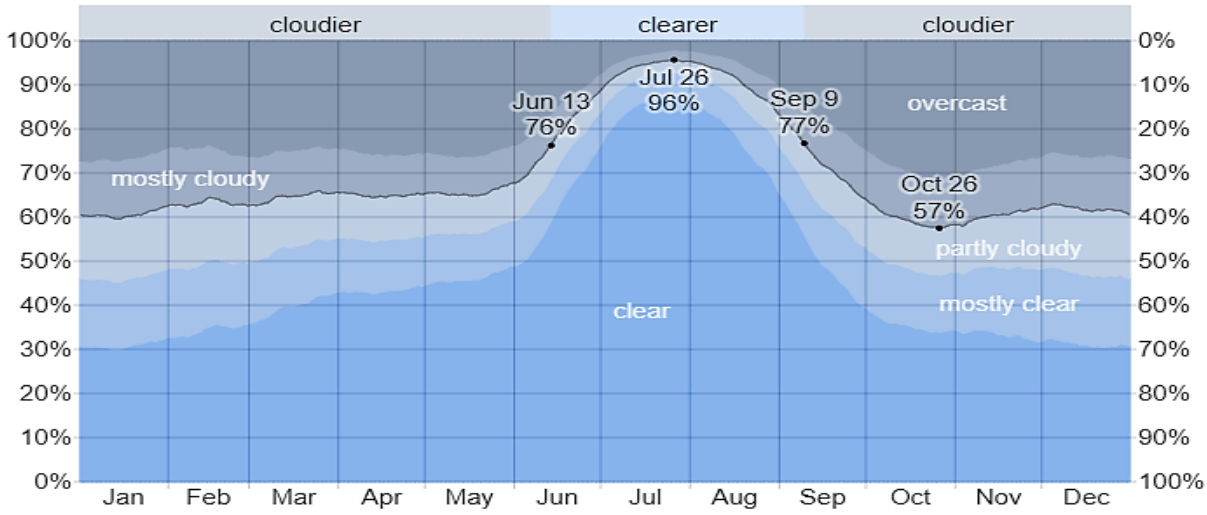

Figure 7: Average percentage of cloud covering the sky [4].

Precipitation

A wet day is one with at least 1.00 millimeters of liquid or liquid-equivalent precipitation. The chance of wet days in Manouba varies throughout the year.
The wetter season lasts 8.7 months, from August 31 to May 21, with a greater than 13% chance of a given day being a wet day. The month with the most wet days in Manouba is October, with an average of 6.6 days with at least 1.00 millimeters of precipitation.

The drier season lasts 3.3 months, from May 21 to August 31. The month with the fewest wet days in Manouba is July, with an average of 1.3 days with at least 1.00 millimeters of precipitation.
Among wet days, we distinguish between those that experience rain alone, snow alone, or a mixture of the two. The month with the most days of rain alone in Manouba is October, with an average of 6.6 days. Based on this categorization, the most common form of precipitation throughout the year is rain alone, with a peak probability of 23% on September 28 [4].

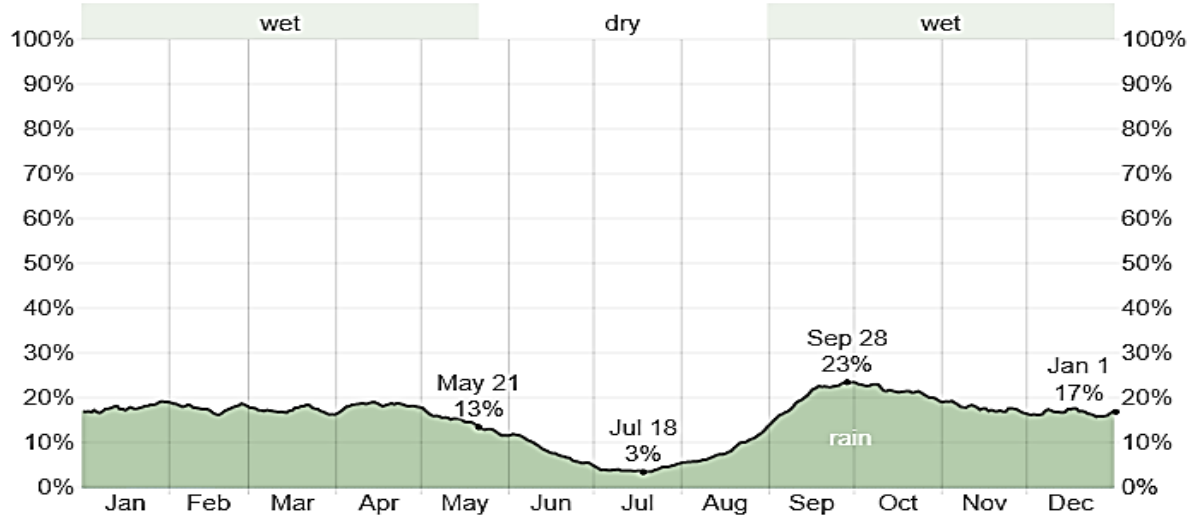

Figure 8: Frequency of wet days [4].

Rainfall

The rainy period of the year lasts for 10 months, from August 18 to June 18, with a sliding 31-day rainfall of at least 13 millimeters. The month with the most rain in Manouba is October, with an average rainfall of 37 millimeters.

The rainless period of the year lasts for 2.0 months, from June 18 to August 18. The month with the least rain in Manouba is July, with an average rainfall of 5 millimeters [4].

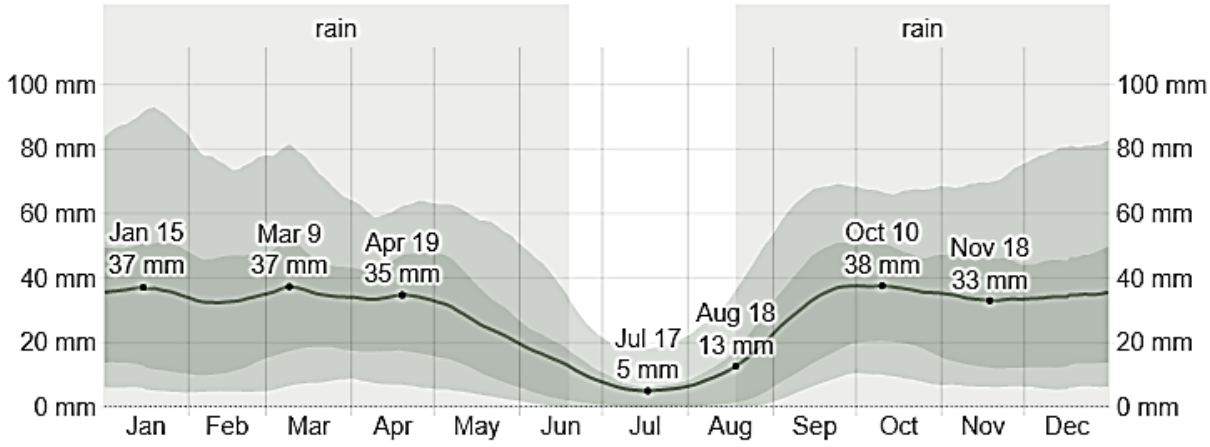

Figure 9: Average monthly Rainfall [4].

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.

Manouba experiences extreme seasonal variation in the perceived humidity. The muggier period of the year lasts for 4.1 months, from June 18 to October 21, during which time the comfort level is muggy, oppressive, or miserable at least 14% of the time. The month with the muggiest days in Manouba is August, with 16.4 days that are muggy or worse. The least muggy day of the year is February 21, when muggy conditions are essentially unheard of [4].

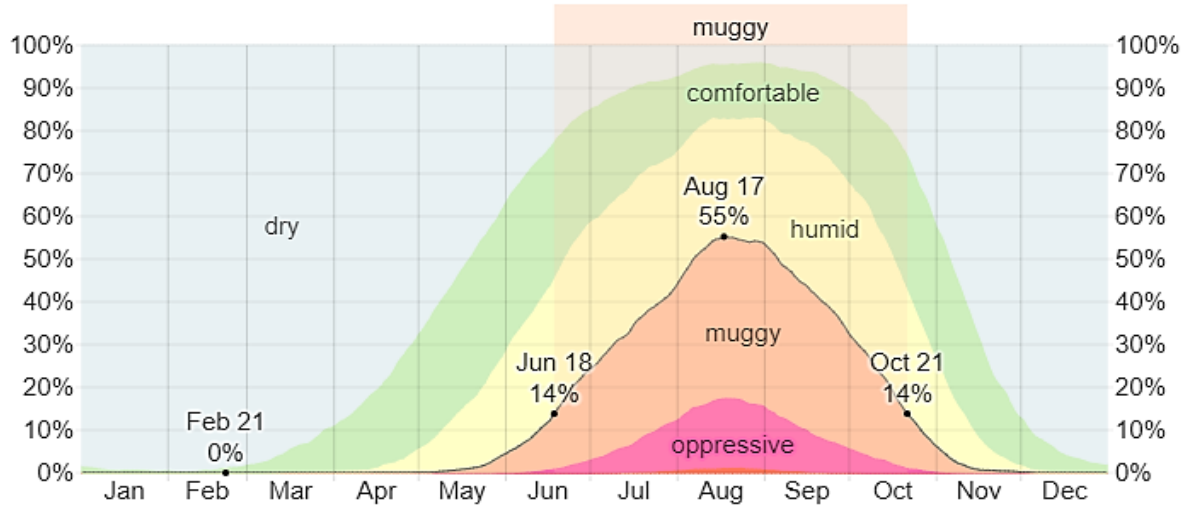

Figure 10: Average percentage of humidity [4].

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 Manouba experiences mild seasonal variation over the course of the year.

The windier part of the year lasts for 6.2 months, from November 9 to May 16, with average wind speeds of more than 4.5 meters per second. The windiest month of the year in Manouba is February, with an average hourly wind speed of 5.0 meters per second. The calmer time of year lasts for 5.8 months, from May 16 to November 9. The calmest month of the year in Manouba is August, with an average hourly wind speed of 4.0 meters per second [4].

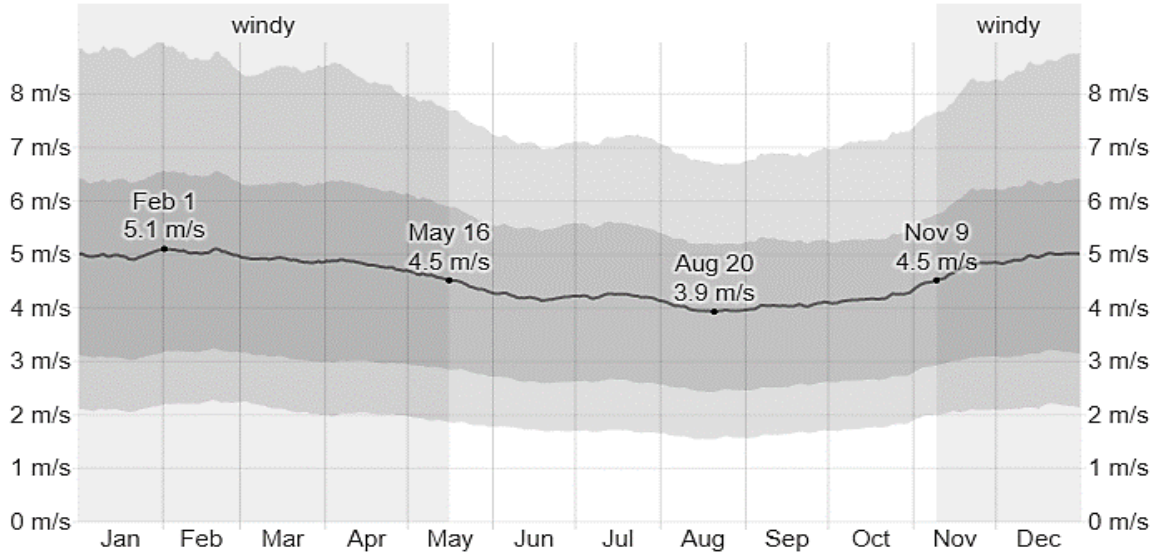

Figure 11: Average monthly wind speed [4].

The predominant average hourly wind direction in Manouba varies throughout the year. The wind is most often from the north for 4.1 months, from May 24 to September 26, with a peak percentage of 39% on August 19. The wind is most often from the west for 7.9 months, from September 26 to May 24, with a peak percentage of 51% on January 1 [4].

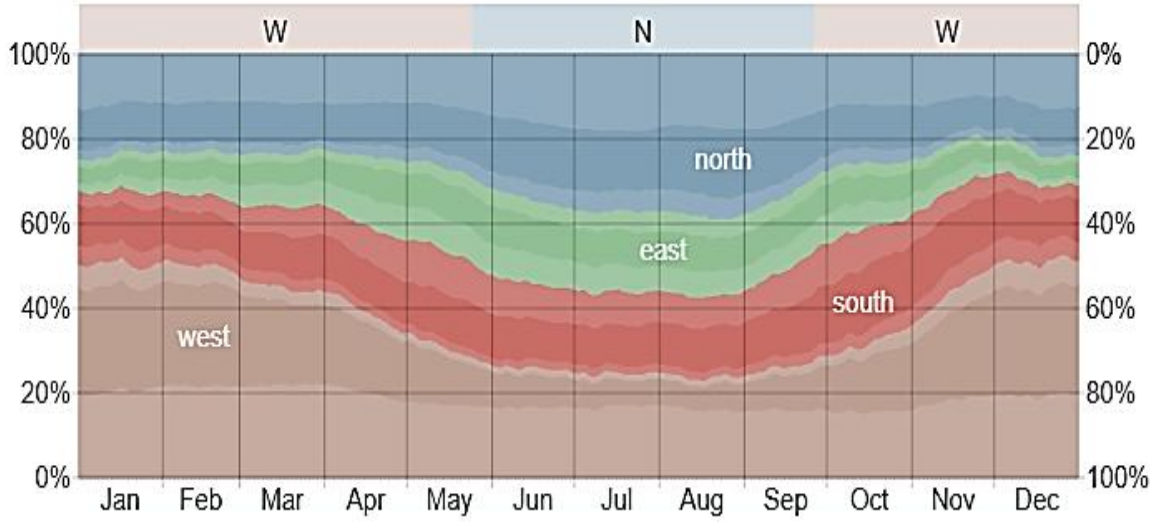

Figure 12: predominant average hourly wind direction [4].

Water Temperature

Manouba 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 extreme seasonal variation over the course of the year.

The time of year with warmer water lasts for 3.0 months, from July 8 to October 8, with an average temperature above 24°C. The month of the year in Manouba with the warmest water is August, with an average temperature of 26°C.

The time of year with cooler water lasts for 4.3 months, from December 25 to May 3, with an average temperature below 17°C. The month of the year in Manouba with the coolest water is February, with an average temperature of 15°C [4].

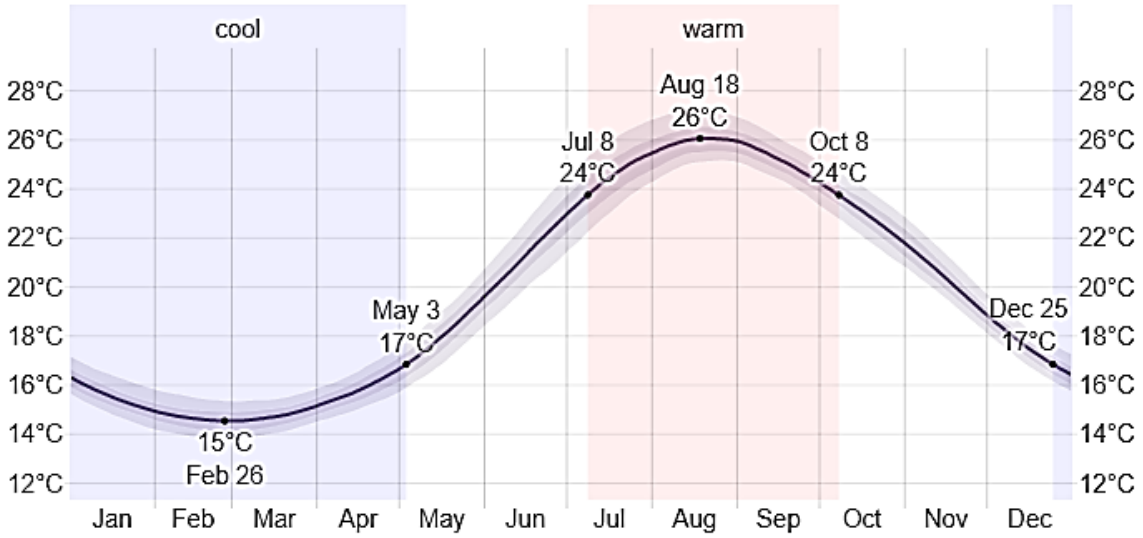

Figure 13: Average water surface temperature [4].

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 3.4 months, from May 6 to August 19, with an average daily incident shortwave energy per square meter above 6.8 kWh. The brightest month of the year in Manouba is July, with an average of 7.9 kWh.
The darker period of the year lasts for 3.5 months, from October 30 to February 12, with an average daily incident shortwave energy per square meter below 3.5 kWh. The darkest month of the year in Manouba is December, with an average of 2.4 kWh [4].

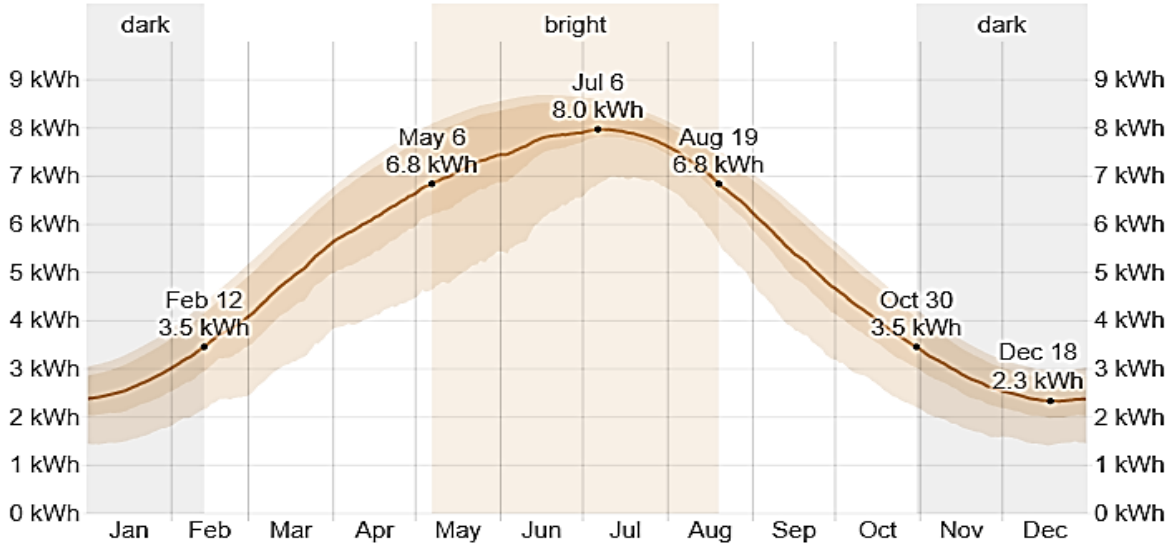

Figure 14: Total daily incident shortwave solar energy [4].

1.1.3. Demographic tendencies

The governorate of Manouba represents the western part of Greater Tunis and it occupies 42.5% of the area of the region and is considered a major link between the capital and the northwest, especially via the Tunis-Wadi Zarqa highway.

It is inhabited by 414,000 people, representing 14.6% of the population The population of Greater Tunis, however, is witnessing an active movement Urban expansion in view of shrinking residential real estate In the capital and in the northern and southern Ahwaz of greater Tunis

It includes 8 delegations with 10 municipalities within it. According to the last population census of 2018, the population living in Manouba delegation was 64,497, representing 15.6% of the entire governate. Referring to the municipality level this number is further reduced to reach 35,111 [5].

1.1.4. Employment

Based on the statistics that was done in 2018, The employees in Manouba District comprise approximately 48.6% of its population, 8.1% of them work in agricultural sector, while 18.7% of them work in technical field, and 58.3% work in services. In the part of economically active citizens there is a 19.4% percentage that is currently unemployed and looking for a job [6].

1.1.5. Education

The total number of primary schools reached 13 schools in Manouba delegation, while the secondary schools contained 9 schools. The primary schools in the delegation served 16% of the governate schools and 25% of the secondary schools' students. The governate puts great efforts to enhance the teaching environment this is clear when reviewing various

education indicators. For example, success rates in the delegation (74%) surpassed the governates average success rate (61%).

As for higher education, the University of Manouba includes 14 university establishments. The total number of students of the University of Monastir is 15,911 students and a total number of teachers 1203 for the academic year 2019/2020, where 31.5% of them are males and 68.5% are female [5].

1.1.6. 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 is approximately a fully developed public sewage system and thus there is 94.2% of the population has access in the public network. The rest of the housing units are been served by cesspools. (2017).
The road network in Manouba delegation consists of 84.1 Km of paved and unpaved roads, of which 29% are regional roads, 10% local roads, and a final 61% farm tracks [5].

1.1.7. Economy

The economy of Manouba is characterized by the Agricultural and farming professions in parallel with irrigation sector covered about 26,000 hectares of fertile land in the lower basin Mejerda valley. Manouba also includes a number of industrial establishments especially foreign and popular ones that concentrated in 8 industrial areas and it is expected that the sector will witness a significant growth.

Furthermore, the traditional industries are emerging as a distinct sector thanks to the presence of the craft village in the Dandan. On top of this, about 80 multidisciplinary craft units such as the manufacture of carpets, traditional clothing, and traditional textiles painting on antiques [5].

1.1.8. Renewable Energy Projects

Referring to the previous and planned projects in Tunisia, there were Renewable Energy projects in Manouba state [7][8].

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 Manouba Municipality in Tunis, the baseline year has

been set to be 2018, since it was the year with the most sufficient and reliable data available[1].

2.1.2. BEI administrative boundaries

Following a meeting of the consultants from the Royal Scientific Society/National energy Research Center (RSS/NERC) with the Manouba representatives, it was agreed that the BEI will cover the administrative boundaries of Manouba municipality.

2.1.3. Sectors to be included in the BEI

Data collection needed for the preparation of the BEI covered the following sectors:

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
- Urban Public transport
- Urban Private and Commercial transport

C. **Solid waste management.**

D. **Livestock breeding.**

E. **Waste Water Treatment**

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 depends on the energy mix of the country. So, the emission factor was calculated based on the Tunisian energy mix and the electricity consumption. According to the IPCC calculation approaches (JRC COM-NEEEFE_1900-2018), the electricity emission factor in Tunisia in 2018 is 0.538 tnCO2equivalent/MWh.

[1] Ref: How to develop a Sustainable Energy Action Plan (SEAP)-Guidebook, European Union, 2010, http://www.eumayors.eu/IMG/pdf/seap_guidelines_en.pdf.

Table 2: Emission Factors & Conversion Rates.

	Emission Factor (tn CO_2/MWh)	Conversion Factors	Source
Electricity	0.538	-	JRC-COM-NEEFE_1990-2018-IPCC approach
Natural Gas	0.202	11.6 MWh/tn	CoM / IPCC
LPG	0.227	13.1 MWH/tn	CoM / IPCC
Diesel	0.267	10 KWh/lt	CoM / IPCC
Gasoline	0.249	9.2 KWh/lt	CoM / IPCC
Solar (thermal/ PV)	0	-	-

Furthermore, emissions from the biomass were calculated according to the IPCC method. Waste separation process, Sewage Sludge and livestock breeding create methane emissions (CH4) which are converted to CO2 emissions according to the equivalence "1 tn CH4 = 25 tn CO2".

2.2. Energy Consumption

The total amount of energy consumed in Manouba municipality is **252,522 MWh**. The allocation of this energy consumption among the different sectors, by fuel type, is presented in

Table 3. Further analysis of the consumptions per sector is provided in the following sections.

Sector	Electricity	Natural Gas	Diesel	Gasoline	LPG	Solar Thermal	Total
	MWh						
Residential sector	19,872	28,156	0	0	7,090	1,964	**57,082**
Municipal Buildings	265	0	0	0	0	0	**265**
Tertiary Sector	20,836	27,548	0	0	3,818	0	**52,202**
Industrial Sector	1,891	2,411	0	0	0	0	**4,302**
Public street lighting	1,086	0	0	0	0	0	**1,086**
Transportation Sector	0	0	106,209	31,376	0	0	**137,585**
Total	**43,950**	**58,115**	**106,209**	**31,376**	**10,908**	**1,964**	**252,522**

Sector	Electricity	Natural Gas	Diesel	Gasoline	LPG	Solar Thermal	Total
	MWh						
Residential sector	19,872	28,156	0	0	7,090	1,964	**57,082**
Municipal Buildings	265	0	0	0	0	0	**265**
Tertiary Sector	20,836	27,548	0	0	3,818	0	**52,202**
Industrial Sector	1,891	2,411	0	0	0	0	**4,302**
Public street lighting	1,086	0	0	0	0	0	**1,086**

Transportation Sector	0	0	106,209	31,376	0	0	**137,585**
Total	**43,950**	**58,115**	**106,209**	**31,376**	**10,908**	**1,964**	**252,522**

Table 3 : Total Energy consumption per sector.

2.2.1. Municipal Buildings & Facilities

Tunisian Electricity & Gas Company (STEG) provided electricity for the year 2018 for municipal buildings, which include: Administration, Sport complex, Collection office and two warehouses. The total electricity consumption of buildings and facilities in the municipality reached **265 MWh**.

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 1,086 MWh according to the provided bills from STEG (Société tunisienne de l'électricité et du gaz) for 2018.

2.2.3. Residential Buildings

Electricity & Natural Gas (NG)

Manouba's households consume electricity for lighting and electrical appliances such as refrigerator, air conditions and others, whereas natural gas (NG) is used for space heating, water heating and cooking in the houses. According to the provided data from STEG, the annual consumed electricity and NG in this sector was 19,872 MWh and 28,156 MWh, respectively in 2018.

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. Thus, the annual LPG consumption in residential sector for Manouba Municipality was around 41,633 bottles (13 kg/bottle capacity) with annual energy consumption of 7,090 MWh.

Solar thermal

IEA gave data for solar thermal usage at a national level (649,444 MWh) [10], 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 11,608,300 in 2018, whereas the population at municipal level was 35,111 (according statistics by MDIIC [9]) with population ratio of 0.3%. Based on that, the annual solar thermal consumption at the municipal level is calculated to be 1,964 MWh.

Summary

Gathering all the data of the residential sector, it seems that the residents consume 4 distinct energy sources. *Table 4* and Figure 15 below, the final consumption per fuel type for this sector is presented.

Table 4:Total energy consumption in the residential sector.

Energy Source	Residential Sector
Electricity (MWh)	19,872
Natural Gas (MWh)	28,156
LPG (MWh)	7,090
Solar Thermal (MWh)	1,964
Total (MWh)	**57,082**

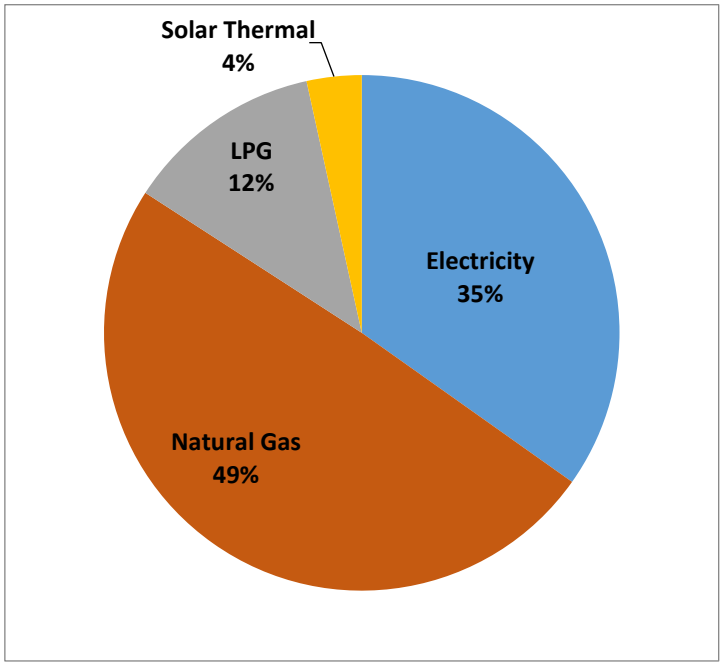

Figure 15: Energy consumption per fuel in Residential Sector.

2.2.4. Tertiary 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, offices and hospitals. Also, this sector includes the educational buildings (Schools and Universities), public buildings, and agriculture as well.

In case of public and commercial buildings, the annual LPG consumption at municipal level was 3,818 MWh.

The annual electricity and natural gas consumptions were given according to the provided data from STEG, with total value of 20,836 MWh for electricity and 27,548 MWh for NG.

The collected data are presented in Table 5 below.

Table 5: Energy consumption in tertiary sector per type of sub-sector

Types of Buildings in the Tertiary Sector	Electricity (MWh)	Natural Gas (MWh)	LPG (MWh)	Total (MWh)
Public & Commercial buildings	19,821	27,548	3,818	51,187
Agricultural	1,014	0	0	1,014
Total	20,835	27,548	3,818	52,201

As can be seen in Figure 16 and Figure 17 below, it is obvious that the consumption's allocation in the tertiary sector is dominated by commercial & public buildings.

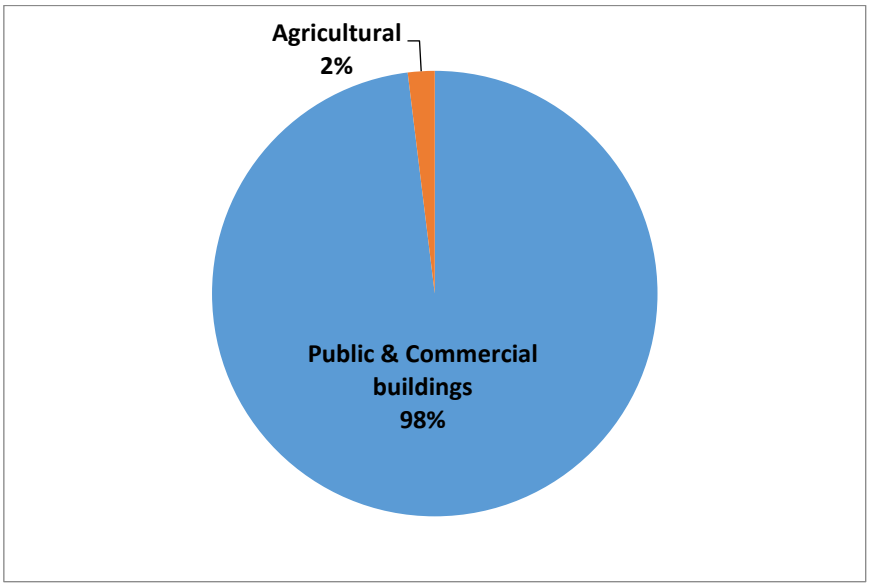

Figure 16: Energy consumption in tertiary sector per type of building.

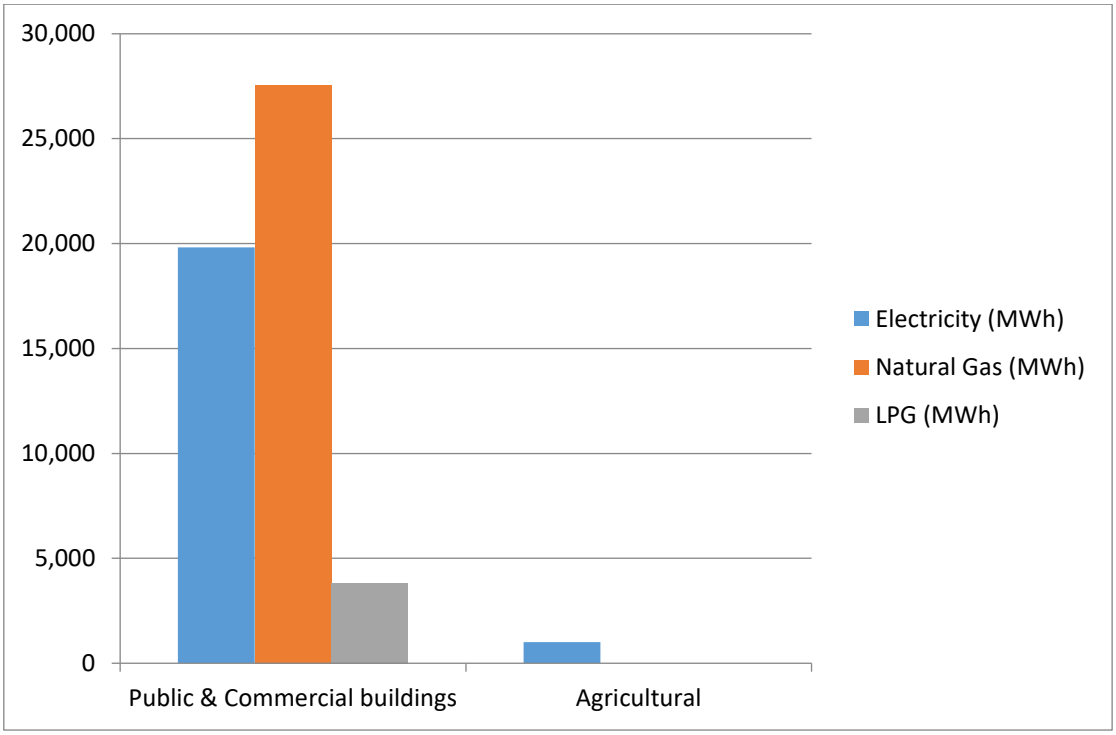

Figure 17: Energy consumption in tertiary sector per type of building and fuel.

2.2.5. Buildings' & facilities Synopsis

The consumed energy allocation for all the buildings and facilities in Manouba Municipality is presented in the *Figure 18*.

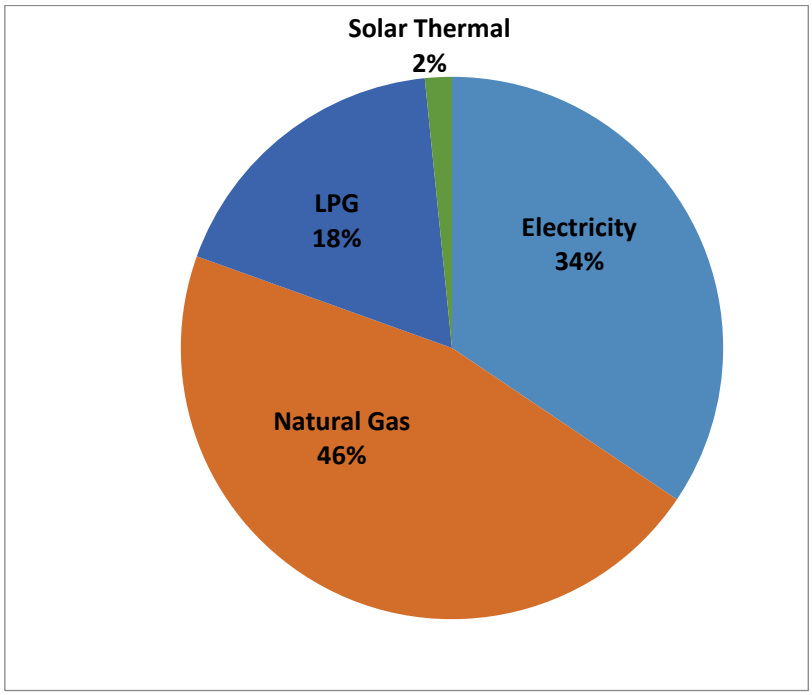

Figure 18: Energy consumption in buildings and facilities per fuel.

2.2.6. Industrial Sector

Electricity and NG consumption for the industrial sector was given according to data provided by STEG with total annual consumption of **1,891 MWh** for electricity and **2,411 MWh** for NG.

2.2.7. Transport Sector

2.2.7.1. Municipal fleet

As far as the consumption of municipal vehicles is concerned, and according to the available data, Manouba municipal fleet has 34 vehicles which use diesel and gasoline. Table 6 shows the consumption per type of fuel and vehicles.

Table 6 : Annual Energy Consumption in Municipal fleet of Manouba

Type of Municipal vehicles	Number of vehicles	Diesel		Gasoline		Total
		Lit	MWh	Lit	MWh	MWh
Waste Transportation Vehicles	7	27,660	276.6	0	0	276.6
Heavy Vehicles	9	46,425	464.25	0	0	464.25
Small Passengers Vehicles	9	1,050	10.5	12,200	112	122.5
Motorcycles	9	0	0	1,920	17.66	17.66
Total	**34**	**75,135**	**751.35**	**14,120**	**129.66**	**881.01**

2.2.7.2. Urban Public Transport

Public transport refers to buses and taxis that serve Manouba citizens. The data available for this sector included the average consumption per type of vehicle according to the total distance travelled within municipal limits, as shown in Table 7: below.

Table 7: Annual Energy Consumption in public vehicles in Manouba.

Vehicle Type	Number of vehicles	Gasoline (Lit/yr)	Diesel (Lit/yr)	Gasoline (MWh/yr)	Diesel (MWh/yr)	Total MWh
Buses	37	0	1,561,290	0	15,613	15,613
Taxis	701	280,500	0	2,580	0	2,580
Total	**738**	**280,500**	**1,561,290**	**2,580**	**15,613**	**18,193**

2.2.7.3. Urban Private and Commercial Transport

The private & commercial transport include: Motorcycles, private cars and trucks. Table 8 below summarizes the fuel and energy consumption for private & commercial vehicles that passes Manouba municipality borders in 2018:

Table 8:Annual Energy Consumption in private & commercial transport in Manouba.

Vehicle Type	Number of vehicles	Gasoline (Lit/yr)	Diesel (Lit/yr)	Gasoline (MWh/yr)	Diesel (MWh/yr)	Total MWh
Motorcycles	103	43,365	0	399	0	**399**
Private passenger cars	8,450	3,072,455	2,414,071	28,267	24,141	**52,408**
Trucks	3,368	0	6,495,429	0	64,954	**64,954**
Total	**11,921**	**3,115,820**	**8,909,500**	**28,666**	**89,095**	**117,761**

2.2.7.4. Off-Road Transport

It is worth mentioning that Manouba municipality is a residential area as there are no agricultural activities within its borders unlike the other municipalities in Manouba state. However, **Error! Reference source not found.** Table 9 below summarizes the annual energy consumption for the agricultural vehicles in Manouba municipality:

Table 9: Annual Energy Consumption in Agricultural transport in Manouba.

Vehicle Type	Number of vehicles	Gasoline (Lit/yr)	Diesel (Lit/yr)	Gasoline (MWh/yr)	Diesel (MWh/yr)	Total MWh
Agricultural vehicles	15	0	75,000	0	750	750

Table 10 and Figure 19 summarize the overall energy consumption and share for each category of transportation sector, which show that the overall energy consumption is 137,585 MWh/yr, whereas urban private & commercial transportation take the largest share with percentage of 85.6 %.

Table 10:Total energy consumption for transportation sector within Manouba municipality borders

Vehicle Type	Diesel (MWh/yr)	Gasoline (MWh/yr)	Total MWh
Municipal fleet	751	130	881
Urban Public Transport	15,613	2,580	18,193
Urban Private and Commercial Transport	89,095	28,666	117,761
Off-Road Transport	750	0	750
TOTAL	**106,209**	**31,376**	**137,585**

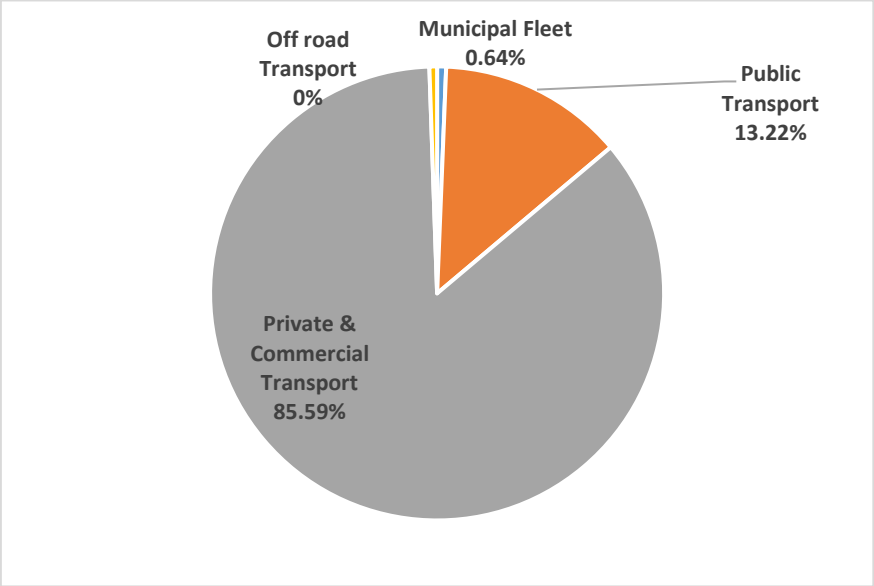

Figure 19: Energy consumption distribution in transportation sector.

2.2.8. Final Energy Consumption

Table 11 shows energy consumptions within Manouba municipality, with a total energy consumption of **252.522 GWh.**

Table 11:Total Energy Consumption in Manouba municipality.

Sector		FINAL ENERGY CONSUMPTION [MWh]						
		Electricity	Fossil fuels				Renewable energies	Total
			Natural Gas	LPG	Diesel	Gasoline	Solar thermal	
Residential sector		19,872	28,156	7,090	0	0	1,964	**57,082**
Municipal Buildings		265	0	0	0	0	0	**265**
Tertiary Sector		20,836	27,548	3,818	0	0	0	**52,202**
Industrial Sector		1,891	2,411	0	0	0	0	**4,302**
Public street lighting		1,086	0	0	0	0	0	**1,086**
Transportation Sector	Municipal Fleet	0	0	0	751	130	0	**881**
	Public Transportation	0	0	0	15,613	2,580	0	**18,193**
	Private & Commercial Transportation	0	0	0	89,095	28,666	0	**117,761**
	Off-Road Transportation	0	0	0	750	0	0	**750**
Total		**43,950**	**58,115**	**10,908**	**106,209**	**31,376**	**1,964**	252,522

Figure 20 below shows the energy consumption distribution for all Manouba's sectors, which can be noted that the energy consumption is almost dominated by transport and residential sectors.

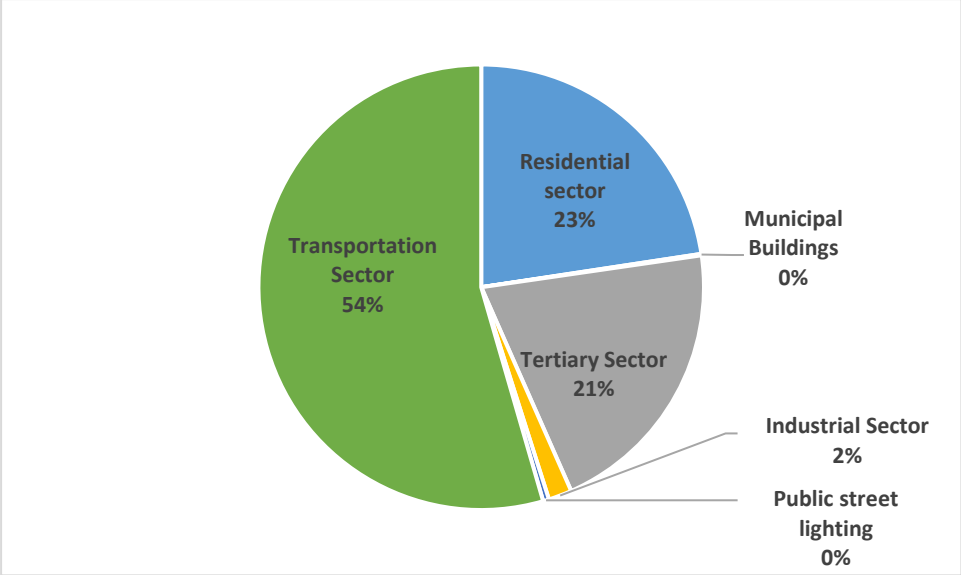

Figure 20: Energy consumption distribution for all sectors in Manouba Municipality.

2.3. Local electricity production

It is expected that 4% of the total households (equals to 350 households) in the Municipality of Manouba have On-Grid Roof-Top PV systems with average capacity of 4 KWp. The total capacity for these systems is around 1.4 MW with total electricity production of **2,180 MWh/yr**.

2.4. CO2 emissions

2.4.1. Energy related emissions

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

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: Off-Grid 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)

$$EFE = \frac{(86736-0-0)*0.538+0+0}{86736} = 0.538 \text{ tn } CO_2/\text{MWh}$$

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 LPG is 0.227 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.
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:

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 putrescibles in SW
- C Percentage of Food waste in SW
- D Percentage of wood and straw waste in SW

The total quantity of solid waste for Manouba Municipality is **13,155 tn**. The entire amount is thrown in landfill. The average waste composition, as well as the results from the calculations is presented in Table 12 and Table 13.

Table 12:Solid waste composition in Manouba, 2018.

Solid waste composition	Percentage	tn/a
Paper	8%	1,052
Wood	3%	395
Glass	1%	132
Organic Waste	61%	8,025
Metal	5%	658
Plastic	13%	1,710
Textiles	2%	263
Others	7%	920
Total annual waste in tn	100%	13,155

Table 13:Waste Emissions Calculation factors.

Variables	Values
MSW_t	13,155 tn/year
MSW_f	1
MCF	0.4

DOC	0.1516
DOC_f	0.574
F	0.5
16/12	1.3333
R	0
OX	0

Where DOC_f=0.014*T+0.28 (T: average temperature in Manouba, 21°C)

According to the available data on solid waste, it was found that 305 tn of methane and 838 tn of CO2 have been released to the atmosphere. This Methane quantity equals to 7,631 tn of equivalent CO2 (According to the guidelines the factor which was used for the conversion is 25) with total equivalent CO2 emissions of 8,469 tn/yr.

B- Waste Water Treatment Plant (WWTP)

In Manouba municipality, there is not any wastewater treatment plant. Therefore, the CO_2 emissions from this sector is zero.

C- Livestock Breeding Sector

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

Table 14 below shows the number of heads from each type of livestock in addition to the annual emission factor:

Table 14 : Number of heads and emission factor for livestock breeding in Manouba Municipality.

Type of livestock	Number of heads	Emission factor (Kg CH_4/year)	Emission factor (Kg CO_2/year)
Cows	98	196	4,900
Sheep	1,032	154.8	3,870
Rabbits	30	2.4	60

According to the available data on solid waste, it was found that 0.35 tn of methane has been released to the atmosphere. This quantity equals to **8.8 tn of equivalent CO2**. (According to the guidelines the factor which was used for the conversion is 25).

2.4.3. Final CO_2 emissions

The emissions of CO_2 equivalent for the sectors that have been described in the previous sections are available, in total, in Table 15 .

Table 15:Total CO2eq emissions for Manouba Municipality

Sector		CO_2 emission (tn CO_2/year)						
		Electricity	Fossil fuels				Renewable energies	Total
			Natural Gas	LPG	Diesel	Gasoline	Solar thermal	
Residential sector		10,691	5,688	1,609	0	0	0	**17,988**
Municipal Buildings		143	0	0	0	0	0	**143**
Tertiary Sector		11,210	5,565	867	0	0	0	**17,642**
Industrial Sector		1,017	487	0	0	0	0	**1,504**
Public street lighting		584	0	0	0	0	0	**584**
Transportation Sector	Urban Municipal Fleets	0	0	0	201	32	0	**233**
	Urban Public Transportation	0	0	0	4,169	642	0	**4,811**
	Urban Private & Commercial Transportation	0	0	0	23,788	7,138	0	**30,926**
	Off-Road Transportation	0	0	0	200	0	0	**200**
Sub-Total		**23,645**	**11,740**	**2,476**	**28,358**	**7,812**	**0**	**74,031**
Non Energy Sources								
Livestock breeders								**8.8**
Solid waste								**8,469**
Sub-Total								**8,477.8**
Total		**23,645**	**11,740**	**2,476**	**28,358**	**7,812**	**0**	**82,509**

2.5. Results' Graphical Analysis

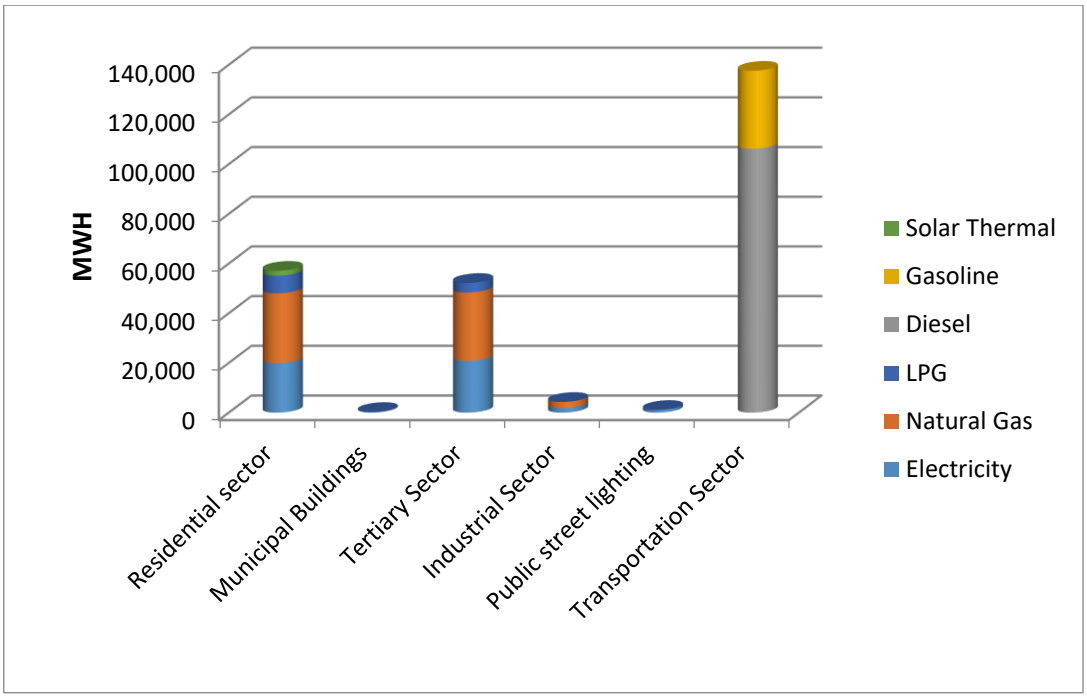

Figure 21: Final Energy consumption per sector and per fuel.

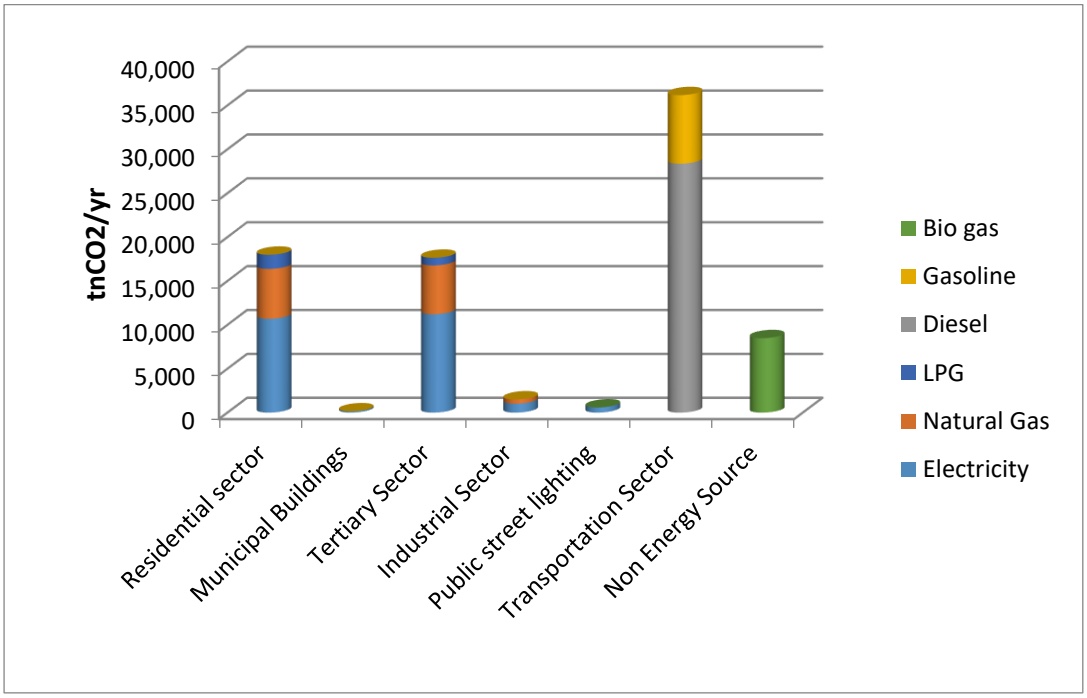

Figure 22: Total CO_2 emissions per sector and per fuel.

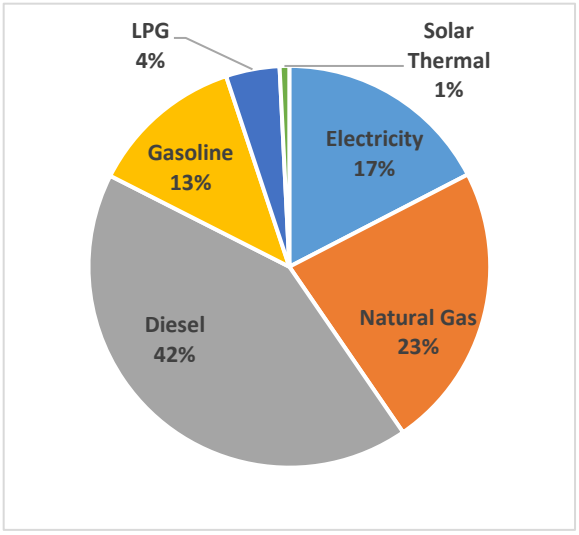

Figure 24: Final Energy Consumption per fuel.

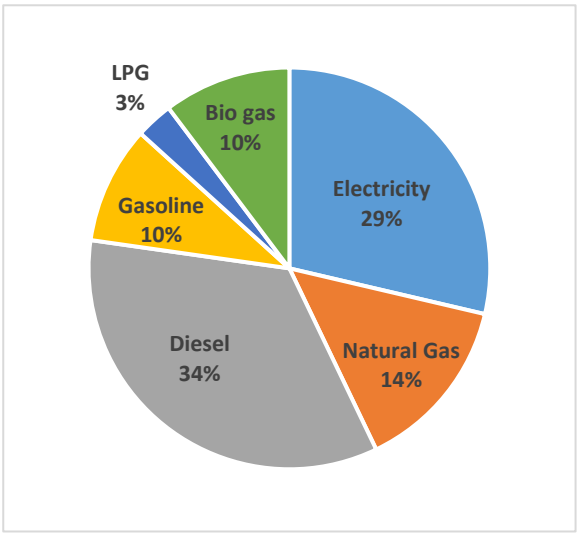

Figure 23: Total CO_2 emissions per fuel.

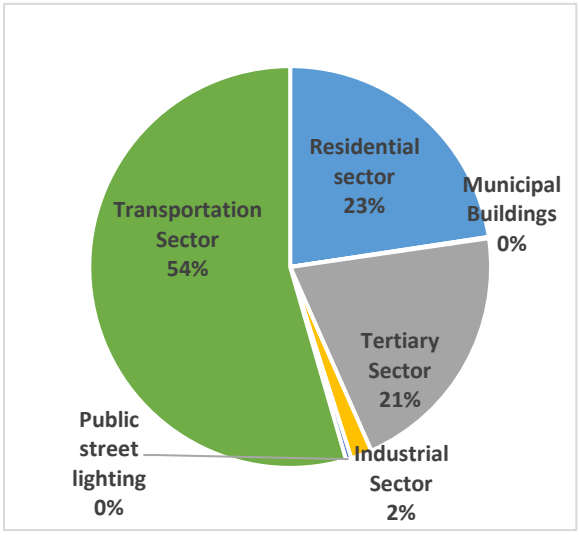

Figure 26: Final Energy Consumption per Sector.

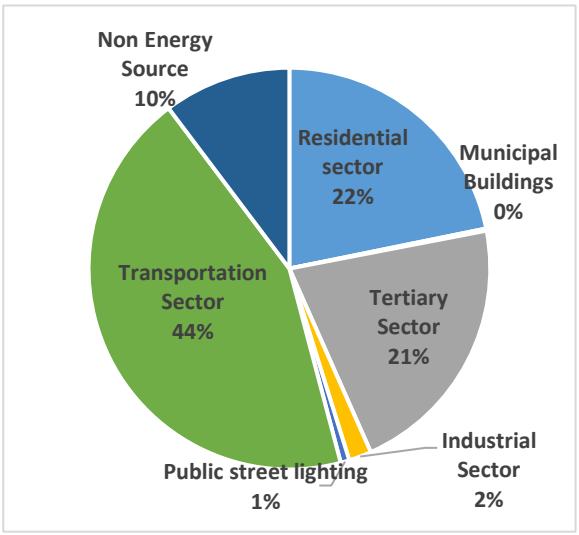

Figure 25: Total CO_2 emissions per Sector.

3. SECAP Actions

3.1. Target for 2030

The following section explains the proposed actions to support the mitigation of emissions due to the use of energy; this will cover all the mandatory sectors, namely the Municipal buildings and facilities, street lighting, the residential sector, the tertiary sector and the transportation one.

The Municipality of Manouba is requested 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 Manouba 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 results, the sectors contributing the most to the carbon footprint are **Transport (44%)**, **Tertiary (21%)**, **Residential (22%)** and **Bio waste (10%)**. 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 regard, 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 Manouba, the emissions for the baseline year, 2018, were 82,509 tn CO2eq. The national coefficient k for the baseline year of 2018 in Tunisia is 1.35. Therefore, the forecasted emissions for 2030 are:

$$Emissions\ CO_2\ 2030 = 82{,}509 \times 1.35 = \mathbf{111{,}387\ tn\ CO_{2eq}}$$

Table 16 below shows the BAU scenario per sector for year 2030:

Table 16:BAU scenario per sector for year 2030

BAU Scenario per sector	MWH	tCO_2
Municipal buildings & facilities	357.75	193
Public Lighting	1,466	788
Residential buildings	77,061	24,284

Tertiary buildings	70,473	23,817
Industrial sector	5,808	2,030
Municipal fleet	1,189	315
Public transport	24,561	6,495
Private & Commercial transport	158,977	41,750
Off-Road transport	1,013	270
Solid waste sector	----	11,433
Livestock breeding sector	----	12
Total	**340,906**	**111,387**

The emission reduction target for Manouba Municipality according to Covenant of Mayors the target should be at least 40% (44,555 tn CO_{2eq}) against the calculated 2030 emissions compared with the BAU scenario.

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

Based on the suggested actions, calculations for a 40% reduction have been completed. The following sections provide a more detailed analysis per action for each sector. It should be noted that for municipal awareness-raising activities, the amount of private funds mobilized is reported in addition to the municipality's implementation costs and potential funding sources. This cost is not included in the NPV calculation. Furthermore, externalities costs are not considered in the calculation of the NPV; this results in actions with a negative NPV from the strict economic calculation, even though their overall impact could be considered positive if additional benefits are considered.

3.2. Municipal Buildings, Equipment / Facilities

This sector contributes less than 1% of the carbon footprint. Nonetheless, the possible actions to be implemented in Municipal Buildings could serve as a model for citizens and employees. The municipality should recognize the measures that best fit its needs in order to achieve energy savings and emission reductions. A comprehensive set of actions is analyzed in the following sections. 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 environmentally friendly, as well as to properly educate the new generations in environmental and energy related issues.

An overview of this sector's actions and expected emission reductions are presented on Table 17 below:

Table 17:Actions in Municipal Buildings, Equipment/Facilities.

Action No.	Action	Emission Reductions (tn CO_2)
3.2.1	Green procurement procedures for municipal buildings	9.65
3.2.2	Energy manager appointment in the municipality	0.59
3.2.3	Awareness raising activities for municipal employees	2.0
3.2.4	Strict application of green building codes in new municipal buildings	25.4
3.2.5	Efficient municipal buildings	26.9
3.2.6	Promotion of recycling	186.75
3.2.7	Install 0.89 MW PV plant	108
Total		**359.29**

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. By choosing high-efficiency products with low environmental impact, it is possible to consume less energy, reduce CO2 emissions, and save money. The action is intended to be applied to all new office equipment that the municipality plans to purchase to meet their growing needs and to gradually replace old, inefficient ones, especially for high energy consuming office equipment, high-efficiency products will be targeted, while minimum efficiency standards and requirements will be set to all relevant municipal tenders. An average Carbon reduction of 7% against BAU consumptions is anticipated.

Table 18 summaries the results of calculations related to the cost, savings and the financial viability of the action.

Table 18:Action 3.2.1 in numbers

Green procurement procedures	
Duration	2023 - 2030
Total Implementation Cost (USD)	7,000
Expected energy Savings in 2030 (MWh)	17.9
Expected emission Reduction in 2030 (tn CO2)	9.65
Funding Source	Own funds
Net Present Value (NPV)	>0

3.2.2. Energy manager appointment in the municipality

The creation of municipal administrative structures, in order to establish the working team to implement and monitor the progress of the SECAP activities, is one of the prerequisites for the municipality's adhesion to the Covenant of Mayors. In this regard, this action goes far beyond the satisfaction of the previously mentioned prerequisite.

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 19:Action 3.2.2 in numbers

Duration	2023 - 2030
Total Implementation Cost (USD)	9,000
Annual Energy Savings (MWh)	1.1
Annual Emission Reduction (tn CO2)	0.59
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 20:Action 3.2.3 in numbers

Duration	2023 - 2027
Total Implementation Cost (USD)	1,000
Annual Energy Savings (MWh)	3.7
Annual Emission Reduction (tn CO_2)	2.0
Funding Source	Own funds & external funds
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 21:Action 3.2.4 in numbers.

Duration	2023 - 2026
Total Implementation Cost (USD)	1,150,000
Annual Energy Savings (MWh)	47.2
Annual Emission Reduction (tn CO2)	25.4
Funding Source	Own and governmental funds
Net Present Value (NPV)	>0

3.2.5. Efficient Municipal Buildings

The current state of Manouba's municipal buildings almost include LED lighting units and old air conditioning units. However, none of the buildings' envelopes are thermally insulated, and the windows are single-glazed. As a result, thermal losses occur, increasing energy consumption. Thus, the Municipality intends to make these buildings more efficient and environmentally friendly by insulating walls and roofs and installing double-glazed windows. These measures are expected to save 35% of the energy used in air conditioning systems.

Table 22:Action 3.2.5 in numbers.

Duration	2023 - 2026
Total Implementation Cost (USD)	15,000
Annual Energy Savings (MWh)	50
Annual Emission Reduction (tn CO2)	26.9
Funding Source	Own and governmental funds
Net Present Value (NPV)	>0

3.2.6. Promotion of Recycling

Because waste accounts for 10% of total municipal emissions, Manouba Municipality is committed to actively implementing awareness activities to promote the recycling context. The goal is to achieve 15% recycling rates by 2030. The promotional campaign will include information days, promotional materials such as leaflets and posters, and even messages in local media (TV, radio, and social media) about the benefits of recycling and how to recycle. The municipality will also ensure that adequate infrastructure (recycling bins and vehicles) is available for waste sorting and collection on the streets, including electrical device recycling. Furthermore, to set a good example, the municipality will place recycling bins in all municipal buildings and facilities, encouraging the use of recycled paper in daily administrative matters.

Table 23:Action 3.2.6 in numbers.

Duration	2023 - 2026
Total Implementation Cost (USD)	1,500,000
Annual Emissions Reduction (tn CO2)	186.75
Funding Source	Own funds

3.2.7. Install 0.89 MW PV plant

As known, Tunisia has abundant solar potential. So, the municipality intends to take advantage of this benefit by constructing a 0.89 MW PV plant to offset some of the electricity consumed by municipal buildings and public lighting. As a result, its reliance on the grid will be reduced through the use of renewable energy, resulting in CO2 reductions.

The Key data on the investment are presented in the Table 24 below:

Table 24:Action 3.2.7 in numbers.

Duration	2023 - 2026
Total Implementation Cost (USD)	1,593,000
Annual Energy Production (MWh)	200
Annual Emissions Reduction (tn CO2)	108
Funding Source	Own funds
Net Present Value (NPV)	>0

3.3. Municipal Public Lighting

Municipal public lighting includes street lighting and lighting for public areas. It is estimated that appropriate upgrades to this system will result in significant energy savings and emission reductions.

Table 25 provides an overview of this system actions, while the following paragraphs provide a detailed analysis with calculations for each action.

Table 25:Actions in Municipal Public Lighting.

Action No.	Action	Emission Reductions (tn CO_2)
3.3.1	Street lighting upgrade	233.7
3.3.2	Astronomical timers	87.6
3.3.3	Green procurement procedures for future lighting equipment	357
Total		**678.3**

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 significant cost savings for Manouba and reduction in electricity consumption.

The key data on the action is presented in the below Table 26.

Table 26:Action 3.3.1 in numbers

Duration	2023 - 2025
Total Implementation Cost (USD)	300,000
Annual Energy Production (MWh)	434
Annual Emissions Reduction (tn CO2)	233.7
Funding Source	Own Funds
Net Present Value (NPV)	>0

3.3.2. Astronomical timers

The operation of street lighting is controlled manually by the operators or photo cells. This control method could be replaced with astronomical timers' control, which are more accurate and precise compared to other techniques. This action will reduce the electricity consumption by at least 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.

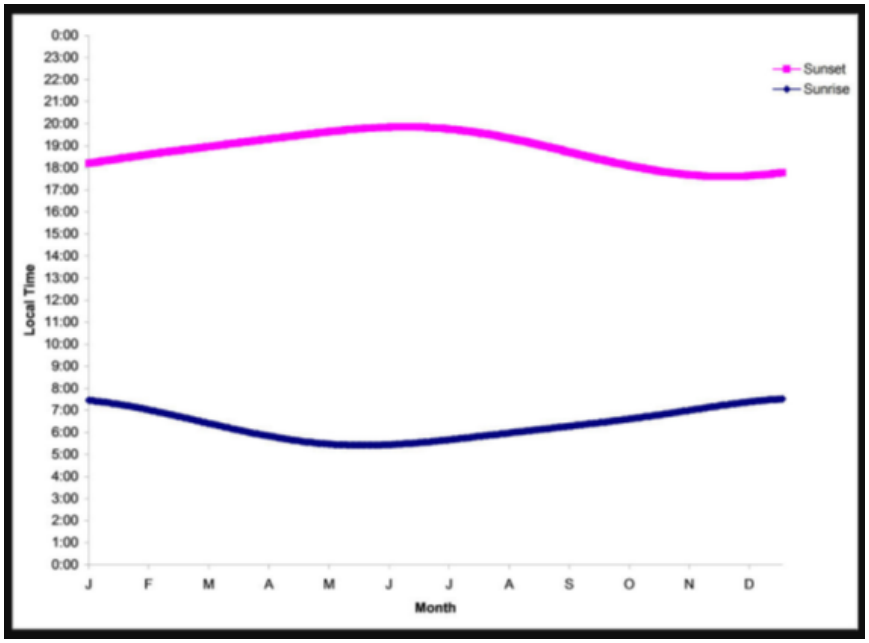

Figure 27: Timing for sunset and sunrise in Tunisia.

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 available.

Key data on the investment are presented in the Table 27 below.

Table 27:Action 3.3.2 in numbers

Astronomical Timers	
Duration	2023-2027
Total Implementation Cost (USD)	7,400
Annual Energy Savings (MWh)	163
Annual Emission Reduction (tn CO2)	87.6
Funding Source	Own funds
Net Present Value (NPV)	>0

3.3.3. Green procurement procedures for future lighting

Green procurement is a procedure where the municipalities seek to procure goods with reduced environmental impact throughout their life cycle and reach high-efficiency standards. In this way, the selection of products will be according to the highest standards that ensures the desired quality, which in turn minimize environmental impacts and carbon emissions. 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 Table 28 below and have been calculated against the BAU scenario.

Table 28:Action 3.3.3 in numbers

Duration	2023 – 2030
Total Implementation Cost (USD)	140,000
Annual Energy Savings (MWh)	664
Annual Emission Reduction (tn CO2)	357
Funding Source	Own Funds
Net Present Value (NPV)	>0

3.4. Residential Buildings

This sector includes the homes energy consumption of all residents related to lighting, heating, use of electric appliances etc. This consumption constitutes 23% of the total consumption with 22% contribution to the CO_2 emissions.

The initial actions are informative and could be initiated by Manouba Municipality. Because the Municipality does not have the ability to intervene directly in project implementation, a series of actions will be planned to encourage residents to implement the proposed measures to reduce their energy consumption and carbon emissions.

An overview of this sector's planned actions is presented in the Table 29 below.

Table 29:Actions in Residential Buildings.

Action No.	Action	Emission Reductions (tn CO_2)
3.4.1	Awareness raising activities for modification of the residents' consumption behavior and energy saving	1,880
3.4.2	Promotion of Green Buildings' concept / Strict application of the building code	673
3.4.3	Campaign for promoting high-energy label home appliances and other awareness activities	309
3.4.4	Replacement of existing lamps with LEDs	715.5
3.4.5	Replacement of existing air-conditioners with more efficient ones	718
3.4.6	Building envelope improvement for existing buildings	943
3.4.7	2.4 MW Photovoltaics on residential rooftops	2,332
3.4.8	Replacing existing water heaters with solar water heaters	4,986
Total		**12,556.5**

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

The initial step is that the municipality should organize frequent awareness raising activities within the horizon of 2030 for Manouba Citizens'. Engaging Citizens in these activities is crucial as residential sector is responsible for almost 23% of the total energy consumption.

The aim is to enhance the environmental consciousness of the citizens through the following activities:

- Organization of "Energy info days"; in these energy days, the focus will be on the importance of energy saving and protecting the environment through simple actions such as changing of energy consumption behavior, replacing inefficient lamps with LED lamps, purchasing high energy efficiency 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 30 below.

Table 30:Action 3.4.1 in numbers

Duration	2023 – 2033
Total Implementation Cost (USD)	10,000
Annual Energy Savings (MWh)	3,495
Annual Emission Reduction (tn CO2)	1,880
Funding Source	Own funds
Net Present Value (NPV)	>> 0

3.4.2. Promotion of Green Buildings' concept

The lack of enforcement of the Energy Efficient Building Code in Tunisia is one of the key issues behind the low energy performance of buildings in Tunis. 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 Manouba 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 31 below.

Table 31:Action 3.4.2 in numbers

Duration	2023 – 2033
Total Implementation Cost (USD)	30,000
Annual Energy Savings (MWh)	1,250
Annual Emission Reduction (tn CO2)	673
Funding Source	Own funds
Net Present Value (NPV)	<< 0

3.4.3. Campaign for promoting high energy label equipment

Another important activity the municipality should organize is a campaign for promoting among the residents the purchase and use of high-class energy labeled equipment. The old equipment (refrigerators, stoves, vacuum cleaners etc.) consumes greater amounts of energy compared to new ones. 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 cost benefits for the users themselves, since when selecting energy efficient products lead to 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 32 below.

Table 32:Action 3.4.3 in numbers

Duration	2023 – 2030
Total Implementation Cost (USD)	17,000
Annual Energy Savings (MWh)	574
Annual Emission Reduction (tn CO2)	309
Funding Source	Own 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 to energy and cost savings on one hand, while these lamps provide great luminosity quality on the other. Their cost is higher than 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 such measures and reach a penetration rate of 30%, thus contributing to the energy savings and CO2 reduction in the city.

In addition, if the Municipality takes an intensive awareness campaign, the penetration rate for high efficiency lamps such as LEDs will reach 100%.

Key data on the action are presented in the Table 33.

Table 33:Action 3.4.4 in numbers

Duration	2023 – 2028
Total Implementation Cost (USD)	75,000
Annual Energy Savings (MWh)	1,330
Annual Emission Reduction (tn CO2)	715.5
Funding Source	Own funds
Net Present Value (NPV)	>0

3.4.5. Replacement of existing air – conditioners with more efficient ones

Due to the region's hot climate, cooling systems in buildings are used extensively, accounting for a sizable portion of electricity consumption. To reduce energy consumption, it is recommended that existing A/Cs be replaced with efficient AC units. The municipality, in collaboration with other stakeholders such as Local Community Organizations, could launch awareness campaigns to encourage people to buy new efficient air conditioners and reduce their energy consumption by 40%, and contribute to achieving the municipality's carbon reduction target by 2030.

Related calculations on the action in terms of initial cost and emission savings are presented in Table 34 below.

Table 34:Action 3.4.5 in numbers

Duration	2023 – 2033
Total Implementation Cost (USD)	970,000
Annual Energy Savings (MWh)	1,335
Annual Emission Reduction (tn CO2)	718
Funding Source	External funds
Net Present Value (NPV)	>>0

3.4.6. Building envelope improvement for the existing buildings

Glazing replacement is an additional action with limited but not insignificant savings. Although summers in Manouba are extremely hot, heating systems are required to achieve thermal comfort inside buildings during the winter. These heating systems use LPG, and it is possible to reduce their consumption by 15% by lowering the building's heating losses by replacing single glazing with double glazing.

This action can also have impact in the electricity consumption, especially if it is to be combined with roof thermal insulation. The electrical consumption will be reduced due to the reduction of ACs consumption as there will be no heat losses through the windows and walls.

Table 35:Action 3.4.6 in numbers

Duration	2023 – 2033
Total Implementation Cost (USD)	5,600,000
Annual Energy Savings (MWh)	1,752
Annual Emission Reduction (tn CO2)	943
Funding Source	External funds
Net Present Value (NPV)	>0

3.4.7. 2.4 MW Photovoltaics on 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, 2.4 MW of PV panels 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 targets such as awareness activities on PV technology.

Key data on the action are presented in the Table 36 below.

Table 36:Action 3.4.7 in numbers

Duration	2023 – 2033
Total Implementation Cost (USD)	4,300,000
Annual Energy Savings (MWh)	4,335
Annual Emission Reduction (tn CO2)	2,332
Funding Source	Private funds, Banks Loans
Net Present Value (NPV)	>>0

3.4.8. Replacing existing water heaters with solar water heaters

Hot water for domestic use is a constant requirement in every household. As a result, this activity currently consumes a significant amount of electricity and gas. Replacing existing electricity and gas water heating systems with solar water heaters will significantly reduce energy consumption and carbon emission. The size of solar water heaters that could be implemented through this action has been estimated cover around 50% of households by 2030 (about 4,380 households), considering that Manouba will work towards this direction with its citizens through awareness raising activities and dedicated events.

Table 37:Action 3.4.8 in numbers

Duration	2023 - 2033
Total Implementation Cost (USD)	2,430,000
Annual Energy Savings (MWh)	9,269
Annual Emission Reduction (tn CO2)	4,986
Funding Source	Private funds
Net Present Value (NPV)	>>0

3.5. Tertiary Sector

This sector includes the energy consumption of public and commercial buildings, Water supply facilities…etc. This consumption constitutes 21% of the total consumption, with 22% contribution to the CO_2 emissions.

The initial actions are informative and will be carried out by Manouba Municipality. Since the municipality does not have the authority to intervene directly in project implementation, a series of actions will be planned to encourage building managers/owners to implement the proposed measures to reduce energy consumption and carbon emissions.

An overview of this sector's planned actions is presented in the Table 38.

Table 38:Action in Tertiary Sector

Action No.	Action	Emission Reductions (tn CO_2)
3.5.1	1.96 MWp Photovoltaics on rooftops	1,875
3.5.2	Replacing existing water heaters with solar collectors	78
3.5.3	Replacement of existing lamps with LEDs	539
Total		**2,492**

3.5.1. 1.96 MW_p Photovoltaics on rooftops

The solar energy potential of the country and the Manouba region is enormous. As a result, businesses will be encouraged to capitalize on this opportunity by installing PVs to offset some of their electricity consumption. 1.96 MW of PV rooftop systems are proposed to be installed. Because solar energy produces no emissions, the reduction in carbon emissions will be significant.

The following assumptions were made for calculating the estimated emission reduction of this action:

- Average solar 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 Manouba would be replaced by solar, which corresponds to the installation of around 1.96 MWp and to production of more than 3,471 MWh per year;
- An average cost of 4,000 TND / kWp in Tunisia.

Table 39:Action 3.5.1 in numbers

Duration	2023 – 2033
Total Implementation Cost (USD)	2,808,000
Annual Energy Savings (MWh)	3,485
Annual Emission Reduction (tn CO2)	1,875
Funding Source	Own funds
Net Present Value (NPV)	>>0

3.5.2. Using of Solar Water Heaters

Several tertiary sector businesses, such as schools and hotels, rely heavily on hot water to meet their daily needs. Because SWH penetration in the sector was very low in the baseline year, there is a significant potential for energy savings through SWH adoption.

It is assumed that 5% of the total energy consumption for water heating of the tertiary sector in the city of Manouba would be replaced by solar water heaters.

Key data on the action are presented in the following Table 40.

Table 40:Action 3.5.2 in numbers

Duration	2023 – 2033
Total Implementation Cost (USD)	260,000
Annual Energy Savings (MWh)	144
Annual Emission Reduction (tn CO2)	78
Funding Source	Own funds
Net Present Value (NPV)	>0

3.5.3. Replacement of existing lamps with LEDs

A campaign to replace existing inefficient lamps with efficient LEDs is another important activity that the municipality should organize. The goal is to raise awareness among business owners/managers about the advantages of goods that have a lower environmental impact throughout their life cycle. As previously stated, awareness raising activities should be carried out in order to disseminate the benefits of purchasing LED lamps.

Table 41:Action 3.5.3 in numbers

Duration	2023 – 2027
Total Implementation Cost (USD)	10,000
Annual Energy Savings (MWh)	1,002
Annual Emission Reduction (tn CO2)	539
Funding Source	Own funds
Net Present Value (NPV)	>0

3.6. Industrial Sector

The share of the industrial sector is 2% out of the total energy consumption and CO_2 in Manouba Municipality. The proposed actions are presented in the next table and a more detailed analysis for each one is following.

Table 42:Actions in Industrial Sector

Action No.	Action	Emission Reductions (tn CO_2)
3.6.1	Install photovoltaic systems in the industrial sector	373
Total		**373**

3.6.1. Install 0.39 MW photovoltaic systems in the industrial sector

It was assumed that solar would replace 25% of the city of Manouba's industrial electricity consumption. The proposed PV system size is around 0.39 MW.

Table 43:Action 3.6.1 in numbers

Duration	2023 – 2033
Total Implementation Cost (USD)	560,000
Annual Energy Savings (MWh)	694
Annual Emission Reduction (tn CO2)	373
Funding Source	Own 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 54% out of the total energy consumption in Manouba Municipality, with 44% contribution in CO_2 emissions. The proposed actions are presented in the Table 43 and a more detailed analysis for each one is following.

Table 44:Actions in Transportation Sector

Action No.		Action	Emission Reductions (tn CO_2)
3.7.1	Municipal fleet	Improve the process of car repair and purchasing new vehicles	34
3.7.2		Eco-driving seminars for the municipal fleet drivers	25.6
3.7.3	Public & Private transport	Improve the city bus network	595
3.7.4		Raise public awareness of public transport	980
3.7.5		Improve and secure pedestrian routes and paths	368
3.7.6		Improve and secure bike paths	1,960

3.7.7		Transfer all government departments and institutions to one complex near to the population centers in the city	1,226
3.7.8		Building vehicle crossing lines with the railway to facilitate local transportation	981
3.7.9		Establishing central markets near dense residential areas	981
3.7.10		Using buses instead of private cars to transport students to the schools and universities	245
3.7.11		Regulating Cargo vehicles work in the City	298
3.7.12		Replacing 5% of the existing Taxi vehicles with electric vehicles	642
		Total	**8,335.6**

3.7.1. Improve the process of car repair and purchasing new vehicles

This action focuses on two essential tasks for optimizing economic performance and energy of the municipal fleet, namely performing maintenance of existing vehicles and purchasing of new vehicles.

- Vehicles' Maintenance: Initially, this activity allows the municipality to determine the current state of the vehicle fleet. As a result, the municipality will be able to distinguish between vehicles that require maintenance and those that must be replaced. A committee comprised of concerned municipal staff could be formed to carry out this activity in accordance with a predetermined criterion for performing maintenance or purchasing new ones.
  Concerning the identified vehicles for maintenance, the following actions can be taken to improve the performance of existing vehicles.
  - Establishment of procedures relating to maintenance management;
  - Implementation of an IT maintenance management system;
  - Reinforcement of the material means of these units;
  - Training and capacity building of the technical staff to improve their technical skills.

  Carrying out this action can reduce fuel consumption by 5%.

- Purchasing new vehicles: The municipality may adopt minimum performance criteria for purchasing new vehicles in order to have a fleet of suitable and efficient vehicles in terms of fuel consumption.

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.

Table 45:Action 3.7.1 in numbers

Duration	2023 - 2033
Total Implementation Cost (USD)	7300
Annual Emission Reduction (tn CO2)	34
Funding Source	Own Funds
Net Present Value (NPV)	>0

3.7.2. Eco-driving seminars for the municipal fleet drivers

This action consists of sensitizing the municipality's drivers to economical driving techniques and road safety through training courses. In most cases, these training courses are provided by a specialized organization. The energy gains expected from this action would amount to 10% of the fleet's total consumption. This action must be linked to the installation of a GPS/GPRS monitoring system.

Table 46:Action 3.7.2 in numbers

Duration	2023 - 2033
Total Implementation Cost (USD)	44,000
Annual Emission Reduction (tn CO2)	25.6
Funding Source	Own Funds
Net Present Value (NPV)	>0

3.7.3. Improve the city bus network

This action consists of working with the Security & Telecom Systems (STS) to improve the offer of bus transport in the city. This action can be part of the realization of the urban development plan (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 public transportation trips by 20% on the commune's perimeter (due to a 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 47:Action 3.7.3 in numbers

Duration	2023 - 2033
Total Implementation Cost (USD)	----
Annual Emission Reduction (tn CO2)	595
Funding Source	Private & External funds

3.7.4. Raise public awareness of public transport

This action entails communicating about the city's public transportation options and alternative modes of transportation in order to encourage residents to reduce their reliance on private automobiles. This project could be undertaken by the municipality's transportation and/or communication services in collaboration with the ANME and the STS. Increased use of soft transport reduces transportation sector emission levels due to a modal shift away from the private car and toward these lower-emitting modes of transportation.

Various communication and awareness-raising actions can be envisaged, a few examples of which are stated 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 48:Action 3.7.4 in numbers

Duration	2023 - 2033
Total Implementation Cost (USD)	23,000
Annual Emission Reduction (tn CO2)	980
Funding Source	Private & External funds

3.7.5. 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 49:Action 3.7.5 in numbers

Duration	2023 - 2033
Total Implementation Cost (USD)	1,050,000
Annual Emission Reduction (tn CO2)	368
Funding Source	Private & External funds

3.7.6. 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 50:Action 3.7.6 in numbers

Duration	2023 - 2033
Total Implementation Cost (USD)	805,000
Annual Emission Reduction (tn CO2)	1,960
Funding Source	Private & External funds

3.7.7. 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 Manouba city is the distance between government departments and institutions, which forces people to drive or take public transportation to get from one to the other in order to complete their government and civil transactions. This issue will cause people to drive more, causing traffic jams on the connecting road. One of the best solutions is to consolidate all related government departments and institutions into a single complex near the city's population centers in order to avoid using transport services.

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 51:Action 3.7.7 in numbers

Duration	2023 - 2033
Total Implementation Cost (USD)	350,000
Annual Emission Reduction (tn CO2)	1,226
Funding Source	Private & External funds

3.7.8. Building vehicle crossing lines with the railway to facilitate local transportation

Another transportation issue in Manouba City is the lack of sufficient crossing lines along the railway that crosses the city. This causes passengers to drive around the rail line and stop at a traffic jam near the city center in order to reach the other side of the railway, resulting in more driving time and thus more GHG emissions.

By establishing vehicles crossing lines along the railway, traffic jams and transportation distance will be reduced. Then the CO_2 emission will be reduced accordingly.

For the calculation of avoided emissions, it was considered that 4% of CO_2 emissions can be avoided (981 tn CO_2) by solving this problem.

Table 52:Action 3.7.8 in numbers.

Duration	2023 - 2033
Total Implementation Cost (USD)	3,500,000
Annual Emission Reduction (tn CO2)	981
Funding Source	Private & External funds

3.7.9. Establishing central markets near dense residential areas

Due to the Central Market's remote location from the majority of city households, people must drive or take public transportation to get to the Central Market and shop.

By establishing new similar central markets near densely populated areas, people can shop without using public transportation, reducing emissions from passenger vehicles.

For the calculation of avoided emissions, it was considered that 4% of CO2 emissions can be avoided (981 tn CO2) by solving this problem.

Table 53:Action 3.7.9 in numbers

Duration	2023 - 2033
Total Implementation Cost (USD)	1,050,000
Annual Emission Reduction (tn CO2)	981
Funding Source	Private & External funds

3.7.10. Using buses instead of private cars to transport students to the schools and universities

The overarching goal of providing buses to schools is to improve student mobility and reduce fuel consumption. The municipality's role in this case is to encourage public schools to use buses for student mobility and to organize public awareness-raising activities to educate citizens about the environmental and economic benefits of using school buses.

Table 54:Action 3.7.10 in numbers

Duration	2023 - 2033
Total Implementation Cost (USD)	15,000
Annual Emission Reduction (tn CO2)	245
Funding Source	Private & External funds

3.7.11. Regulating Cargo vehicles work in the City

Some traffic jams occur in market complexes as a result of cargo vehicle operations. Regulating their operations by requiring them to load and unload goods at off-peak hours rather than during peak hours will result in fewer traffic jams and thus fewer CO2 emissions.

For the calculation of avoided emissions, it was assumed that solving this problem could save 1% of CO2 emissions (298 tn CO2).

Table 55:Action 3.7.11 in numbers

Duration	2023 - 2028
Total Implementation Cost (USD)	
Annual Emission Reduction (tn CO2)	298
Funding Source	Private & External funds

3.7.12. Replacing 5% of the existing Taxi vehicles with electric vehicles

Inefficiencies in today's transportation systems can result in poor service, increased costs, increased energy consumption, and negative environmental impact. As mentioned in the public transportation section, Manouba city has 37 taxi cars, the majority of which are old. If they were replaced with hybrid vehicles, energy efficiency would improve, resulting in fuel and cost savings. This action is planned as a result of a provision in the relevant legislative framework that allows for exemptions for replacing taxis with electric vehicles.

For the calculation of avoided emissions, it was considered that 1.9% of CO_2 emissions by public transportation can be avoided (642 tn CO_2) by solving this problem.

Table 56:Action 3.7.12 in numbers

Duration	2023 - 2028
Total Implementation Cost (USD)	210,000
Annual Emission Reduction (tn CO2)	642
Funding Source	Private & External funds

3.8. Agriculture Sector

3.8.1. Planting trees (increasing green areas)

Planting forest trees will help to reduce GHG emissions by absorbing CO2 emissions through the photosynthesis process, which allows plants to create oxygen and energy from sunlight, water, and carbon dioxide. To reduce CO2 emissions, the municipality will plant forest trees and encourage the local community to do the same.

Table 57 below illustrates the information that present the action.

Table 57:Action 3.8.1 in numbers

Duration	2023 - 2033
Total Implementation Cost (USD)	500,000
Number of Trees	50,000
Annual Emission Reduction (tn CO2)	1,085
Funding Source	Own & External funds

3.9. Other Actions applying the WEF NEXUS approach

3.9.1. Development of a smart municipal market for the sale of various local products (28,000 m²)

Brief description of the project

The project consists in the realization of a smart municipal market for the sale of various products produced in the Manouba region, including organic agricultural products, handicrafts, etc. The market place will cover about 28 thousand square meters, located in the Hassan Belkhoja neighborhood.

The project consists of a number of shops with small areas made of light metal and equipped with sewage and all required equipment to carry out trade of all kinds of products. It will also include various administrative departments to bring services closer to citizens, including a security center, health facilities and a nursing shop.

The market will be equipped by rooftop PV installation to provide electricity for the market. All the lighting in the market will be LED to reduce the electricity consumption. The project also includes car shelters covered with photovoltaic solar panels for indoor and outdoor use.

Regarding water, a tank for collecting rainwater will be constructed to be used for the irrigation of the green space in the area of the market and for space cleaning.

Project impacts

The project provides a demonstration of an optimal management of the energy, water and food security nexus. The market will also provide additional revenue to the municipality which will be used in other projects for the benefit of citizens.
It also helps to strengthen the social issue as this project targets craftsmen, farmers and small traders and provides about 900 jobs.

Compliance with the national policies

This project falls within the general directions of the State encouraging the use of renewable energy and energy efficiency as well as reducing the unemployment rate.

Financing sources

The project can be financed in partnership between the public and private sectors, as well as the contribution of international donors.

3.10. Actions' Overview

Table 58 shows the complete list of the SECAP Actions and respective energy savings/production and CO_2 Emission reduction.

Table 58:Summary of the mitigation actions

Action No.	Action	Emission Reductions (tn CO_2)
Municipal Buildings & Facilities		
3.2.1	Green procurement procedures for municipal buildings	9.65
3.2.2	Energy manager appointment in the municipality	0.59
3.2.3	Awareness raising activities for municipal employees	2.0
3.2.4	Strict application of green building codes in new municipal buildings	25.4
3.2.5	Efficient municipal buildings	26.9
3.2.6	Promotion of recycling	186.75
3.2.7	Install 0.89 MW PV plant	108
Municipal Public Lighting		
3.3.1	Street lighting upgrade	233.7
3.3.2	Astronomical timers	87.6
3.3.3	Green procurement procedures for future lighting equipment	357
Residential Buildings		
3.4.1	Awareness raising activities for modification of the residents' consumption behavior and energy saving	1,880
3.4.2	Promotion of Green Buildings' concept / Strict application of the building code	673
3.4.3	Campaign for promoting high-energy label home appliances and other awareness activities	309
3.4.4	Replacement of existing lamps with LEDs	715.5
3.4.5	Replacement of existing air-conditioners with more efficient ones	718
3.4.6	Building envelope improvement for the existing buildings	943
3.4.7	2.4 MW Photovoltaics on residential rooftops	20,332
3.4.8	Replacing existing water heaters with solar water heaters	4,986
Tertiary Sector		
3.5.1	1.96 MWp Photovoltaics on rooftops	1,875
3.5.2	Replacing existing water heaters with solar collectors	78
3.5.3	Replacement of existing lamps with LEDs	539

Industrial Sector		
3.6.1	Install 0.39 MW photovoltaic systems in the industrial sector	373
Transportation Sector		
3.7.1	Improve the process of car repair and purchasing new vehicles	34
3.7.2	Eco-driving seminars for the municipal fleet drivers	25.6
3.7.3	Improve the city bus network	595
3.7.4	Raise public awareness of public transport	980
3.7.5	Improve and secure pedestrian routes and paths	368
3.7.6	Improve and secure bike paths	1,960
3.7.7	Transfer all government departments and institutions to one complex near to the population centers in the city	1,226
3.7.8	Building vehicle crossing lines with the railway to facilitate local transportation	981
3.7.9	Establishing central markets near dense residential areas	981
3.7.10	Using buses instead of private cars to transport students to the schools and universities	245
3.7.11	Regulating Cargo vehicles work in the City	298
3.7.12	Replacing 5% of the existing Taxi vehicles with electric vehicles	642
Agricultural Sector		
3.8.1	Planting trees (increasing green areas)	1,085
Total		**43,878**

To meet the 40% target, Manouba Municipality and the Government should make concerted efforts to strictly implement the SECAP and seek agreements and funds from national and international funding agencies.

4. Adaptation to climate change

4.1. Introduction on climate change impact

Tunisia is a signatory party of the 2015 Paris Agreement (PA) on climate change and as part of its Nationally Determined Contribution (NDC) for 2030, it has committed to reduce its greenhouse gas (GHG) emissions in all sectors (energy, industrial processes and product use, agriculture, forestry and other land uses, and waste). In this framework, Tunisia's NDC pledge is to reduce its carbon intensity by 45% by 2030, relative to 2010 levels, according to the most recent update, in order to reach the PA objectives.

The general objective of adaptation as per Tunisian NDC aims to «promote a Tunisia resilient to climate change, having significantly reduced vulnerabilities and strengthened the adaptive capacity of its ecosystems, its population, its economy, its territories, and having resolutely operated the necessary transformations, able to ensure a model of socio-economic development inclusive and sustainable and thus, can participate in the construction of a more resilient world". To achieve this objective, the adaptation component of the updated NDC is based on a «Resilience Star», designed as a framework to support Tunisian actors and their technical and financial partners, both public and private. In order to strengthen its resilience in all its different sectors, namely food, water, ecological, social, economic, territorial and health resilience, as well as resilience to natural disasters, the adaptation component of the NDC is based on both a paradigm shift and a cross-sectoral approach. The paradigm shift is based on a new way of acting in a more global and cross-cutting framework of adaptation that concerns all parts of the nation and its development. The implementation of the updated NDC is based on a prioritized action plan, with vertical actions that address specific sectoral issues and cross-cutting actions to better address cross-sectoral challenges. To this end, the sectoral actions affect the six most vulnerable sectors: water resources, agriculture, ecosystems, the coastline, health and tourism, while considering three new cross-cutting areas of intervention: gender, land use planning and natural disaster risk reduction.[2]

The updated version of the adaptation component of Tunisia's Nationally Determined Contribution (NDC) is based on a precise review of the exposure of national and sectoral vulnerabilities. This review is based on finer climate projections allowing a more robust downscaling to the level of territories. In addition, the update of the NDC integrates three new cross-cutting dimensions (gender, land use planning and natural disaster risk reduction) axes and measures aimed at limiting the impacts of climate change by 2050.

Several past and ongoing initiatives and projects included studies to assess the major impacts of climate change and develop adaptation strategies and plans in highly vulnerable sectors and ecosystems. These include in particular:

• A strategy related to the adaptation of the agricultural sector and ecosystems to climate change, elaborated with GIZ support (2007).

[2] Updated NDC - TUNISIA https://unfccc.int/sites/default/files/NDC/2022-08/CDN%20-%20Updated%20-english%20version.pdf

• Vulnerability assessment of water resources to climate change, with support from the Global Water Partnership (2016)
• Study of the environmental and socio-economic vulnerability of the Tunisian littoral in the face of an accelerated rise of sea levels (2008), Study of the vulnerability map of the Tunisian coastline to sea level rise due to climate change, with UNDP support (2012).
• Adaptation Strategy for health sector to climate change, with GIZ support (2010).
• Adaptation Strategy for the tourism sector to climate change, with GIZ support (2010).
• Study on an early warning system for the management of risks related to climate extremes and climate change in Tunisia, with GIZ support (2009).
• A portfolio of projects to cope with climate change in fragile sectors, with GIZ support.
• A strategy related to the adaptation of the littoral with UNDP support (2012).

4.2. Adaptation Needs and Priorities

Tunisia, a middle-income country in North Africa, covers 164,000 km2 and has a 1,300 km coastline on the Mediterranean Seai. Its estimated population was 11.304 million in 2016. ii Two-thirds of the population and 80 percent of the country's economic activity is focused along the coast.

Tunisia's current climate varies considerably across the country. Hot, dry summers give way to mild, rainy winters in the north. In the center, a semi-arid climate results in modest rainfall and relatively high temperatures. The key climate vulnerabilities identified in Tunisia's First National Communication (2001) were largely framed in relation to sea level rise, rather than the impacts of temperature rise and changes in precipitation. Tunisia's coastal zone is particularly vulnerable to sea level rise.

Tunisia is expected to experience a significant increase in temperature by 2100. Temperatures are expected to increase at a greater rate in North Africa than anywhere else on the continent, with summer temperature increase exceeding 4°C by the end of the century (Christensen 2007). A general increase in the intensity of high-rainfall events is expected across Africa, and Tunisia, this will likely be offset by a greater decrease in the number of rain days. Finally, Tunisia can expect a rise in sea level of between 38cm and 55 cm by 2100 (Christensen, 2007)

The key climate vulnerabilities identified in Tunisia's First National Communication (2001) were largely framed in relation to sea level rise, rather than the impacts of temperature rise and changes in precipitation. A National Climate Change Strategy was developed in 2012, which outlined a vision and major climate change considerations in the Tunisian context.

The strategy highlighted spatial planning as one of the best ways for integrating adaptation in development planning, with the Land-Use Master Plan and Urban Development Plans being some of the best tools at national and local levels respectively.

Despite it´s relatively small size, Tunisia has great environmental diversity.
Differences in Tunisia, like the rest of the Maghreb, are largely north-south environmental differences defined by sharply decreasing rainfall towards the south. Tunisia's landscape is mountainous in the northwest, where the eastern extension of the Atlas Mountains lies. To the south, a hot and dry central plain comprises a semi-arid area that merges into the Sahara Desert. Tunisia has a diverse, market-oriented, economy. However, it is facing an array of challenges following the 2011 Arab Spring revolution, with slow economic growth, chronic socio-economic challenges, and especially high levels of youth unemployment.

4.3. National Policies and Strategies

The country's First National Communication was prepared by the Ministry of Environment and Land Planning, and submitted in 2001. The Ministry of the Environment and Sustainable Development is in the process of completing Tunisia's Second National Communication. Other actions taken by Tunisia to address climate change adaptation include establishing a national committee on climate change in 1996. The committee is mandated to coordinate national action on climate change and participate in international climate negotiations[3].

Tunisia is currently involved in a number of regional adaptation projects, and small number of national projects- leading it to have a high level of programme based adaptation activity. The projects and programs currently underway reflect a mix of Agriculture and food security as dominant sectors. Other projects also address vulnerabilities in natural resource management, infrastructure, water, health, tourism, cities, forests, and coastal zone management.

4.4. Proposed Adaptation Actions

Tunisia has taken important steps to plan for adaptation, with actions primarily focused at the sectoral level. The country has several sectoral adaptation plans and strategies that highlight the need to address climate risks and outline priority actions for key sensitive sectors (agriculture, tourism, coastal, health). These plans have started to build awareness among affected ministries and stakeholders. Currently, the Government of Tunisia wishes to further a cross-sectoral approach to adaptation planning and effectively guide choices for resilient development planning and investments that consider climate risks and integrate adaptation needs, both at central and local levels.

The aim of these actions is to characterize the current situation of Tunisian municipalities in matters of climate change policies and actions and to understand the barriers and best practices. By surveying municipalities in Tunisia, we were able to provide an overview of the Tunisian municipalities in matters of climate change actions and strategies, as well as finding the main barriers and best practices. First, we found that most Tunisian municipalities are facing different effects of climate change. Second, the majority of municipalities do not have a strategy for mitigation and adaptation of climate change at the local level. Third, the main

[3] http://www.changementsclimatiques.tn/latunisieetlescc_introduction.htm

barrier that municipalities face in investing in climate change actions is the lack of financial resources and funding. Four, we have identified some of the best climate change mitigation and adaptation practices of surveyed cities, which should be taken into consideration and implemented also by the other cities. The Government of Tunisia is aware of these challenges and has adopted a proactive policy of fighting climate change, via both mitigation and adaptation measures, as shown in its NDC.

The general objective of the proposed adaptive actions is to promote a Tunisia resilient to climate change, reduce vulnerabilities and strengthen the adaptive capacities of its ecosystems, its population, its economy, its territories, and operate the necessary transformations, to ensure a model of socio-economic development inclusive and sustainable.

Faced with more frequent and intense climate hazards, a resilient Tunisia must be able to ensure a renewed and shared economic growth can lead to progress, and create jobs for all, anticipate climate disturbances (sudden or slow), and combat the effects. To be achieved, this objective must be based on a comprehensive and cross-cutting framework for adaptation that concerns all aspects of the nation and its development.

The following actions address the municipality's adaptation needs for the benefit of the inhabitants, and to identify priority actions at the sectoral level that aim to maximize cross-sectoral co-benefits:

Improving Governance:

Tunisia has taken many steps to strengthen the institutional framework and improve climate governance in order to implement the Paris Agreement. Notably, within the Ministry of Local Affairs and the Environment, where the national focal point for the Paris Agreement is designated, the National Coordination Unit on Climate Change (UGPO-CC) was established by Decree No. 2018-263 of March 12, 2018, whose mission of coordinating climate action by public and private actors and measures taken to implement the NDC was specified, as was its central role in promoting the integration of climate change into all public policies and building capacity at the national and local levels.

Measure 1: Support the development of a 5-year work plan for the Adaptation Technical Consultative Committee at Manouba Municipality

Measure 2: Establish an Adaptation consultation and coordination mechanism with various stakeholders including civil society, private sector, gender experts and taking into consideration gender balance

Measure 3: Develop a communication strategy for increasing awareness and engagement of high level decision makers and stakeholders.

Measure 4: Develop a sustainable financing strategy for identified adaptation measures with identification of options for private sector investments.

Measure 5: Integrate lessons learned from the experience of Manouba municipality, develop a guideline for all municipalities and local authorities on how to integrate climate risks and

adaptation in urban and local land -use planning and communication products for its dissemination.

Capacity building and technology transfer needs

If Tunisia is to meet their NDC targets and sustain climate action over the long term, six action will require the implementation of six accompanying measures referred to by the UNFCCC Secretariat and UNESCO as ACE. This term refers to the measures that to be taken under Article 6 of the UNFCCC and Article 12 of the Paris Agreement, and Agreement, and is closely linked to the Sustainable Development Goals (notably SDG targets 4.7 and 4.7 and 13.3):

• Education • Training • Public awareness • Public access to climate information • Public participation • International cooperation

Capacity building:

The roadmap has to be set up for the strengthening of the following aspects in particular:

Measure 1: Monitoring and reporting,

Measure 2: Education, awareness of the effects of climate change, and good adaptation practices,

Measure 3: Integration of climate change into development planning,

Measure 4: Management of genetic resources (collection, conservation, valorization),

Measure 5: Negotiations on climate change,

Measure 6: Drafting of climate financing requests,

Measure 7: Rehabilitation of local know-how and spin-offs,

Measure 8: Monitoring and sustainability of works,

Measure 9: Conflict management and mediation,

Measure 10: Strengthening the human and material resources of the various key institutions

Research and technology transfer:

National research priorities have clearly incorporated climate change adaptation and adaptation to climate change as well as the sectors considered as priorities at the level of the sustainable water resources management, biodiversity conservation and climate change, agriculture, coastal erosion and climate change, agriculture, coastal erosion and desertification, epidemics and diseases, development models and land use planning.

Indeed, Tunisia is an associated partner in the EU research program (Horizon 2020) and has demonstrated the capacity and expertise of its research structures to mobilize to mobilize the necessary funding and participate in a framework of scientific excellence.

The development of scientific research in the field of adaptation to climate change is a key pillar in the climate change is an essential pillar in the different stages of the adaptation process.

It requires a holistic, multidisciplinary approach that considers the different nexuses and integrates global and local thematic models. All of this in a framework of RRI (responsible research and innovation) that involves several actors. In order to consolidate the national effort and consider the global nature of climate change, Tunisia will want to mobilize international cooperation to finance:

Measure 1: The development of integrated models for the study of vulnerability with dynamic mapping and dynamic mapping and vulnerability trajectories well traced and applied to sectors, territories or production processes (integrated and adapted system of monitoring and monitoring and modeling system). The objective is to reduce the existing uncertainties in the analysis of the impact of climate change and to create tools for integrated quantitative assessment of risks and vulnerability. This will allow the design of adaptive management tools and to select appropriate measures, technologies and practices;

Measure 2: The development of digital innovation in the areas of adaptation;

Measure 3: The scaling up of innovative solutions through PPPs.

Technology Transfer

Programs will be necessary to allow Tunisia to access the main technological innovation niches related to the low-carbon transition, as well as the know-how and the appropriate industrial means to ensure the sustainability of its contribution.

The priority technologies selected are:

- Conservation agriculture and payment for environmental services for the agricultural sector.
- The implementation of a smart water system and an early warning system for the water sector.
- The strengthening of the information and decision support system (SIAD) and coastal zone management for the coastal and marine sector.

Ecological Resilience

Measure 1: Stocktake and compile available information on climate change impacts, vulnerability and adaptation; assess gaps and needs related to creating an enabling environment to effectively integrate adaptation needs in development planning.

Measure 2: Conduct a study of socio -economic vulnerabilities for the entire Tunisian territory, with data analysed at the municipality level.

Measure 3: *Food Resilience:* improve the efficiency of green water by promoting rainfed and irrigated agriculture resilient to the effects of climate change (cultivation practices, seeds)

Measure 4: *Water Resilience*- Improve the quantitative and qualitative management of conventional water resources in the face of climate change impacts.

Cross-Cutting Issue of Adaptation

Measure 1: Endorse the national policy on gender mainstreaming and the fight against climate change

Strengthen women's economic empowerment in the face of climate change impacts.

Measure 2: Support the inclusion of gender issues and women's participation among political leaders

and public affairs managers.

Measure 3: Develop a GIS -based interactive Decision Support Tool to enable municipal decision-makers to visualize impacts of climate change on their localities and elements of adaptation choices.

Territorial Resilience

Measure 1: Integrate vulnerability and risks related to climate change into territorial planning processes.

Measure 2: Legal frameworks for land use planning that are sensitive to climate change, in particular by explicitly introducing the fight against climate change as a principle in the new Land Use and Urban Planning Code)

Measure 3: Update the planning approach to integrate climate change (establishment of a methodological toolbox that integrates climate change and land use planning for the preparation and development of five-year plans)

Measure 4: Establish a monitoring and evaluation system for the impacts of climate change (take advantage of the creation of the ODT to make it a reference institution for the M&E of phenomena related to climate change)

Measure 5: Consideration of a climate risk budget in territorial planning (define and introduce new provisions in the future regulations that codify the new organic law on the budget to provide guidance on the integration of adaptation needs in sectoral and local budgets).

Coastal Areas and Fisheries

The Tunisian coast has a total length of 2,290 km, distributed as follows: 1,280 km of continental coastline, 450 km of island coastline and 560 km of lagoons. The three main types of fishing encountered in Tunisia are trawling, lamp fishing and inshore fishing. The main marine production area is located in the governorates of Sousse, Monastir and Nabeul, while the production of continental aquaculture, is mainly located in the governorate of Béja. Fishery production has steadily increased since the 1990s, reaching a total production of 118,000 tons in 2012, with an annual growth rate of 2.6% between 1996 and 2012.

Tunisian coasts are subject to the continuous action of physical hazards (current, swells, tide, etc.) which can be amplified by sea level rise (SLR) induced by climate change. A progressive retreat of the coastline is therefore expected.

Measure 1: Produce and share information, knowledge and know-how to improve the resilience of the coastal sector to the effects of climate change and natural disasters.

Measure 2: Develop and integrate innovative processes, methods and tools that integrate climate change and natural disaster risks into planning in the coastal sector.

Economic Resilience

Measure 1: Modernize information management, facilitate access to and sharing of knowledge and forecast risks related to climate change

Measure 2: Increase the resilience of economic sectors, including tourism and its subsectors, of their actors and rationalize the use of resources.

Climate-related Natural Disaster Resilience

Measure 1: Develop integrated and multi-level governance of DRR
Measure 2: Implement Early Warning Systems (EWS)
Measure 3: Strengthen, raise awareness, and share knowledge on risks
Measure 4: Undertake integrated multi -hazard risk assessment in Manouba municipality.

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 Raoued have been identified.

General Climate Hazard Types	Applicable for Manouba 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.

Manouba 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.

	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 • Chronic respiratory diseases • Vector Born Diseases (VBD) • Skin diseases Melanoma and sunburn	Medium
		Droughts	• Increased allergic incidents • Decreased air quality • More respiratory problems • Consumption and use of unsafe (contaminated) water for drinking due to water scarcity • Malnutrition • Food shortages	Medium
Infrastructure	Transport	Extreme heat	• Damages on road network • Modification of transport frequency and means • Air quality problems • Higher maintenance costs	Medium
		Droughts	• Difficult transport of bulk material	Medium
	Energy	Extreme heat	• Blackouts and inability to cover demand load • Damages, especially in the thermal power plants	High

		Droughts	• Blackouts and inability to cover demand load • Higher maintenance costs • Cooling problems in power plants	Medium
	Water	Extreme heat	• Water scarcity • Water quality issues	High
		Droughts	• Water scarcity • Water quality issues	Medium
	Social	Extreme heat	• Increased needs for air conditioned public spaces	Medium
		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)	Medium
Built Environment	Building stock and material	Extreme heat	• Concrete's damages • Increased cooling demands • Higher maintenance costs • Urban heat island effect	Low
		Droughts	• Higher water demand	Medium
Economy	Agriculture	Extreme heat	• Changes in growth cycle • Damages / loss of harvest • Livestock loss and impacts on health • Lower crop yields • Increased fire risks	High
		Droughts	• Damages / loss of harvest • Lower crop yields • Livestock loss and impacts on health • Land degradation • Increased fire risks	High