European Commission

Clean energy for EU islands: Energy Baseline Scenario for Gozo

Gozo, Malta

Clean energy for EU islands

Energy Baseline Scenario for Gozo

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Executive summary

The Gozo Regional Development Authority (GRDA) intends to prepare and present to competent authorities a decarbonisation plan for the island of Gozo. To this end, GRDA in cooperation with Gozo Business Chamber and Energy & Water Agency, applied to Clean energy for EU islands technical assistance to understand the island's current energy system, by calculating the energy consumption and CO_2 emissions from electricity, transport on the island, transport to and from the island and heating and cooling, following the Clean energy for EU islands secretariat guidelines. The calculation was performed in a five-year time frame, i.e., between 2016 and 2020.

The results showed that a large share of Gozo's CO_2 emissions is concentrated in the transport sector (more than 60%), largely influenced by road transport. However maritime transport also has a high relative importance, which tends to increase due to the recent introduction of two fast ferries. Electricity consumption is responsible for around 25% of the total energy consumption on the island. Energy consumption due to heating and cooling purposes has a more residual contribution (less than 10% of the total consumption).

Introduction

Gozo (Figure 1) is an island located in the Mediterranean Sea, which belongs to Malta territory. Its location is relatively close to the island of Malta (about 5 km from the closest point), and it measures about 14,4 km long and 6 km wide. Gozo's main sources of income come from tourism, agriculture and fishing. According to 2021 census, Gozo's population is 39 287 (also including Comino Island).

Figure 1 - Map of Gozo (image from Google Earth).

As part of the national effort, the Government of Malta has declared its intention to make the island of Gozo carbon neutral. This is in line with Malta's Low Carbon Development Strategy (Page 22). Furthermore, Gozo will be the leading region in the Maltese Islands to achieve this target, as per political mandate Malta Flimkien (Chapter six – Malta Gzira Climate Neutral) and as stated by, amongst others, the Prime Minister (Newspaper article one, Newspaper article two). The Gozo Regional Development Authority (GRDA) will develop of a long-term Decarbonisation Plan for the island of Gozo.

This Plan will be used for discussions with competent authorities including the Ministry for Gozo, the Ministry responsible for energy and climate change, and Transport Malta. To do so, GRDA, together with Gozo Business Chamber and Energy & Water Agency applied for the Clean energy for EU islands technical assistance to develop the first steps of a detailed decarbonisation plan for the island of Gozo by assessing and understanding the current energy system. This assessment acts as a baseline for the future, allowing to establish the measures, priorities, and the main sectors that the plan should address.

Methodology

In this section, we explain the methodological procedure to calculate the energy consumption and CO_2 emissions in the electricity, transport on the island, transport to and from the island, and heating and cooling, following the Clean energy for EU islands secretariat guidelines. In this study a timeframe of five years was adopted, i.e., the energy calculations were performed from 2016 to 2020 (most recent data comprising all the sectors).

Conversion factors

This section summarised the energy and emissions conversion factors for the different fuel types analysed in this study.

Energy consumption

Table 1 gives the energy conversion factors used for the different fuel types.

Table 1 - Energy consumption conversion factors.

Type	Value and unit	Reference
Petrol	8,85 kWh/L	Values agreed upon between Energy & Water Agency and National Statistics Office
Diesel	10,08 kWh/L	
Combined[1]	9,47 kWh/L	Mean value of Petrol and Diesel
LPG	6,67 kWh/L	Values agreed upon between Energy & Water Agency and National Statistics Office
Marine Diesel	10,08 kWh/L	

CO_2 emissions

Table 2 gives the CO_2 emission factors used for the different fuel types.

Table 2 - CO_2 emissions conversion factors.

Type	Value and unit	Reference
Petrol	2,64 kg CO_2/L	Ecoscore (here)
Diesel	2,39 kg CO_2/L	
Combined	2,52 kg CO_2/L	Mean value of Petrol and Diesel
LPG	1,67 kg CO_2/L	Ecoscore (here)
Marine Diesel	2,70 kg CO_2/L	Energy Consumption and Carbon Dioxide Emissions of a Suburban Coastal Transport System (here)
Fuel Oil	0,278 kg CO_2/kWh	The Netherlands: list of fuels and standard CO_2 emission factors version of January 2020 (here)
Electricity	2016: 0,653 kg CO_2/kWh 2017: 0,435 kg CO_2/kWh 2018: 0,356 kg CO_2/kWh 2019: 0,357 kg CO_2/kWh 2020: 0,357 kg CO_2/kWh[2]	European Energy Agency – value estimated for Malta, considering the country's energy mix (here)

[1] Combined means half petrol and half diesel.

[2] The reference does not have a conversion factor for 2020. So, the same of 2019 was used.

Electricity

In 2015, Maltese archipelago only had 4,3% of the electricity from the renewable energy sources[3]. However, the country has been increasing the generation of electricity from renewable sources - according to Eurostat, the share of RES in electricity was 9,5% in 2020.

Electricity is mainly generated at Delimara Power Station. The total combined nominal installed capacity of this power station is 537,8 MW[4]. The power station is composed by four units. The two main units in regular operation (operated by Electrogas Malta and Delimara 3 Power Generation Ltd, respectively) are:

- DPS Phase four, a 205 MW natural gas-fired CCGT system commissioned in 2017.
- DPS Phase three, the 2012 152 MW diesel engine plant which was refurbished in 2017 to run on natural gas and gasoil instead of heavy fuel oil.

The remaining two gasoil-fired plants have a combined nominal capacity of 180 MW and consist in: the 1994 DPS Phase 2A OCGT, and the 1999 DPS Phase 2B CCGT. These units are utilised as standby capacity during emergencies or when other sources are unavailable. The power station is connected to the national electricity network through four 132 kV and six 33 kV outgoing feeder cables.[4]

To overcome the growing demand of electricity, the Malta–Italy Interconnector was inaugurated in April 2015, connecting the Italian station located in Ragusa (Sicily). This interconnector has a length of 120 km and a high voltage (220 kV) alternating current system, capable of bidirectional flow of electrical power, transferring 200 MW of electricity.

Currently Gozo is supplied with electricity from Malta via three submarine cable circuits which pass over the island of Comino (33 kV). Malta electrical grid is shown on Figure 2.

Since there is no electricity generation in Gozo, and the island is connected to Malta via a cable that provides the required electricity, which in turn is connected to Italy, the Gozo's electricity was purely analysed from a final energy consumption viewpoint – the key data collected corresponds to the total electricity consumed in Gozo by the end-users. This approach follows the Clean energy for EU islands guidelines.

Data of Gozo's electricity consumption as well as estimated energy generation from PV's was provided by the National Statistics Office for 2017 to 2020 (despite being available the value for 2021, and the 2016 is absent). To estimate the electricity consumption for 2016, the linear regression method was used, based on the data for 2017, 2018, 2019, 2020 and 2021. With the available data, a coefficient of determination (R-squared or R^2) of 0,88 was obtained. The distribution per sector in 2016 was performed according to the 2017 distribution. Then, the yearly electricity consumption was converted to CO_2 emissions through the conversion factors presented in Table 2.

[3] Information provided by the island representatives.
[4] Official information from Enemalta: https://www.enemalta.com.mt/about-us/delimara-power-station/

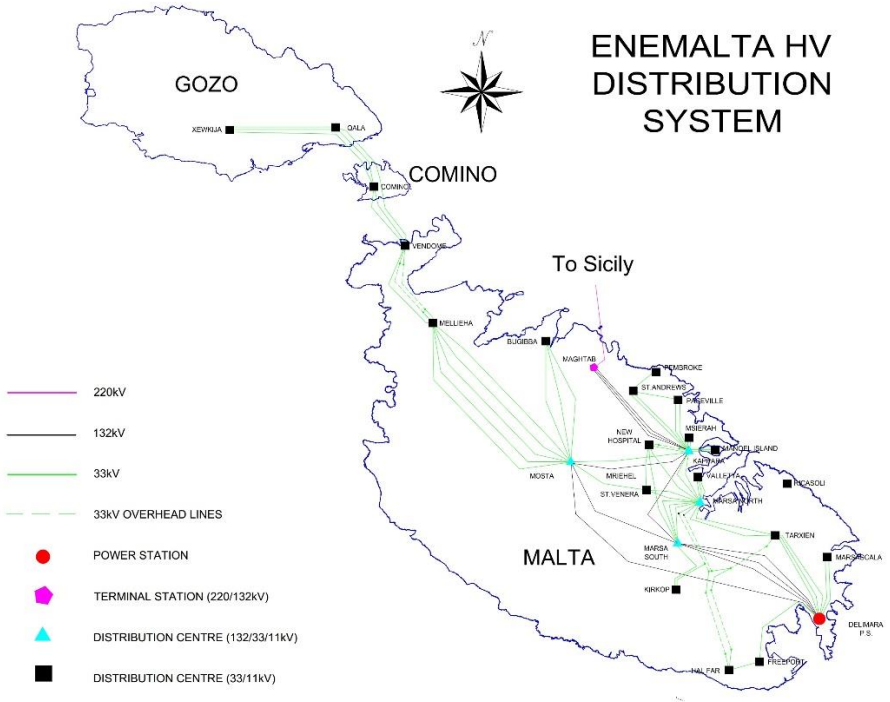


Figure 2 - Malta's electrical grid (Source: Enemalta).

Transport on the island

The analysis of land transport energy consumption was based on the yearly reports from the National Statistics Office of Malta. This includes not only private vehicles, but also leisure, agricultural and work vehicles. The data available on the reports were not consistent throughout the years, so different approximations needed to be performed to make the calculations.

The approach adopted to perform the calculations uses as main inputs: the number of vehicles on the island per vehicle type, number of vehicles per fuel type, fuel consumption per vehicle type and estimated mileage per car per year. The most recent data available is from 2020, and for the calculations a timeframe of five years was considered, i.e., from 2016 to 2020.

Some methodological considerations to calculate the energy consumption are described below:

- The number of vehicles per type in Gozo is available for all the years considered in this study.
- The number of vehicles per fuel type is only available at the country level. Therefore, the distribution of vehicles per fuel type in Malta was considered also for Gozo (For example: 98% of the country's minibuses uses Diesel. This 98% was also adopted for Gozo).
- For 2016, the only input data available is the number of vehicles per type in the island. Hence, the mileage per car per year was considered the same as 2017.
- For 2017 and 2018, the total number of kilometres travelled per vehicle type is available together with the total vehicles per type. As a result, it is possible to calculate the mileage per car per year on the island. However, for 2019 and 2020 the total number of kilometres travelled per vehicle type is only available at the country level. Therefore, the distribution of mileage per car in Malta was adopted for Gozo.
- For all the years analysed, there is no data regarding the total number of kilometres travelled (and consequently the mileage per car per year) for agricultural vehicles. For

2020, this data is also absent for quad and ATV vehicles – the mileage per car per year for quad and ATV vehicles for 2020 was considered the same as 2019. Since there is no data regarding agricultural vehicles, and their contribution to island's CO_2 emissions is not significant, they were not considered in the energy calculations.

The main output of this model is the total fuel usage in litres (per fuel type and per vehicle type). This fuel usage was converted to energy consumption (in GWh) based on the energy conversion factors available in Table 1 and to respective CO_2 emissions through the emission conversion factors in Table 2. The average fuel consumption for the different vehicle types is shown on Table 3.

Table 3 - Description of the average fuel consumption assumptions for the different vehicle types.

Vehicle type	**Fuel used**	**Value adopted**	**Source / Explanation**
Coach and private bus	Diesel	Diesel: 40,43 L/100 km	Estimations from the Energy & Water Agency based on national VERA database, national Oil Consumption and international COPERT database for vehicle emissions.
Minibus	Petrol, Diesel, Electric	Petrol and Diesel: 22,73 L/100 km Electric: 42,38 kWh/ 100 km	
Motorcycle / E-Bicycle/ PA-Bicycle	Petrol, Diesel, Electric	Petrol and Diesel: 2,54 L/100 km Electric: 2,84 kWh/100 km	
Quad and ATV	Petrol, Electric	Petrol: 4,75 L/100 km Electric: 2,84 kWh/100 km	
Passenger car	Petrol, Diesel, LPG, Electric, Hybrid, Combined	Petrol: 7,32 L/100 km Diesel: 6,23 L/100 km LPG: 12,30 L/100 km Electric: 17,12 kWh/100 km Hybrid: 2,77 L/100 km Combined: 6,78 L/100 km	
Goods-carrying vehicle	Petrol, Diesel, LPG, Electric, Combined	Petrol: 15,8 L/100 km Diesel: 13,17 L/100 km LPG: 12,27 L/100 km Electric: 66,9 kWh/100 km Combined: 14,48 L/100 km	
Road tractor	Diesel	Diesel: 27,00 L/100 km	
Special purpose vehicle	Petrol, Diesel, LPG, Electric, Combined	Fossil fuels:18 L/100 km Electric: 27 kWh/100 km	These vehicles vary very much in terms of size, weight, engine structure, and consequently, in fuel consumption. Within these vehicles are fire brigade vehicles; mobile cranes; self-propelled rollers; bulldozers with metallic wheels or track; vehicles for recording film, radio, and TV broadcasting; mobile library vehicles; mobile kiosks; towing vehicles for vehicles in need of repair; other special purpose road motor vehicles. Due to this variety, it is difficult to reach an average value. Since the estimations for special purpose vehicle were not provided by the project beneficiaries, it was assumed a consumption value of 18 L/100 km and 27 kWh/100 km on the electric vehicles.

Transport to and from the island

As for transport on the island, the calculations for the ferry transportation between Malta and Gozo were elaborated based on the data from the yearly reports from the Gozo Channel Co. Ltd. Following the guidelines of the Clean energy for EU islands secretariat, both trajectories (to and from Gozo) were considered to calculate the energy consumption and the corresponding CO_2 emissions.

There are four ships operating on the route between Mġarr (Gozo) and Ċirkewwa (Malta) – Malita, Nikolaos, Ta' Pinu and Gaudos. Gozo Channel Co. Ltd provided the data of the total fuel consumption per year. This fuel usage was converted to energy consumption (in GWh) based on the energy conversion factors available in Table 1 and to respective CO_2 emissions through the emission conversion factors in Table 2. Table 4 summarises the data available.

Table 4 - Number of trips per year and total fuel consumption for each of the vessels operating to and from Malta and Gozo.

Year	Malita	Nikolaos	Ta' Pinu	Gaudos	Total	Fuel consumption (L)
	Trips					
2016	9 594	-	9 642	3 168	22 404	6 161 100[5]
2017	8 742	-	9 460	4 327	22 529	6 197 870
2018	9 464	-	8 973	5 182	23 619	6 457 410
2019	8 983	2 352	10 161	6 135	27 631	7 663 326
2020	9 820	4 390	8 814	6 028	29 052	7 535 547

Furthermore, in the second quarter of 2021 two fast ferries started operating connecting Valletta and Mġarr — a longer trip compared to the four ferries mentioned above. The trip Valleta – Mġarr and vice-versa takes 45 minutes[6], while the trips Mġarr – Ċirkewwa take around 20 minutes. The fuel consumption of the fast ferries was estimated based on the fuel consumption per minute of the four vessels mentioned above. Since these are new vessels and therefore more efficient, it was assumed that the fast ferries consume 30% less per minute than the other four ferries. From these assumptions, the estimated fuel consumption per Fast Ferry trip is 423,4 litres. Table 5 represents the number of trips of the fast ferries since it is operating.

Table 5 - Number of trips carried out by the fast ferries.

Year	Quarter	Trips
2021	Q1	-
	Q2	1 086
	Q3	4 206
	Q4	2 736
2022	Q1	1 519
	Q2	1 663

[5] For 2016, no data was provided. So total consumption was estimated based on the average consumption per trip.
[6] https://www.facebook.com/gozofastferry/photos/a.138697968258319/537540861707359

The transportation of goods does not imply extraordinary emissions as these are included in the ferry trips (Table 4). Regarding leisure boats, which during the summer may have a significant importance, there is no data to estimate their contribution for the total island emissions, therefore they were not considered in this report. Therefore, in the future, it would be important to assess their impact on the total emissions from maritime transport.

Heating and cooling

The estimation of the energy consumption due to heating and cooling was performed according to the following assumptions, based on the knowledge of the technical assistance beneficiaries:

- The heating and cooling in Gozo households comes mainly from two different sources: electrical systems (e.g., A/C systems, electric boilers, or heat pumps) and LPG. Electric heating and cooling are considered as part of the electricity consumption, while fossil heating is considered in this section.
    - Energy & Water agency provided estimated LPG consumption in Gozo, which was assigned to consumption in households.
- In commercial services and industrial sector, other fossil fuels are used for heating and cooling purposes such as gasoil, fuel oil and diesel.
    - For gasoil, fuel oil and diesel, data was also provided by Energy & Water agency, based on the 2017 NSO-EWA Fuel Survey. However, this data refers to the total national consumption. Since we are talking about commercial services and industry sector, the proxy used to estimate usage in Gozo was Gross Domestic Product (GDP). According to the Malta National Statistics Office, the Gozo and Comino region is responsible for 4,3% of the total national GDP, so it was assumed that consumption in Gozo for the different fuels is 4,3% of the total national consumption.

Results: Energy consumption baseline

Electricity

The electricity consumption per year per sector is shown on Table 6 and graphically displayed on Figure 3.

Table 6 - Electricity consumption per year per sector in Gozo, in GWh.

Electricity consumption per sector [GWh]	**2016**	**2017**	**2018**	**2019**	**2020**
Industry sector (including energy and transport sector)	8,30	8,73	9,30	10,07	9,90
Residential	62,65	65,96	70,03	74,79	73,48
Commercial and public services	33,29	35,05	37,20	39,59	38,89
Agriculture and fishing	0,64	0,67	0,71	0,75	0,74
Others	1,46	1,54	1,63	1,74	1,71
Total	**106,34**	**111,95**	**118,87**	**126,94**	**124,72**

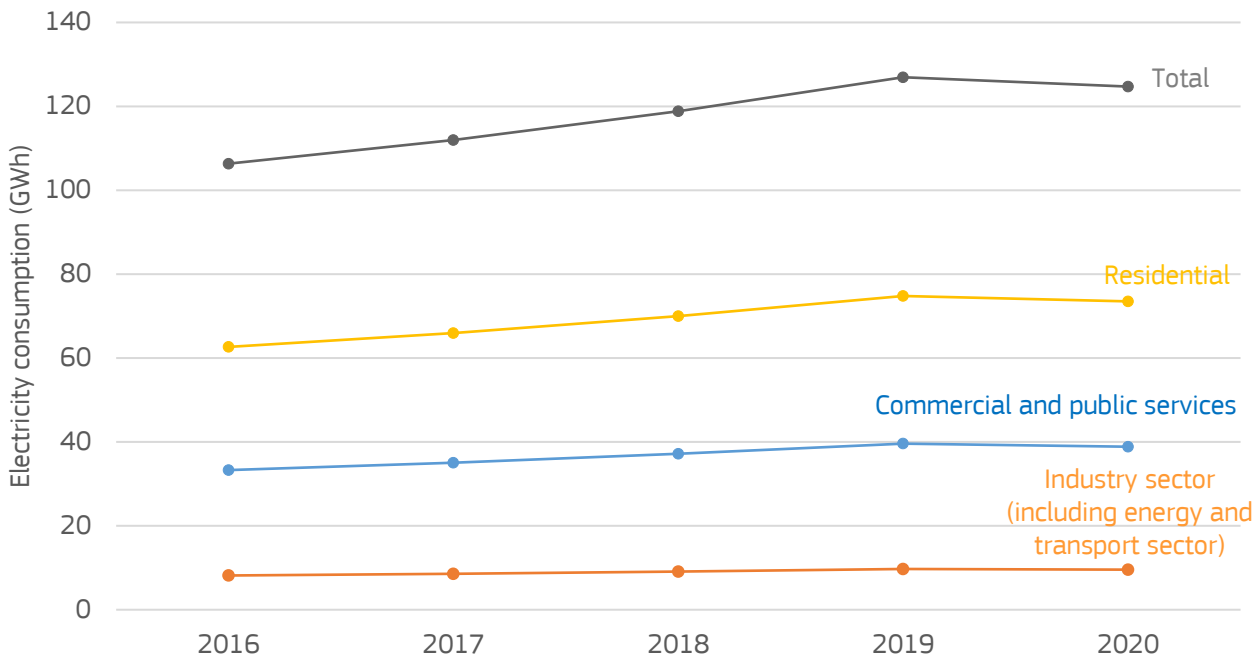


Figure 3 - Annual evolution of the energy consumption per sector (GWh). The contribution of Agriculture and fishing, and Others is very low (almost negligible) compared to the rest of the sectors and therefore is not shown in the graph

The annual evolution shows an upward trend in electricity consumption. In fact, from 2016 to 2020, island's electricity consumption increased by 17,3%, ranging from 106,34 to 124,72 GWh – despite not comprised in the reporting period, the Gozo's consumption in 2021 was 139,8 GWh, confirming the increasing trend. Regarding the percentage distribution of electricity consumption in the different sectors, it does not vary over the years (maximum variation from one year to another is 0,1%). Therefore, the graph below shows the relative importance of each sector in total consumption.

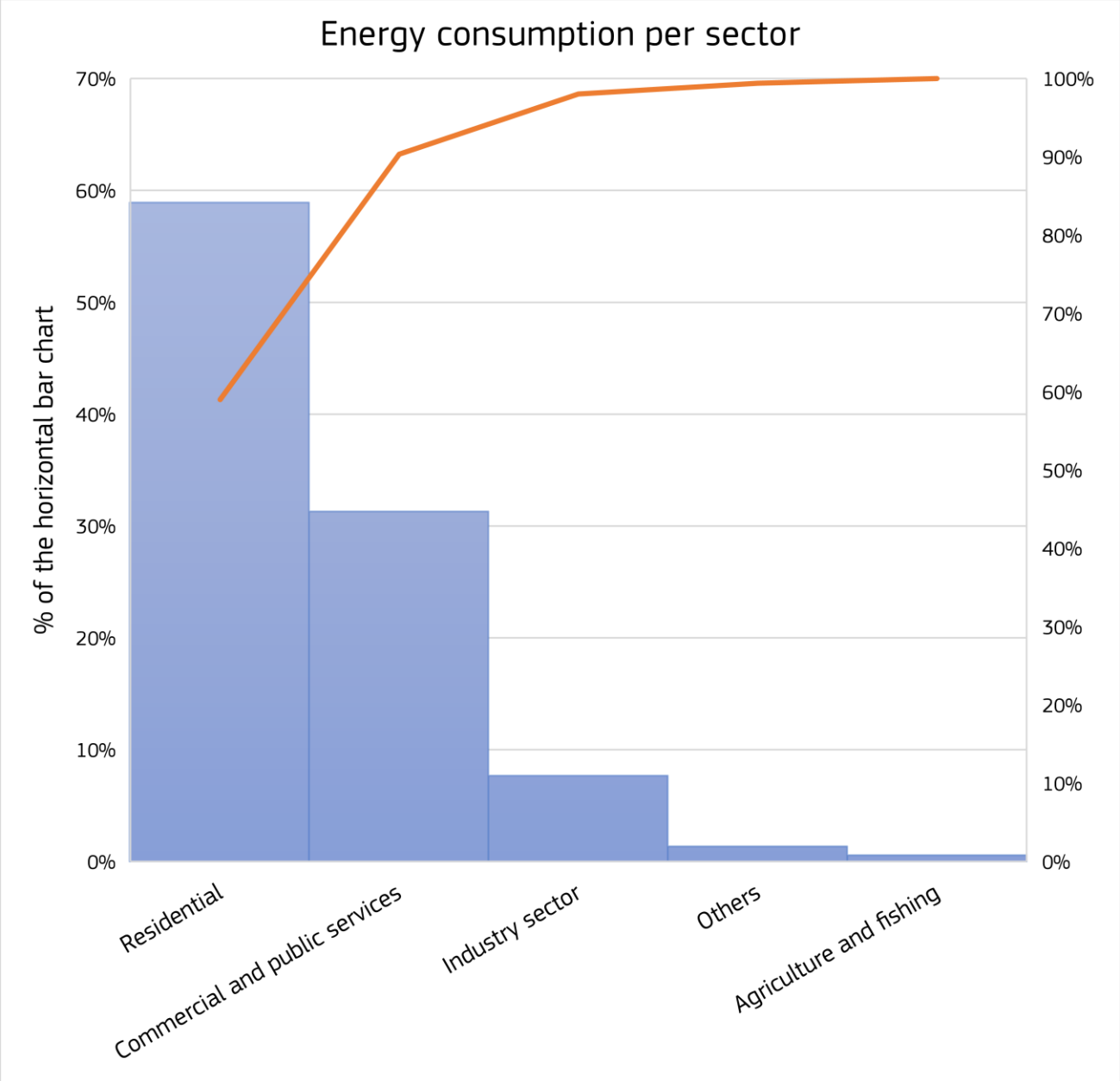


Figure 4 - Electricity consumption per sector, in percentage. (Note: The label is not available for the sectors with less than 1%).

From Figure 4, it is possible to conclude that the residential and commercial and public services sectors are the biggest consumers of electricity in Gozo (with 59% and 31%, respectively),

followed by the industry sector (8%). The remaining sectors have residual effects on total electricity consumption (≤1%).

Regarding CO_2 emissions, Table 7 was generated by converting the electricity consumption to CO_2 emissions, through the conversion factors available on Table 2 – the conversion factors adopted vary from year to year according to Malta's energy mix. Actually, the decrease of the conversion factor from 0,653 kg CO_2/kWh in 2016 to 0,357 kg CO_2/kWh in 2020 reflects the introduction of renewable energy production.

The CO_2 emitted through the electricity consumption decrease from 69 440 tonnes in 2016 to 44 524 tonnes in 2020, reaching a minimum in 2018 of 42 317 tonnes. Despite the energy consumption increased from 2016 to 2020 (Table 6), the CO_2 emissions decreased 35.9% from 2016 to 2020, as result of the introduction of renewable energy production in Malta, Gozo (as presented below in Table 8) and Italy, where Malta is interconnected.

Table 7 - CO_2 emissions from electricity consumption per year per sector in Gozo, in tonnes.

CO_2 emissions per sector [tonnes]	**2016**	**2017**	**2018**	**2019**	**2020**
Industry sector (including energy and transport sector)	5 417,35	3 799,32	3 309,18	3 593,84	3 533,97
Residential	40 911,28	28 692,09	24 931,70	26 698,67	26 231,95
Commercial and public services	21 740,69	15 247,28	13 241,64	14 132,95	13 883,11
Agriculture and fishing	416,53	292,13	253,70	270,78	265,99
Others	954,16	669,18	581,15	620,27	609,31
Total	**69 440,02**	**48 699,99**	**42 317,36**	**45 316,51**	**44 524,33**

Renewable energy

PVs are the only source of renewable energy in Gozo. Hence, the data for PV generation was provided by National Statistics Office from 2016 to 2020 (it was also provided for 2021[7], but it is out of this reporting period), and is available in Table 8.

Table 8 - Estimated energy generation from PVs.

Year	**Energy generation from PVs**	**% of the total electricity consumption**
2016	17,1 GWh	16,1%
2017	24,5 GWh	21,9%
2018	29,2 GWh	24,6%
2019	30,7 GWh	24,2%
2020	33,8 GWh	27,1%

[7] The estimated energy generation in 2021 was 35,3 GWh, confirming the upward trend.

Transport on the island

The analysis of the energy consumption and CO_2 emissions of land transport in Gozo is based on the number of vehicles on the island per vehicle type, number of vehicles per fuel type, fuel consumption per vehicle type and estimated mileage per car per year (Table 9).

Table 9 - Stock of licensed motor vehicles for Gozo: 2016-2020 (Source: National Statistics Office – Malta).

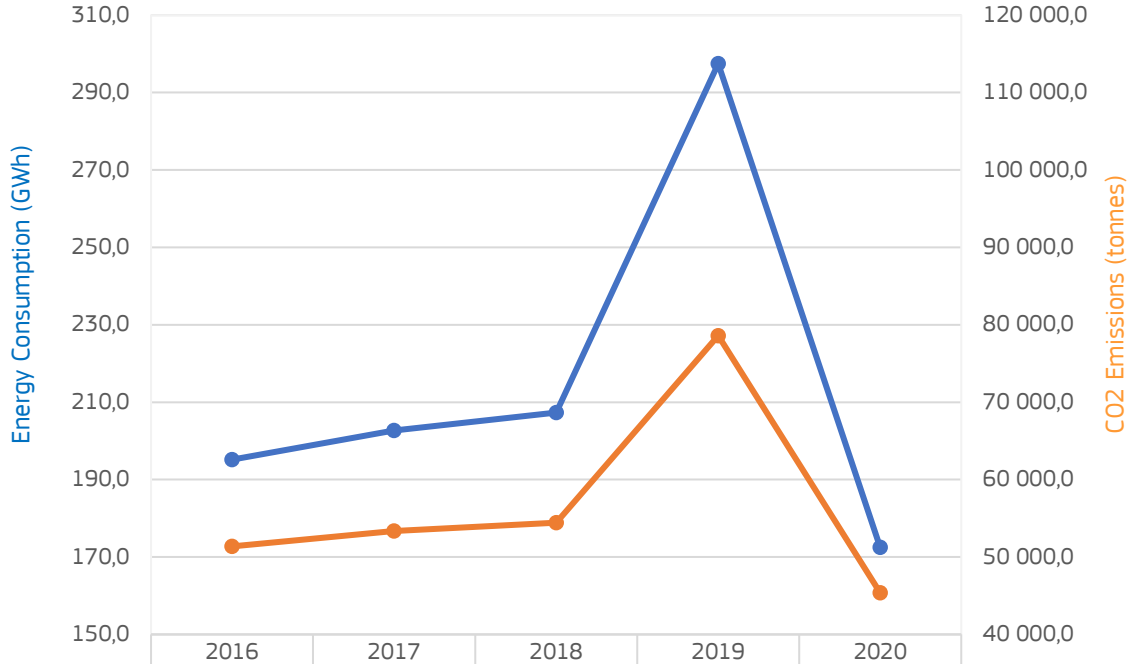
Year	Stock	Total Distance travelled (km)
2016	32 996	N/A
2017	34 194	256 295 000
2018	35 761	254 414 834
2019	39 699	382 000 000
2020	40 599	212 000 000

Table 10 shows Gozo's road transports energy consumption for 2020, which is the most recent data available. The methodology adopted results in 172,47 GWh of energy consumed, which brings the annual emissions due to road transport to 45 375,94 tonnes of CO_2. However, this is not the most suitable year to analyse due to the covid restrictions and expected decrease in the energy consumption. The same methodology developed for 2020 was developed from 2016 to 2019, and the results for energy consumption (GWh) and CO_2 emissions are summarised in Figure 5.

Table 10 - Energy consumption of land transport overview in Gozo, for 2020.

Vehicle type	Quantity	Fuel used	Mileage/ car/ year	Total energy consumption (GWh)	CO_2 emissions (tonnes)
Coach and private bus	42	Diesel, Combined	15 099	2,58	614,14
Minibus	197	Petrol, Diesel, Electric	10 631	4,78	1 135,63
Motorcycle / E-Bicycle/ PA-Bicycle	4 990	Petrol, Diesel, Electric	574	10,63	188,28
Quad and ATV	348	Petrol, Electric	974	0,13	34,68
Passenger car	26 978	Petrol, Diesel, LPG, Electric, Hybrid, Combined	6 054	103,28	28 827,07
Goods-carrying vehicle	6 883	Petrol, Diesel, LPG, Electric, Combined	5 561	50,83	12 139,81
Special purpose vehicle	421	Petrol, Diesel, LPG, Electric, Combined	7 150	5,34	1 272,32
Road tractor	158	Diesel	11 417	4,90	1 164,01
Total	**40 017**[8]			**172,47**	**45 375,94**

[8] Different value than the one available on Table 9 because here the agricultural vehicles were removed.



	2016	2017	2018	2019	2020
Energy Consumption	195,2	202,7	207,3	297,5	172,5
CO2 emissions	51 357,4	53 366,3	54 430,5	78 601,4	45 375,9

Figure 5 - Temporal evolution of Energy consumption and CO_2 emissions due to land transport.

From 2016 to 2018 there is a slight increase in the energy consumption and consequently in the emissions, however the greatest increase occurs in 2019 due to the increase in the number of vehicles, but mainly due to the considerable increase in the number of km travelled – increased around 50% from 2018 to 2019[9]. Then, as expected due to covid effects, the mileage per car per year in 2020 decrease significantly which led to an energy consumption and CO_2 emissions decrease (42,0%).

Transport to and from the island

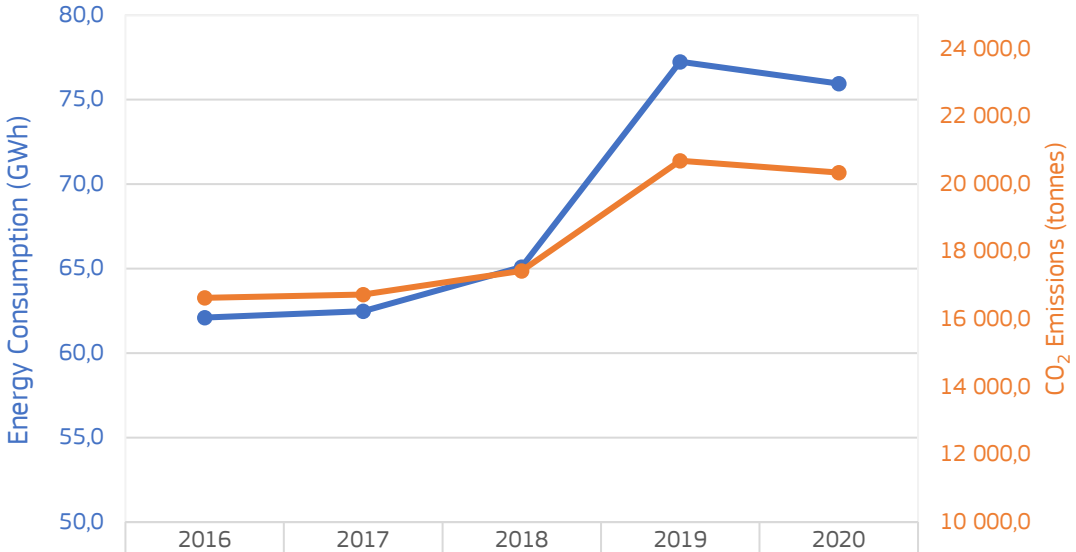
The fuel consumption (in litres) estimated in the methodology section, and presented on Table 4, was converted to energy consumption (in GWh) based on the energy conversion factors available in Table 1 and to respective CO_2 emissions through the emission conversion factors in Table 2 – Figure 6.

The four ferry vessels have been gradually increasing the energy consumption, from 62,1 GWh in 2016 to 76,0 GWh in 2019[10], which reflects an increase of 22,4% in the analysed period. This energy consumption resulted in a range of CO_2 emissions from 16 635 tonnes CO_2 to 20 691 tonnes CO_2. In 2020, there was a slight decrease in the energy consumption (1,55%). Despite the number of trips were the maximum in the analysed period (29 052 in 2020 - Table 4), the number of passengers and vehicles on board were the minimum – Table 11). In fact, there was a decrease of 36,2% and 12,9% in the number of passengers and cars, respectively, from 2019 to 2020,

[9] The data of the distance travelled in 2019 is official, and published by the NSO. Therefore, in the future, the values must be confirmed and it must be verified if the methodology used to estimate the distance travelled per year is consistent throughout the years.

[10] It is important to refer that the 4th ferry has only been added to the fleet in 2019.

probably due to covid 19 effects. Therefore, the decrease in the weight of the vessels on the trips resulted in a decrease in the fuel consumption. However, this significant decrease in the number of passengers and vehicles only led to an energy consumption decrease of 1,55%, i.e., during this year there was a high level of inefficiency in Gozo's maritime transport.



	2016	2017	2018	2019	2020
Energy Consumption	62,1	62,5	65,1	77,2	76,0
CO2 emissions	16 635,0	16 734,2	17 435,0	20 691,0	20 346,0

Figure 6 - Temporal evolution of Energy consumption and CO_2 emissions due to maritime transport.

Table 11 - Number of passengers and vehicles to and from Ċirkewwa and Mġarr, per year.

Year	Passengers	Vehicles
2016	5 133 000	1 459 114
2017	5 383 840	1 544 022
2018	5 758 318	1 659 902
2019	5 917 780	1 782 909
2020	3 773 981	1 552 138

In addition to the analysed period (2016 to 2020), and as mentioned in the methodology section, in the second quarter of 2021, started operating 2 fast ferries that make the trip between Valletta and Mġarr, therefore a longer trip when compared to the four ferries mentioned above. So, Table 12 represents the energy consumption and the CO_2 of these five quarters of operation (at the time of this report, data from 2022 is only available until the Q2).

Table 12 - Energy consumption and CO_2 emissions of the fast ferries.

Year	Trips	Consumption (L)	Consumption (GWh)	CO_2 emissions (tonnes)
2021	8028	3 398 734	34,3	9 176,6
2022	3182	1 347 132	13,6	3 637,3

From these results, it is concluded that the two fast ferries represent almost 40% of the total energy consumption due to maritime transport, i.e., the operation of these 2 ferries consumes almost as much as the other 4 that have been operating for a few years, which will lead to an important increase when the analysis for 2021, 2022 and upcoming years will be carried out.

Heating and cooling

Table 13 refers to the LPG consumption in Gozo. Fueloil, diesel and gasoil were already provided in GWh (the conversion factors used by Energy & Water Agency matches with the ones presented in Table 1 – we got variations of one decimal place probably due to rounding).

Table 13 - Yearly LPG consumption in Gozo (data: Energy & Water Agency).

Year	LPG (L)[11]
2016	4 970 972
2017	5 266 001
2018	5 046 213
2019	5 137 696
2020	4 417 785

The LPG consumption in litres was converted to energy consumption through the conversion factors available on Table 1. Table 14, Figure 7, Figure 8, Figure 9 and Figure 10 summarises the energy consumption and CO_2 emissions from heating and cooling purposes.

The first conclusion from the results is that energy consumption and CO_2 emissions due to heating and cooling purposes increased from 2016 to 2017, but have been gradually decreasing from 2017 to 2020 (41,1 GWh to 32,4 GWh and 10 221,1 to 8 086,9 tonnes of CO_2). To this end, the reduction in the consumption of the two main fuels was crucial - LPG and diesel. A possible interpretation for these results is that inhabitants are switching their heating (and also cooking) equipment's to electrical systems - in fact, as observed previously, electricity consumption increased considerably over the period analysed.

From Figure 9 and Figure 10, it is possible to understand that LPG is clearly the largest contributor to the total CO_2 emissions, and its relative importance has been increasing over time. This increase is not due to the fact that the consumption of LPG increased over the period analysed (actually, it is decreasing), but that the reduction in gasoil consumption for heating and cooling decreases in a greater proportion (from being responsible for 13% of emissions in 2016 to 5% in 2020). With regard to fuel oil, in the years analysed, it always represents less than 1% of total emissions. Diesel, despite having a residual importance, increased its relative importance from 2016 to 2020 (from 0,18% in 2016 to 1% in 2020).

[11] Includes consumption in cylinders and bulk consumption.

Table 14 - Yearly energy consumption and CO_2 emissions from heating and cooling purposed, for the different fuel.

Year	LPG		Gasoil		Fuel oil		Diesel	
	Energy (GWh)	CO_2 (tonnes)	Energy (GWh)	CO_2 (tonnes)	Energy (GWh)	CO_2 (tonnes)	Energy (GWh)	CO_2 (tonnes)
2016	33,16	8 301,5	5,95	1 401,3	0,03	8,3	0,08	18,7
2017	36,28	9 081,5	4,73	1 113,4	0,03	7,9	0,08	18,3
2018	34,77	8 702,5	3,04	715,0	0,03	7,2	0,08	19,3
2019	35,40	8 860,2	1,96	461,4	0,03	8,3	0,25	58,3
2020	30,44	7 618,7	1,61	379,8	0,03	9,6	0,33	78,8

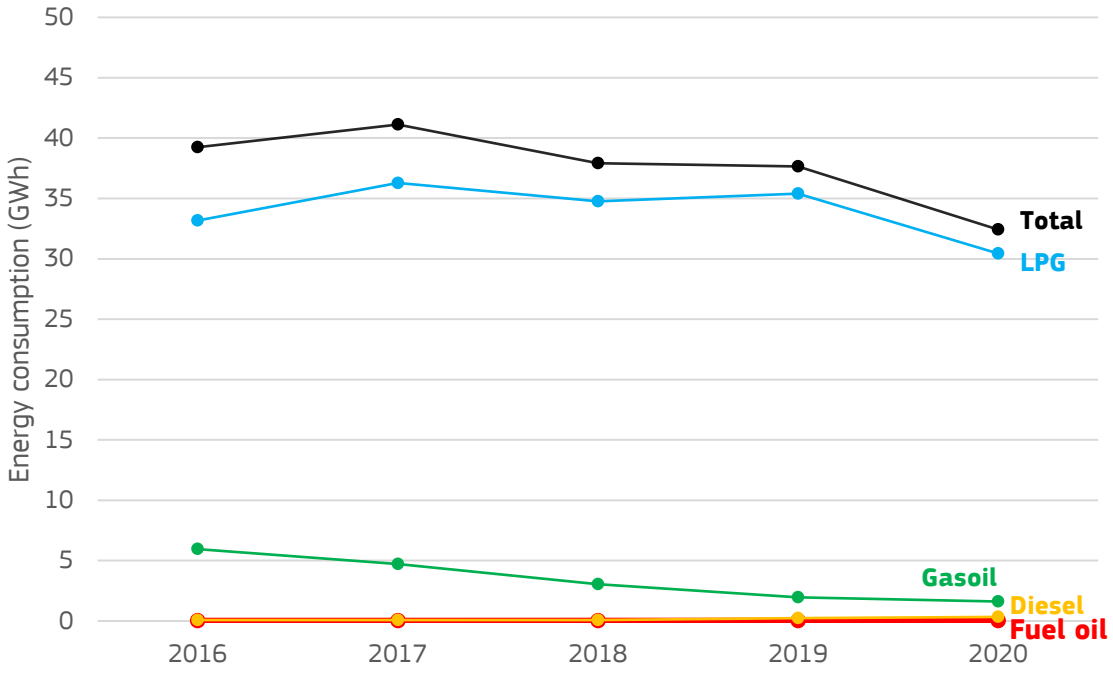


Figure 7 - Yearly evolution of the energy consumption from the different fuels used for heating and cooling.

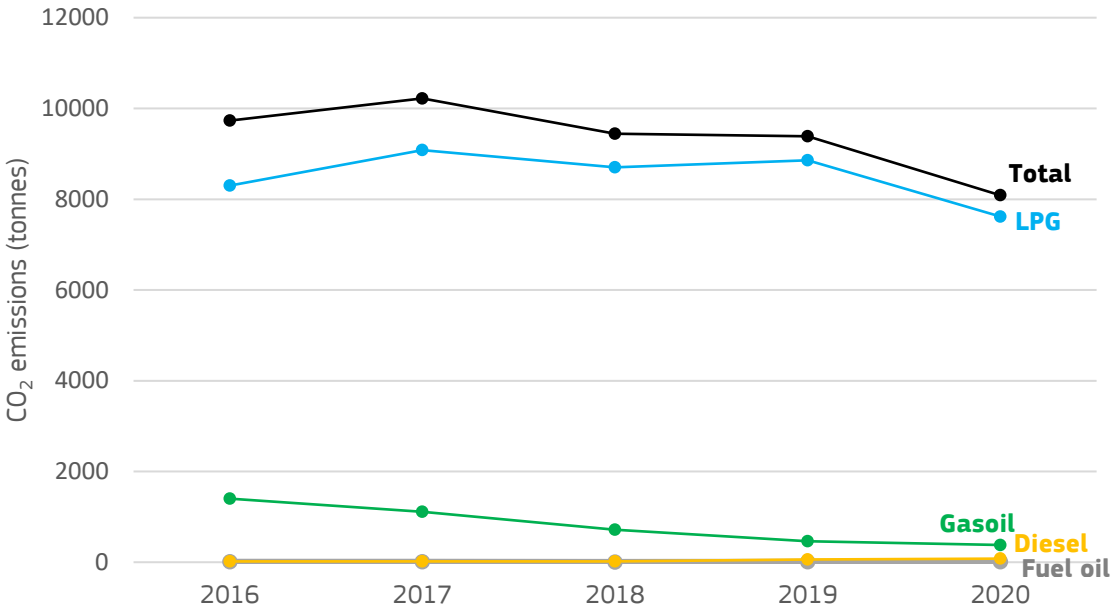


Figure 8 - Yearly evolution of the CO_2 emissions from the different fuels used for heating and cooling.

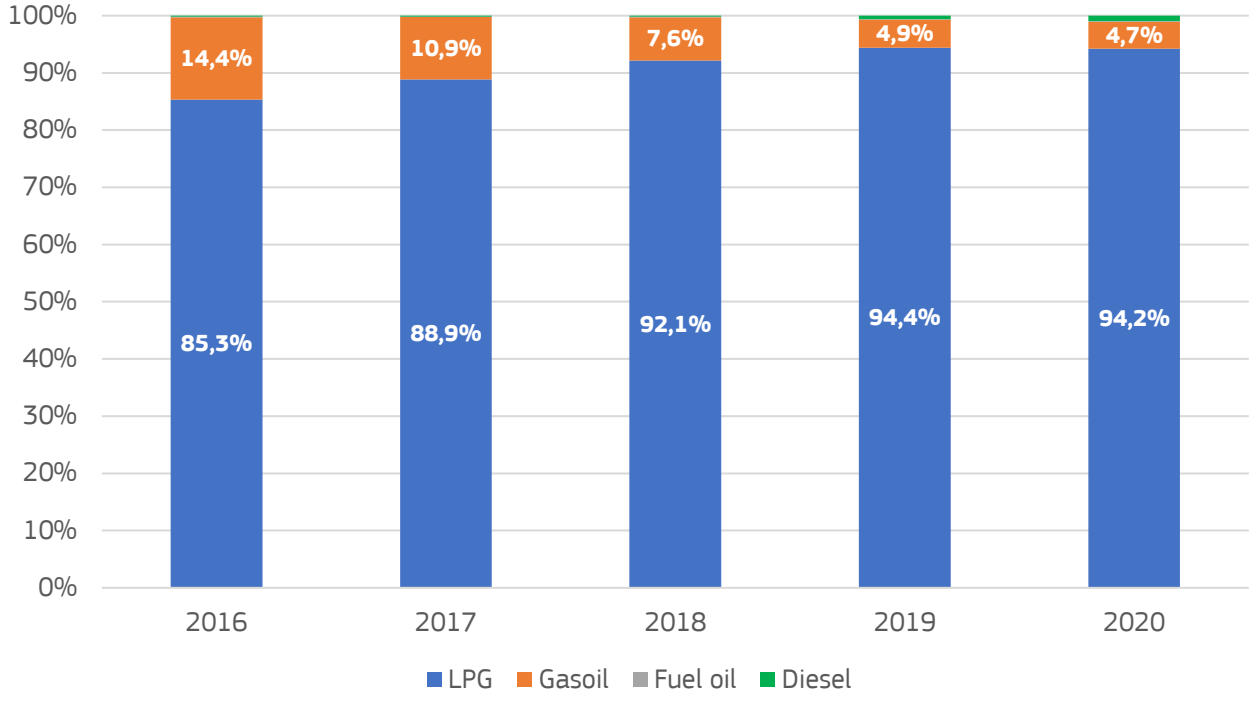


Figure 9 - Yearly contribution of the different fuels in the total CO_2 emissions, for heating and cooling purposes.

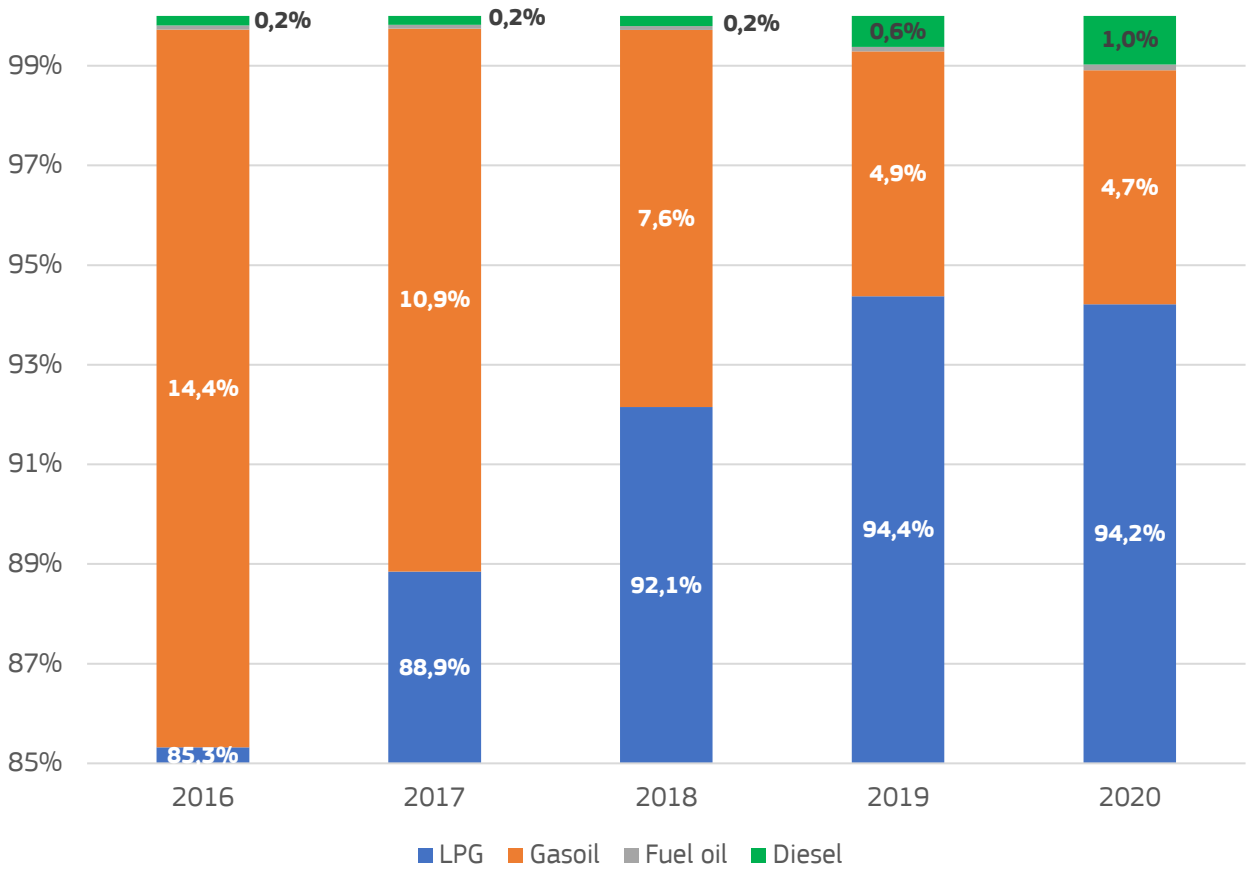


Figure 10 - Zoom of the Figure 9 (from 85% to 100%), to show, in more detail, the contribution of the fuels with less relative importance. Note: fuel oil has a contribution lower than 0,1%.

Overview and conclusions

The final energy consumption and associated CO_2 emissions for electricity consumption, transport on the island, transport to and from the island are summarised in Table 15 and Table 16. Regarding energy consumption, there is a peak in 2019 (25,6% increase compared to 2018 - from 429,2 GWh to 539,2 GWh) that does not continue in 2020 (24,8% decrease compared to 2019). As we all know, 2020 was an atypical year due to the effects of covid-19, so it is important to analyse whether in 2021 and subsequent years, the increasing trend, that took place between 2016 and 2019, continues. For example, regarding electricity consumption, data for 2021 is already available and the consumption in Gozo was 139,8 GWh, i.e., the maximum value of the last 6 years. A similar pattern is observed in maritime transport, where consumption for 2021 is the maximum for the period analysed (excluding fast ferries, in order to have a proper comparison).

Regarding CO_2 emissions, with exception of 2019, it has a gradual decrease. 2020 is the year with the lowest emissions (118 333,1 tonnes), followed by a peak in 2019 of 153 997,1 tonnes. It is important to highlight that the peak observed in 2019 is mainly due to the significant increase in CO_2 emissions due to land transport[12] – the remaining sectors did not increase in the same proportion as land transportation – in fact, emissions due to heating and cooling decreased in 2019, in comparison with 2018. The temporal evolution pattern of CO_2 emissions is contrary to energy consumption (the energy consumption increased over the analysed period). This is due to the introduction of renewable energies into the Malta energy mix, considerably reducing the kg of CO_2 per each kWh consumed in Gozo.

Table 15 - Overview of the energy consumption in Gozo, in GWh.

Sector	**2016**	**2017**	**2018**	**2019**	**2020**
Final electricity consumption	106,3	112,0	118,9	126,9	124,7
Transport on the island	195,2	202,7	207,3	297,5	172,5
Transport to and from the island	62,1	62,5	65,1	77,2	76,0
Heating and cooling	39,2	41,1	37,9	37,6	32,4
Total	**402,8**	**418,3**	**429,2**	**539,2**	**405,6**
Yearly change[13]	-	3,8%	2,6 %	25,6%	-24.8%

[12] In this case, it is important to understand if in 2019 there is any change in the methodology for obtaining data, or if there is any plausible explanation that allows determining the consistency of the methodology for the following years.
[13] By yearly change, it means the percentage variation from the analysed year and previous year.

Table 16 - Overview of the CO_2 emissions in Gozo, in tonnes.

Sector	2016	2017	2018	2019	2020
Final electricity consumption	69 440,0	48 700,0	42 317,4	45 316,5	44 524,3
Transport on the island	51 357,4	53 366,3	54 430,5	78 601,4	45 375,9
Transport to and from the island	16 635,0	16 734,2	17 435,0	20 691,0	20 346,0
Heating and cooling	9 729,9	10 221,1	9 443,9	9 388,2	8 086,9
Total	**147 162,3**	**129 021,6**	**123 626,8**	**153 997,1**	**118 333,1**
Yearly change	-	-12,3%	-4,2%	24,6%	-23,2%

Transport on the island is the main contributor to Gozo's final energy consumption and consequently CO_2 emissions, ranging from 42,5% in 2020 and 55,2% in 2019 of the total energy consumption and ranging from 38,3% and 51,0% of the total CO_2 emissions in 2020 and 2019, respectively. Maritime transportation to and from Gozo represents between 14,3% and 18,7% (2019 and 2020, respectively) of the energy consumption and 13,0% to 17,2% of the CO_2 emissions in 2017 and 2020.

In summary, transport systems (land and maritime) in Gozo are responsible for 60% to 70% of the total energy consumption. In this context, it is advisable for the island to focus on Gozo's mobility and to develop plans for the decarbonisation of maritime and road transport. Some good examples are available here.

Electricity consumption contribution ranges from 23,5% in 2019 and 30,7% in 2020 of the total energy consumption and 29,4% and 47,2% of the total CO_2 emissions in 2019 and 2016, respectively. According to the European Energy Agency, Malta is the eighth member state in the highest greenhouse gas emission intensity of electricity generation. Therefore, encouraging the use of renewable energies will be very important to reduce greenhouse gas emissions in Gozo.

Finally, heating and cooling represents 7,0% to 9,8% of the total energy consumption and 6,1% to 7,9% of the CO_2 emissions.

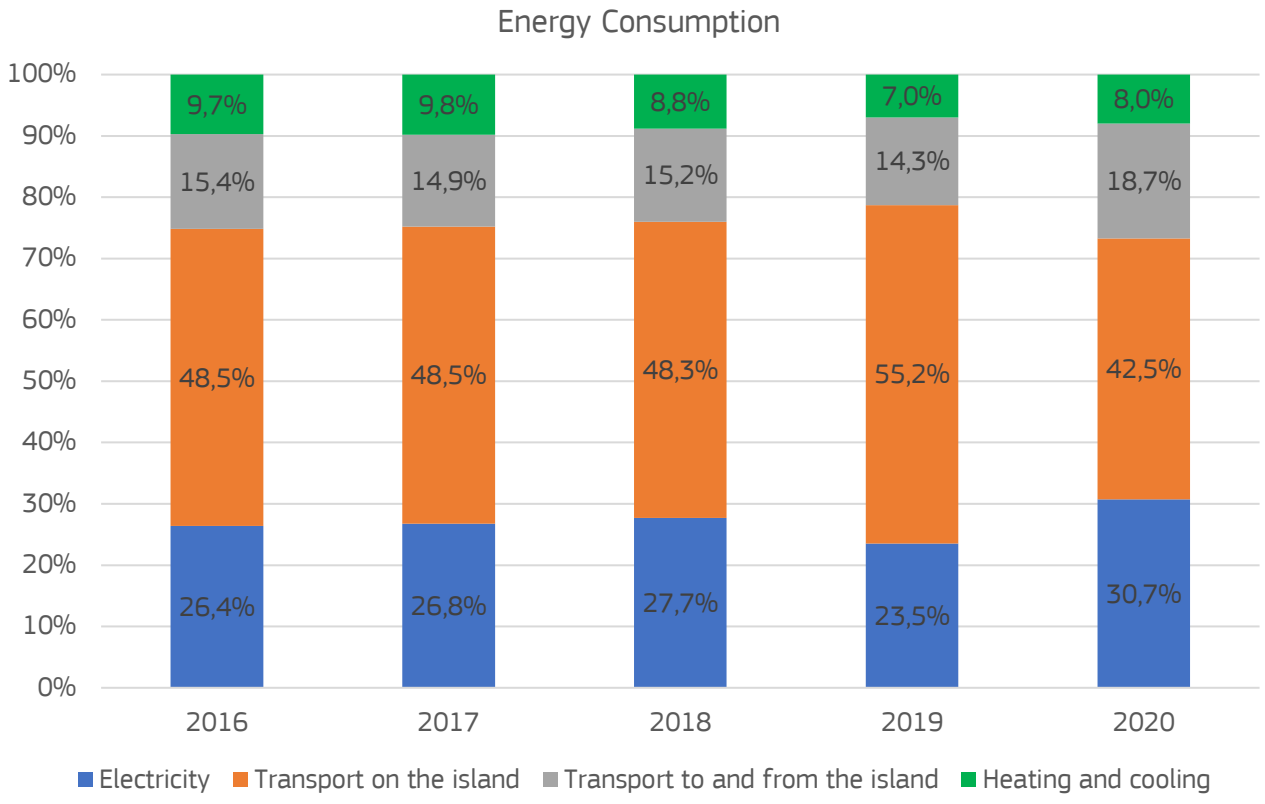


Figure 11 - Yearly contribution of the different sectors in the total energy consumption.

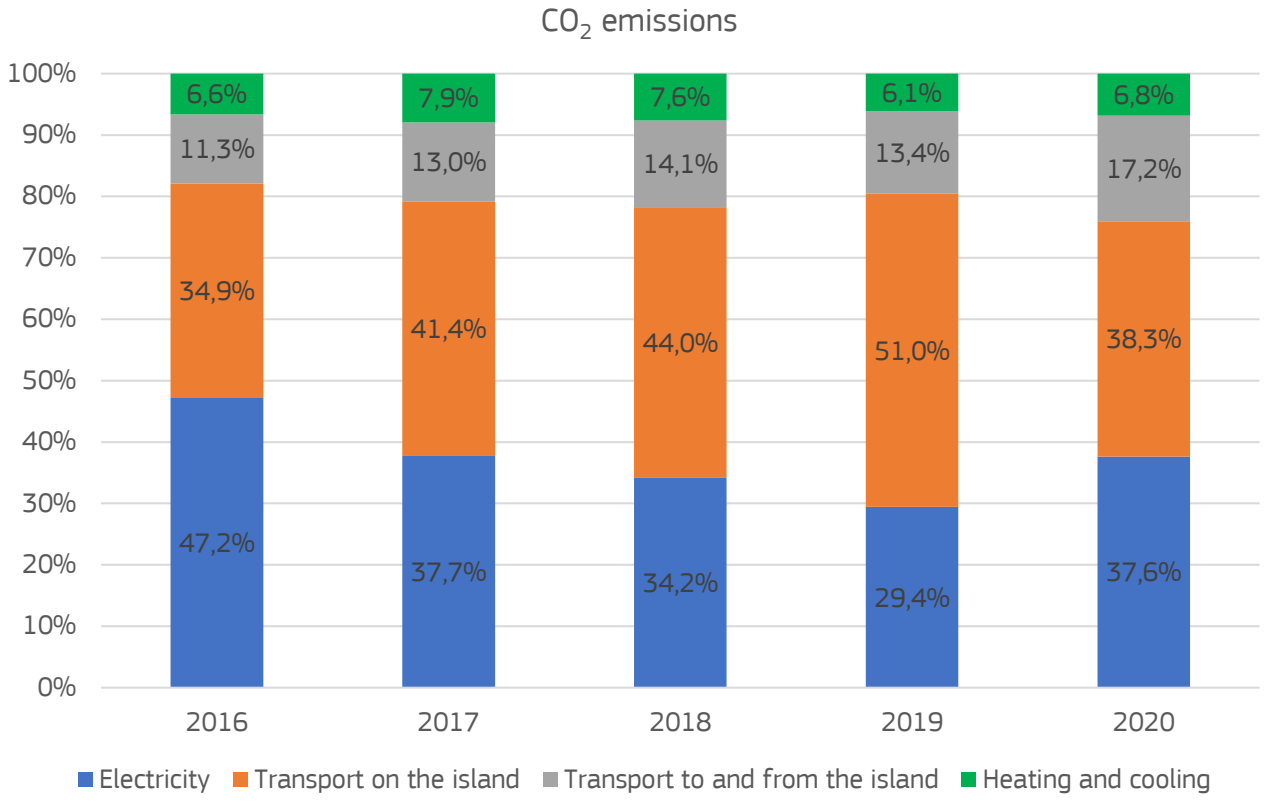


Figure 12 - Yearly contribution of the different sectors in the total CO_2 emissions.

Recommendations for improved monitoring

This report presents a first baseline of energy consumption in Gozo. The data provided for its implementation are official data from public institutions and therefore should always be considered in the future. However, in order to get accurate calculations in the upcoming years, this section intends to give some recommendations for improved and efficient monitoring.

General

The first recommendation is to verify, with the different institutions providing data, that the methodology for the different calculations/estimations has not changed from one year to the next. This is the most important general recommendation since different methodologies will lead to different results, making it impossible to compare different years.

This comment must have already been considered in the results presented in this report, since there is no obvious explanation for the peak in km travelled by road transports in 2019. In this case, there may have been a different approach to the estimations.

Electricity

In this report, electricity was analysed from a final energy consumption viewpoint, since Gozo receives the required electricity from Malta, which in turn is interconnected with Italy. From this approach, a conversion factor (from kWh consumed to kg CO_2) was adopted considering Malta's energy mix.

However, another approach could also be added to the analysis, which is the total energy produced per technology per year, that reaches Gozo via the submarine cables. For the technology that requires fuel, such as the energy produced at Delimara Power Station, the annual fuel consumption must be estimated, i.e., the primary energy consumption[14] of the electricity that reaches Gozo.

Transport on the island

In order to be more accurate on the Gozo's road transportation, the recommendations are the following:

- The number of vehicles per type is available in Gozo, however the number of vehicles per fuel type is only available at the country level. For a more accurate calculation, this value must be properly estimated.
- Make sure the data is consistent throughout the years. For example:
  - In 2016, the only input data available is the number of vehicles per type in the island. All the rest need to be estimated.
  - For 2017 and 2018, the total number of kilometres travelled per vehicle type is available together with the total vehicles per type. As a result, it was possible to calculate the mileage per car per year on the island. However, for 2019 and 2020 the total number of kilometres travelled per vehicle type was only available at the country level.
- Consider agriculture vehicles in the calculations. For that, it is need data about the mileage per vehicle per year and estimated fuel consumptions.

[14] Renewable energies do not consume primary energy in the electricity generation process.

- For goods-carrying vehicle, NSO divides it into light goods-carrying vehicle (gross vehicle weight of not more than 3,500 kg designed) and heavy goods-carrying vehicle (gross vehicle weight above 3,500 kg). However, in the annual reports only the total number of good-carrying vehicles is specified, not differentiating the number of light and heavy vehicles. Since they have very different fuel consumptions, specifying the number of light and heavy vehicles in Gozo would be essential for better results accuracy.

Transport to and from the island

Regarding maritime transportation, for the ferries operating between Mġarr (Gozo) and Ċirkewwa (Malta), Gozo Channel Co. Ltd provided the data of the total fuel consumption per year, so the calculations are very accurate. The main recommendations for the improvements are:

- For the fast ferries, operating between Valleta – Mġarr, although they are out of this reporting period, it was not possible to know the fuel consumption per trip or per year, therefore, in the future, this data is crucial to accurately estimate the energy consumption and corresponding CO_2 emissions of these two vessels.
- Analyse the impact of the leisure boats, by estimating how many leisure boats travel around the island. On this, data from the marinas in Gozo and Malta may be useful to estimate the impact.

Heating and cooling

The main recommendation for improvements on heating and cooling calculations is the access to data or estimations on gasoil, fuel oil and diesel consumption in Gozo, as the data provided for LPG. Assuming Gozo consumption through national data can lead to an important uncertainty.