Baseline Emission Inventory for the Municipality of Karak

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1 Introduction

1.1 Current status

1.1.1 Geographical location

Karak is the capital city of Karak Governorate in eastern Jordan. It lies 140km to the south of Jordan capital, Amman, while it is located on a hilltop 1.000 meters above sea level, surrounded on three sides by a valley, on the western edge of the Karak Plateau. Its area extends to 765 km^2. The boundaries of the Governorate are defined by the Dead Sea to the west, Wadi El Mujib to the north, Wadi El Hasa to the south, and the boundary of Ma'an Governorate to the east.

Greater Karak Municipality (GKM) was established in 1893 by an Ottomans Law and other rural councils were merged with it as the years passed. [1]

Figure 1: Karak map

The city is known for its Crusader castle, the Karak Castle, which is the largest one between the three castles in the region. It is a 12th century Crusader-era fortification which nowadays operates as a visitor attraction. The castle's construction began in 1142 and was completed after 20 years. It contains a maze of corridors and chambers. A characteristic picture of it is presented in Figure 2. [2]

Figure 2: Karak castle

1.1.2 Climate characteristics

The weather in Jordan is almost exclusively dry and sunny from May to October, where there is barely any rainfall. Jordan is a very sunny country, with over 310 days of sunshine a year. The rainy season begins at the end of November and continues till the end of March. Nonetheless, rainfall is sporadic even then, which is the main reason that Jordan faces such severe water scarcity. The climate in Karak is warm with winters rainier than summers. The average annual temperature is 16,5°C and the average annual precipitation is 359 mm. [3]

Although the average wind speed is 2,1 km/h, winds can be relatively high on occasions, and when they blow from the desert, they are cold in winter and hot and dusty in the summer. Winds are predominantly from the west and southwest and they provide some cooling during the summer, especially on the higher areas around Karak. [4]

In the next table and graphs, data is presented regarding the monthly temperature and precipitation in Karak.

Table 1: Monthly temperatures and precipitation in Karak

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Min Temp.(°C)	3,1	4	5,8	9	12,2	14,9	16,8	17,2	15,1	12,4	8,4	4,4
Max Temp.(°C)	12,3	13,9	17,1	21,8	26,5	29,8	31,6	31,8	29,6	26,2	19,6	14,1
Average Temp.(°C)	7,7	8,95	11,45	15,4	19,35	22,35	24,2	24,5	22,35	19,3	14	9,25
Precipitation (mm)	86	75	68	17	4	0	0	0	0	5	32	72

Considering the climate conditions in Karak area, and the average desired temperature for internal conditions to be 21°C, the heating degree days for the area are calculated to be approximately 1.892 HDD.

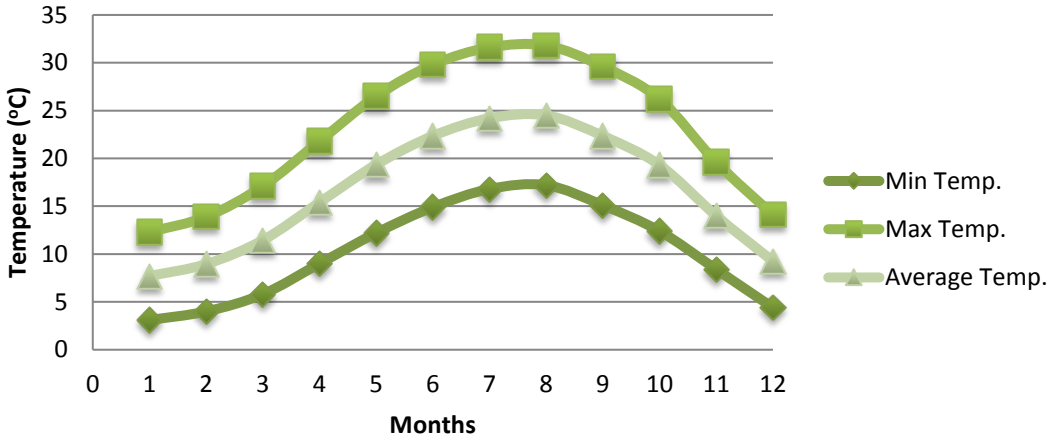

Figure 3: Monthly Temperatures in Karak

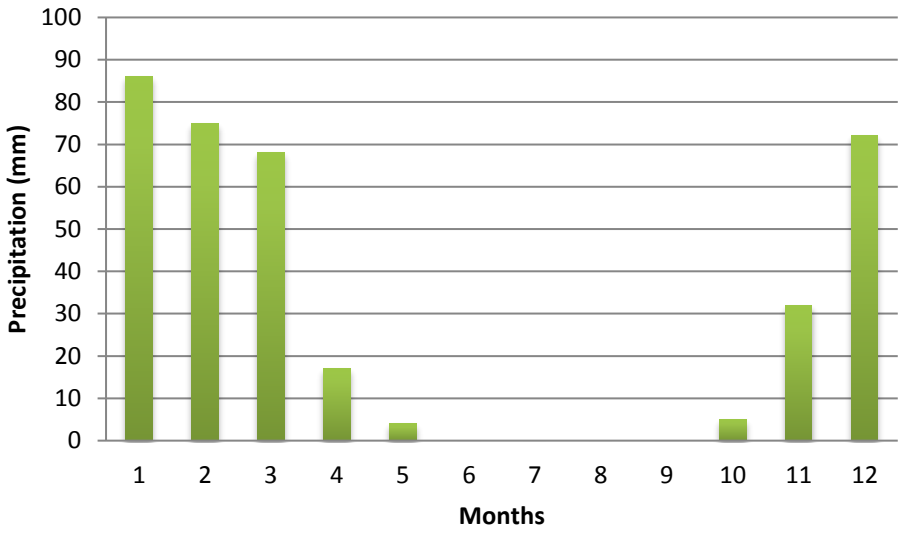

Figure 4: Monthly Precipitation in Karak

1.1.3 Demographic tendencies

According to the last population census of 2015, the population living in Karak Governorate was 315.998, consisting of 48% women and 52% men. For the same region, the population in 2004 was 203.595 which means that there has been a significant rise of 55% in only 11 years.[5]

Concerning the population at the Karak Municipality level, this rises up to 114.000.

Also, Karak Governorate presents one of the highest Christian percentages in the country, approximately 25%, while the rest of the population is Muslim.

1.1.4 Employment

The employees in Karak Governorate comprise approximately 37% of its population over 15 years of age, according to the most recent population census. In the part of economically active citizens there is a 15% percentage that is currently unemployed and looking for a job. An important mention is that only a population percentage of 17% (ages under 15 not included) are economically active women. (2015) [5]

1.1.5 Education

Regarding the educational status of Karak Governorate's citizens, a percentage of 32% of the total population was enrolled in the education in 2015, the majority of which (69%) was in primary education and only 13% in the highest education levels (Diplomas, Masters, PhD etc). Considering two population groups, the first one between 4 and 25 years old and the second one older than 25 years old, the following assumptions can be extracted:

- In the first age group, which comprises a little over than half the governorate's population (52%), almost 8,4% has not enrolled, while another 67% is currently following educational courses at all levels. The remaining 24,6% had enrolled in courses in the past, but has now either completed or terminated his education.
- In the second age group, almost 20% has received no education at all, another 1% is currently enrolled, while the rest of the population (79%) has received education. [5]

1.1.6 Infrastructures

The registered households in Karak Governorate are 63.490 while there are 59.868 housing units in conventional buildings, according to the 2015 population census.

The Governorate provides a public network for access in water and drinking water. 99% of the housing units have access in the water network, of which however only 56% has access to drinking water. The remaining percentage uses, mainly, mineral water for drinking purposes. (2013)

In addition, it seems that there isn't a fully developed public sewage system and thus only an 8% of the population has access in the public network. The rest of the housing units are been served by cesspools. (2013) [5]

Karak is accessed by the Desert Highway that connects Amman with the southern regions. The road network in the Governorate consists of 671 Km of paved and unpaved roads, of which 43% are primary roads, 25% secondary roads, and a final 32% village roads. Based on the data, it is evident that the road infrastructure can be further improved, also putting emphasis on increasing the number of parking lots in the city, which currently is not able to efficiently serve the increased numbers of citizens and visitors in the city centre. [4]

1.1.7 Economy

Agriculture is one of the most important sectors of the regional economy, and it is the Department of Agriculture's aim that farming should continue to develop in a sustainable manner and provide further jobs and improved incomes. About a quarter of the land area of the region is considered suitable for agriculture, although less than 60% of this is actually

used. The upland areas account for over 80% of agricultural production, the bulk of it being rain fed crops. Out of a total of over 20,000ha of upland farmland, 16,000ha is in arable production, 3,000ha is devoted to tree crops and a further 1,000ha produce vegetables. The best areas for rain fed agriculture lie fairly close to the Kings Highway, and farming becomes less viable further east as rainfall levels decline.

In addition, livestock and poultry account for a large part of the agricultural resource of the Governorate. The recent expansion of intensive chicken farming in the desert areas west of Al Qatranah, has made the area a large exporter of meat and eggs.

Extensive irrigated farming, predominantly vegetables is undertaken in the Ghor Safi area. Farming in the Dead Sea Escarpment is generally concentrated in the upper wadis, where seasonal rivers and perennial springs are used to support large areas of tree crops, principally olives, and also other crops such as vegetables and fruit. Wadi Al Karak and Wadis Al Mujib and Al Hasa have extensive areas of such planting. Much of the agricultural production of the area is consumed locally, although some surplus produce is sent to the market in Amman, including much of the output of the broiler chicken industry.

Water supplies for certain agricultural crops and forestry are supplemented in the Wadi Al Karak through the use of treated sewage effluent. [4]

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 isn't adequate data for this year, as baseline year should be considered the nearest year to 1990 for which there are complete and reliable data. Thus, for the Karak Municipality the baseline year has been set to 2014, since it was the year with the most sufficient and reliable data available. [6]

2.1.2 SECAP administrative body

Following a meeting of the consultants (consortium ICCS/NTUA and NERC) with the Karak representatives, it was made clear that their wish for the SECAP is to cover the administrative boundaries of Karak municipality, and not that of the whole governorate. All the figures provided on the municipal sector concern strictly Karak municipality.

2.1.3 Sectors to be included in the BEI

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

A. Buildings, Equipment & Facilities
   - Municipal Buildings, Equipment and Facilities
   - Public lighting

- Residential buildings
- Tertiary buildings, equipment and facilities (non municipal)

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

C. Solid waste management

The industry sector is not included because the collection of its actual data was impossible and it was considered that approaches based on national averages will not be representative of the actual consumptions. This decision was further enforced by the fact that the non ETS industrial sector is an optional sector according to the Guidelines, since the municipality has limited potential on actually reducing its consumptions through convincing the respective key stakeholders.

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

2.1.4 Emission factors and Conversion rates

The emission factors which are used in this SECAP were derived from the Covenant of Mayors Guidebook, with the only exception of the electricity emission factor, which is characteristic for the country. It was not possible to acquire the electricity emission factor for Jordan directly from the Ministry of Energy and Mineral Resources (MEMR), or any of the utilities servicing the country. Therefore, as the best approach to identify it was considered to be the utilization of available statistical data from the International Energy Agency (IEA) and MEMR. To this end, data regarding the emissions from fuel combustion for the generation of electricity and heat from the IEA [7] highlight publication, as well as data regarding the electricity generation from the annual MEMR [8] reports were used, and the EF results as follows:

$$EF = \frac{CO_{2\ emissions\ tot}}{Total\ Electricity\ Production}$$

The available data for 2014 (the baseline year) are presented in the next table:

Table 2: Electricity Emission Factor

	2014
CO_2 Emissions (tn)	12.000.000
Electricity Generation (GWh)	18.207
Electricity Emission Factor (tn/MWh)	**0,659**

Emissions Factors for each source are gathered in table below.

Table 3: Emission Factors & Conversion Rates

	Emission Factors (tn CO_2/MWh)	Conversion Factors
Electricity	0,659	Not applicable
LPG	0,227	13,1 MWh/tn
Heating Oil (diesel)	0,267	10 KWh/lt
Diesel	0,267	10 KWh/lt
Gasoline	0,249	9,2 KWh/lt
Kerosene	0,259	790 kgr/m3
		12,2 MWh/tn
Solar (thermal/ PV)	0	Not applicable

Furthermore, emissions from the waste management were calculated according to the IPCC method. Landfilling process creates methane emissions (CH_4) which are converted to CO_2 emissions according to the equivalence "*1 tn CH_4 = 25 tn CO_2*".

2.2 Energy Consumption

The total amount of energy consumed in Karak Municipality is 410,37 GWh. The allocation of this energy consumption among the different sectors, by fuel type, is presented in the next table. Further analysis of the consumptions per sector is provided in the following sections.

Table 4: Total Energy consumption per sector

MWh Sector	Electricity	LPG	Heating Oil	Diesel	Gasoline	Kerosene	Solar thermal
Municipal Buildings, Equipment, Facilities	5.104,60	117,59					
Public Lighting	5.872,16						
Residential Buildings	112.872,60	18.864,00	16.308,58			3.373,30	23.785,77
Tertiary Buildings, Equipment, Facilities	96.351,65	1.553,33	9.931,21		320,01		
Municipal fleet				9.000,00	98,57		
Public Transport				5.037,00	999,01		
Private & Commercial Transport				47.891,65	52.886,65		

2.2.1 Municipal Buildings, Equipment & Facilities

This sector includes buildings such as the Municipal Hall, libraries, cultural buildings and health buildings (30 buildings). The initial data given for electricity was provided in the form of annual costs in JOD (Jordanian Dinar, the currency of Jordan), and were appropriately transformed into energy. As for the Liquefied Petroleum Gas, in line with the respective invoices, municipal buildings consume 561 cylinders of 16 kg each. According to the IPCC 2006 guidelines, the calorific value of Liquified Petroleum Gas is 13,1 MWh/tn. More specifically, the consumed energy from LPG is calculated as follows:

$$561\ cylinders * 0{,}016\ tn * 13{,}1 \frac{MWh}{tn} = 117{,}59 MWh$$

The numbers provided in the next table concern electricity, diesel, gasoline and LPG consumptions of this sector in MWh.

Table 5: Energy consumption in Municipal Buildings & Facilities per fuel

Site Type	Electricity (MWh)	Diesel (MWh)	Gasoline (MWh)	LPG (MWh)	**Total (MWh)**
Municipal Buildings	5.104,60	0,00	0,00	117,59	**5.222,19**
- Municipal hall					
- Libraries					
- Cultural buildings					
- Health Buildings					

According to the above presented data, the electricity consumption in the municipal buildings' and facilities has the lion's share, while LPG use rises up to only 2%, since it is predominantly being consumed for space and water heating, as well as cooking purposes in health buildings.

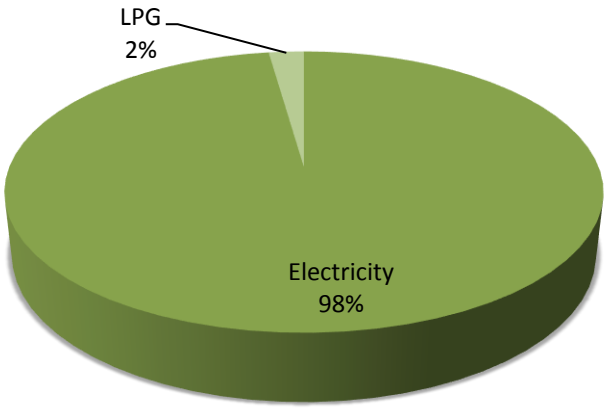

Figure 5: Energy consumption per fuel in Municipal Buildings

2.2.2 Municipal public lighting

As far as the municipal public lighting is concerned, this sector is related to the street lighting and public areas' lighting. The electricity consumption for this sector is **5.872,16 MWh**

according to the data from bills that were provided. A detailed table with an analysis of the consumptions per geographical area is provided in Appendix A.

2.2.3 Residential Buildings

Electricity

Karak's households consume electricity for lighting and electrical appliances such as refrigerator, air conditions and others, as well as in space and water heating.

Accurate electricity consumption data from the utility servicing the area is not available. For this reason, approaches based on the national average level have been utilized in order to estimate the electricity consumptions. More specifically, according to NERC's expert opinion, the average household's daily electricity consumption is 12 kWh. This number derives from the calculation that there are approximately 4,4 persons per household and the daily electricity consumption is 2,8 KWh per capita. In addition the number of people per households is calculated from the division of population in Karak with the number of electricity subscriptions. Furthermore, the electricity consumption per capita (2,8 KWh) is the total household electricity consumption divided by the population in Karak. Considering the amount of houses in Karak municipality to be 25.770, the overall consumption is calculated to be 112.873 MWh.

The initial assumptions for the specific consumption indicators used are also verified through the International Energy Agency (IEA), according to which the annual electricity consumption in the residential sector is 0,996 MWh/capita in Jordan which is very close to the calculated 0,990 MWh/capita in Karak municipality.

Liquified Petroleum Gas

LPG is mainly used in cooking and space heating. A smaller amount is also consumed in water heating. According to NERC's expert opinion and verified by Karak municipality's technical service, the households consume around 200 cylinders (16 kgr/cylinder) daily for 3 months for space heating and 200 cylinders daily during the whole year for cooking. According to the IPCC 2006 guidelines, the calorific value of Liquified Petroleum Gas is 13,1 MWh/tn, and it is thus calculated that the residential sector consumes:

$$(200cylinders * 30days * 3months + 200cylinders * 30days * 12months) * 16kg = 1.440.000kgr\ LPG$$

$$1.440tn * \frac{13{,}1MWh}{tn} = 18.864MWh$$

Kerosene

Many households in Karak Municipality use kerosene for heating purposes. The gas stations provided data at the Municipal level, which was 350.000 lt annualy. Kerosene's density, 790 kg/m^3, and net calorific value, 12,2 MWh/tn, were used in order to calculate the consumption as follows:

$$350m^3 * 790\frac{kgr}{m^3} = 276.500kg$$

$$276{,}5tn * 12{,}2\frac{MWh}{tn} = 3.373{,}30MWh\ kerosene$$

Diesel (heating oil)

There is also an amount of diesel which is consumed by the residents for space and water heating. This consumption was calculated based on a report with Energy Facts & Figures (2015) from the Ministry of Energy and Mineral Resources.[8] Therefore, since the diesel consumption in households for 2014 is given 81,8 ktoe at a national level, this number will be adjusted to the municipal level. In addition the rate used to convert tons of oil equivalent (toe) to MWh is: "1 ktoe=11.630 MWh", according to the SECAP guidelines. [6]Consequently the diesel consumption in Karak's municipality residential sector is:

$$81{,}8\ ktoe * 11.630\ \left(\frac{MWh}{ktoe}\right) = 951.334\ MWh \text{ Diesel at national level}$$

$$\frac{951.334 * 114.000 \text{ inhabitants}}{6.650.000\ inhabitants(Jordan)} = 16.308{,}58\ MWh\ Diesel\ in\ Karak\ Municipality$$

Since the Heating Degree Days in Karak are very close to that of Jordan in average, no correction of the above figure considering the HDD takes place.

Solar thermal

In addition, a great number of households own solar water heaters thus they consume solar power in order to heat water. In order to determine this energy production, data from the Ministry of Energy and Mineral Resources (2014) at a national level are used, namely 1.400.000 MWh production from SWH in households for the entire country.

Subsequently, the solar thermal energy produced per capita was calculated, based on the population owning solar heaters. According to Department of Statistics the 10,88% of Jordan population has solar heaters (723.746 inhabitants), thus the specific production per capita is 1,934 MWh per SWH owner. From national statistics it is known that 10,79% of Karak Governorate population own solar heaters as well. It was assumed that the percentage is the same between the Governorate and Karak Municipality, thus the population with SWH is 12.296 at the municipal level.

Based on the above, the solar thermal consumption at the municipal level is calculated to be 23.786 MWh in 2014.

Summary

Gathering all the data of the residential sector, it seems that residents consume 5 distinct energy sources. In the figure below, the final consumption per fuel type for this sector is presented.

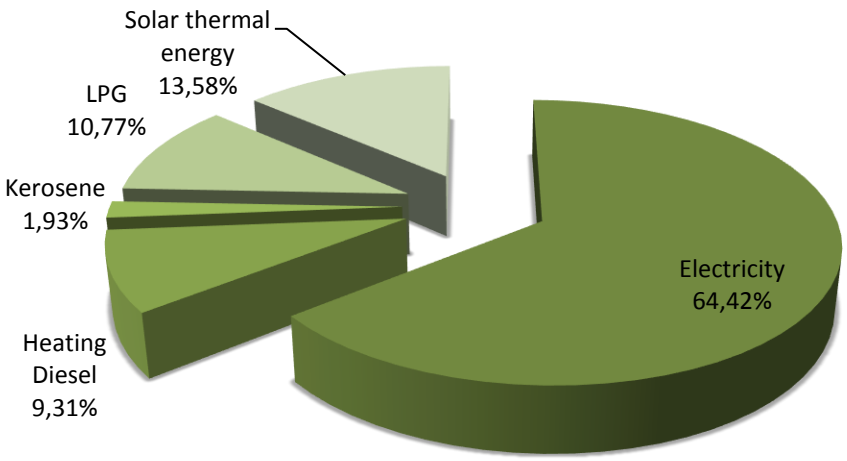

Figure 6: Energy consumption per fuel in Residential Sector

2.2.4 Tertiary Buildings, Equipment & Facilities

Tertiary sector includes a number of buildings such as hotels, offices, restaurants, shops, educational buildings, churches, hospitals and water management facilities as well, which provide services to Karak's citizens. It should be noted that water management facilities include facilities for drinking water (water pumping) and irrigation. The number provided was impossible to be disaggregated in order to separate the drinking water from the irrigation facilities for agricultural activities. The data derived from bills that the Municipality provided. In case of two subsectors, offices and shops, a correlation was used based on electricity consumption in Sahab Municipality, the share of population occupied in these sectors and the respective operational hours. The total energy consumption which refers to electricity, diesel, LPG and gasoline was 108.156 MWh in the tertiary sector. In the table below the collected data are presented.

Table 6: Energy consumption in tertiary sector per type of building

Types of Buildings in the Tertiary Sector	Electricity (MWh)	Diesel (MWh)	Gasoline (MWh)	LPG (MWh)	Total (MWh)
Hotels	83,00	140,00	NA	52,40	**275,40**
Offices	1.825,63	NA	NA	NA	**1.825,63**
Educational buildings (Universities)	8.752,47	426,84	NA	NA	**9.179,31**
Shops	5.150,83	NA	NA	NA	**5.150,83**
Restaurants	380,06	NA	NA	1.432,16	**1.812,22**
Schools	119,00	72,00	33,12	NA	**224,12**
Hospitals (3)	3.071,26	8.294,84	154,69	68,78	**11.589,57**
Masjids	261,40	NA	NA	NA	**261,40**
Churches (5)	27,00	NA	NA	NA	**27,00**
Water management facilities	76.681	997,53	132,20	NA	**77.810,73**
Total(MWh)	**96.351,65**	**9.931,21**	**320,01**	**1.553,33**	**108.156,20**

In the next chart, it is obvious that the consumption's allocation in the tertiary sector is dominated by water management facilities.

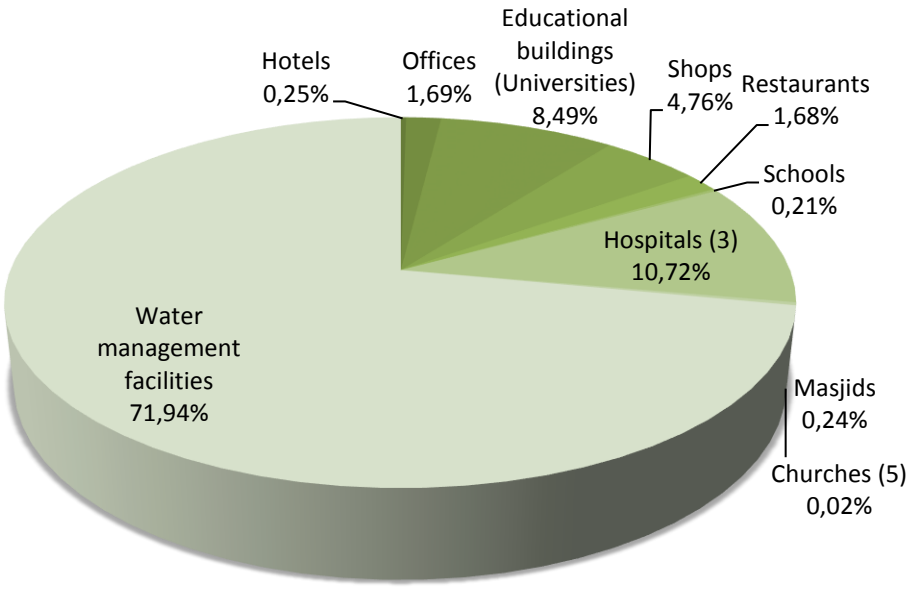

Figure 7: Energy consumption in tertiary sector per type of building

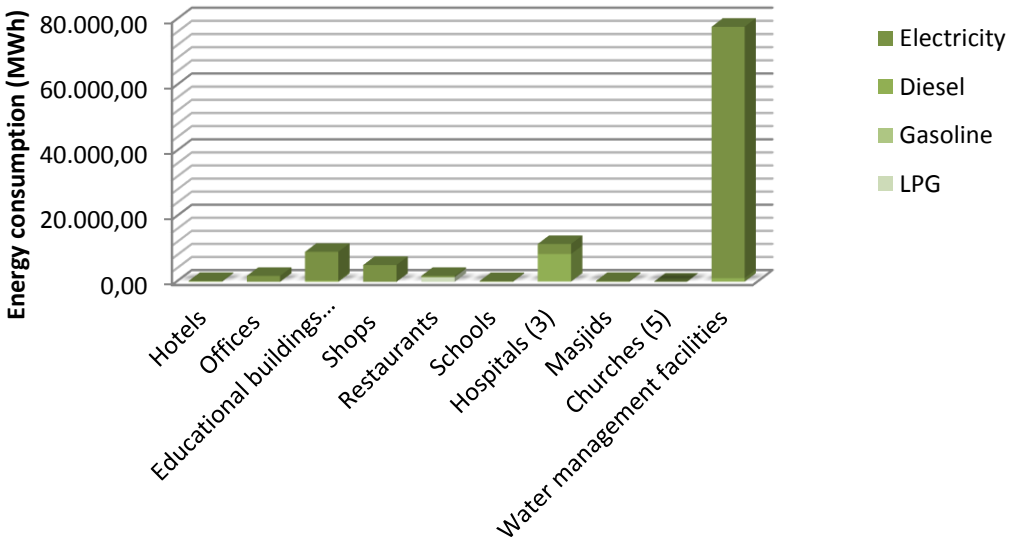

Figure 8: Energy consumption in tertiary sector per type of building and fuel

2.2.5 Buildings' & facilities Synopsis

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

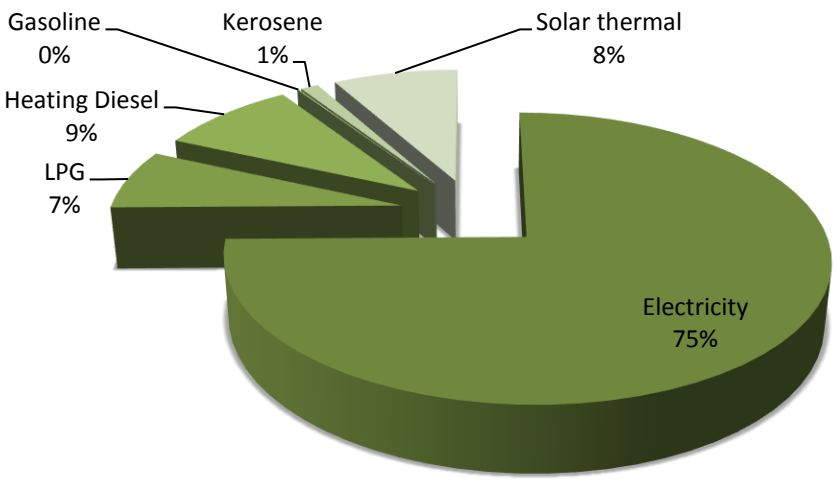

Figure 9: Energy consumption in buildings and facilities per fuel

2.2.6 Transport

2.2.6.1 Municipal fleet

As far as the consumption of the municipal vehicles is concerned, the available data, followed by the vehicles' type, was collected and is presented in the next table. Karak's municipal fleet has 111 vehicles which use diesel and gasoline.

Table 7: Energy Consumption in Municipal fleet of Karak

Type of Municipal vehicles	Number of vehicles	Diesel (MWh)	Gasoline (MWh)	Total (MWh)
Passenger Vehicles	4	0	98,57	**9.098,57**
Pick-Up	36	9.000,00	0	
Garbage vehicles	32			
Light trucks < 4 tns	9			
Medium to large trucks > 4 tns	3			
Electricity Maintenance Crane	2			
Rollers	2			
Loaders	9			
Waste water trucks	1			
Tractor	9			
Other vehicles	4			

2.2.6.2 Public Transport

Public transport refers to buses and taxis that serve Karak's citizens. The data available for the sector included the average consumption per type of vehicle according to the total distance travelled within municipal limits. The results are summarized in the table below. Further analysis is presented in Appendix B.

Table 8: Energy consumption in Public Transport

Vehicle Type	Number of vehicles	Diesel (MWh)	Gasoline (MWh)	Total (MWh)
Buses	23	5.037,00		**6.036,01**
Taxis	7		999,01	

2.2.6.3 Private and Commercial Transport

The previous methodological approach and assumptions was used in this sector too. In Appendix B is presented the detailed analysis per vehicle category. The registered private and commercial vehicles are 17.815 and the total consumption, regarding Diesel and Gasoline, is 100.778,30 MWh.

Table 9: Energy consumption in Private and Commercial Transport

Vehicle Type	Number of vehicles	Diesel (MWh)	Gasoline (MWh)	Total (MWh)
Motorcycles	37	-	74,55	**100.778,30**
Small Passenger cars	11438	-	52.812,11	
Medium Passenger Cars	231	1.264,73	-	
Cargo Vehicles	2417	13.233,08	-	
Trailer Head	246	1.459,09	-	
Trailer	1	53,38	-	
Semi-Trailer	2			
Construction vehicles	260	4.626,38	-	
Agricultural Vehicles	383	6.815,01	-	
Van	2800	20.440,00	-	
Total	**17.815**	**47.891,65**	**52.886,65**	

In the next figure is presented the proportion between Diesel and Gasoline in the Private and Commercial vehicles.

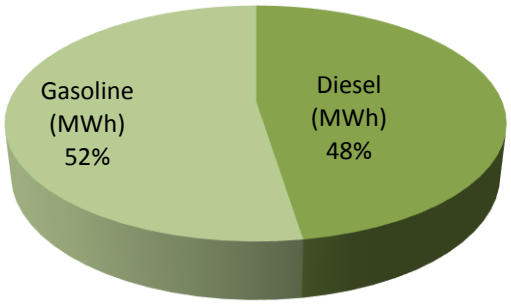

Figure 10: Energy consumption in Private and Commercial vehicles per fuel.

2.2.7 Final Energy Consumption

In the next table all the energy consumptions within Karak city are presented, totaling 410.368 GWh.

Table 10: Total Energy Consumption in Karak city

Sector	FINAL ENERGY CONSUMPTION [MWh]															
			Fossil fuels								Renewable energies					
	Electricity	Heat/cold	Natural gas	Liquid gas	Heating oil	Diesel	Gasoline	Lignite	Coal	Other fossil fuels	Plant oil	Biofuel	Other biomass	Solar thermal	Geothermal	Total
BUILDINGS, EQUIPMENT																
Municipal buildings, equipment/facilities	5.104,60			117,59												5.222,19
Tertiary (non municipal) buildings, equipment/facilities	96.351,65			1.553,33	9.931,21		320,01									108.156,20
Residential buildings	112.872,60			18.864,00	16.308,58					3.373,30				23.785,77		175.204,25
Public lighting	5.872,16															5.872,16
Industry Non-ETS																0,00
Industry ETS (not recommended)																0,00
Subtotal	**220.201,01**	**0,00**	**0,00**	**20.534,92**	**26.239,79**	**0,00**	**320,01**	**0,00**	**0,00**	**3.373,30**	**0,00**	**0,00**	**0,00**	**23.785,77**	**0,00**	**294.454,80**
TRANSPORT																
Municipal fleet						9.000,00	98,57									9.098,57
Public transport						5.037,00	999,01									6.036,01
Private and commercial transport						47.891,65	52.886,65									100.778,30
Subtotal	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**61.928,65**	**53.984,23**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**115.912,88**
OTHER																
Agriculture, Forestry, Fish	0,00															0,00
TOTAL	**220.201,01**	**0,00**	**0,00**	**20.534,92**	**26.239,79**	**61.928,65**	**54.304,24**	**0,00**	**0,00**	**3.373,30**	**0,00**	**0,00**	**0,00**	**23.785,77**	**0,00**	**410.367,68**

2.3 Local electricity production

In municipality of Karak there are photovoltaic panels producing electricity. The total installed capacity of these PVs is 90KWp with 19% capacity factor. Based on these facts, it is calculated that the electricity production from these Renewable Energy Sources is 153MWh.

2.4 CO_2 emissions

2.4.1 Energy related emissions

In the previous sections the energy consumptions in Karak municipality were described, in line with which the CO_2 emissions will be calculated in this section, using the IPCC emission factors.

Electricity

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

$$EFE = \frac{(TCE - LPE - GEP) * NEEFE + CO2LPE + CO2GEP}{TCE}$$

Where:

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

$$EFE = \frac{(220.201{,}01-153-0)*0{,}659+0+0}{220.201{,}01} = 0{,}6585 \approx 0{,}659 \text{ tn } CO_2/\text{MWh}$$

As calculated from the above, due to the very low electricity production from PVs, the emission factor for electricity remains basically the same.

Heating Oil (Diesel)

According to the SECAP guidelines the CO_2 emission factor for the diesel used in heating is 0,267 tn/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.

LPG

According to the SECAP guidelines the CO_2 emission factor for liquefied petroleum gas is 0,226 tn/MWh.

Kerosene

According to the SECAP guidelines the CO_2 emission factor for kerosene is 0,259 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 there is also a significant amount of Greenhouse Gases derived from waste management. In order to calculate these emissions, the IPCC default method was used as it appears below.[10]

Methane emissions (Gg/yr) = (MSW_T ● MSW_F ● MCF ● DOC ● DOC_F ● F ● 16/12-R) ● (1-OX) **(1)**

Where:

- MSW_T total MSW generated (Gg/yr)
- MSW_F fraction of MSW disposed to solid waste disposal sites
- MCF methane correction factor (fraction)
- DOC degradable organic carbon (fraction) (kg C/ kg SW)
- DOC_F fraction DOC dissimilated
- F fraction of CH_4 in landfill gas (IPCC default is 0.5)
- 16/12 conversion of C to CH_4
- R recovered CH_4 (Gg/yr)
- OX oxidation factor (fraction – IPCC default is 0)

The IPCC default method assumes that all the potential of CH_4 emissions are released 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 in 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
- B 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 form of this suggested equation wasn't followed directly because in the case of Karak municipality there was a different composition of solid waste. New factors were found in order to calculate the DOC.

The total quantity of solid waste for 2014 was 109.500 tn. All the amount is landfilled because there is no recycling. Waste composition, as well as the results from the calculations is presented in the next two tables.

Table 11: Solid waste composition in Karak, 2014

Solid waste composition	Percentage	Quantity(tn)
Paper and Cardboard	11%	12.045
Glass	2%	2.190
Metal	2%	2.190
Plastic	16%	17.520
Organic Waste	62%	67.890
Other	7%	7.665
Annual Quantity of Solid waste (tn)	100%	109.500

Table 12: Waste Emissions Calculation factors

Variables	Values
MSWt:	109,50 Ggr
MSWf:	1
MCF:	0,4
DOC:	0,1708
DOCf:	0,5067
F:	0,5
16/12:	1,3333
R:	0
OX:	0

Where DOCf=0,014*T+0,28 (T: average temperature in Karak, 16,19^{o}C)

All things considered, 2.527,26 tn of methane are released due to the waste management. This quantity equals to 63.181,47 tn of equivalent CO_2. (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 for the sectors that have been described in the previous sections are available, in total, in the following table.

Table 13: Total CO_2 emissions for the Karak city

Sector	CO_2 emissions [t] / CO_2 eq. emissions [t]															
			Fossil fuels								Renewable energies					Total
	Electricity	Heat/cold	Natural gas	Liquid gas	Heating Oil	Diesel	Gasoline	Lignite	Coal	Other fossil fuels	Biofuel	Plant oil	Other biomass	Solar thermal	Geothermal	
BUILDINGS, EQUIPMENT																
Municipal buildings, equipment/facilities	3.363,93	0,00	0,00	26,69	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	**3.390,63**
Tertiary (non municipal) buildings, equipment/facilities	63.495,73	0,00	0,00	352,61	2.651,63	0,00	79,68	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	**66.579,66**
Residential buildings	74.383,04	0,00	0,00	4.282,13	4.354,39	0,00	0,00	0,00	0,00	873,68	0,00	0,00	0,00	0,00	0,00	**83.893,25**
Public lighting	3.869,76	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	**3.869,76**
Industry – Non-ETS	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	**0,00**
Industry – ETS (not recommended)	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	**0,00**
Subtotal	145.112,47	0,00	0,00	4.661,43	7.006,02	0,00	79,68	0,00	0,00	873,68	0,00	0,00	0,00	0,00	0,00	**157.733,29**
TRANSPORT																
Municipal fleet	0,00	0,00	0,00	0,00	0,00	2.403,00	24,54	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	**2.427,54**
Public transport	0,00	0,00	0,00	0,00	0,00	1.344,88	248,75	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	**1.593,63**
Private and commercial transport	0,00	0,00	0,00	0,00	0,00	12.787,07	13.168,78	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	**25.955,85**
Subtotal	0,00	0,00	0,00	0,00	0,00	16.534,95	13.442,07	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	**29.977,02**
OTHER																
Agriculture, Forestry, Fish	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	**0,00**
OTHER NON-ENERGY RE																
Waste management																**63.181,47**
Waste water management																**0,00**
Other non-energy related																**0,00**
TOTAL	**145.112,47**	**0,00**	**0,00**	**4.661,43**	**7.006,02**	**16.534,95**	**13.521,76**	**0,00**	**0,00**	**873,68**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**250.891,78**

2.5 Results' Graphical Analysis

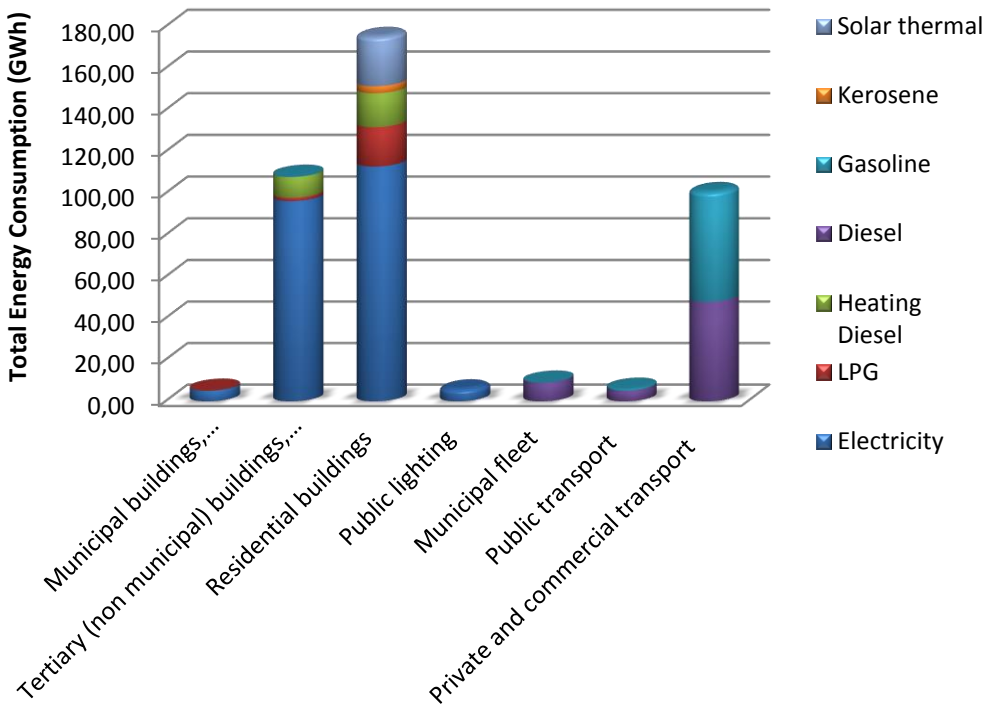

Figure 11: Final Energy consumption per sevtor and per fuel.

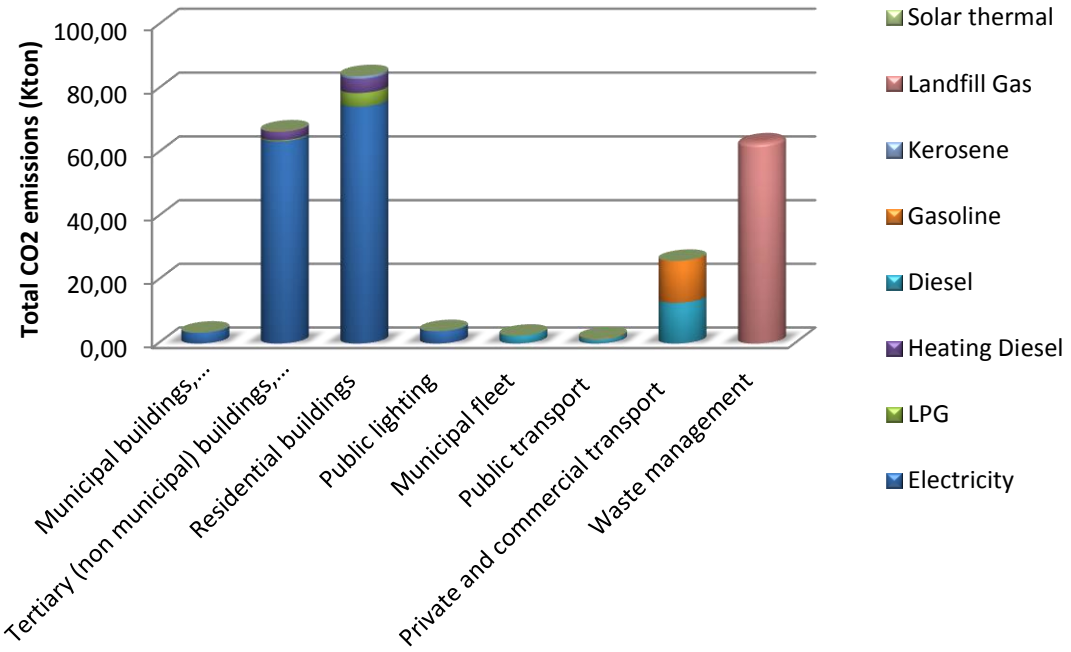

Figure 12: Total CO_2 emissions per sector and per fuel.

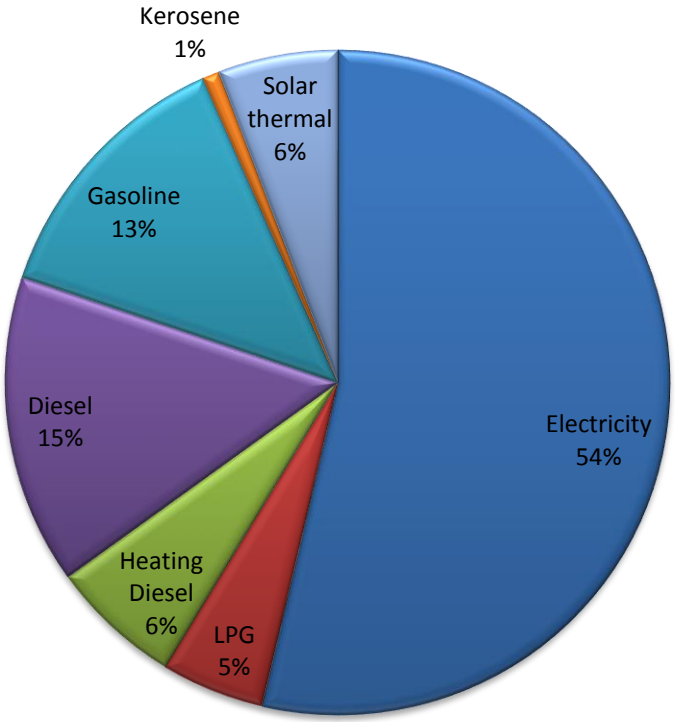

Figure 13: Final Energy Consumption per fuel.

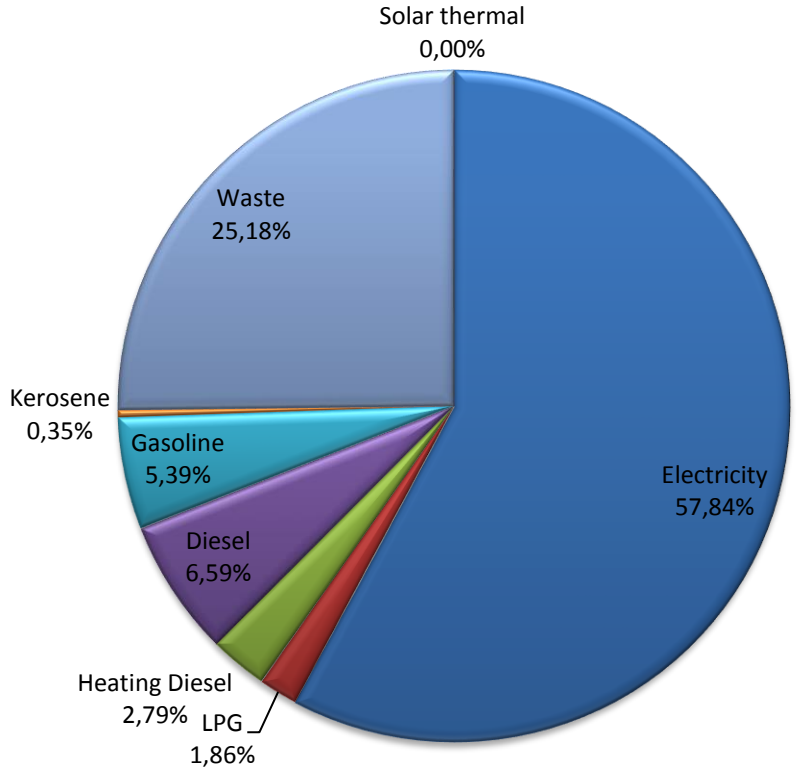

Figure 14: Total CO2 emissions per fuel.

3 Appendix

3.1 Appendix A

Public Lighting in Karak city (KWh)	
AL GHOUER	170.424
AL THANEH	376.056
AL MAMOUNIEH	126.216
AL SBEHAT	233.868
KEMNE	42.336
AL BAWAB	1.572
RAKEEN	159.336
BTEER	234.960
AL MARJ	271.464
AL LGOUN	35.184
AL MREGA	18.096
MAROUD	219.528
EAST ADAR	160.044
AL MANSHEYE	476.760
AL GDEDE	222.516
ZAHOUM	415.752
AL RASHDEYEH	191.604
AL ADNANIEH	438.084
AL ABDALI	11.520
MOUMYA	47.628
GREFLE	215.496
SAMRAA	147.216
AENOUN	31.980
BARDE	188.148
ALBGEE	45.720
MDEIN	173.364
SAAKA	68.676
WADI BN HAMMAD	5.736
ALSHAHABEY	322.644
OM ROMANE	10.800
ALMSHERFEH	138.036
ALWASEEH	520.404
ALHAWEH	150.996
Total (MWH):	**5.872,16**

3.2 Appendix B

Public Transport									
Vehicle Type	Vehicles in Governate	Vehicles in Karak Municipality	Lit/km (@50 km/hr)	Lit/hr (@50 km/hr)	Fuel type	Driving time within Karak Region plus stops (hr)	Type's total fuel consumed (Lit/day)	Annual Gasoline consumed (1000 Lit/year)	Annual Diesel consumed (1000 Lit/year)
Buses	65	23	0,16	8	Diesel	7,5	1.380		504
Taxis	Up to 20 Taxis just	20	0,11	5,67	Gasoline	7,5	850	310	

Private and Commercial Transport									
Vehicle Type	Vehicles in Governate	Vehicles in Karak Municipality	Lit/km (@50 km/hr)	Lit/hr (@50 km/hr)	Fuel type	Driving time within Karak Region plus stops (hr)	Type's total fuel consumed (Lit/day)	Annual Gasoline consumed (1000 Lit/year)	Annual Diesel consumed (1000 Lit/year)
Motor cycle	103	37	0,05	2,40	Gasoline	0,25	22,20	8,10	
Small Passenger cars	31.705	11.438	0,11	5,50	Gasoline	0,25	15.727,25	5.740,45	
Medium Passenger Cars	641	231	0,12	6,00	Diesel	0,25	346,50		126,47
Cargo Vehicles	6.701	2.417	0,12	6,00	Diesel	0,25	3.625,50		1.323,31

Trailer Head	681	246	0,39	19,50	Diesel	0,25	1.199,25		437,73
Trailer	2	1	0,39	19,50	Diesel	0,25	14,63		5,34
Semi-Trailer	5	2							
Construction vehicle	721	260	0,39	19,50	Diesel	0,25	1.267,50		462,64
Agricultural Vehicle	1.061	383	0,39	19,50	Diesel	0,25	1.867,13		681,50
Van	7.760	2.800	0,16	8,00	Diesel	0,25	5.600,00		2.044,00
Total	**49.380**	**17.815**					**29.669,95**	**5.748,55**	**5.080,98**

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