

**Comprehensive Assessment of the potential for efficient heating and cooling, including the overall final and useful energy used for heating and cooling purposes, in the Maltese Islands.**



MINISTRY FOR ENERGY, ENTERPRISE  
AND SUSTAINABLE DEVELOPMENT

This report was drawn up in line with the requirements of Article 14(1) and 14(3) of Directive 2012/27/EU on Energy Efficiency.

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## List of Abbreviations

AC	Air-conditioning
ARMS	Automated Revenue Management Systems
BM	Benchmark Scenario
B/C Ratio	Benefit Cost Ratio
CDD	Cooling Degree Days
CIF	Cost Insurance and Freight
COP	Coefficient of Performance
CPI	Consumer Price Index
DCF	Discounted Cash Flow
EER	Energy Efficiency Ratio
EIB	European Investment Bank
ENPV	Economic Net Present Value
ETS	Emissions Trading System
ERR	Economic Rate of Return
EWA	Energy and Water Agency
FDR	Financial Discount Rate
FNPV	Financial Net Present Value
FRR	Financial Rate of Return
GDP	Gross Domestic Product
GWh	Giga Watt-hour
GWh/a	Giga Watt-hour per annum
HDD	Heating Degree Days
HH	Heat Pumps
HVAC	Heating, Ventilation and Air-conditioning
ICT	Information and Communications Technology
KWh	Kilo Watt-hour
LPG	Liquified Petroleum Gas
MTA	Malta Tourism Authority
NSO	National Statistic Office
NPV	Net Present Value
OPH	Old People's Homes
O&M	Operating and Maintenance
REWS	Regulator for Energy and Water Services
R&I	Research and Innovation
RPI	Retail Price Index
SC	Space Cooling
SH	Solar Heating
SWH	Solar Water Heating
W	Watts
WEM	With Existing Measures

## Executive Summary

This report presents a Comprehensive Assessment of the potential for efficient heating and cooling, including the overall final and useful energy used for heating and cooling purposes, in the Maltese Islands. This analysis was based on the guidelines and methodology as indicated in the *Commission Delegated Regulation 2019/826 of 4 March 2019 amending Annexes VIII and IX to Energy Efficiency Directive 2012/27/EU of the European Parliament and of the Council on the contents of comprehensive assessments of the potential for efficient heating and cooling*. This study serves as an update to the 2015 report titled 'Analysis for A Cost-Effective and Efficient Heating and Cooling' submitted in accordance with Article 14 of the Energy Efficiency Directive 2012/27/EU.

The report is divided into four main parts as explained hereunder:

**Part 1** is an overview of heating and cooling in Malta for both the final and useful energy. This analysis was based on 2018 data, which was taken as a base year for the purposes of this study. This is applicable across the board for all the sectors included in the analysis, that is, the residential sector, the services sector and the industrial sector. The relevant data was extracted from real measured and verified consumption information and identifies the energy sources and technologies used to satisfy the demand. This part of the report also includes a high-level forecast of demand for heating and cooling for the next 30 years, taking into consideration the current applicable policy initiatives and measures. Finally, this section also includes maps covering the Maltese national territory showing energy dense areas as well as supply points based on the results obtained in the first part of this section.

**Part 2** reports on the current objectives, strategies and policy measures applicable in the field of heating and cooling in the Maltese Islands. These mainly stem from Malta's National Energy and Climate Plan published in 2019, with particular emphasis to the energy efficiency and decarbonization dimension.

The analysis undertaken in **Part 3** is based on results obtained from Part 1 of this study. This section now includes an analysis of the technical, financial and economic potential for efficiency in heating and cooling, through the identification of technologies suitable for supplying low-carbon and energy efficient heat and cold energy on the national territory, using a Cost-Benefit analysis. Through this study, the maximum potential of different technologies was analysed in order to identify those which are technically feasible for local climatic conditions and resources. For the economic analysis, a baseline and several alternative scenarios were considered while taking into account external costs.

Building on the conclusions of Part 3 of the said report, **Part 4** identifies those technical solutions whose financial and economic potential gave positive results in the Cost-Benefit analysis carried out. These mainly included the following:

- Replacing electrical water heating and LPG water heating with heat pumps in the residential sector;
- Replacing fuel-fired boilers for water heating purposes with electric heat pumps in the services sector, primarily in the hotels sub-sector;

- Using highly efficient condensing boilers rather than standard boilers in the services sector, again focusing mainly on the hotels sub-sector;
- The addition of a heat recovery system on both water-cooled and air-cooled chillers used for space cooling purposes, to provide free energy which can be used for water heating purposes in the hotels sub-sector.

Moreover, this part of the report includes proposals for additional and future policy measures in heating and cooling that may be adopted at a national level in order to facilitate the implementation of cost-efficient solutions to satisfy heating and cooling needs using more sustainable methods, and other measures aimed at reducing heating and cooling demand.

The main and overall target of this analysis is to investigate the characteristics of the heating and cooling demand in Malta and how it is expected to develop in the coming years. On the basis of this analysis, Malta will be in a better position to make a correct assessment vis-a-vis the best technological proposals to increase energy efficiency and decarbonisation in the heating and cooling sector in the Maltese islands.

For the purposes of this study, the residential sector, the services sector and the industry sector. The consumption data for each sector was broken down according to the source being electrical, fuel and other. This actual consumption data was later used to carry out projections for heating and cooling demands, taking into account current and future policies, technology evolution and substitution rates in line with methodologies established in Malta's National Energy and Climate Plan.

The tables below show a summary of the final and useful heating and cooling energy for the three sectors under study for 2018 reflecting a summary of conclusions from Part 1:

*Final Energy Consumption for the three sectors in 2018*

FINAL ENERGY	Sector	Space Cooling	Space heating	Water Heating	Total
		GWh/a	GWh/a	GWh/a	GWh/a
	Residential	138.59	231.70	274.24	644.54
	Services	393.20	299.58	141.61	834.39
	Industry	120.43	10.95	10.43	141.81
	<b>Total</b>	<b>652.22</b>	<b>542.23</b>	<b>426.29</b>	<b>1620.74</b>

*Useful Energy Demand for the three sectors in 2018*

USEFUL ENERGY	Sector	Space Cooling	Space heating	Water Heating	Total
		GWh/a	GWh/a	GWh/a	GWh/a
	Residential	376.52	191.76	222.83	791.11
	Services	1064.18	637.37	116.58	1818.13
	Industry	322.20	9.30	8.87	340.37
	<b>Total</b>	<b>1762.90</b>	<b>838.43</b>	<b>348.28</b>	<b>2949.61</b>

As can be seen from the tables above, it results that for the base year 2018 the final energy consumption for heating and cooling purposes (defined as the energy supplied to the final consumer) was 1621 GWh, of which the services sector uses 834 GWh for heating and cooling purposes. The sector which is the second highest consumer of energy for heating and cooling purposes is the residential sector with a consumption of 645 GWh while the industry sector is the least consuming sector with 142 GWh. It is worth noting that the highest end use in the residential sector is water heating, while space heating is the highest consuming use in the services sector. Similarly, the space and process cooling are the highest consumer use in the industry sector, with the space and water heating consumption considered negligible when compared to the cooling requirement. It is clear that the hot and dry summer days in the Maltese island are the main reason for high consumption for cooling purposes especially in the services sector. The latter includes the commercial sub-sector which is considered the highest consumer from all sub-sectors in the services sector.

In general, the local climatic conditions require a much higher summer cooling demand than the wintery heating energy requirements. This cooling demand is currently almost entirely supplied by very efficient heat-pumps particularly in the residential and services sectors. Based on detailed analysis into current spatial heating technologies, it is being highly recommended that the use of high energy efficiency heat pump technologies also be used for space heating, particularly in the residential sector. Similarly, the use of heat pumps for water heating, both in the residential and services sector could further be promoted as high efficient alternatives to the existing technologies.

It is important to note that the total final energy consumption for heating and cooling purposes in 2013 was estimated at 685 GWh<sup>1</sup> whilst the 2018 energy consumption is 1621 GWh. This can be attributed to the very high economic growth experienced in Malta between 2013 and 2018, amounting to an average annual growth of 7.1%<sup>2</sup>, significantly surpassing averages recorded in the past two decades.

From the Cost-Benefit analysis carried out for the scenario of **replacing electrical water heating with heat pumps** in the **residential sector**, the results show a positive ENPV, thus showing that it is economically feasible to install such systems for a household. Nonetheless, despite the positive FNPV, the payback period for such a system is still very high, mainly due to the significant initial capital investment required when compared to a conventional electrical water heater. It is for this reason that it is being recommended that the current governmental scheme being offered for heat pump water heaters is increased. This is deemed necessary to incentivize the general public invest in heat pump systems rather than in electrical water heating.

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<sup>1</sup> An Energy Roadmap- Towards Achieving Decarbonization for the Maltese Islands – Analysis for a Cost-Effective and Efficient Heating and Cooling report delivered to the Commission in accordance with Article 14(1) of Directive 2012/27/EU, 2015.

<sup>2</sup> Article by the Malta Independent, published on the 9<sup>th</sup> March 2019 and named: Malta continues to be one of the fastest growing economies in the EU, covering a speech by the Ministry of Finance, retrieved from <https://www.independent.com.mt/articles/2019-03-09/local-news/Malta-continues-to-be-one-of-the-fastest-growing-economies-in-the-EU-Scicluna-6736204763>



On a similar note, for the **services sector**, mainly the hotels sub-sector which have a significantly high consumption for water heating, a scenario for **changing boilers with electric heat pumps** was analysed through a Cost Benefit Analysis. This resulted in positive FNPV and ENPV values, again making this a feasible change in technology for this sub-sector. In this case, the payback period is relatively reasonable for hotel owners to consider such a change. Based on this, the Investment Aid scheme offered jointly by Malta Enterprise and the Energy and Water Agency is considered to be adequate. It is strongly recommended that more efforts should be made to create more awareness about this already existing scheme to the applicable beneficiaries.

The Cost-Benefit analysis also includes another scenario, that is, that of **replacing standard boilers with highly efficient condensing boilers** in the **services sector**. The conclusion of this scenario shows a positive result from an economic and financial point of view, with good payback period. The current Investment Aid scheme can also be used for this scenario.

Another technology change which was considered in the Cost-Benefit analysis is the **introduction of heat recovery systems on both air and water cooled chillers** in the hotels sub-sector (**services sector**). Such technologies are deemed to be financially and economically feasible, with a low payback period. This is mainly due to the relatively low investment cost for the addition of a heat exchanger with a new chiller, when compared to the cost of the same new chiller without a heat recovery. Again, in this case, the current Investment Aid scheme can be utilized to cover this scenario.

With regards to the **industry sector**, due to its small size and extremely diverse nature in Malta, and the resulting relatively small energy consumption of this sector, it has been concluded that a 'one-size-fits-all' approach cannot be adopted for heating and cooling measures for this sector. Therefore, rather than developing policies specifically targeting the whole industry sector, emphasis should be made on specific individual energy audits which serve to identify particular and specific energy saving measures related to the type of industry concerned. Moreover, this report concludes that the existing low thermal loads and heat demands in the industry sector do not make district heating and cooling solutions feasible in Malta. Co-generation units are not being proposed as recommended technologies for the industry sector, particularly in view of the lack of a natural gas grid and spatial restrictions required for LPG storage and safety of use of equipment. Taking all the aforementioned restrictions into consideration, finding solutions to improve efficiency in heating and cooling or to achieve long-term decarbonisation within this sector might require innovative solutions.

## Introduction

Malta comprises an archipelago of five islands; the island of Malta being the largest, followed by Gozo, Comino, Cominotto and Filfla. The latter two are uninhabited islets. The Maltese Islands are situated in the central Mediterranean Sea, with a total land area of 316 km<sup>2</sup>, just 93 km south of Sicily and 290 km north of Libya, with Gibraltar being 1826 km to the west and Alexandria 1510 km to the east.

The climate of the Maltese Islands is a Mediterranean one, characterized by hot, dry summers and cool winters, with an annual average rainfall of nearly 476 mm. Temperatures are stable, the annual mean being 18°C and monthly averages ranging from 12°C to about 31°C between winter and the summer months<sup>3</sup>.

During the period between 2011 and 2017 Malta's population increased every year with an overall growth of 56,835 inhabitants<sup>4</sup> and it now has the highest population density in Europe, although it is still the smallest EU Member State by population. In 2014 almost 94% of the resident population was constituted of Maltese citizens but in the last years Malta has experienced net immigration. Life expectancy in the Maltese Islands is continuing to increase and reached 82.1 years in 2014 (79.8 years for men and 84.3 years for women).

The Maltese economy has progressed over the years from one harnessed to the needs of the British colonial administration up to the mid-1960s, to a market-driven economy with an emphasis on higher value added economic activities in services, notably financial services and tourism. Challenges to the Islands' economy are the relatively small domestic market and the disadvantages brought about by insularity. Major assets are a pleasant and attractive climate, and a qualified and skilled labour force. Although small, Malta's economy is highly diversified and exposed to international market forces. Economic development relies heavily on the generation of local investment resources and foreign direct investment. The economy is dependent on manufacturing, tourism and key service sectors including financial, business, information technology (IT) and remote gaming.

The Maltese economy weathered the financial and economic crisis successfully and has experienced marked growth rates over the past years.

In 2018 the Maltese economy grew by 6.8% in volume terms. In terms of current prices, Gross Domestic Product (GDP) for this year was estimated at €12.3 billion<sup>5</sup>. Malta's thriving economy is based primarily on tourism and financial services and immigration has become an important phenomenon which is changing the traditional cultural context. Malta is changing from a mono-ethnic population around fifteen years ago to a more diverse, multi-ethnic society.

The current developments in the Maltese social, economic and demographic contexts in Malta in recent years has undoubtedly had an impact on the energy demands of the Maltese Islands. From a European Union perspective, Malta's National Energy and Climate Plan (NECP) sets out Malta's national objectives

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<sup>3</sup> Working and living in Malta:2018, retrieved from [https://www.trademalta.org/wp-content/uploads/pdfs/106\\_doc%20\(1\).pdf](https://www.trademalta.org/wp-content/uploads/pdfs/106_doc%20(1).pdf)

<sup>4</sup> Regional Statistics Malta: 2019, by NSO

<sup>5</sup> Key Figures for Malta, Visual and Words: 2019 Edition by NSO

and contributions for 2030 in five dimensions, namely: decarbonisation, energy efficiency, energy security, internal energy market and research, innovation and competitiveness. This is complemented projections until 2040 under two main scenarios: 'With Existing Measures' and 'With Planned Measures'. Thus, this document serves as reference framework and policy document guiding Malta's contribution toward the achievement of the Energy Union's 2030 objectives and targets, with the clear milestones of the measures necessary for the said achievements up to 2030, with a further outlook until 2040.

The EU Energy Efficiency Directive 2012/27/EU establishes a common framework of measures for the promotion of energy efficiency within the EU in order to ensure the achievement of the EU's 2020 energy efficiency targets. In line with its obligations as part of the European Union under the said directive, Malta needs to submit a comprehensive assessment of the potential for the application of high-efficiency cogeneration and efficient district heating and cooling, as indicated in Article 14 of the said directive. The first comprehensive assessment was submitted to the EU Commission in 2015, and this report is the required update to be submitted to the EU Commission in 2020.

## Part I – Overview of Heating and Cooling

The aim of Part I is to give an overview of the heating and cooling scenario in Malta, with a comprehensive assessment of the following:

- the amount of useful energy and quantification of final energy consumption in GWh per year for the residential, industrial and services sectors, respectively;
- the estimated and identified current heating and cooling supply to sectors of final consumption in GWh per year for the residential, industrial and services sectors, respectively;
- a forecast of demand for heating and cooling for the next 30 years in GWh for the residential, industrial and services sectors, respectively;
- the shares of energy from renewable energy sources from waste heat over the past five years; and
- a map covering the entire Maltese territory that presents the heating and cooling demands covering all sectors.

It should be noted that for the purpose of this assessment the year 2018 is being used as the reference year for all consumption data and the base year for all calculations. Where other ancillary information was needed, this assessment takes into consideration the nearest data available to the year 2018. In cases where direct data was not available, indirectly derived data was used with the necessary assumptions and methodologies which have been formulated specifically for the objectives of this task.

This assessment has been carried out at a national level according to different sectors, that is:

- the Residential sector;
- the Services sector which is further sub-divided into several sub-sectors; and
- the Industry sector.

No other sector, including the agricultural sector, have been taken into consideration for the purpose of this study since none of them consume more than 5% of the total national useful heating and cooling demand.

The assessment carried out for each sector starts off by an evaluation of the real measured and verified consumption data of electricity and fuel used in the Maltese islands. This data was further analysed in order to determine the consumption related to space heating, space cooling and hot water generation per sector. This exercise also identifies the energy sources and technologies generally employed to cover these energy demands.

## 1.1 Heating and Cooling Demand

### 1.1.1 Residential Sector

The number of households in the Maltese Islands has increased in a dramatic way since 2010, reaching a total of 187,749<sup>6</sup> households in 2018. On average, each household is calculated to have an occupancy rate of 2.7 members<sup>7</sup>. A total of 93% of the said households are registered in Malta, whereas the remaining 7% are registered in Gozo and Comino. Being the most densely populated districts, the Northern Harbour and Southern Harbour areas account for 50.1% of the total households in Malta<sup>8</sup>.

Figure 1 below shows the number of registered households in Malta over a period between 2010 and 2018.

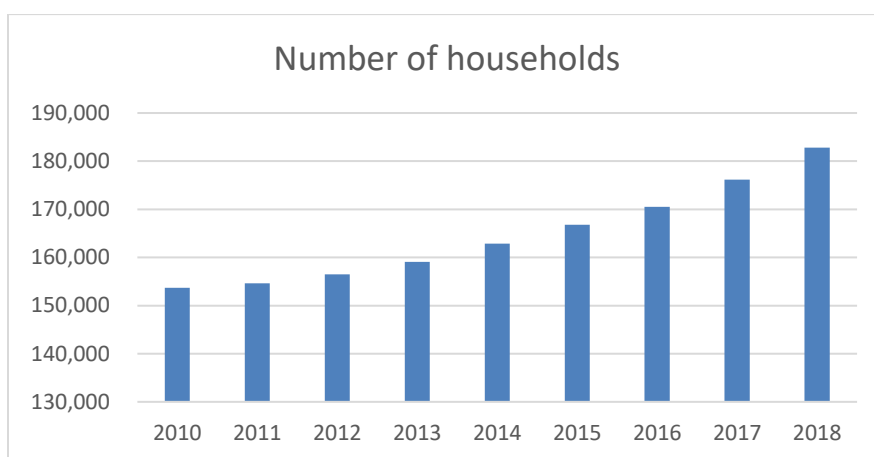


Figure 1 – Number of households in Malta between 2010 and 2018. Source: EWA

By way of background, Maltese households typically use energy namely for generation of hot water and space heating in the winter months, space cooling in the summer months, and lighting and electrical appliances and cooking throughout the whole year. Most of the energy demands for households related to water heating, space cooling and lighting are covered by electricity. On the other hand, LPG, which is considered as the fossil fuel most commonly used in the residential sector, also plays an essential role in terms of space and water heating as well as cooking. Hence for the residential sector the energy provided by electricity and LPG shall be considered for the purposes of this assessment.

The main sources of data about energy consumption for the residential sector in the Maltese islands between 2010 and 2018 have been obtained from the below entities:

<sup>6</sup>

[https://nso.gov.mt/en/News\\_Releases/View\\_by\\_Unit/Unit\\_C1/Living\\_Conditions\\_and\\_Culture\\_Statistics/Documents/2019/News2019\\_143.pdf](https://nso.gov.mt/en/News_Releases/View_by_Unit/Unit_C1/Living_Conditions_and_Culture_Statistics/Documents/2019/News2019_143.pdf)

<sup>7</sup> Data provided by EWA.

<sup>8</sup> Regional Statistics in Malta, 2020 edition, NSO;

[https://nso.gov.mt/en/publicatons/Publications\\_by\\_Unit/Documents/02\\_Regional\\_Statistics\\_\(Gozo\\_Office\)/2020/Regional\\_Statistics\\_Malta-2020%20Edition.pdf](https://nso.gov.mt/en/publicatons/Publications_by_Unit/Documents/02_Regional_Statistics_(Gozo_Office)/2020/Regional_Statistics_Malta-2020%20Edition.pdf).

- Enemalta Ltd., which has provided the monthly energy consumption;
- Regulator for Energy and Water Services (REWS), which has provided the number of solar water heaters installed in the residential sector;
- Energy and Water Agency (EWA), which has provided the household survey done in collaboration with the National Statistics Office (NSO), including the number of households.

### 1.1.1.1 Electrical Consumption for Residential Sector

The total yearly electricity consumption in the residential sector for the base year of 2018, obtained from the Enemalta Ltd. billing data, is indicated in Table 1 below.

*Table 1 – Electrical Consumption for 2018 in GWh*

	<b>2018</b>
January	66.38
February	59.54
March	61.99
April	55.58
May	56.6
June	59.91
July	69.88
August	73.76
September	65.93
October	60.67
November	58.18
December	67.29
<b>Total [GWh/a]</b>	<b>755.71</b>

The total electricity consumption for the residential sector in 2018 was 756 GWh. The gradual increase in electrical consumption over the last five years, as can be seen in Figure 2 below, is noteworthy, with an increase of 25% in the past 5 years.

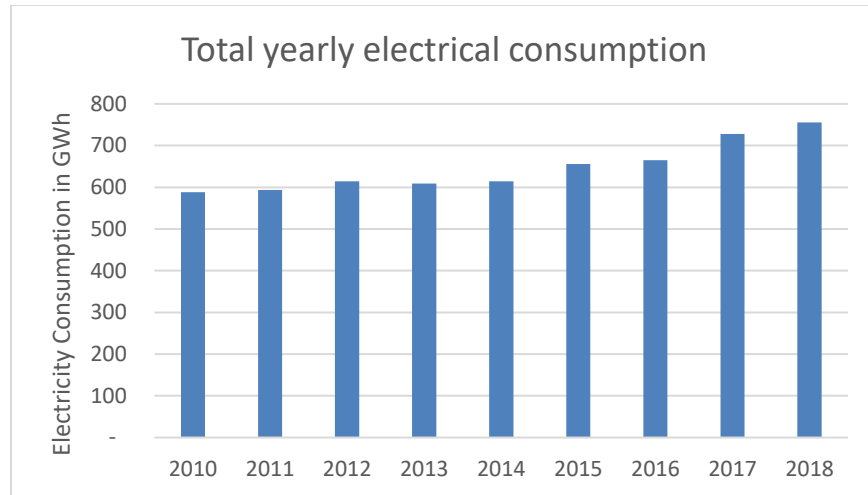


Figure 2 – Electrical Consumption between 2010 and 2018 in the Residential Sector, data provided by EWA

For this assessment, the above data showing the yearly electrical consumption for the residential sector has been further segregated to show the monthly electrical consumption of Maltese households. This is important to showcase the seasonality of the electrical consumption in Malta, mainly dependant on Malta's weather conditions. The figure below immediately shows the spike in energy consumption in the summer months, particularly in August, when the energy for cooling demand is at its peak.

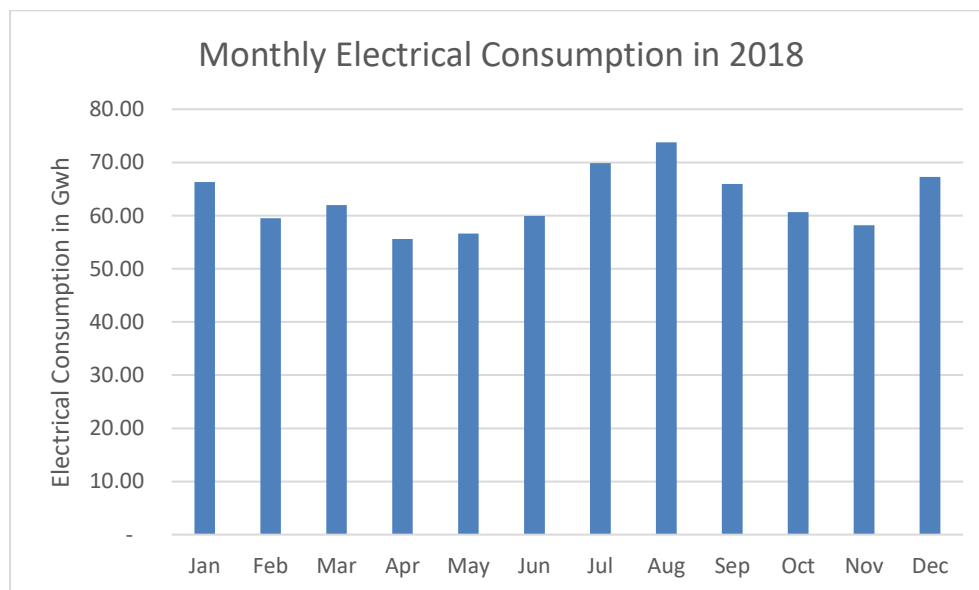


Figure 3 – Monthly Electrical Consumption for the Residential Sector in 2018, data provided by EWA.

As already indicated above, electricity consumption in households is mainly divided into water heating, space heating, space cooling, energy for appliances and lighting. An analysis of the electricity consumption for the aforementioned uses was carried out by using the following methodology. The monthly Enemalta electrical energy in kWh for 2018 (Figure 3) was split into daily consumption per household by dividing the number of days per month. The daily thermal demand for domestic water heating was calculated by obtaining the difference in average monthly temperatures and water outlet temperature, using an

assumption of 30 litres of hot water per day per person<sup>9</sup> together with an occupancy rate of 2.7 per household.

Given that solar water heaters are generally used for domestic water heating, it is being assumed that all the solar water heaters installed in Malta are used for domestic or residential purposes. Thus, the generation from installed solar water heaters was estimated by using average monthly temperatures as an indication of the monthly solar water heating performance.

The remaining portion of the daily thermal requirement for domestic water heating for an average household with solar water heaters installed is assumed to be met by an electric boiler with an efficiency of 0.9. Hence, using the above method, the electrical units for domestic water heating for an average household was calculated, from which the solar water heating portion was removed and the remaining domestic water heating consumption was then reduced from the energy consumption billed.

The above calculation thus gives rise to the results indicated in the table below (Table 1Table 2) for the monthly hot water generation by electricity means for residential households.

*Table 2 – Daily hot water generation per household between January and December 2018*

<b>DWH kWh/day – excl. SWH</b>	<b>2018</b>
Jan	3.96
Feb	4.10
Mar	3.83
Apr	3.55
May	3.23
Jun	2.73
Jul	2.31
Aug	2.32
Sep	2.49
Oct	3.01
Nov	3.40
Dec	3.91
<b>Total yearly (kWh) per household</b>	<b>1180.19</b>

Moreover, the hot water demand by Maltese households according to whether such demand is covered from solar water heaters or electrical heaters is shown in Figure 4 below. Such data shows the overarching use of electrical water heating, when compared to solar water heating in households. This is a result of the building scenario in the Maltese islands, with the ever-increasing trend of households living in apartments rather than terraced houses, which poses a problem for the installation of solar water heaters on roofs. Noteworthy is also the fact that the demand for water heating is much less during the summer months.

<sup>9</sup> Assumption of 30 litres of hot water per day per person as recommended by EWA.



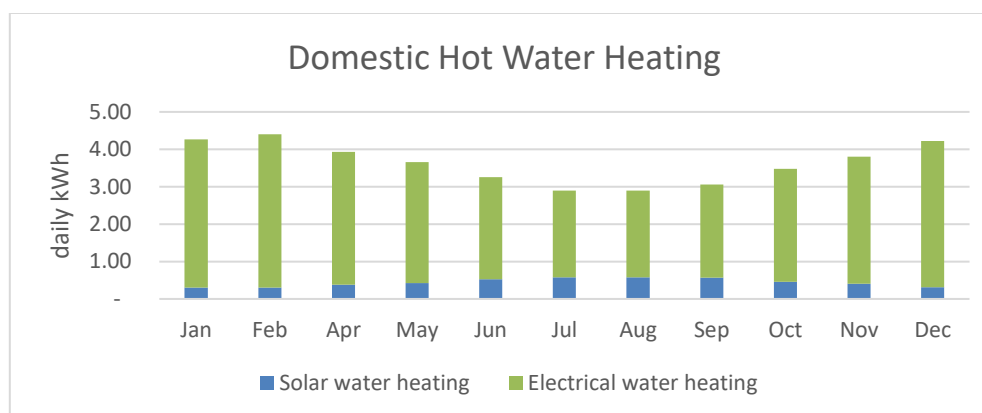


Figure 4 – Solar water heating compared with electrical water heating

The baseload, that is, the electrical energy consumption for appliances and lighting, was calculated based on the penetration rate of appliances from the POTEnCIA model Central Scenario,<sup>10</sup> calibrated with the EWA household survey carried out by the EWA together with NSO in 2017 and 2018. This was found to be 1,712kWh per year per household, amounting to 4.69 kWh per day per household. This amount was then removed from billed electrical units and the remaining electrical consumption was attributed to space heating and cooling as indicated in Table 3 below:

Table 3 -Electrical energy consumption for space heating and cooling in 2018

<i>Space heating/cooling in 2018</i>	<i>kWh/month/HH</i>
Jan	94.29
Feb	79.36
Mar	74.75
Apr	56.60
May	63.92
Jun	104.96
Jul	165.09
Aug	186.06
Sep	145.13
Oct	93.01
Nov	75.42
Dec	101.33
<b>TOTAL Annual Space Heating per household [kWh/year/HH]</b>	
	<b>481.76</b>
<b>TOTAL Annual Space cooling per household [kWh/year/HH]</b>	
	<b>758.16</b>

The average daily units that remained following the removal of the domestic water heating and baseload units were attributed to space heating and cooling, depending on the month, that is between November

<sup>10</sup> POTEnCIA model Central Scenario, JRC Science for Policy Report, 2019 - <https://ec.europa.eu/jrc/en/potencia>

and April it is assumed that energy was used for space heating whilst between May and October energy is assumed to be used for space cooling.

Figure 1 below depicts the above-mentioned analysis showing the annual electrical energy consumption by end use by households between 2010 and 2018.

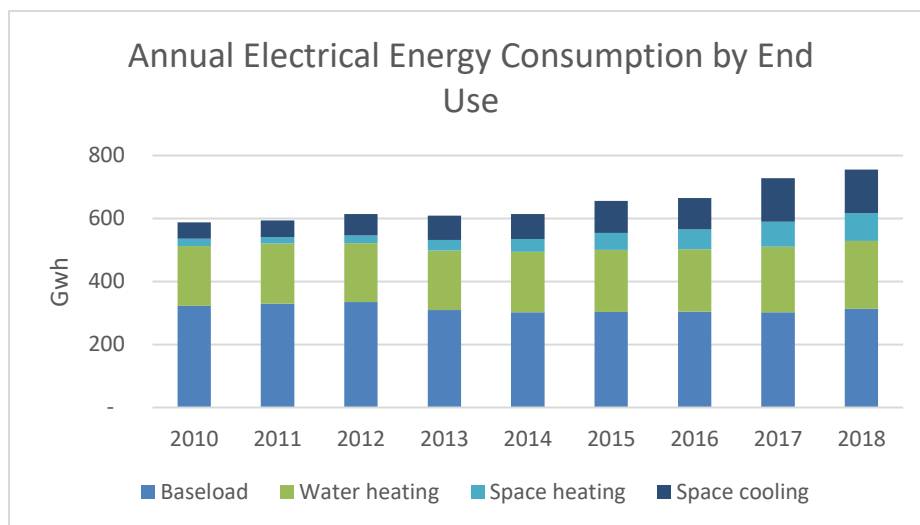


Figure 5 – Residential Annual Electrical Energy Consumption split by end use per household

The electrical consumption estimated for space cooling was then focused within the number of households that have a heat-pump, based on the assumption that only those who have a reversible heat-pump would have additional units on their bill between the months of May and October. This resulted in the annual kWh for space cooling through heat-pumps, as can be seen in Figure 6 below.

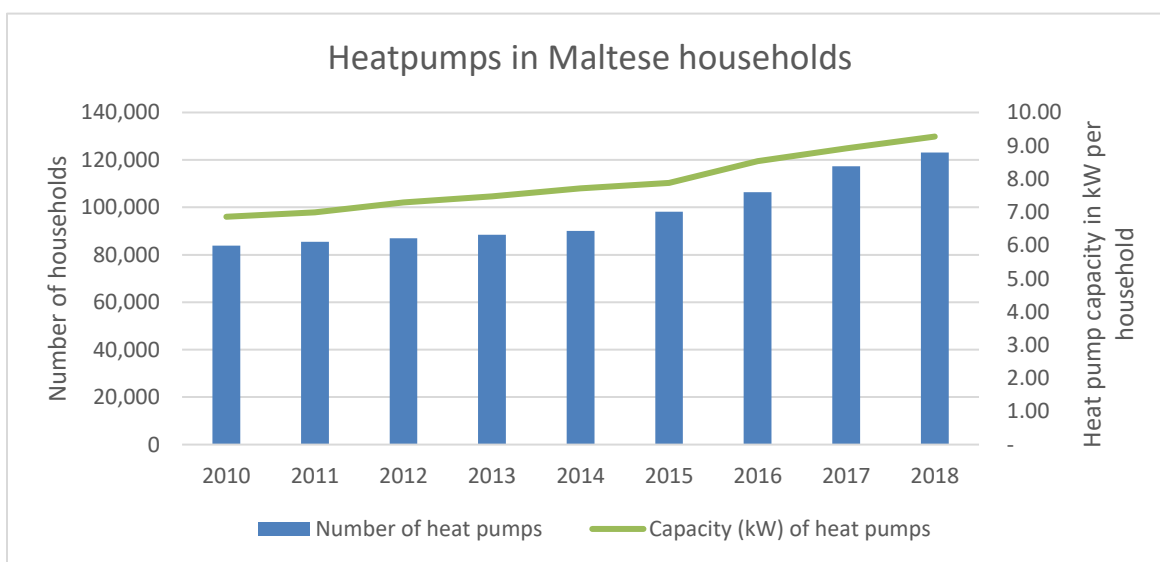


Figure 6 – Number of households in the Maltese Islands with heat pumps, data from EWA.

The electricity used for space heating could be attributed to electrical resistance heaters or heat-pumps. It was important to distinguish between the two, in order to calculate the thermal demand of an average household and understand the frequency of use of a conventional space heater. The number of households using a heat-pump for heating purposes was calculated on the basis of the EWA/NSO household survey carried out in 2017 and 2018, and back-casted for previous years based on trends. These households were assumed to use a heat-pump for heating to the same extent as for cooling, although to a slightly lesser extent given the lower number of heating degree days (HDD) to cooling degree days (CDD) in Malta. The number of full load hours on heat-pumps in households using heat-pumps for space heating was thus calculated based on the proportion between HDD and CDD. This provided the total estimated electrical consumption from heat-pumps, whilst the remaining portion was allocated to conventional space heaters, as can be seen in Table 4 below.

*Table 4 – Space cooling and heating by existing heat pumps in the residential sector*

<b>Space cooling</b>	
No. HH with heat-pumps	123,108
Capacity for SC (GW)	1.14
Capacity per household	9.27
Avg. capacity/unit	4.60
kWh/yr/HH w. HP	1,126
Cooling hours/HH	324
<b>Space heating</b>	
<b>Advanced space heating</b>	
Households w. HP for SH	42,289
Capacity for SH (GW)	0.39
Estimated. HP consumption for SH (GWh)	23
SH with HP – kWh/HH	551
Heating hours/HH	159
EWA CDD	859
EWA HDD	420
<b>Conventional space heating</b>	
Conventional SH – GWh	64.76
Conventional SH – kWh/HH	354.29

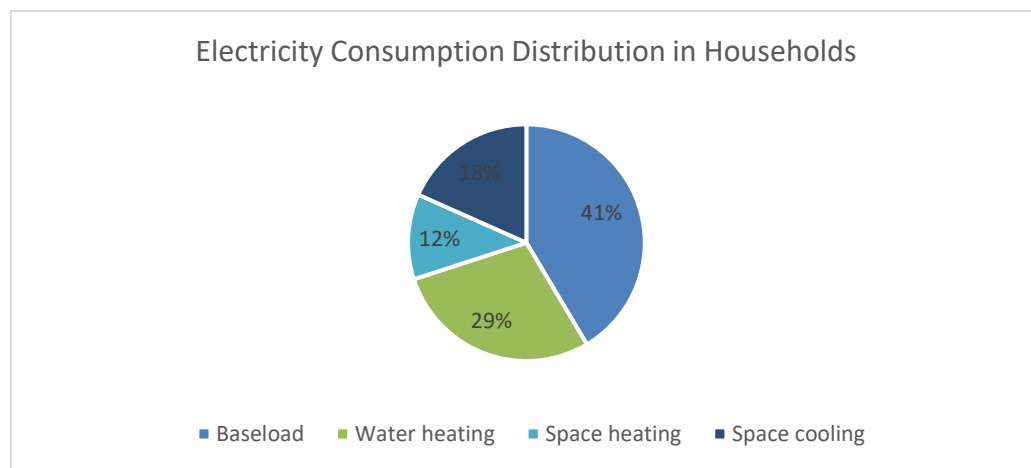
The historical heating and cooling hours were then “normalised” to an average-year HDD and CDD respectively, using basic proportion, to observe trends in heating and cooling behaviour.

Table 5 below shows a summary of end-use by Maltese household for the base year 2018 representing the final electrical energy consumption for the residential sector.

*Table 5 – Summary of electrical energy by end-use for 2018 in GWh*

<b>End-Use</b>	<b>GWh/a</b>
Baseload	313
Water heating	216
Space heating	88
Space cooling	139
<b>Total</b>	<b>756</b>

As can be seen from the Figure 7 below, one can note that the baseload has the largest percentage of energy demand by electricity means in the Maltese households. This is followed by the generation of hot water and space cooling.



*Figure 7 – Distribution by end use for electrical consumption in 2018*

In order to determine the useful energy in Maltese households using electricity means, the conversion efficiency of the different types of technologies being used was applied. Table 6 below summarises the efficiency parameters used for the transformation of the final electrical energy into useful energy.

*Table 6 – Derated efficiencies of residential technologies*

<b>Technology</b>	<b>Efficiency</b>
Electrical water heaters	0.9
Heat Pumps COP	2.717
Heat pumps EER	2.898

The heat pumps EER and COP values were calculated using the below methodology.

## Calculating the Survival Rate of Heat Pump

To calculate the total number of heat pumps still functional in a particular year (and therefore the capacity in that year), a survival function was applied to the stock of heat pumps according to their year of installation. The Weibull function was used to estimate the survival curve of new units according to their year of import, and based on the following assumptions:

- that the survival function does not change over time;
- that the survival function is independent of other household factors;
- that the survival function is consistent across different BTU ranges; and
- that all surviving heat pumps are still in use.

The Weibull function with the parameters used in the study by Hopkins et al. (2011)<sup>11</sup> was applied. This study was selected as the values of all parameters required in the equation were available at a national level and, when unavailable, default parameters identified by the authors based on their data for the years 2001 to 2007 could be used. These values define a mean lifetime of 16.8 years for heat pumps.

The survival function was estimated using a modified Weibull distribution:

$$P(x) = e^{-Ln(2)\left(\frac{x-\theta}{M-\theta}\right)^\beta}$$

Where:

P(x) is the probability that the appliance is still in use at age x.

x is the appliance age.

M is the median; Hopkins et al. (2011) estimate this is 14.6.

β is the shape parameter which determines the way in which the failure rate changes through time; Hopkins et al. (2011) estimate this is 1.525.

θ is the delay parameter which provides for a delay before any failures occur; Hopkins et al. (2011) estimate this is 0.

However, when these default parameters were applied, the survival curve generated did not fit the data as the curve overestimated the number of units which would no longer be alive after 5 years. The majority of heat pumps imported into Malta have a 5-year warranty and therefore a negligible number of units would decay before the first five years. Furthermore, when the survival function was applied to the number of imports, the resulting figure for surviving units in 2014 (191,968 units) underestimated that reported by the surveys (a total of 219,691 in 2014).

Through a curve fitting exercise involving the modification of the median and shape of the survival function, a survival function was determined which, when applied to the number of imports, yields the number of heat pumps still functional which tallies that reported by the survey. The median was set at

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<sup>11</sup> Lutz, J.D., Hopkins, A., Letschert, V., Franco, V.H. and Sturges, A., 2011. Using national survey data to estimate lifetimes of residential appliances. *HVAC&R Research*, 17(5), pp.726-736.

16.7, the delay at 0, and the shape at 7. This implies that the maximum age of split-units in Malta is 24 years, as depicted in Figure 8 below.

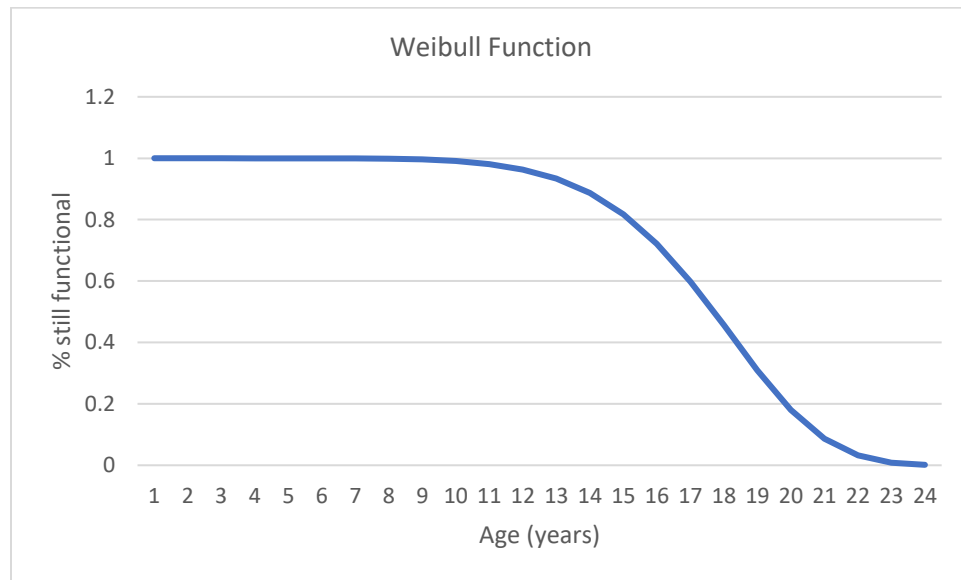


Figure 8 – Weibull Function

### Calculating the Reduction of Efficiency of a Heat Pump over time

It is proven that the performance of the energy supply systems such as the air-conditioning deteriorates with time as a result of: natural ageing, mismanagement and poor maintenance, leading to lower energy efficiency of the systems. Generally, HVAC performance deteriorates with time because of natural ageing and wear due to operation. This performance degradation is expressed by a drop in the Coefficient of Performance or Energy Efficiency Ratio (COP/EER) of an HVAC system.

Based on the method presented by Struck et al.<sup>12</sup> for predicting the COP drop of HVAC systems over their lifetime, the decrease in COPs and EERs has been taken into consideration. According to this study, long-term HVAC performance depends on part load performance and annual COP drop expressed by a degradation factor. Similar degradation factors that take maintenance quality into account are applied by the national renewable energy laboratory (NREL) of the US department of energy to equations predicting performance decline over time.

Hence the below exponential equation was applied:

$$\text{Eff} = \text{BaseEff}(1-M)^{\text{age}}$$

<sup>12</sup> Struck, C.; Markov, D.; Stankov, P.; Ilic, G.; Seravimov, M.; Bionda, D.; Seerig, A. Towards compensating HVAC system degradation phenomena with adaptable building elements. In Proceedings of the 13th International Conference on Sustainable Energy Technologies, Geneva, Switzerland, 25–28 August 2014.

Where:

Eff is the annual efficiency of the equipment at a certain age

BaseEff is the efficiency of the equipment when new

M is the factor used to consider the maintenance, taken as xx in our case

Age is the age of the equipment in years

Through the decay rate of the heat pump units in Malta and the efficiency reduction of the same, the below weighted COPs and EERs were calculated using the two formulas explained above, resulting with the following:

Weighted EER	2.717
Weighted COP	2.898

By way of conclusion, Table 7 below depicts the final and useful energy generated by electricity in GWh by Maltese households in Malta in 2018.

*Table 7 – Final and Useful Energy generated by electricity for the residential sector in 2018*

End Use	Technology	Final Energy [GWh/a]	Conversion Factor	Useful Energy [GWh/a]
Space Cooling	Heat pumps	138.59	2.72	376.52
Space Heating	Heat pumps	23.30	2.90	67.52
Space Heating	Electrical Heaters	64.76	0.95	61.53
Water Heating	Electric Water Heaters	215.74	0.90	194.16
<b>Total</b>		<b>442.39</b>		<b>699.73</b>

### 1.1.1.2 Fuel Consumption for Residential Sector

From the fossil fuel survey report<sup>13</sup>, it results that LPG (mixture of butane and propane) is the main source of fossil fuel used in the residential sector, with other types of fuel having a minor, if not negligible use, in the residential scenario. Hence for the purpose of this study the only fossil fuel which will be considered for the residential sector will be LPG. This LPG consumption for the residential sector is used mainly for cooking and space heating purposes.

<sup>13</sup> Survey on Fuel Consumption in the Economic Sectors, Version 1.0\_Final, dated 6th December prepared by EWA.

Data for LPG consumption has been extracted from the Survey on Fuel Consumption in the Economic Sectors<sup>14</sup> together with data provided by REWS. The above-mentioned survey is the result of a joint exercise carried out by the NSO and EWA and covers data for reference years 2013 to 2016.

The results from the said survey reflecting LPG cylinders sale per month in the residential sector are indicated in Table 8 below.

*Table 8 – Monthly cylinder sales for the residential sector*

<b>2018</b>	<b>10kg</b>	<b>12kg</b>	<b>15kg</b>	<b>Total (kgs)</b>
January	-	1,236,428	272,822	1,509,250
February	230	1,308,252	267,401	1,575,883
March	51	865,334	234,326	1,099,711
April	269	642,336	198,178	840,783
May	180	601,545	192,588	794,313
June	180	540,207	165,713	706,099
July	160	570,471	166,962	737,593
August	220	520,661	169,022	689,903
September	10	508,891	154,757	663,658
October	50	641,263	185,236	826,549
November	70	689,495	194,660	884,226
December	210	1,097,318	253,708	1,351,237
<b>TOTAL</b>	<b>1,630</b>	<b>9,222,200</b>	<b>2,455,373</b>	<b>11,679,204</b>

Based on a detailed analysis of the monthly sales, a baseline for cooking was extracted by calculating a yearly average of the sales. The difference causing the spike in LPG sales between the months January to April and November to December was assumed to be used for domestic space heating.

The Figure 9 below depicts the monthly LPG consumption in cylinders split between cooking and heating purposes in the residential sector.

<sup>14</sup> Survey on Fuel Consumption in the Economic Sectors, Version 1.0\_Final, dated 6th December prepared by EWA.



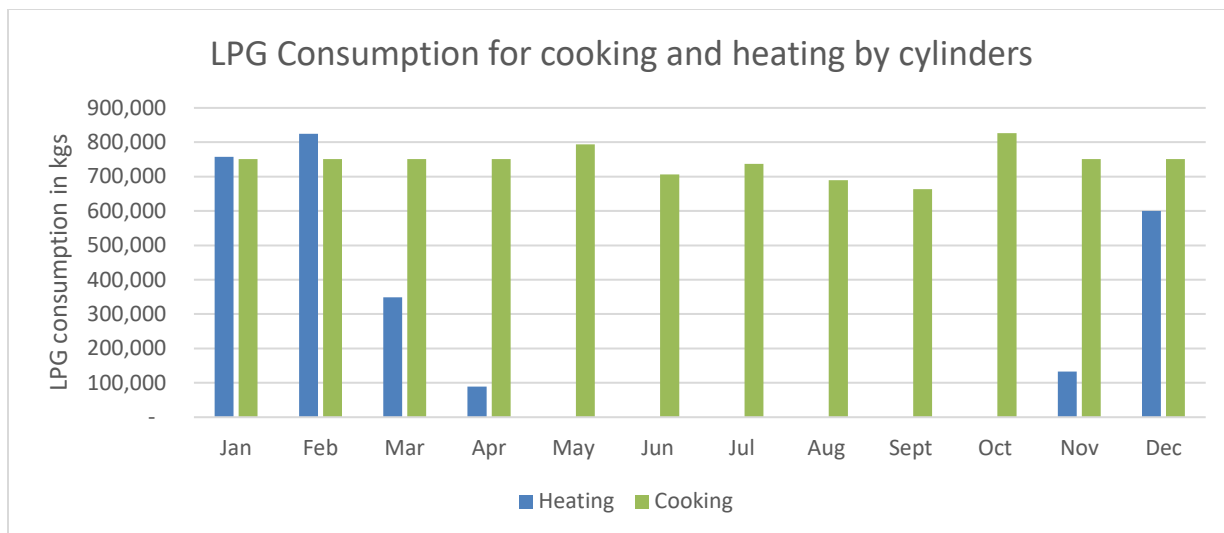


Figure 9 – Monthly LPG Consumption (cylinders) split for cooking and heating purposes

Over and above the use of LPG in cylinders, it is being assumed that the domestic sector used 1,450 tons of bulk LPG in 2018, based on the assumption that the bulk storage in the domestic sector is filled out once a year<sup>15</sup>. The bulk LPG consumption was then added to the LPG cylinder consumption for heating purposes, since most of the bulk LPG installations in households are typically used for central heating or underfloor heating systems.

Figure 10 below shows the total LPG fuel consumption split between cooking and space heating purposes in Maltese households.

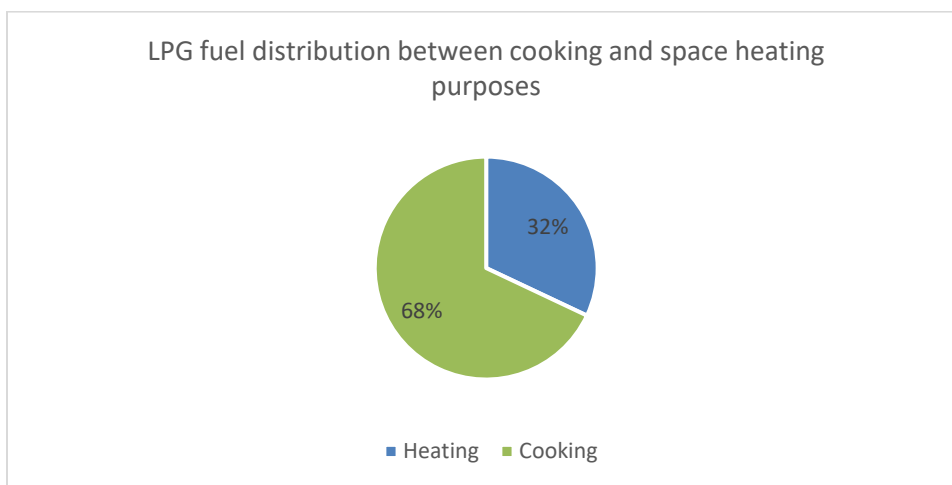


Figure 10 – Percentage distribution of LPG used for cooking and heating purposes.

<sup>15</sup> Assumptions recommended by REWS.

The above-portrayed split of 32% of total LPG use in households for space heating and 68% of total LPG use for cooking was used to arrive at the total amount of LPG in tonnes used for space heating in the domestic scenario, as indicated in Table 9 below, which also shows the total LPG consumption in residential units in GWh.

*Table 9 – LPG consumption in Residential Use, source EWA*

	<b>LPG consumption in GWh/a</b>
Grand total (cylinders and bulk)	175.78
Cooking purposes	119.53
Space heating purposes	56.25

In order to determine the useful energy for space heating generated by fuel in the domestic sector, namely LPG, the below conversion efficiency factors as shown in Table 10 were used:

*Table 10 – Efficiency Factor for fuel fired heating technologies*

<b>Technology</b>	<b>Efficiency</b>
Gas heater efficiency	0.9
Boilers for under-floor water heating	0.9

Based on the above-indicated efficiency factors, the useful energy for space heating generated by LPG in the residential sector has been calculated and is shown in Table 11 below.

*Table 11 – Final and Useful Energy generated by the fuel for the residential sector in 2018*

<b>End Use</b>	<b>Technology</b>	<b>Final Energy</b>	<b>Conversion Factor</b>	<b>Useful Energy</b>
		GWh/a		GWh/a
Space Heating	Fuel Heaters/boilers	54.98	0.90	49.48

### 1.1.1.3 Total Final and Useful Energy for Residential Sector

On the basis of the data outlined above and taking into consideration the methodologies and assumptions indicated above, the following is a quantification of the final and useful energy for the residential sector for space heating and cooling as well as water heating as indicated in Table 12 below.

Table 12- Final and Useful Energy for Residential Sector

	End Use	Technology	Final Energy	Conversion Factor	Useful Energy
			GWh/a		GWh/a
Electricity	Space Cooling	Heat pumps	138.59	2.72	376.52
	Space Heating	Heat pumps	23.30	2.90	67.52
	Space Heating	Electrical Heaters	64.76	0.95	61.53
	Water Heating	Electric Water Heaters	215.74	0.90	194.16
	Total		442.39		699.73
Fuel	Space Cooling				
	Space Heating	Fuel Heaters/boilers	54.98	0.90	49.48
	Water Heating				
	Total		54.98		49.48
Solar Thermal	Space Cooling				
	Space Heating				
	Water Heating		58.51	0.49	28.67
	Total		58.51		28.67
Biomass	Space Cooling				
	Space Heating	Biomass boilers/heaters	15.56	0.85	13.23
	Water Heating				
	Total		15.56		13.23
Heat pumps	Space Cooling				
	Space Heating	Ambient heat from heat pumps	73.1	-	-
	Water Heating				
	Total		73.10		198.83
Total	Space Cooling		138.59		376.52
	Space Heating		231.70		191.76
	Water Heating		274.24		222.83
	Others		435.96		-
Total energy consumption			1080.50		

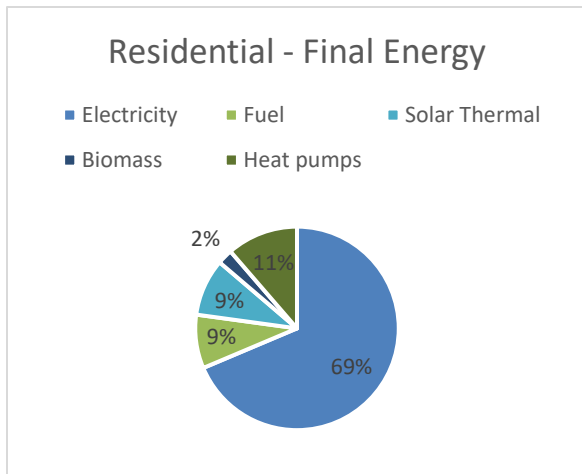


Figure 14 – Final Energy Consumption by source

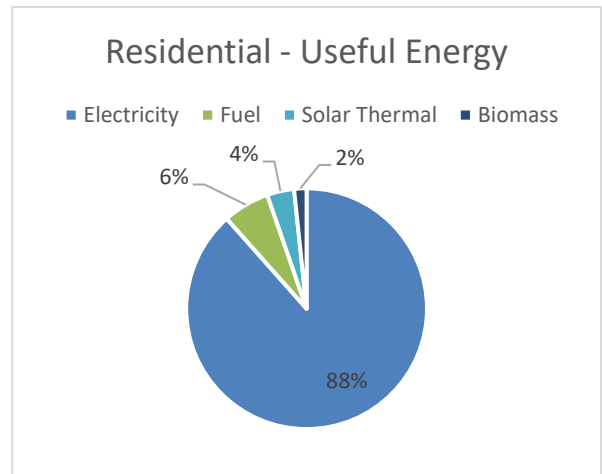


Figure 13 – Useful Energy Consumption by source

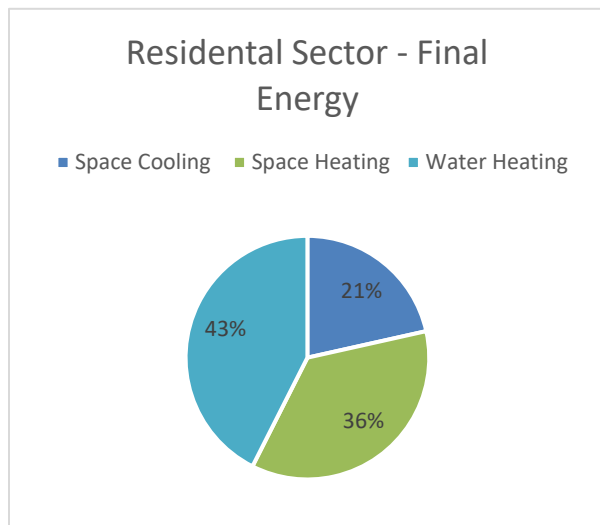


Figure 11 – Final Energy Consumption by end-use

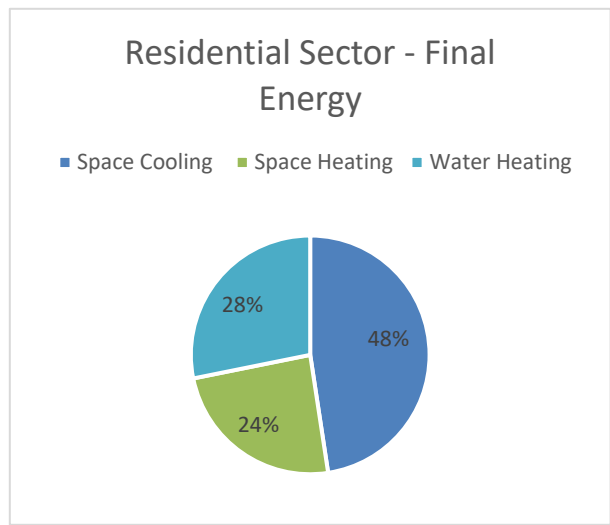


Figure 12 – Useful Energy Consumption by end-use

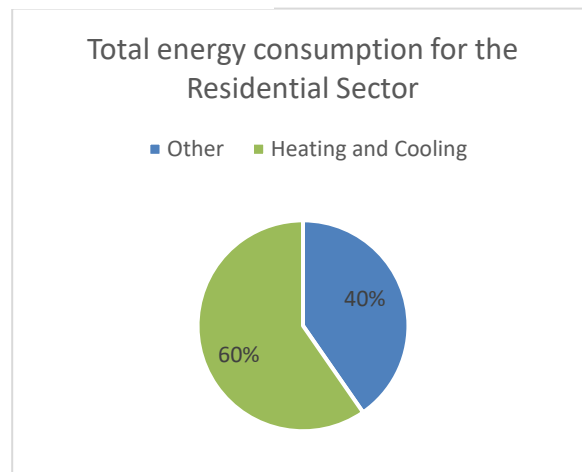


Figure 15 – Electrical energy consumption distribution between heating and cooling and other end-uses

## 1.1.2 Services Sector

The importance of the services sector in the Maltese economy has grown significantly in recent years. In 2019, the share of the services sector in Malta's gross domestic product was 75.79%.<sup>16</sup> Tourism is another mainstay of the Maltese economy, with data from the World Travel and Tourism Council (WTTC) showing that the travel and tourism industry's total contribution to Malta's GDP stood at 27.1% in 2017.<sup>17</sup> This primarily reflects the economic activity generated by industries such as hotels, travel agents, airlines and other passenger transportation services (excluding commuter services), but it also includes, for example, the activities of the restaurant and leisure industries directly supported by tourists. Moreover, Malta has also seen a steep growth in the on-line betting industry. Its share in the economy total edged up to around 13.2%, confirming that the gaming sector is the third largest productive sector in Malta.<sup>18</sup>

As can be seen from the above, the services sector in Malta is characterised by a high level of heterogeneity and comprises many different branches, each linked to different demand patterns and levels of energy requirements. Even though these branches present different energy intensities, reflecting the different nature of the services offered, their generic structure as regards energy processes is identical.

For the purposes of this study, the services sector is being divided into the following categories: hotels, hospitals, old people's homes and other commercial outlets including public buildings, offices, retail, schools and others as depicted in table below. It is important to note that the energy load and consumption can vary from one sub-sector to another due to different usages.

*Table 13- Sub-sectors within the services sector*

SECTOR	SUB-SECTOR
Services	1) Hotels
	2) Hospitals
	3) Old people's homes
	4) Commercial including Public Buildings, Offices, Retail, Schools, and Others

<sup>16</sup> Share of Economic Sectors in GDP in Malta 2019 retrieved from: <https://www.statista.com/statistics/731269/share-of-economic-sectors-in-the-gdp-in-malta/#:~:text=Share%20of%20economic%20sectors%20in%20GDP%20in%20Malta%202019&text=In%202019%2C%20the%20share%20of,sector%20contributed%20about%2075.79%20percent.>

<sup>17</sup> THE EVOLUTION OF MALTA'S TOURISM PRODUCT OVER RECENT YEARS, Central Bank of Malta, published in 2018

<sup>18</sup> MGA's annual report for 2018

The services sector typically uses electrical energy for water heating, space heating, space cooling, lighting and equipment, and cooking, amongst other uses. Fossil fuels are mainly used for water heating, space heating and cooking.

The main sources of data about energy consumption for the services sector in Malta for the base year 2018 have been obtained from the below entities:

- Enemalta Plc, which has provided the monthly energy consumption, split into different sub-sectors and geographical locations;
- Energy and Water Agency (EWA), which provided the amount of fossil fuels, per type of fuel, according to their specific end use.

The fuel consumption used for the services sector for the year 2018 has been obtained from the Fuel Survey carried out by EWA<sup>19</sup>. The data provided includes the distribution of fuels per use for each sub-sector, being space heating and hot water generation. On a more specific note, data on fossil fuel consumption is also being categorised for: i) the accommodation sub-sector, ii) the food and beverage services and iii) the commercial services sub-sector (retail, offices, schools and others) respectively. This data is being provided according to the type of fossil fuel being consumed for the base year 2018.

As regards electricity consumption, it should be noted that in the absence of actual and specific data of electricity consumption for space heating and cooling purposes in the services sector, the methodologies explained below in relation to each sub-sector were used to be able to calculate and determine these consumptions.

### 1.1.2.1 Hotels sub-sector

Hotel facilities in Malta are deemed to rank amongst the top five in terms of energy consumption in the tertiary building sector. The main energy consuming activities in a hotel are: heating rooms, cooling rooms, lighting, hot water use and other energy consuming activities by guests, preparation of meals and the use of swimming pools and spa facilities as well as laundry services.

Hotel energy consumption is influenced by physical and operational parameters. The physical parameters common to most hotel buildings include size, structure and design of the building (prevailing architectural / construction practices), geographical and climatic location, the age of the facility, the type of energy and water systems installed, the way these systems are operated and maintained, types and amounts of energy and water resources available locally, as well as energy-use regulations and cost.

Operational parameters that influence energy use in hotels include operating schedules for the different functional facilities in the hotel buildings, the number of facilities (restaurants, kitchens, in-house laundries, swimming pools and sports centres, business centres, etc.), services offered, fluctuation in occupancy levels, variations in customer preference relevant to indoor comfort, on-site energy

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<sup>19</sup> Survey on Fuel Consumption in the Economic Sectors, Version 1.0\_Final, dated 6th December prepared by Ms. Rebecca Camilleri for EWA.

conservation practices, as well as culture and awareness of resource consumption among personnel and guests.

The hotel sector in Malta consists of a number of hotels in different categories namely: 5-Star, 4-Star, 3-Star, 2-Star, guesthouses and hostels. In total, there are 202 hotels registered with the Malta Tourism Authority (MTA).<sup>20</sup>

#### 1.1.2.1.1 Electrical Consumption for Hotels Sub-Sector

Due to the hotels' seasonality and yearly fluctuations, the calculations for the hotel sub-sector have been based on hourly electrical consumption profiles. Such profiles have been obtained from Enemalta plc for the year 2018 for a large number of hotels in Malta.

The hourly electrical consumption profiles for each hotel have been summed up, arriving at a total hourly consumption profile for the hotel sector for the whole year 2018. From this profile, a daily electrical consumption trend for the year 2018 has been calculated, as shown in Figure 16 below.

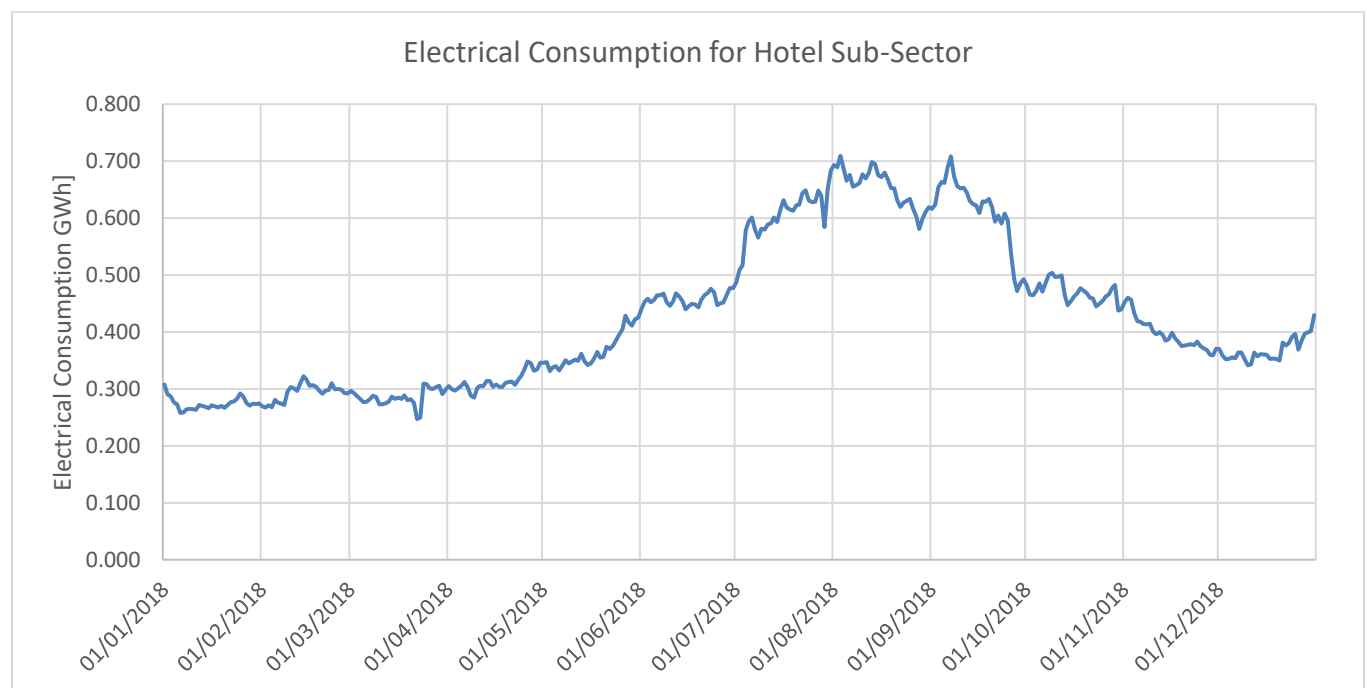


Figure 16 – Total Electrical Consumption for the hotels sub-sector in 2018

The daily electrical consumption profile for the hotel sector was then extrapolated to include all hotels in Malta on the basis that the total yearly electrical load for the whole sector for the year 2018 was 155GWh,

<sup>20</sup> <https://www.visitmalta.com/en/hotels> retrieved on the 7.07.2020

as reported by NSO<sup>21</sup>. Figure 17 below shows the total monthly electrical consumption for all the hotel sub-sector in Malta for 2018.

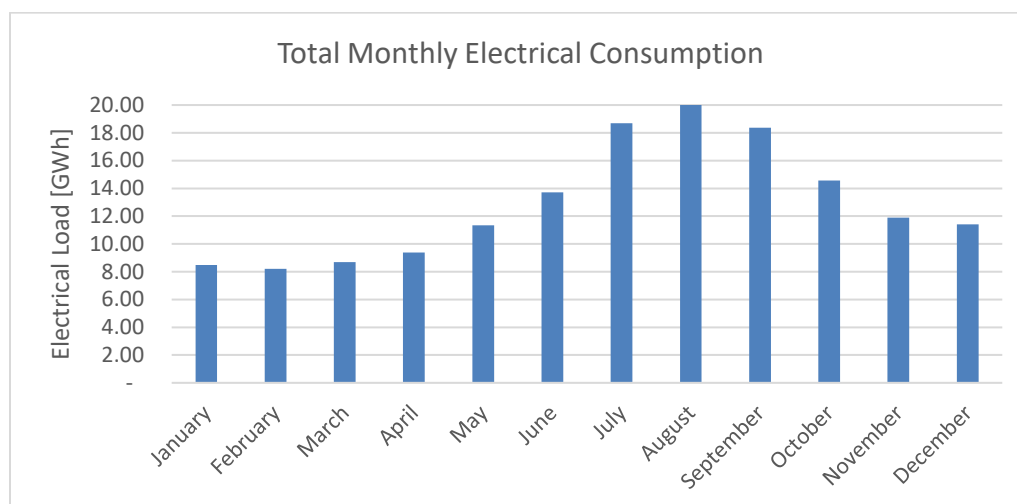


Figure 17 – Electrical consumption for the hotels sub-sector in 2018

In order to calculate the baseload for hotels in Malta, reference was made to the publication issued by the European Commission<sup>22</sup>, which shows that such baseload is calculated as being 37%. This accounts for the energy requirements for lighting, cooking, office equipment, ventilation, refrigeration, amongst others, in the hotel industry, as shown in Figure 18 below.

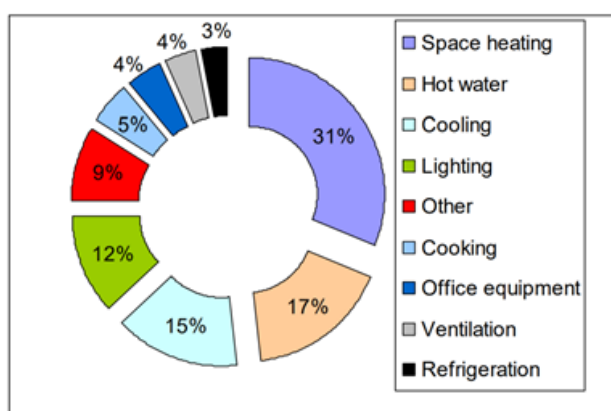


Figure 18 – Energy consumption by end-use in hotels.

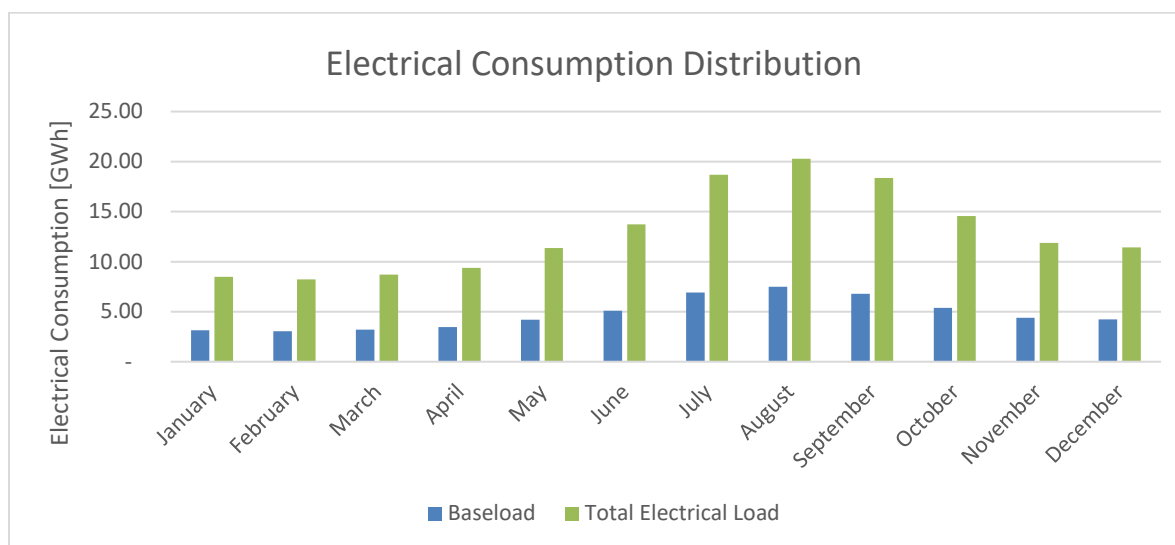
Hence, based on the above, a percentage of 37% is being applied to the monthly actual consumption profile for the actual data for the Maltese hotels, thus arriving at a baseload. The Figure 19 below shows

<sup>21</sup> Enemalta monthly Electrical Consumption by NACE Sector

<sup>22</sup> Best Environmental Management Practice in the Tourism Sector, JRC Scientific and Policy Reports, David Styles, Harald Schönberger and Jose Luis Galvez Martos, 2013



the total electrical consumption of the hotel sub-sector in Malta together with the applicable baseload, on a monthly basis.



*Figure 19 – Electricity consumption for baseload in relation to the total electrical consumption*

The baseload workings were further elaborated to assess such baseload in relation to the number of occupants per night in hotels. Figure 20 below shows the baseload distribution based on the guest night occupancy, which has been obtained from the Quarterly Hotel Occupancy surveys carried out by NSO<sup>23</sup>. This shows the correlation between the baseload and the number of guest nights reflecting the hotels' occupancy, indicating a peak in the months of July – October, being Malta's tourism peak season for hotel occupancy.

<sup>23</sup>

[https://nso.gov.mt/en/News\\_Releases/View\\_by\\_Unit/Unit\\_C3/Tourism\\_Statistics/Documents/2018/News2018\\_080.pdf](https://nso.gov.mt/en/News_Releases/View_by_Unit/Unit_C3/Tourism_Statistics/Documents/2018/News2018_080.pdf)  
[https://nso.gov.mt/en/News\\_Releases/View\\_by\\_Unit/Unit\\_C3/Tourism\\_Statistics/Documents/2018/News2018\\_131.pdf](https://nso.gov.mt/en/News_Releases/View_by_Unit/Unit_C3/Tourism_Statistics/Documents/2018/News2018_131.pdf)  
[https://nso.gov.mt/en/News\\_Releases/View\\_by\\_Unit/Unit\\_C3/Tourism\\_Statistics/Documents/2018/News2018\\_186.pdf](https://nso.gov.mt/en/News_Releases/View_by_Unit/Unit_C3/Tourism_Statistics/Documents/2018/News2018_186.pdf)  
[https://nso.gov.mt/en/News\\_Releases/View\\_by\\_Unit/Unit\\_C3/Tourism\\_Statistics/Documents/2019/News2019\\_032.pdf](https://nso.gov.mt/en/News_Releases/View_by_Unit/Unit_C3/Tourism_Statistics/Documents/2019/News2019_032.pdf)

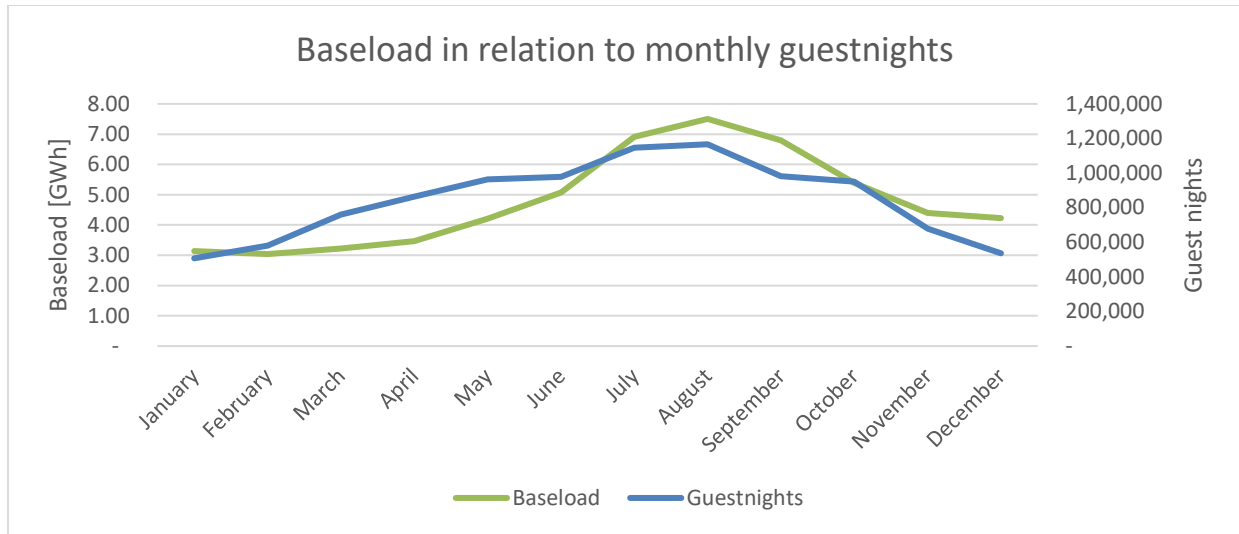


Figure 20 – Electrical consumption for baseload distribution compared to the hotels' occupancy (guest-nights)

In the assessment being carried in relation to the hotel sub-sector, it is being assumed that the hot water requirements are being generated by means of fuel fired boilers. Hence there was no need to remove the electricity demand for the hot water from the 'base' electricity consumption.

The daily consumption profile for the electricity used for space heating and cooling in the hotel sub-sector has been determined using the below formula:

$$\text{Total Daily Consumption for Heating or Cooling} = [\text{Total Daily Consumption}] - [\text{Baseload}]$$

The electricity consumption that remained after the removal of the baseload units was attributed to heating and cooling, depending on the months. The months between November to mid-April are assumed to cover space heating and those from mid-April to October are assumed to cover space cooling.

Table 14 – Yearly electrical consumption distribution for baseload, space heating and space cooling

	Total Electrical Consumption [GWh]	Electrical Consumption for Baseload [GWh]	Final Electrical consumption for Space Heating [GWh]	Final Electrical Consumption For Space Cooling [GWh]
January	8.48	3.14	5.34	
February	8.21	3.04	5.17	
March	8.77	3.24	5.53	
April	9.67	3.58	3.05	3.05
May	11.35	4.20		7.15
June	13.77	5.09		8.64
July	18.69	6.92		11.77
August	20.28	7.50		12.78
September	18.36	6.79		11.57
October	14.57	5.39		9.18
November	11.88	4.40	7.48	
December	11.52	4.26	7.26	
<b>TOTAL</b>	<b>155.55</b>	<b>57.55</b>	<b>33.83</b>	<b>64.14</b>

The Figure 21 below shows the total electrical consumption in hotels on a monthly basis, as well as the baseload and the electrical consumption for space heating and cooling.

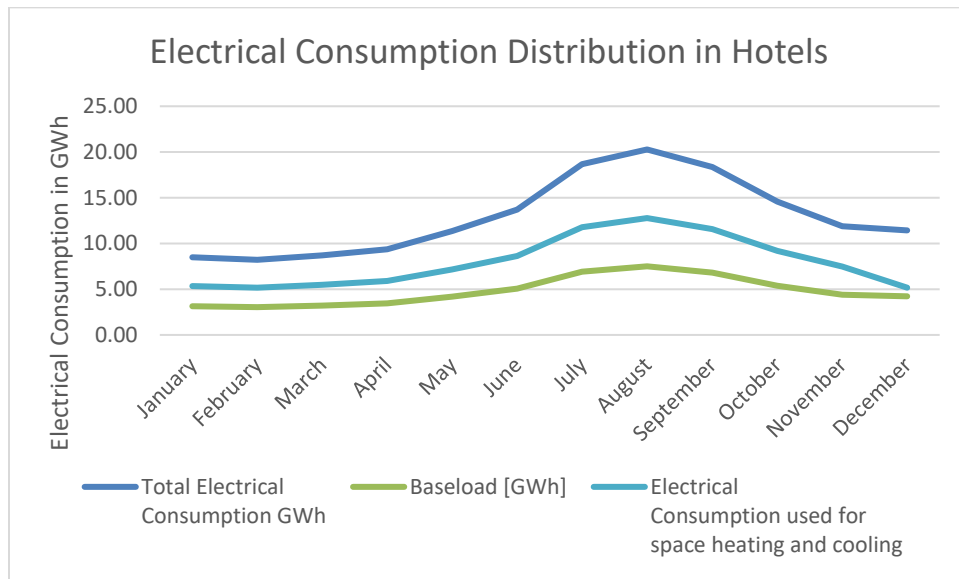


Figure 21 – Yearly profile of electrical energy distribution between energy use for baseload and space heating and cooling.

From the above calculations, the final energy for space heating and cooling generated by electrical means in the hotel sub-sector can be seen in the Figure 22 below, with a total value of **31.60GWh** for space heating purposes and **64.04GWh** for space cooling.

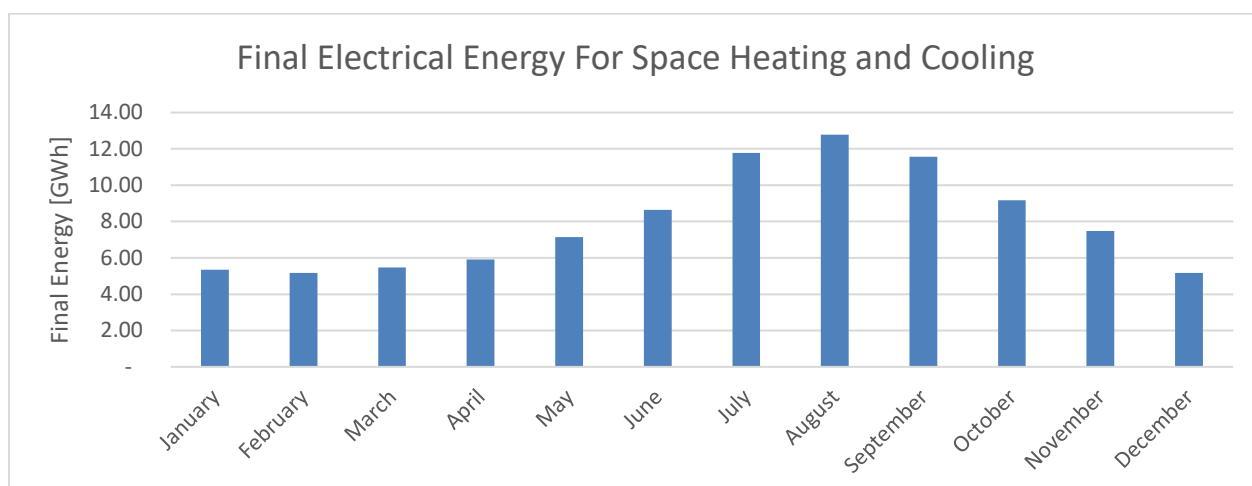


Figure 22 – Final electrical energy consumed for space heating and cooling in 2018 for the hotels sub-sector.

In order to arrive at the useful energy for heating/cooling for the hotel sub-sector in Malta, COPs and EERs of boilers and a mixture of water, air-cooled chillers and VRV systems have been used. A survey was carried to determine the type of air-conditioning technology used in hotels in Malta. Based on the hotel list from the Malta Tourism Authority<sup>24</sup>. The results, again showing an overall common use of VRVs in hotels in Malta, can be seen in Figure 23 hereunder.

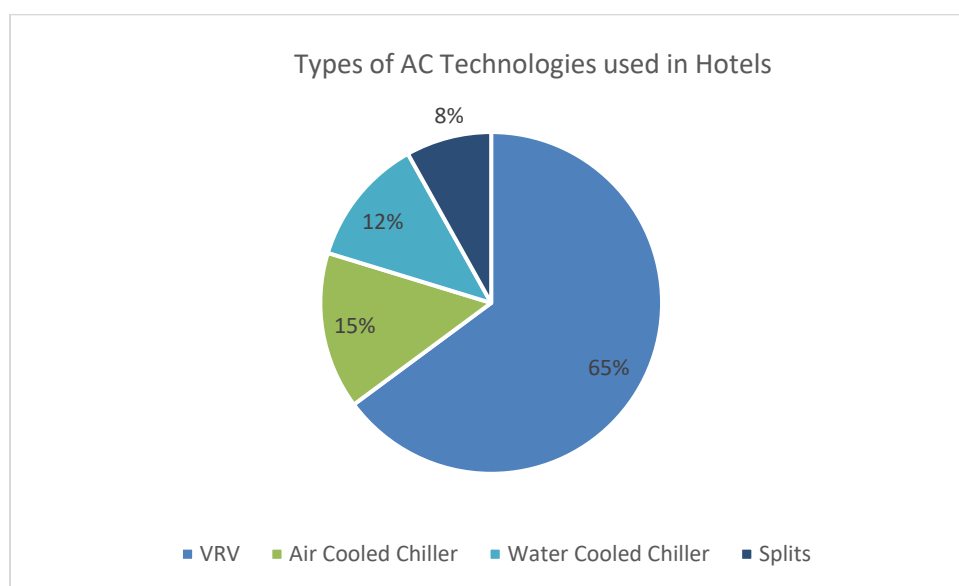


Figure 23 – Types of AC technologies used in hotels

For the average COP calculation purposes, it was assumed that all hotels which have a water-cooled chiller do not use them for heating purposes. The COP and EER values used in Tables 15 and 16 below were

<sup>24</sup> <https://www.visitmalta.com/en/hotels> retrieved on the 7.07.2020

typical declared COP and EER values for the various technologies, considering the fact that different installations have different COP and EER values based on their age and condition.

Based on the number of water-cooled chillers, air-cooled chillers and VRV systems installed in the sample taken from the hotel sub-sector, the average weighted EER has been calculated and applied to determine the useful energy demand for space cooling purposes, as can be seen in Table 15.

The electrical consumption for space heating purposes in the hotel sub-sector in Malta has been based on the number of air-cooled chillers and VRV systems installed in the sample taken. An average weighted COP has been calculated and applied to determine the useful energy demand for space heating purposes, as can be seen in Table 16. Moreover, the decay in efficiency factors for the COP and EER values have been calculated by the same method as described in Section 1.1.1.1 of the Residential Sector.

*Table 15 – EER for different cooling technologies*

EER		
VRF	65 %	3.85
Air Cooled Chiller	15 %	2.15
Water Cooled Chiller	12 %	4.25
Split Units	8 %	2.90
Weighted Average		3.57
Degraded EER		3.23

*Table 16 – COPs for different heating technologies*

COP		
VRF	74 %	4.04
Air Cooled Chiller	17 %	2.85
Water Cooled Chiller	-	-
Split Units	9 %	2.72
Weighted Average		3.71
Degraded COP		3.36

Based on the above-indicated COPs and EERs, the useful energy for space heating and space cooling generated by electricity in the hotel sub-sector has been calculated and is shown in Table 17 below.

Table 17 – Final and useful electrical energy for the hotels sub-sector

	End Use	Technology	Final Energy	Conversion Factor	Useful Energy
			GWh/a		GWh/a
Electricity	Space Cooling	Heat pumps	64.04	3.23	206.86
	Space Heating	Heat pumps	31.60	3.36	106.19
	Water Heating				-
	<b>Total</b>		95.65		313.05

#### 1.1.2.1.2 Fuel Consumption for Hotels Sub-Sector

The fossil fuel consumption data for the hotel sector was obtained from the EWA. This was split in the consumption per end use and can be seen in Table 18 hereunder:

Table 18 – Fossil Fuel Consumption for Accommodation Services for 2018<sup>25</sup>

Fuel Type	Fuel Use	Energy Consumption for Accommodation and Food Service Activities - GWh/a
Diesel	Space Cooling	-
	Space Heating	0.515
	Water Heating	1.910
	<b>TOTAL</b>	<b>2.424</b>
Fuel Oil	Space Cooling	-
	Space Heating	0.020
	Water Heating	0.620
	<b>TOTAL</b>	<b>0.640</b>
Gasoil	Space Cooling	-
	Space Heating	16.238
	Water Heating	44.548
	<b>TOTAL</b>	<b>60.790</b>
LPG	Space Cooling	-
	Space Heating	1.576
	Water Heating	21.423
	<b>TOTAL</b>	<b>23.000</b>
<b>TOTAL</b>	<b>Space Cooling</b>	<b>-</b>
	<b>Space Heating</b>	<b>18.349</b>
	<b>Water Heating</b>	<b>68.501</b>

Note: Petrol and Kerosene are not included in the above table since consumption is zero for the hotels sub-sector.

<sup>25</sup> Data obtained from EWA Fuel Survey

The above data shows clearly that gasoil is the mostly used fossil fuel in the hotel sub-sector with the second mostly used fossil fuel being LPG. These two fossil fuel types are mainly used to generate hot water and space heating in the hotel sub-sector, as can be seen in Figure 24 below.

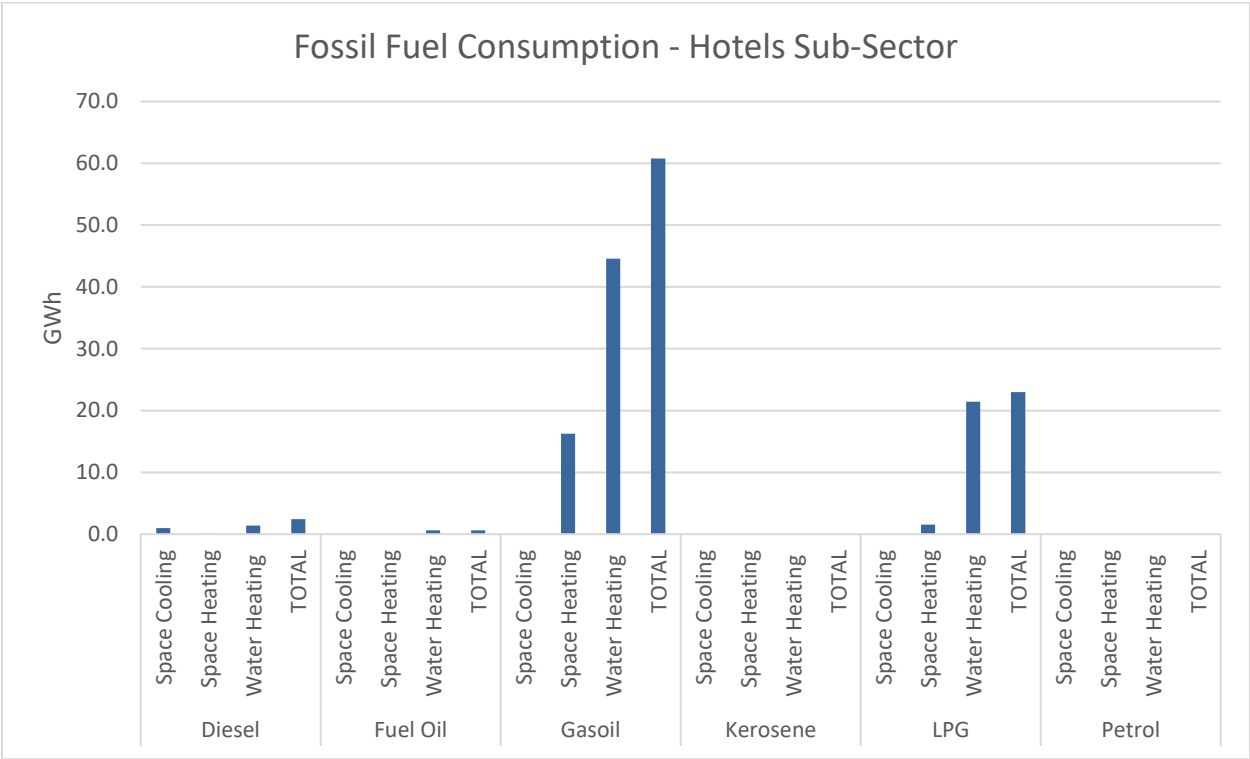


Figure 24 – Fossil Fuel Consumption for accommodation services for each type of fossil fuel

On the basis of the data indicated above, the Figure 25 below shows the percentage distribution of the fossil fuel end uses in the hotel sub-sector, namely space cooling, space heating and water heating.

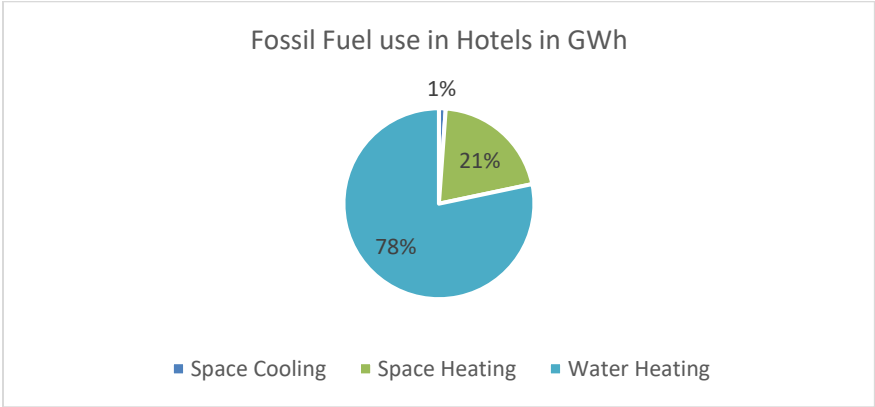


Figure 25 – Percentage Fossil Fuel distribution in the accommodation sub-sector

From the above calculations, the final energy for hot water generation, space heating and cooling generated by fossil fuels in the hotel sub-sector can be seen in the Table 20 below.

In order to calculate the useful energy from the fossil fuel generation the below efficiency factors were used:

*Table 19 – Efficiency Factor for fuel fired heating technologies*

Technology	Efficiency
Fuel Fired boilers	0.85

*Table 20 – Final and Useful Energy for fossil fuel use in the hotel sub-sector*

	End Use	Technology	Final Energy	Conversion Factor	Useful Energy
Fuel	Space Cooling				
	Space Heating	Fuel Fired Boilers	18.35	0.85	15.60
	Water Heating	Fuel Fired Boilers	68.50	0.85	58.23
	<b>Total</b>		86.85		73.82

#### 1.1.2.1.3 Total Final and Useful Energy for Hotels Sub-Sector

Table 21 hereunder depicts the total final and useful energy for the hotels sub-sector, split by different energy source types and by end use.

*Table 21 – Total final and useful energy for the hotels sub-sector*

	End Use	Technology	Final Energy	Conversion Factor	Useful Energy
			<b>GWh</b>		<b>GWh</b>
Electricity	Space Cooling	Heat pumps	64.04	3.23	206.86
	Space Heating	Heat pumps	31.60	3.36	106.19
	Water Heating				-
	<b>Total</b>		95.65		313.05
Fuel	Space Cooling				
	Space Heating	Fuel Fired Boilers	18.35	0.85	15.60
	Water Heating	Fuel Fired Boilers	68.50	0.85	58.23
	<b>Total</b>		86.85		73.82
<b>Total</b>	<b>Space Cooling</b>		<b>64.04</b>		<b>206.86</b>
	<b>Space Heating</b>		<b>49.95</b>		<b>121.79</b>
	<b>Water Heating</b>		<b>68.50</b>		<b>58.23</b>
	<b>Total</b>		<b>182.50</b>		<b>386.87</b>



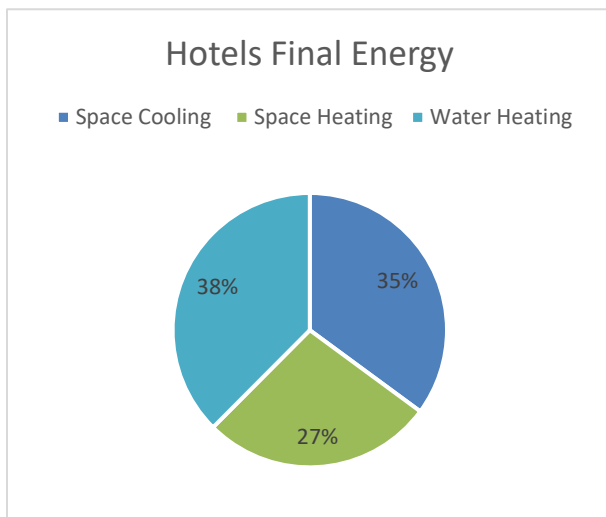


Figure 29 – Final energy consumption by end-use

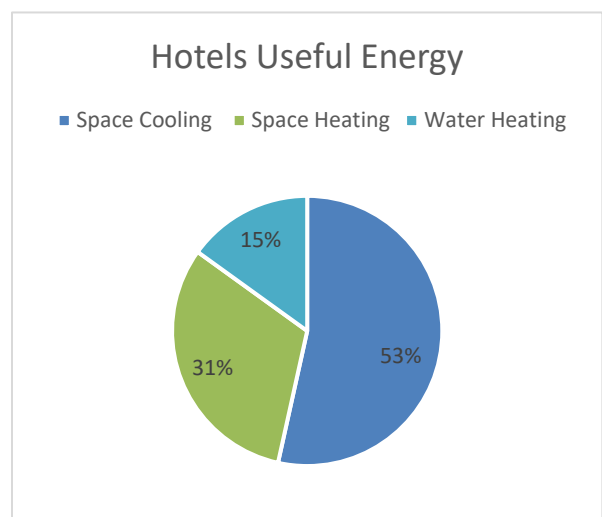


Figure 28 -Useful energy by end-use

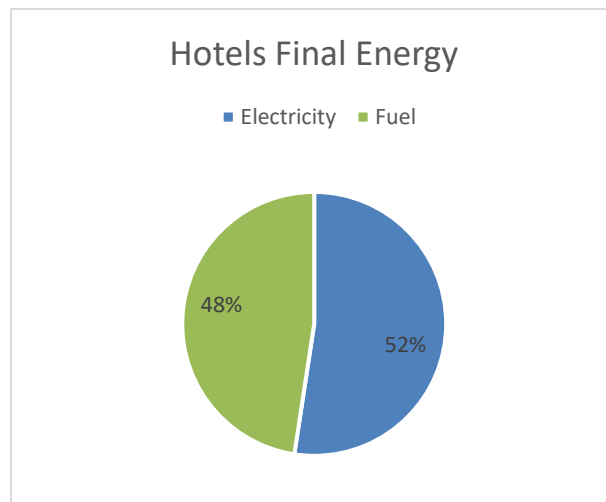


Figure 27 – Final energy consumption by source

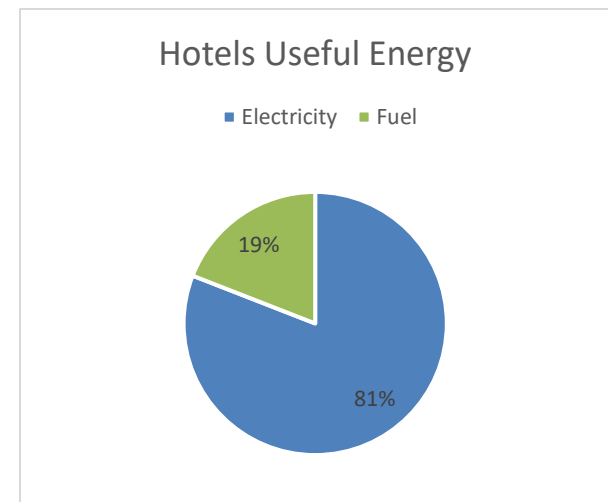


Figure 26 – Useful energy by source

### 1.1.2.2 Hospital sub-sector

The hospital sector in Malta consists of a number of hospitals around the island, with the largest one being the Government-run Mater Dei hospital, which is an 825-bed acute general teaching hospital offering a full range of hospital services. The other hospitals on the island include both public and private hospitals, namely:

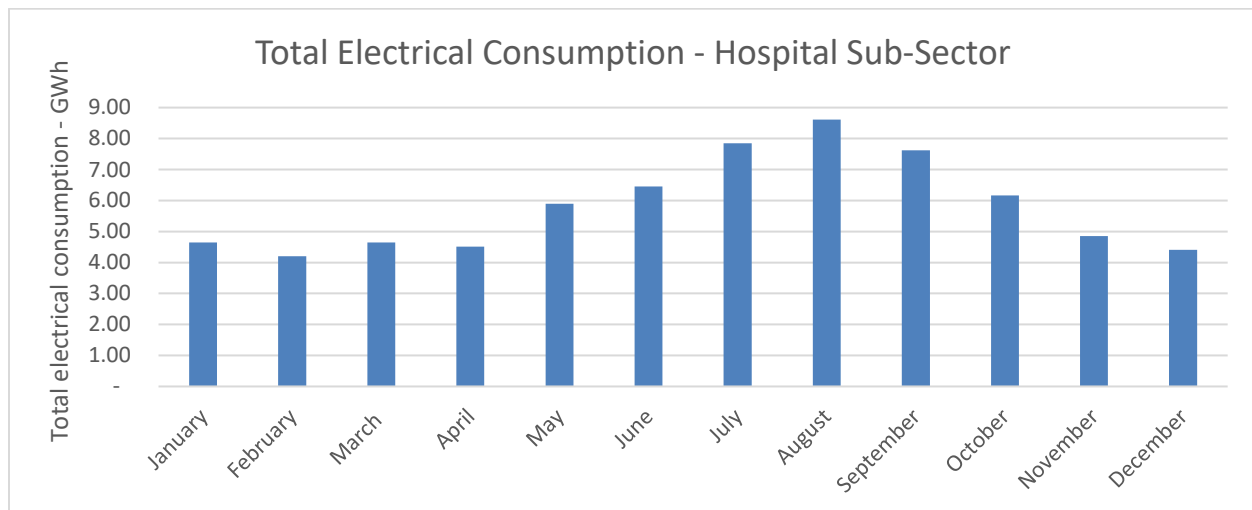
- Sir Anthony Mamo Oncology Hospital – a public oncology hospital
- Sir Paul Boffa Hospital – a public specialised hospital for palliative care and Dermatology

- Mount Carmel Hospital – a public psychiatric hospital
- Gozo General Hospital – a public regional hospital for the island of Gozo
- Karin Grech Hospital – a public rehabilitation hospital
- St James Capua Hospital Sliema – a 74-bed private hospital
- St James Hospital Zejtun – a 25-bed private hospital
- Da Vinci Hospital – a 30-bed private hospital
- St Thomas Hospital – a 40-bed private hospital<sup>26</sup>

For the purposes of this study, the energy profile of the largest hospital in Malta was created and it was then extrapolated to include all the other minor hospitals on the island.

#### 1.1.2.2.1 Electrical Consumption for Hospitals Sub-Sector

The data for the monthly energy consumption by hospitals in Malta was obtained from Enemalta plc. Figure 30 below shows this total monthly electrical consumption for the hospital sub-sector. The data available has been grossed up to reflect all the public and private hospitals in Malta based on the NSO total electrical consumption of 70.04GWh for the hospitals sub-sector for the year 2018.



*Figure 30 – Electrical Consumption in 2018 for the hospital sub-sector*

Due to the fact that no specific and actual data for the space heating and cooling consumption was available, the following method based on some data available from the largest hospital in Malta was used to determine the energy requirements for space heating and cooling purposes. These results were finally extrapolated to include the electrical consumption for the space heating and cooling of all other hospitals on the Maltese islands.

<sup>26</sup> Malta Health System Review published in 2017 and retrieved from [https://www.euro.who.int/data/assets/pdf\\_file/0009/332883/Malta-Hit.pdf?ua=1](https://www.euro.who.int/data/assets/pdf_file/0009/332883/Malta-Hit.pdf?ua=1)

From electrical consumption profile of the largest hospital in Malta, the electrical baseload for the hospitals sub-sector was determined, based on the lowest months' energy consumption. This is defined as the minimum daily electrical consumption over the whole year. This value represents a daily baseload when the seasonal cooling requirement was at the minimum level.

Since normally a HVAC system for a hospital includes humidity control, it is important to point out that hospitals require energy for space cooling all year round. Hence this requirement forms part of the above-mentioned baseload. Thus, a constant cooling requirement has to be calculated before determining the actual baseload for general electrical requirements such as lighting and power for medical equipment, amongst others.

The cooling requirements for most of the hospitals in Malta are generated via air-cooled chillers together with air handling units which form a complete HVAC system. These air handling units require cooling all year round as the units are used for dehumidification purposes to maintain humidity levels inside the hospital areas and even more importantly, in the operating theatres, under tight control. During dehumidification process, the air is cooled until dew point so as to lower the absolute humidity of the air entering the conditioned space.

For the purpose of this study and analysis, in order to cater for the dehumidification requirements in hospitals, a constant cooling load throughout the year was taken into consideration. Thus, an average cooling load factor of 20.45W per square metre<sup>27</sup> was used to calculate this constant cooling load which is considered to take place throughout the year. This was multiplied by the total floor area of the hospitals taken into consideration for this study, amounting to 158,202 metres squared to determine the total cooling load for the dehumidification process in hospitals all year round. This value was then removed from the lowest electricity consumption to determine the actual baseload of hospital electricity consumption without the constant energy required for space cooling. Moreover, for the hospitals sub-sector it is being assumed that the hot water generation is being carried out by fossil fuels which will be explained in more details in section 1.1.2.2.2 below.

Finally, the portion of the electrical consumption for space cooling purposes attributed to high temperatures was calculated on the basis of the daily electrical consumption profile. Thus, this has been calculated using the below formula:

$$\text{Daily Electrical Consumption for Space Cooling Purposes} = [\text{Total Daily Consumption}] - [\text{Minimum Monthly Electricity Consumption}]$$

The two portions of the electrical consumption used space cooling [i.e. the electrical consumption for space cooling attributed to fluctuations in temperature and the electrical consumption for constant space cooling all year round] were then added to calculate the final energy used for space cooling in hospitals, as can be seen in Figure 31.

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<sup>27</sup> [Average for Base load factor] Tables 5, 6, 7, 8, 9, 10 - Benchmarking acute hospitals: Composite electricity targets based on departmental consumption intensities? – Paula Morgenstern et al.

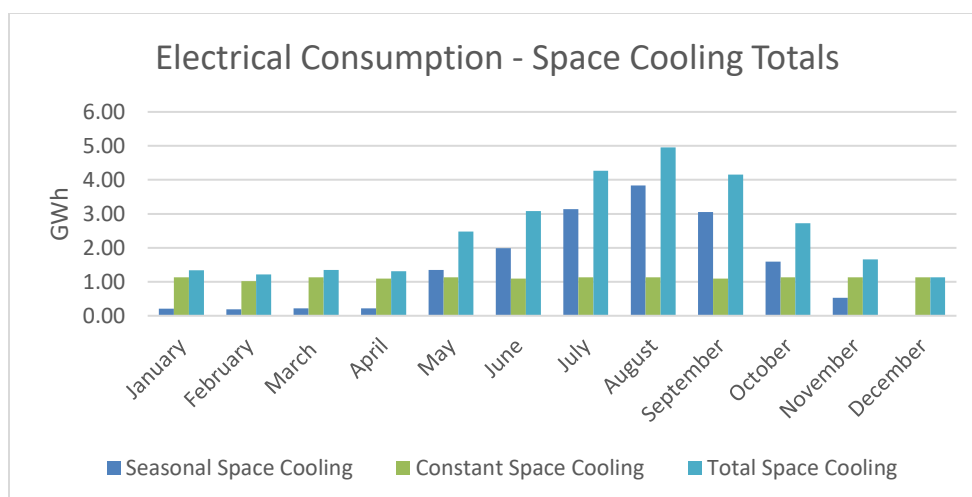


Figure 31 – Distribution of space cooling generated by electrical means for 2018

The values obtained for the space cooling profile for Malta’s largest hospital has been extrapolated by an additional 42% (reflecting a total electricity consumption of 70.04GWh as indicated by NSO) to account for the space cooling requirements in the other private and public hospitals across the islands. Table 22 below show the monthly electrical consumption for all the hospitals separated into consumption for baseload and space cooling.

Table 22 – Electrical Consumption Distribution for Maltese Hospitals

	Electrical Consumption [GWh]	Electrical Consumption for Base Load [GWh]	Electrical Consumption for Space Cooling [GWh]	Electrical Consumption for Space Cooling for all the hospital sub-sector [GWh]
January	3.26	2.23	1.03	1.46
February	2.95	2.01	0.93	1.33
March	3.27	2.23	1.04	1.47
April	3.17	2.16	1.01	1.44
May	4.14	2.23	1.91	2.71
June	4.53	2.16	2.37	3.37
July	5.51	2.23	3.28	4.66
August	6.05	2.23	3.82	5.42
September	5.35	2.16	3.19	4.53
October	4.33	2.23	2.10	2.98
November	3.41	2.16	1.28	1.81
December	3.10	2.23	0.87	1.23
<b>Total</b>	<b>49.06</b>	<b>26.26</b>	<b>22.82</b>	<b>32.41</b>

The final energy for space cooling generated by electricity in the hospitals sub-sector can be seen in the Figure 32 below shown as the ‘Total electrical consumption for space cooling for all hospitals’. On the other hand, the requirement for space heating for Malta’s largest hospital will be taken into consideration

under the next section related to fuel consumption for hospitals sub-sector, in view of the fact that space heating is covered by fuel.

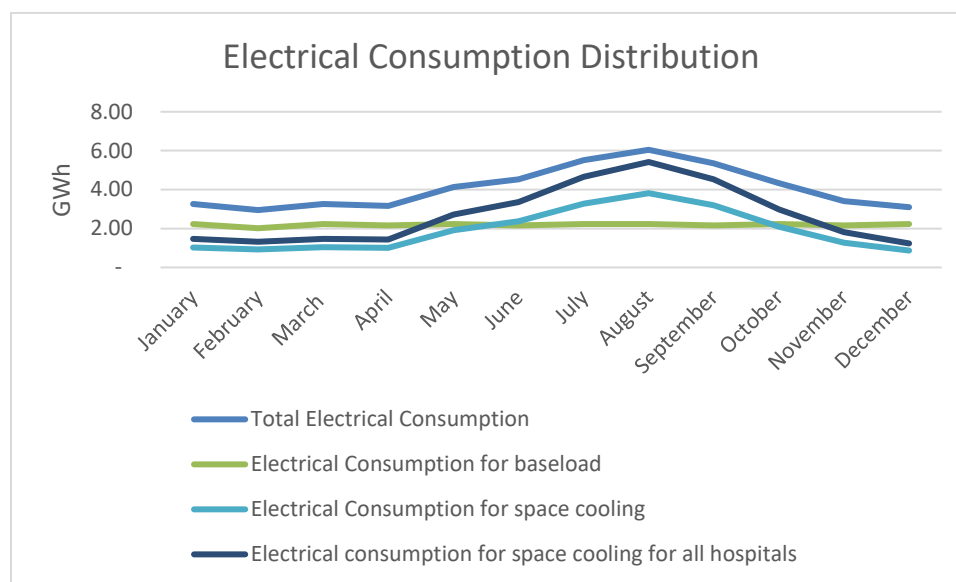


Figure 32 – Yearly profile of electrical distribution in hospitals

The useful energy was calculated using typical EER value for chillers used in Maltese hospitals, this value being 2.77<sup>28</sup>.

Table 23 – Electrical final and useful energy for the hospitals sub-sector

	End Use	Technology	Final Energy	Conversion Factor	Useful Energy
			GWh/a		GWh/a
Electricity	Space Cooling	Chillers	32.41	2.77	89.75
	Space Heating				-
	Water Heating				-
	Total		32.41		89.75

#### 1.1.2.2.2 Fuel Consumption for Hospitals Sub-Sector

<sup>28</sup> Carrier - 13050-IOM-07-2003

The fuel consumption data for the hospitals sub-sector for the year 2018 was obtained from EWA and further consolidated with data extracted from a report on the existing HVAC system at Mater Dei Hospital<sup>29</sup>.

In 2018, most of the space heating requirements for the hospitals sub-sector were met by diesel-fuelled boilers and heat recovered from space cooling chillers. The mostly consumed fuel type used for this hospital's space and water heating is diesel, whereas gasoil is mostly used for hot water generation purposes for the other hospitals.

In hospitals, space heating is required all year round. As already described above, air-handling units are used for dehumidification purposes and hence heating is required all year round to heat the air being discharged into the conditioned space and thus lower its relative humidity.

For the purpose of this study, it is being assumed that space heating is generated by fossil fuels.

The requirements for the hot water supply for most of the hospitals sub-sector is being catered for by the heat energy recovered by means of heat exchangers from the water-cooled chillers. In fact, this has been removed from the hot water demand, since it is referred to 'free energy'. The remaining demand for the hot water supply has been determined and removed from the total fuel consumption. Thus, the fuel and hence energy used for space heating has been established. This results in the useful energy for space heating for the hospitals sub-sector.

The Table 24 below shows the monthly energy consumption for space heating and water heating through fossil fuels for Malta's largest hospital in 2018.

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<sup>29</sup> A report carried out by University Consulting Ltd, namely Ing. Damien Gatt and Dr. Ing. Charles Yousif, entitled 'Assessment of the Financial Feasibility and Environmental Sustainability of a Proposed Modification to the existing HVAC system at Mater Dei Hospital'.

Table 24 – Monthly Energy Consumption for space heating and hot water generation for most of the hospitals sub-sector in Malta for 2018

	Energy for space heating [GJ] <sup>30</sup>	Energy for DHW [GJ] <sup>31</sup>	Useful Energy for space heating [GWh]	Useful Energy for water heating [GWh]	Efficiency of Boilers	Final Energy for space heating [GWh]	Final Energy for water heating [GWh]
January	5,383	823	1.495	0.229	95.2%	1.572	0.009
February	7,416	743	2.060	0.206	95.2%	2.165	0.008
March	4,030	823	1.119	0.229	95.2%	1.176	0.009
April	4,031	796	1.120	0.221	95.2%	1.177	0.008
May	4,706	823	1.307	0.229	95.2%	1.374	0.009
June	4,707	796	1.308	0.221	95.2%	1.374	0.008
July	3,861	823	1.072	0.229	95.2%	1.127	0.009
August	4,706	823	1.307	0.229	95.2%	1.374	0.009
September	4,031	796	1.120	0.221	95.2%	1.177	0.008
October	4,030	823	1.119	0.229	95.2%	1.176	0.009
November	4,707	796	1.308	0.221	95.2%	1.374	0.008
December	5,383	823	1.495	0.229	95.2%	1.572	0.009
<b>TOTAL</b>	<b>56,992</b>	<b>9,685</b>	<b>15.8</b>	<b>2.69</b>		<b>16.6</b>	<b>2.83</b>

It is important to point out that due to the fact that the energy required for the hot water generation from most of the hospitals sub-sector, is being recovered from the water-cooled chillers (used for space cooling purposes), the final energy is very small when compared to the useful energy for the same use.

Similarly to the procedure carried out in the calculations for the energy requirements for space cooling to include for all other hospitals on the Islands, the space heating requirements for the largest hospital have been extrapolated by 30% to reflect the total space heating requirements for all hospitals.

The hot water requirements for most of the hospitals sub-sector are considered to be the useful energy and hence in order to obtain the final energy for space heating the boiler efficiency values shown in Table 25 below <sup>32</sup> have been used.

<sup>30</sup> Data taken from the report entitled 'Assessment of the Financial Feasibility and Environmental Sustainability of a Proposed Modification to the existing HVAC system at Mater Dei Hospital' - Ing. Damien Gatt et al.

<sup>31</sup> Data taken from the report entitled 'Assessment of the Financial Feasibility and Environmental Sustainability of a Proposed Modification to the existing HVAC system at Mater Dei Hospital' - Ing. Damien Gatt et al.

<sup>32</sup> Inspection Report for Heating Systems – BRO A 005 30 05 2017.

*Table 25 – Boiler Efficiency*

<b>Boiler Efficiency</b>	
Boiler 1 – High Flame	94.3%
Boiler 1 – Low Flame	95.0%
Boiler 2 – High Flame	94.8%
Boiler 2 – Low Flame	95.6%
Boiler 3 – High Flame	94.9%
Boiler 3 – Low Flame	96.3%
Average	95.2%

On a different note, in the case of the smaller hospitals, the hot water demand has been calculated based on the following: the difference in average monthly temperatures and water outlet temperature, the hot water demand indicated below and the total number of number of beds for the other hospitals.

The hot water demand has been based on the UK Plumbing Design Guide with an average hot water daily usage for hospitals of 136.25litres/person/day (average for all hospitals). The total number of beds for the other hospitals was taken as total of 1120 beds as shown in Table 26 below:

*Table 26 – Number of bed available in all other local hospitals<sup>33</sup>*

<b>Other Hospitals</b>	<b>No. of Beds</b>
Sir Paul Boffa	48
Mount Carmel	501
Gozo General Hospital	158
Karin Grech	274
St. James Capua	74
St. James Zejtun	25
St. Thomas Hospital	40
<b>Total</b>	<b>1120</b>

Thus, the useful and final energy requirements for the hot water generation for the other hospitals in Malta can be seen in Table 27 hereunder. It was assumed that fuel fired boilers are the technology used for the generation of hot water in other hospitals, with an average efficiency of 95.2%.

<sup>33</sup> Malta Health System Review published in 2017 and retrieved from [https://www.euro.who.int/\\_data/assets/pdf\\_file/0009/332883/Malta-Hit.pdf?ua=1](https://www.euro.who.int/_data/assets/pdf_file/0009/332883/Malta-Hit.pdf?ua=1)



Table 27 – Total Useful and Final Energy for hot water requirements for the hospitals sub-sector

	Useful Energy for hot water generation for all hospitals [GWh]	Final Energy for hot water generation for all hospitals [GWh]
January	0.445	0.247
February	0.418	0.230
March	0.440	0.241
April	0.424	0.222
May	0.424	0.214
June	0.390	0.186
July	0.375	0.173
August	0.375	0.173
September	0.370	0.176
October	0.415	0.204
November	0.418	0.215
December	0.443	0.245
<b>Total [GWh/a]</b>	<b>4.937</b>	<b>2.524</b>

### 1.1.2.2.3 Total Final and Useful Energy for Hospitals Sub-Sector

Table 28 – Total final and useful energy for the hospitals sub-sector

	End Use	Technology	Final Energy GWh	Conversion Factor	Useful Energy GWh
Electricity	Space Cooling	Chillers	32.40	2.77	89.75
	Space Heating				-
	Water Heating				-
	<b>Total</b>		<b>32.40</b>		<b>89.75</b>
Fuel	Space Cooling	Fuel Fired Boilers	20.25	0.95	19.24
	Space Heating	Fuel Fired Boilers	23.12	0.95	22.01
	Water Heating	Fuel Fired Boilers	4.94	*	2.52
	<b>Total</b>		<b>48.31</b>		<b>43.78</b>
Total	Space Cooling		<b>52.65</b>		<b>108.99</b>
	Space Heating		<b>23.12</b>		<b>22.01</b>
	Water Heating		<b>4.94</b>		<b>2.52</b>
	<b>Total</b>		<b>80.71</b>		<b>133.52</b>

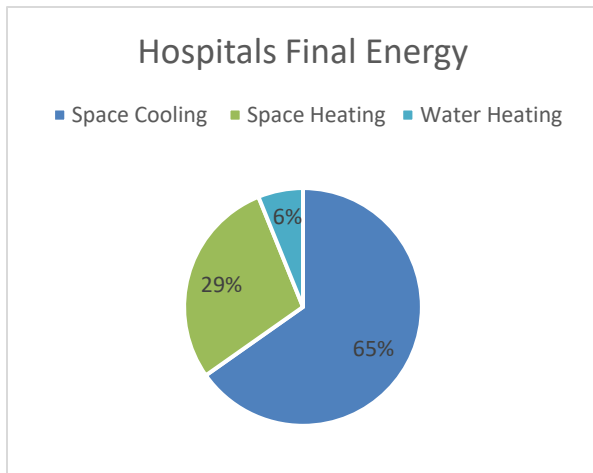


Figure 35 – Final energy consumption by end-use

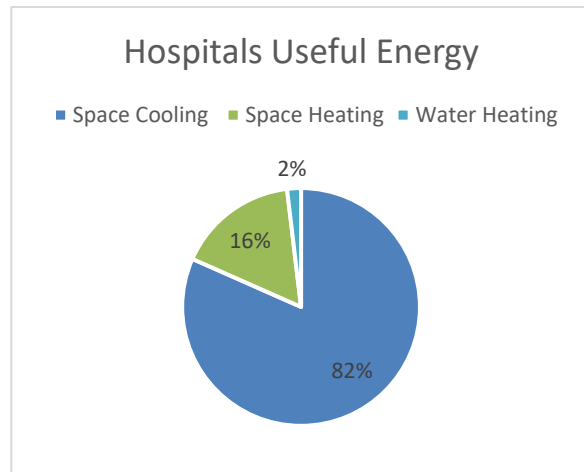


Figure 34 – Useful energy by end-use

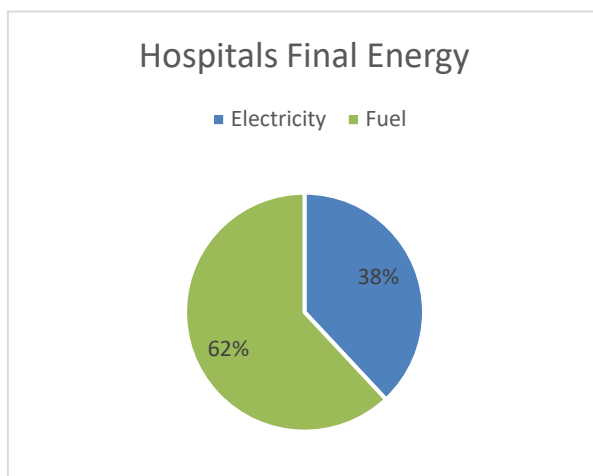


Figure 36 – Final energy consumption by source

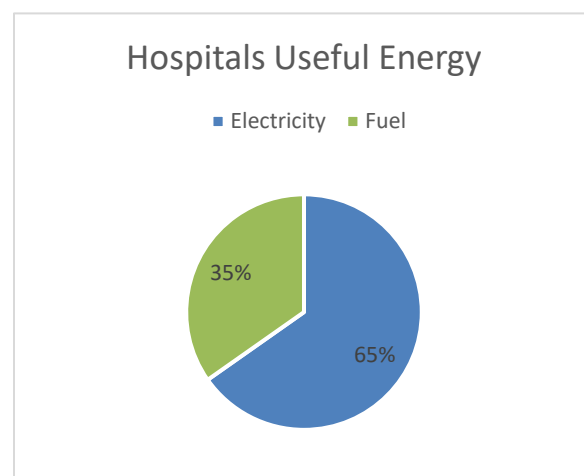


Figure 33 – Useful energy distribution by source

### 1.1.2.3 Old People's Homes Sub-Sector

Along the years Malta's population has experienced a sharp ageing transition due to both increasing and decreasing levels of life expectancy and fertility rates. At end of 2017, 18.8% of the total population, or 89,517 persons, were aged 65-plus.<sup>34</sup> Moreover, population projections indicate clearly that Malta will be one of the fastest ageing countries in the European Union. As a result of this reality, the demand for old people's homes which is already saturated is expected to continue to grow in the coming years. In Malta there are currently 5,312 available beds<sup>35</sup> in old people's homes, as indicated in the Table 28Table 29 below:

*Table 29 – Number of beds in long term care facilities across the Maltese Islands*

Long-Term Care Facilities	Facilities/Wards	Licensed Beds
Public long-term care facilities		
Community care homes	9	1,004
Long-term care wards at Gozo General Hospital	2	121
St. Vincent de Paul Long-Term Care Facility	1	1,033
Church-run care homes	14	740
Private care homes	17	2,414
<b>Total</b>	<b>43</b>	<b>5,312</b>

It should be noted that for the purpose of this study the old people's home sub-sector shall be treated similarly to the hotels sub-sector since the usage and seasonality factors are similar.

#### 1.1.2.3.1 Electrical Consumption for Old People's Homes Sub-Sector

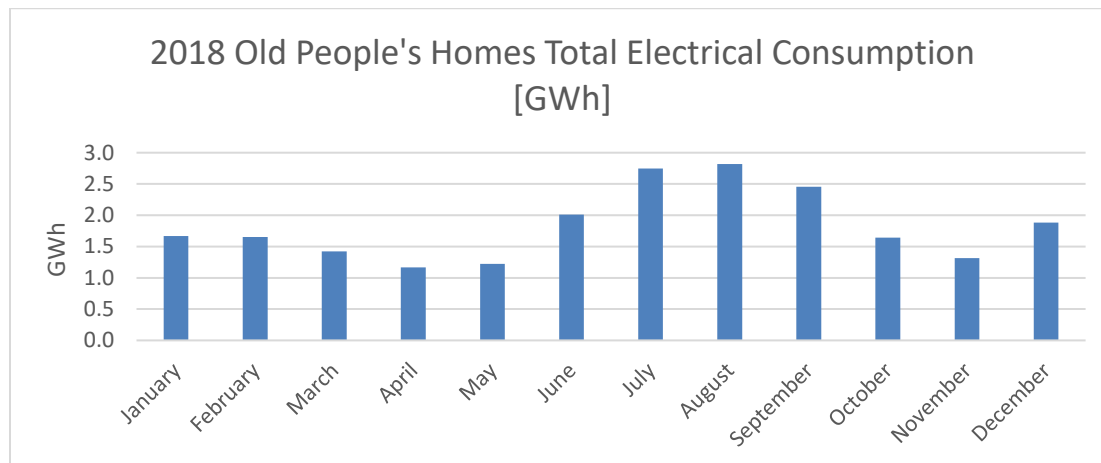
For the old people's home sub-sector, the monthly electrical consumption for the baseline year 2018 has been obtained from Enemalta plc. This data covers all old people's homes run by the Maltese Government, as per list below:

- Saint Vincent De Paule Residence
- Zammit Clapp Residence
- Mtarfa Home
- Msida Home
- Floriana Home
- Luqa Home
- Santa Venera Home

<sup>34</sup> Measuring and Modelling Demographic Trends in Malta: Implications for Ageing Policy by Prof. M. Formosa

<sup>35</sup> Report 'Long term care facilities for older persons in Malta: policies, trends and challenges' drawn up by Profs. M. Formosa

The total monthly electrical consumption for the above-mentioned homes has been added up and eventually grossed up to include the electrical consumption for all the other private old people's homes to a total yearly electrical consumption value of 24.08GWh, as reported by NSO<sup>36</sup>. Figure xxx below shows the total monthly electrical consumption for both public and private old people's homes sub-sector in Malta for 2018.



*Figure 37 – Electrical energy consumption in old-people's homes for 2018*

In view of the fact that the energy profile of old people's homes is similar to the hotels' energy profile, the same baseload used for the latter sub-sector (as indicated in the hotels sub-sector section above) is also being used as a baseload for the old people's homes sub-sector.

The Figure 38 below shows the total electrical consumption of the old people's home sub-sector in Malta together with the applicable baseload, on a monthly basis.

<sup>36</sup> Enemalta monthly Electrical Consumption by NACE Sector

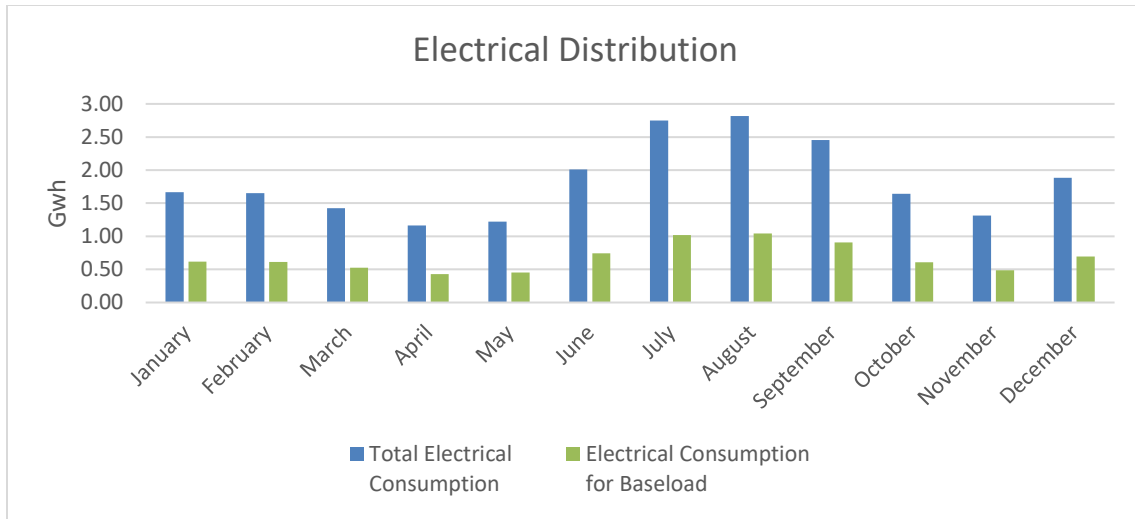


Figure 38 – Total electrical consumption and electrical consumption for baseload in old people's homes

It should be noted that the calculation of the daily thermal demand for water heating in old people's homes was based on the following: the difference in average monthly temperatures and water outlet temperature, the hot water demand and the total number of available beds. The hot water demand for old people's homes has been based on the UK Plumbing Design Guide with a hot water daily usage of 90l/person/day. The number of available beds has been obtained from a national report as indicated in footnote 34 above. The total annual thermal demand for water heating thus amounts to 7.22 GWh.

On the basis of an analysis undertaken in relation to the hot water generation technologies used in old people's homes in Malta, it results that 88% of such establishments use fuel-fired boilers to heat water while the remaining balance of 12% use heat-pump technologies for hot water generation. Therefore, a portion reflecting 88% consumption of fuel for hot water generation needs to be removed from the above-mentioned calculation. The result shows the total annual electrical consumption for water heating at 0.23GWh (reflecting the 12% of the final energy consumption by means of electricity). It is to be noted that the electricity required for the generation of hot water is used by heat-pumps and hence the useful energy demand was converted to final energy consumption by using a factor of 3.8 which is a typical COP factor for heat pump technology. Since the heat pump technology is relatively new in the Maltese islands, no degradation in the COP has been taken into account.

By way of conclusion, the consumption profile for the electricity used for space heating and cooling in old people's homes sub-sector has been determined using the below formula:

$$\text{Total Consumption for Heating or Cooling} = [\text{Total Consumption}] - [\text{Baseload}] - [\text{Hot water generated by electricity}]$$

The electricity consumption that remained after the removal of the baseload units and the electricity consumption for hot water generation was attributed to space heating and cooling, depending on the months. The months between November to mid-April are assumed to cover space heating and those from mid-April to October are assumed to cover space cooling.

*Table 30 – Electricity distribution for different purposes in old people's homes sub-sector*

	<b>Total Yearly Electrical Consumption [GWh]</b>	<b>Yearly Electrical Consumption for Baseload [GWh]</b>	<b>Yearly Electrical Consumption for DHW [GWh]</b>	<b>Yearly Electrical Consumption Used for Space Cooling and Heating [GWh]</b>
January	1.82	0.68	0.02	1.13
February	1.81	0.67	0.02	1.12
March	1.56	0.58	0.02	0.96
April	1.28	0.47	0.02	0.78
May	1.34	0.49	0.02	0.82
June	2.20	0.81	0.02	1.37
July	3.01	1.11	0.02	1.88
August	3.08	1.14	0.02	1.93
September	2.69	0.99	0.02	1.68
October	1.80	0.66	0.02	1.11
November	1.44	0.53	0.02	0.89
December	2.06	0.76	0.02	1.28
<b>TOTAL [GWh/a]</b>	<b>24.08</b>	<b>8.91</b>	<b>0.23</b>	<b>14.94</b>

The Figure 39 below shows the total electrical consumption in old people's homes on a monthly basis, as well as the baseload, electricity consumption for hot water generation and the electricity consumption for space heating and cooling.

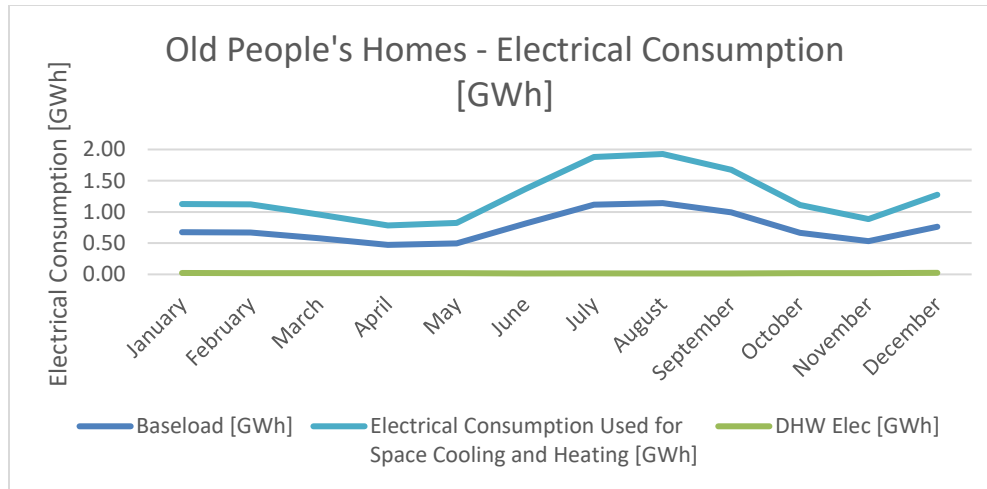


Figure 39 – Yearly profile of electrical energy distribution between energy use for baseload, space heating and cooling and hot water generation.

From the above calculations, the final energy for space heating and cooling generated by electrical means in the old people's homes sub-sector can be seen in the Figure 40 below.

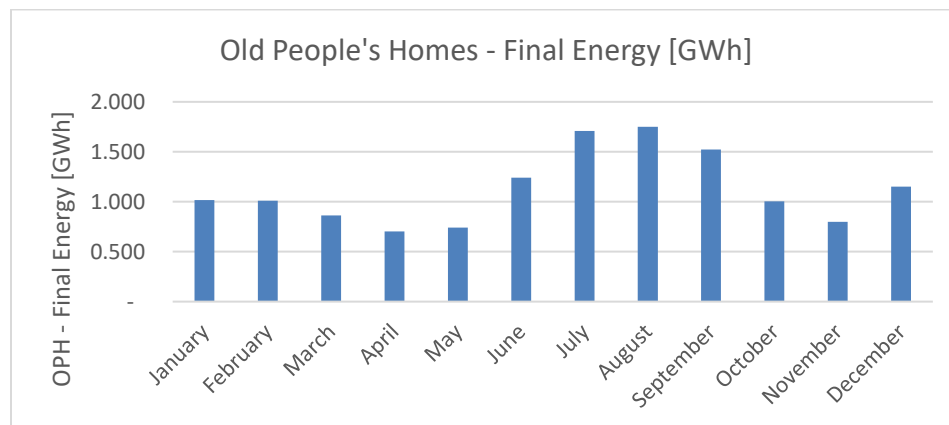


Figure 40 – Monthly final electrical distribution for space heating and cooling in old people's homes.

In order to arrive at the useful energy for space heating and cooling for the old people's homes sub-sector in Malta, COPs and EERs of heat pump systems have been used. An analysis has been carried out to determine the percentage distribution of different heat pump technologies use for space cooling purposes in the old people's homes sub-sector. Based on this study it was determined that 85% use VRV systems while the remaining 15% use air-cooled chiller technology. The decay in efficiency factors for the said type of air-conditioning technologies has been calculated by the same method described in Section 1.1.1.1 in the Residential Sector, resulting in the below efficiency factors:

Table 31 – EER for different cooling technologies

EER		
VRF	85 %	2.712
Air Cooled Chiller	15 %	2.893
Weighted Average		2.739

Table 32 – COPs for different cooling technologies

COP		
VRF	85 %	3.435
Air Cooled Chiller	15 %	3.616
Weighted Average		3.462

Based on the above-indicated COPs and EERs, the useful energy for space heating and space cooling generated by electricity in the old people's homes sub-sector has been calculated and is shown in Table 33 below.

Table 33 – Final and Useful Electrical Energy Consumption for old people's homes

End Use		Technology	Final Energy	Conversion Factor	Useful Energy
			GWh/a		GWh/a
Electricity	Space Cooling	Heat pumps	8.23	2.74	22.55
	Space Heating	Heat pumps	6.71	3.46	23.23
	Water Heating	Heat pumps	0.23	3.80	0.87
	Total		15.17		46.65

#### 1.1.2.3.2 Fuel Consumption for Old People's Homes Sub-Sector

For the purpose of this study, in view of the fact that no specific data was available for the fossil fuel consumption for the old people's homes sub-sector, an assumption that the above-mentioned 88% of the total hot water requirements are the only fuel consumption for this sub-sector was used. It is being assumed that no fuel consumption is used for space heating and cooling purposes in old people's homes.

Table 34 below shows the energy required for the hot water generation by fuel means by this sub-sector.



Table 34 – Final and useful energy by fuel means for old people's homes

	Useful energy (88% of the total) generated by boilers [GWh]	Boiler Efficiency	Final Energy for hot water generation [GWh]
January	0.625	0.85	0.74
February	0.583	0.85	0.69
March	0.610	0.85	0.72
April	0.560	0.85	0.66
May	0.539	0.85	0.63
June	0.466	0.85	0.55
July	0.430	0.85	0.51
August	0.431	0.85	0.51
September	0.439	0.85	0.52
October	0.513	0.85	0.60
November	0.542	0.85	0.64
December	0.619	0.85	0.73
<b>TOTAL</b>	<b>6.358</b>		<b>7.480</b>

### 1.1.2.3.3 Total Final and Useful Energy for Old People's Homes Sub-Sector

The final and useful energy produced by electricity and fuel means for the old people's home sub-sector is recorded in Table 35 hereunder.

Table 35 – Total final and useful energy in the old people's homes sub-sector

	End Use	Technology	Final Energy	Conversion Factor	Useful Energy
			GWh/a		GWh/a
Electricity	Space Cooling	Heat pumps	8.23	2.74	22.55
	Space Heating	Heat pumps	6.71	3.46	23.23
	Water Heating	Heat pumps	0.23	3.80	0.87
	Total		15.17		46.65
Fuel	Space Cooling				-
	Space Heating				-
	Water Heating	Fuel Fired Boilers	7.47	0.85	6.35
	Total		7.47		6.35
Total	Space Cooling		8.23		22.55
	Space Heating		6.71		23.23
	Water Heating		7.70		7.22
	Total		22.64		53.00

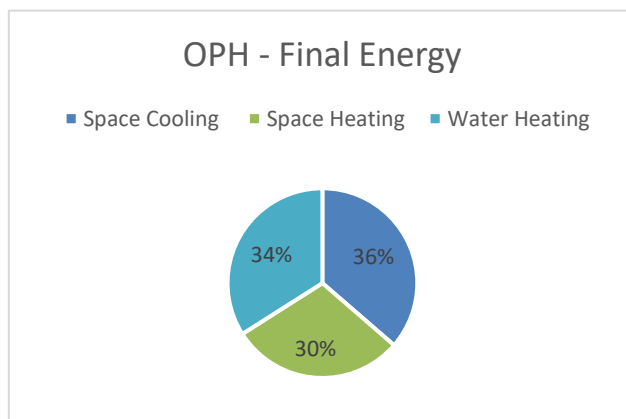


Figure 42 – Final energy consumption by end-use

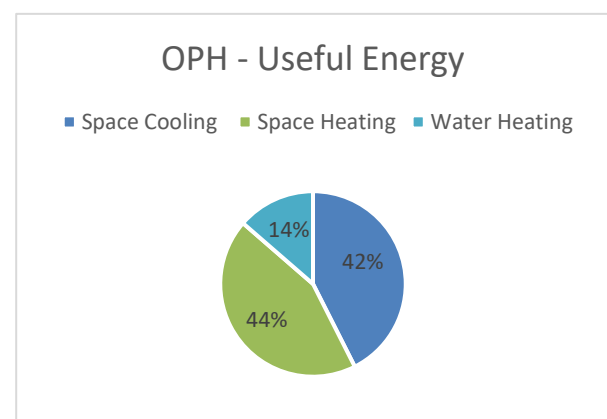


Figure 41 – Useful energy by end-use

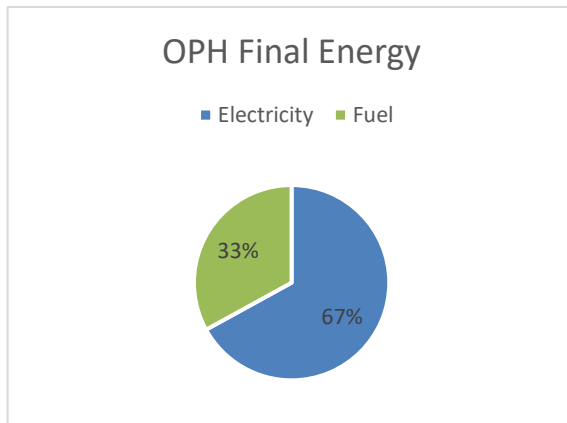


Figure 44 – Final energy consumption by source

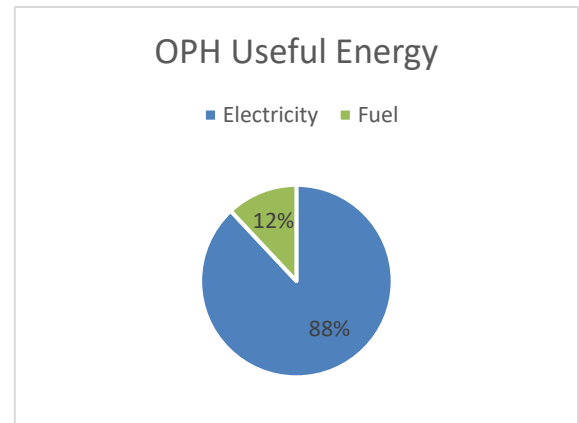


Figure 43 – Useful energy by source

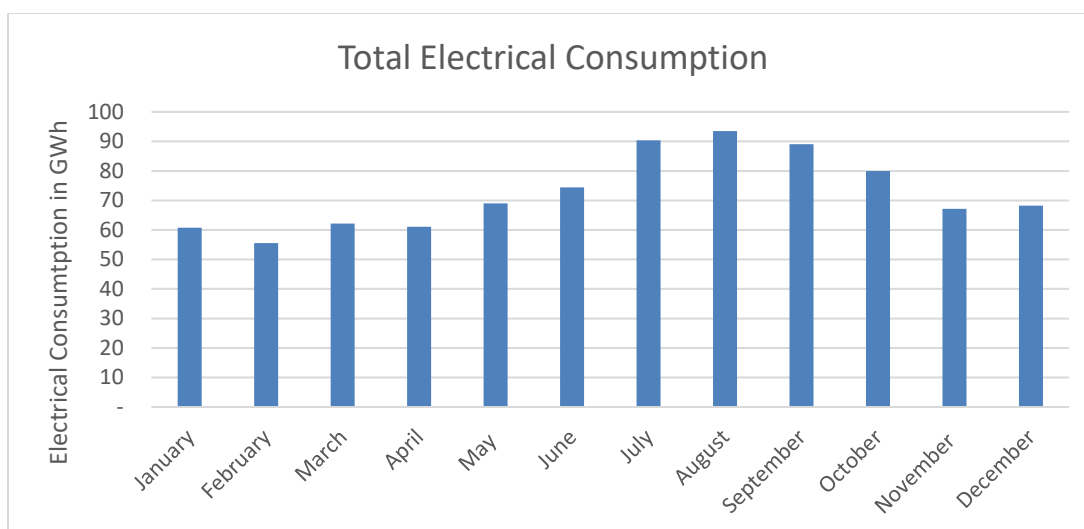
#### 1.1.2.4 Commercial sub-sector including public buildings, retail, offices, food and beverage outlets, schools and others

In recent years commercial spaces in Malta have been on the increase with spaces dedicated to retail and offices, as well restaurants and bars increasing dramatically, probably reflecting the expanding tourism industry. This indicates that development in retail and offices is likely to continue to increase in the coming years, with additional space allocation and increasing energy demands.

Apart from retail, food and beverage outlets, public buildings, office spaces, schools are also being considered under this commercial sub-sector. The public buildings include all Government-owned properties; these range in size, building characteristics and age as well as energy use, however the these buildings are being considered to have an energy profile similar to the offices, hence they have been included in this sub-sector. The electrical consumption for hospitals and old peoples' homes has been completely removed from the workings of this sub-sector as they have been studied separately in the hospitals and old people's home sub sectors above.

##### 1.1.2.4.1 Electrical Consumption for Commercial Sub-Sector

The total electrical energy consumed monthly for the commercial sub-sector cover the above-mentioned areas for the base year 2018 has been obtained from Enemalta plc. This data is shown in Figure 45 hereunder. The total electrical consumption in this sub-sector for 2018 is 871GWh. This value does not include 25GWh which is consumed for street lighting and is not included in the total electrical consumption in 2018 since it is not required for the purpose of this report.



*Figure 45 – Monthly Electrical Consumption for the Commercial sub-sector*

For this sub-sector, the daily thermal demand for water heating was calculated based on the following: the difference in average monthly temperatures and water outlet temperature, the hot water demand indicated above and the total number of employees. It has been assumed that this sub-sector uses electrical water heaters for water heating production together with the assumption that no solar water heating is being generated from the services sector.

The hot water demand has been based on the UK Plumbing Design Guide with a hot water daily usage for office workers of 12.5l/person/day (average for all categories). The number of full-time employees in 2018 for the following categories was obtained from the NSO News Release, Gainfully Occupied Population: December 2018 and January 2019.

The number of full-time employees in 2018 in the private sector was obtained from NSO data<sup>37</sup>, as indicated in Table 36 below.

<sup>37</sup> News release by NSO dated 12<sup>th</sup> July - Gainfully Occupied Population: December 2018 and January 2019, downloadable from [https://nso.gov.mt/en/News\\_Releases/View\\_by\\_Unit/Unit\\_C2/Labour\\_Market\\_Statistics/Documents/2019/News2019\\_110.pdf](https://nso.gov.mt/en/News_Releases/View_by_Unit/Unit_C2/Labour_Market_Statistics/Documents/2019/News2019_110.pdf)

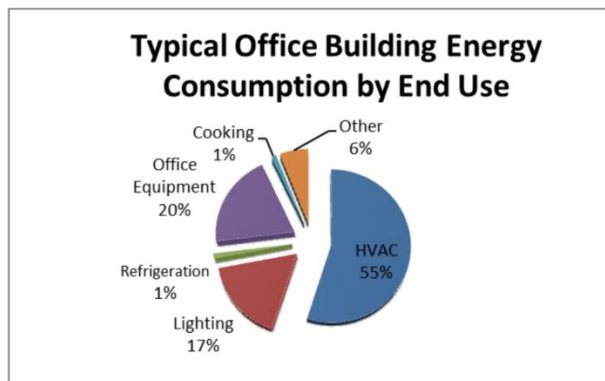
Table 36 – No of full-time employees working in the commercial sub-sector

Category	NACE CODE	No. of employees
Wholesale and Retail	45-47	26,898
Food and Beverage	56	7,532
Information and Communication	58-63	7,591
Financial and Insurance Activities	64-66	10,620
Real Estate Activities	68	1,861
Technical Activities	69-75	13,874
Administration	77-82	19,088
Education	85	17,323
Social work activities	88	1,432
Libraries, archives & museums	91	416
Sports	92	1,003
Others	94-96	4,229
<b>Total</b>		<b>111,867</b>

Assuming that some workers are on either on leave, sick leave or not at the office every day, a factor of 0.8 was applied to the above total, resulting in a total of full-time employees for the private sector of 89,494.

Due to the fact that this sub-sector includes also food and beverage outlets, it is known that a part of the hot water generation is being covered by LPG (fossil fuel).<sup>38</sup> This portion of hot water demand will be removed from the thermal hot water demand and it will be assumed that the remaining amount will be generated by electrical water heating. No solar water heating is being generated in this sub-sector.

The baseload energy consumption, which reflects the electrical energy used for lighting, power of equipment and appliances, is being assumed to be a constant throughout the year. In order to determine the said baseload several publications were consulted. In one case, as per



<sup>38</sup> EWA fuel survey

Figure 46 below, the baseload is being defined as consuming around 45% of the total energy use in a typical office building.

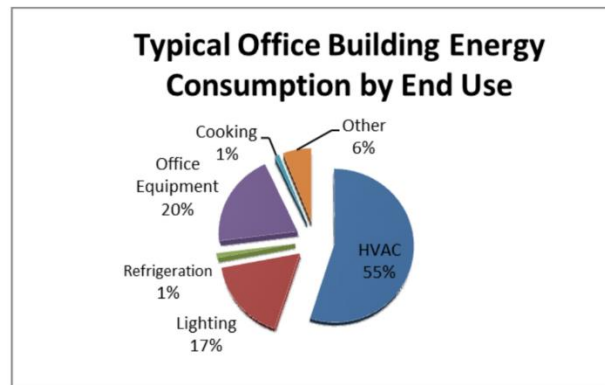


Figure 46 – Typical Office Building Energy Use<sup>39</sup>

Another publication states that the baseload for an office scenario is 47% of the total energy consumption as shown in Figure 47 below:

Typical energy usage in a large, airconditioned office.

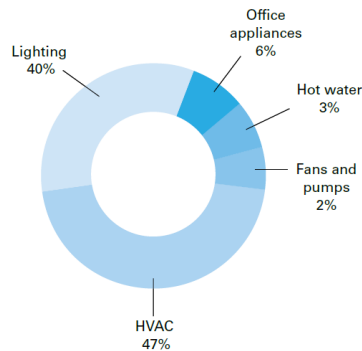


Figure 47 – Typical energy usage in a large, airconditioned office.<sup>40</sup>

Hence, in this study, a constant baseload consumption of 45% has been applied to the total yearly electrical consumption for this sector; this has been split into twelve months to determine the monthly baseload value.

<sup>39</sup> A PROCESS MODEL FOR HEATING, VENTILATING AND AIR CONDITIONING SYSTEMS DESIGN FOR ADVANCED ENERGY RETROFIT PROJECTS, Thesis by Yifan Liu, Research Gate Publication and downloadable from [https://www.researchgate.net/publication/333671816\\_A\\_PROCESS\\_MODEL\\_FOR\\_HEATING\\_VENTILATING\\_AND\\_AIR\\_CONDITIONING\\_SYSTEMS\\_DESIGN\\_FOR\\_ADVANCED\\_ENERGY\\_RETROFIT\\_PROJECTS](https://www.researchgate.net/publication/333671816_A_PROCESS_MODEL_FOR_HEATING_VENTILATING_AND_AIR_CONDITIONING_SYSTEMS_DESIGN_FOR_ADVANCED_ENERGY_RETROFIT_PROJECTS)

<sup>40</sup> HEATING, VENTILATIONAND AIR CONDITIONING Saving energy without compromising comfort, PSEE and NBI, [www.psee.org.za](http://www.psee.org.za)

After removing the monthly hot water generation consumption and the monthly baseload consumption, the remaining monthly energy consumed was assumed to be used for space heating and cooling. The heating and cooling months have been determined to be mid-October to mid-April as 'heating' months and mid-April to mid-October as 'cooling' months.

The resulting energy consumptions are indicated in Table 37 hereunder.

*Table 37 – Electricity distribution for different purposes*

	<b>Total Electrical Consumption [GWh]</b>	<b>Electrical Hot Water requirement [GWh]</b>	<b>Baseload Consumption [GWh]</b>	<b>Electrical Energy for Space Heating and Cooling [GWh]</b>
January	60.72	4.86	33.29	22.56
February	55.53	4.54	30.07	20.92
March	62.13	4.74	33.29	24.09
April	61.08	4.35	32.22	24.51
May	68.96	4.19	33.29	31.47
June	74.45	3.63	32.22	38.61
July	90.34	3.35	33.29	53.70
August	93.49	3.35	33.29	56.85
September	89.01	3.41	32.22	53.38
October	79.99	3.99	33.29	42.71
November	67.13	4.22	32.22	30.70
December	68.26	4.81	33.29	30.15
<b>Total</b>	<b>871.08</b>	<b>49.45</b>	<b>391.99</b>	<b>429.65</b>

The Figure 48 below shows the total electrical consumption of the commercial sub-sector in Malta per month together with the electricity consumption for the baseload and finally the remaining electricity consumption which is allocated to space heating and cooling for the commercial sub-sector in Malta.

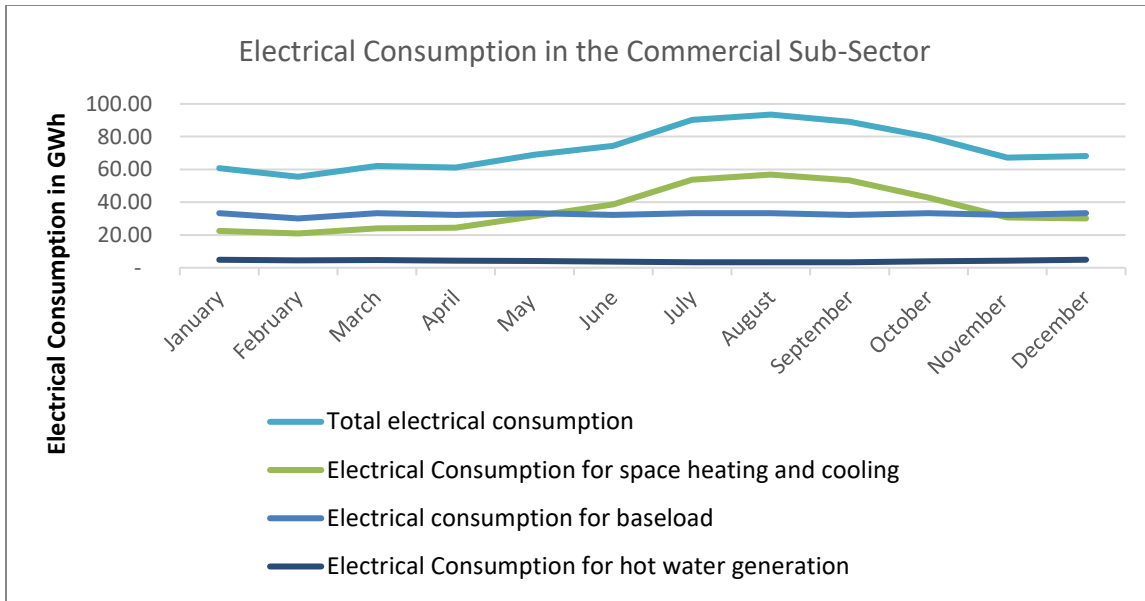


Figure 48 – Yearly profile of electrical energy distribution between energy use for baseload, space heating and cooling and hot water generation.

On the basis of the above, Figure 49 below shows the percentage distribution of electrical energy in the commercial sub-sector in Malta. The baseload has the largest percentage, followed by space cooling and space heating.

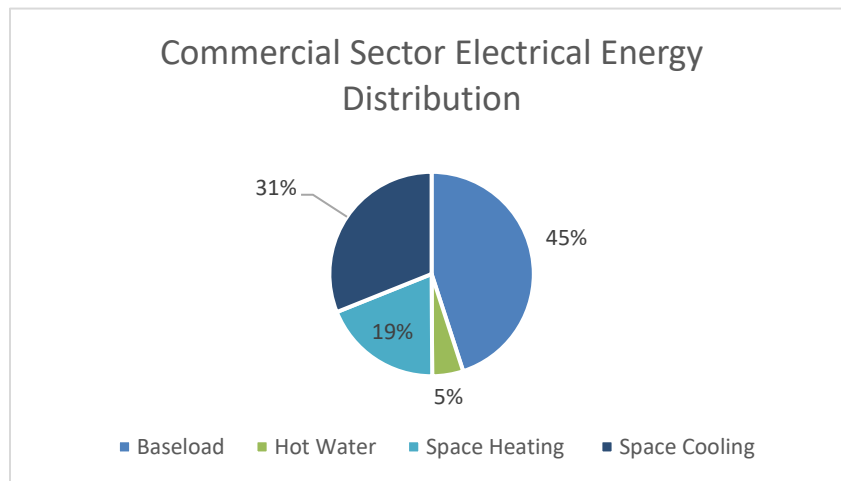


Figure 49 – Electrical energy Distribution by end use for the commercial sub-sector

The final energy resulting from electrical consumption for the space heating and cooling requirements in commercial buildings is shown in Figure 50 below.



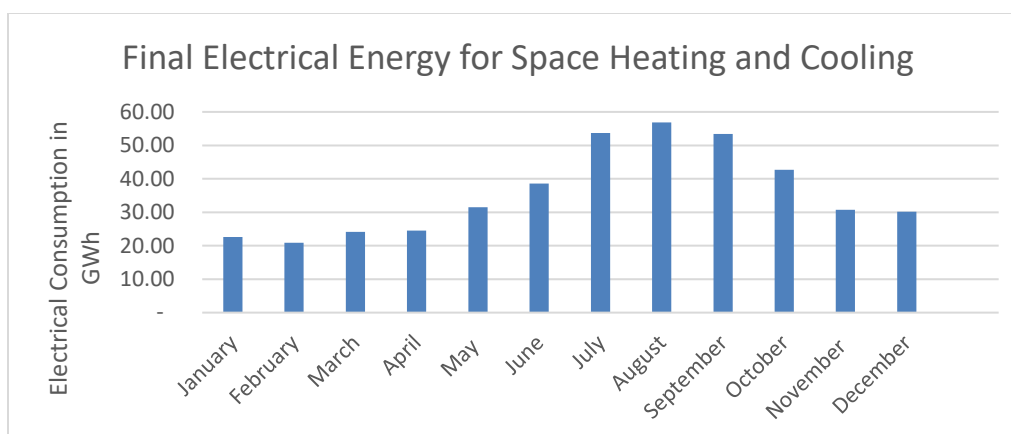


Figure 50 – Monthly final electrical distribution for space heating and cooling in the commercial sub-sector.

Due to the fact that actual data for space heating and cooling technologies for the commercial sub-sector was not available at the time of writing, it was assumed that space heating and cooling for this particular sub-sector is being carried out by means of VRV systems. Moreover, since no information about the age of the VRV systems installed is available, an average age of 5 years was considered in order to calculate the degradation of COPs and EERs of such VRV systems. The degraded values of COPs and EERs was calculated as per method explained in section 1.1.1.1 of the Residential Sector and the results can be found in Table 38 below.

Table 38 – Degraded EER and COP values for VRV technology

Degraded value EER	2.712
Degraded value COP	2.892

These values have then been used to calculate the useful energy for electrical consumption in commercial buildings as indicated in Table 39 below :

Table 39 – Final and useful electrical energy for the commercial sub-sector

	End Use	Technology	Final Energy	Conversion Factor	Useful Energy
			GWh/a		GWh/a
Electricity	Space Cooling	Heat pumps	267.62	2.712	725.78
	Space Heating	Heat pumps	162.03	2.892	468.59
	Water Heating	Electrical Heating	49.45	0.90	44.50
	Total		479.09		1,238.87

### 1.1.2.4.2 Fuel Consumption for Commercial Sub-Sector

The fossil fuel consumption data for the commercial sub-sector was obtained from the EWA. This was split in the consumption per end use and can be seen in Table 40 hereunder:

*Table 40 – Fossil Fuel Consumption for Commercial Services Sector including retail, offices, schools, food and beverage outlets and others for 2018<sup>41</sup>*

<b>Fuel Type</b>	<b>Fuel Use</b>	<b>Energy Consumption for Commercial including Offices, Schools and Others (NACE H, J, K, L, M, N, P, R, G and S) GWh/a</b>	<b>Energy Consumption for Food Service Activities (NACE I 56) – GWh/a</b>	<b>Total for Commercial Sub-Sector GWh/a</b>
Fuel Oil	Spatial cooling/ventilation and refrigeration	-	-	-
	Spatial Heating Purposes	-	-	-
	Water Heating Purposes	1.66	-	1.66
Gasoil	Spatial cooling/ventilation and refrigeration	-	0.46	0.46
	Spatial Heating Purposes	-	0.68	0.68
	Water Heating Purposes	1.08	-	1.08
Kerosene	Spatial cooling/ventilation and refrigeration	-	-	-
	Spatial Heating Purposes	0.06	-	0.06
	Water Heating Purposes	-	-	-
LPG	Spatial cooling/ventilation and refrigeration	0.11	0.09	0.20
	Spatial Heating Purposes	0.85	0.46	1.32
	Water Heating Purposes	2.08	0.02	2.10
Total	Spatial cooling/ventilation and refrigeration			0.65
	Spatial Heating Purposes			2.06
	Water Heating Purposes			4.84
<b>TOTAL [GWh/a]</b>				<b>7.55</b>

Note: Diesel and petrol are not included in the above table since their consumption value for the commercial sub-sector is considered negligible.

<sup>41</sup> Data obtained from EWA Fuel Survey

The above data shows clearly that LPG is the mostly used fossil fuel in the commercial sub-sector with the second mostly used fossil fuel being Gas Oil. These two fossil fuel types are mainly used to generate hot water and space heating in the commercial sub-sector, as can be seen in Figure 51 below.

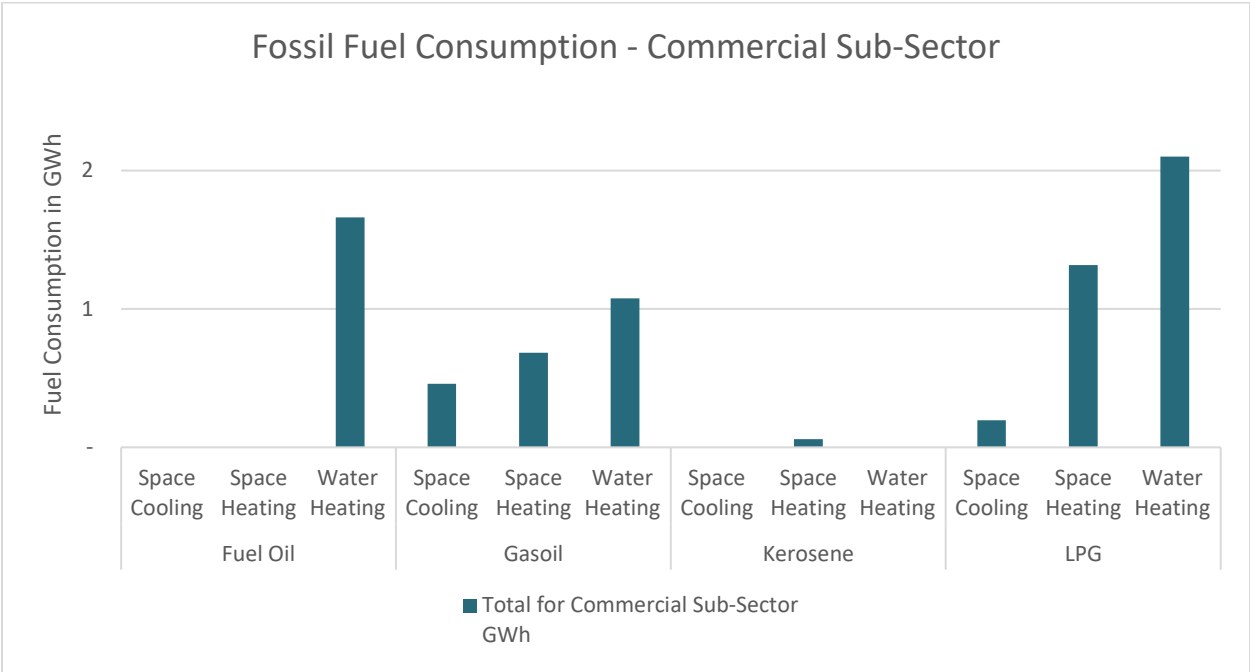


Figure 51 – Fossil fuel consumption by fuel type and end-use

On the basis of the data indicated above, Figure 52 below shows the percentage distribution of fossil fuel and uses in the commercial sub-sector, namely space cooling, space heating and water heating.

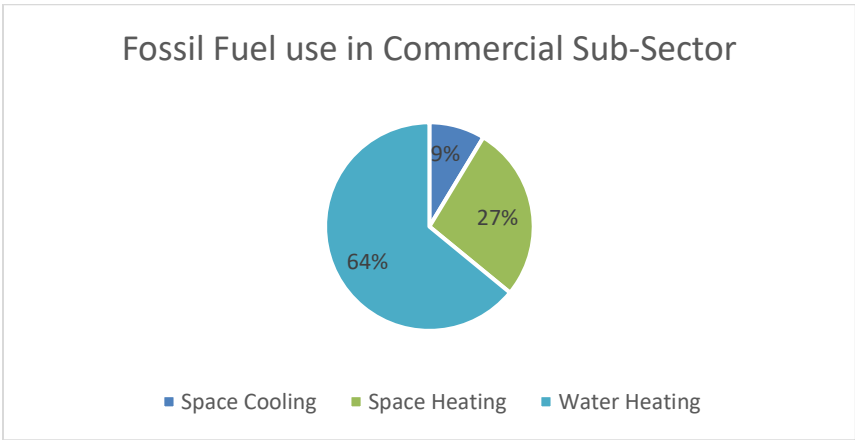


Figure 52 – Fossil fuel distribution by end use for the commercial sub-sector

In order to determine the useful energy derived from the fossil fuel consumption in the commercial sub-sector, it was assumed that fuel fired boilers with an efficiency of 85% are used as indicated in Table 41

below. For the purpose of this study, it was assumed that the space cooling generated from fossil fuels was negligible and hence will not be considered in the useful energy calculations.

#### 1.1.2.4.4 Total Final and Useful Energy for Commercial Sub-sector

The final and useful energy produced by electricity and fuel for the commercial sub-sector is shown in Table 41 hereunder.

Table 41 – Total final and useful energy in the commercial sub-sector

	End Use	Technology	Final Energy	Conversion Factor	Useful Energy
			<b>GWh/a</b>		<b>GWh/a</b>
Electricity	Space Cooling	Heat pumps	267.62	2.712	725.78
	Space Heating	Heat pumps	162.03	2.892	468.59
	Water Heating	Electrical Heating	49.45	0.90	44.50
	Total		479.09		1,238.87
Fuel	Space Cooling	Fuel Fired Boilers	0.65	0.85	0.56
	Space Heating	Fuel Fired Boilers	2.06	0.85	1.75
	Water Heating	Fuel Fired Boilers	4.84	0.85	4.11
	Total		7.55		6.42
Total	Space Cooling		<b>267.62</b>		<b>725.78</b>
	Space Heating		<b>164.09</b>		<b>470.34</b>
	Water Heating		<b>54.28</b>		<b>48.61</b>
	<b>Total</b>		<b>485.99</b>		<b>1244.74</b>

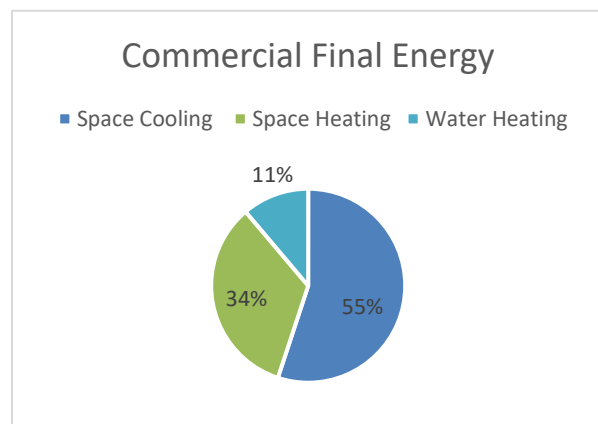


Figure 54 – Final energy consumption by end use

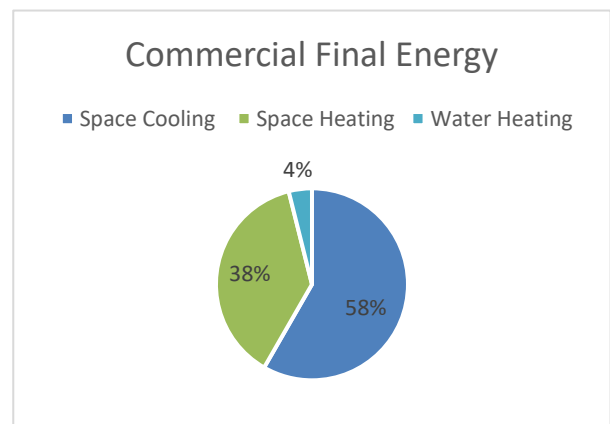


Figure 53 – Useful energy by end use

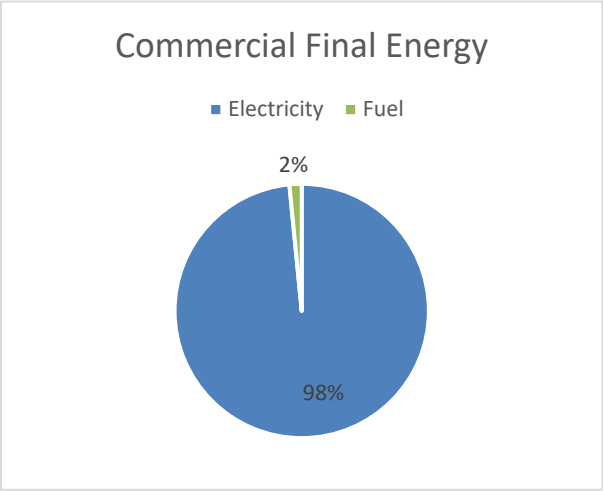


Figure 56 – Final energy consumption by source

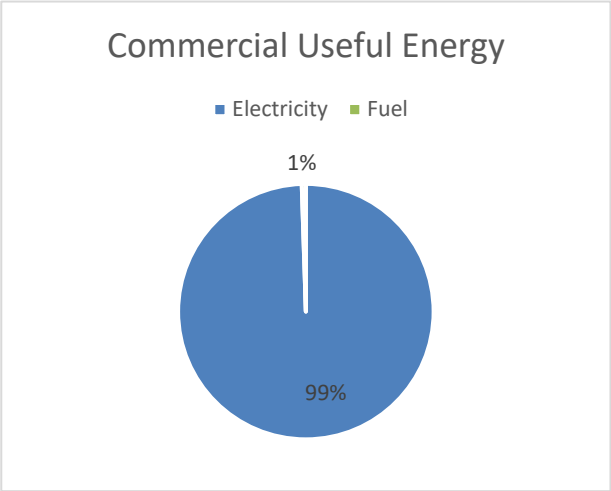


Figure 55 – Useful energy by source

### 1.2.1.5 Aggregate Results for the Services Sector

The total Final Energy and Useful Energy in 2018 including the electricity and fuel consumption attributed to space cooling, space heating and water heating for the entire services sector (sub-divided into different sub-sectors) can be found in Table 42. These aggregate results reflect the methodologies and calculations described earlier in this chapter.

*Table 42 – Total final and useful energy for the services sector in 2018*

SECTOR	SUB-SECTOR	End Use	Total final energy in GWh in 2018	Total useful energy in GWh in 2018
Services	Hotels	Space Cooling	64.04	206.86
		Space Heating	49.95	121.79
		Water Heating	68.50	58.23
	Hospitals	Space Cooling	52.65	108.99
		Space Heating	23.12	22.01
		Water Heating	4.94	2.52
	Old People's Homes	Space Cooling	8.23	22.55
		Space Heating	6.71	23.23
		Water Heating	7.70	7.22
	Commercial including Offices, Public Buildings, Schools and Others	Space Cooling	267.62	725.78
		Space Heating	164.09	470.34
		Water Heating	54.28	48.61
	<b>TOTAL</b>	<b>Space Cooling</b>	<b>392.55</b>	<b>1064.18</b>
		<b>Space Heating</b>	<b>243.88</b>	<b>637.37</b>
		<b>Water Heating</b>	<b>135.42</b>	<b>116.58</b>
		<b>Heating and cooling purposes</b>	<b>771.84</b>	<b>1818.13</b>
	<b>Other purposes</b>		729.69	

As evidenced in the table above, the highest energy consuming sub-sector is the commercial one, with the highest energy demand being for space cooling purposes. It should be noted that the commercial sub-sector which includes not only offices and public buildings but also food and beverage outlets, amongst others, has grown significantly in the last years and hence the high consumption could also be attributed to such growth. The next highest consuming sub-sector is the hotel industry with a high demand for water heating. This high rate of consumption can also be a result of the high demand for accommodation following an exponential growth in the tourism sector in Malta in the last years.

The figures below give a snapshot of the distribution of the final and useful energy consumption for the services sector. As can be seen from the said figures, energy consumption is mostly used for space cooling across the board, apart from the hotels sub-sector which is the only exception given that its water heating consumption is more than that of its consumption for space cooling.

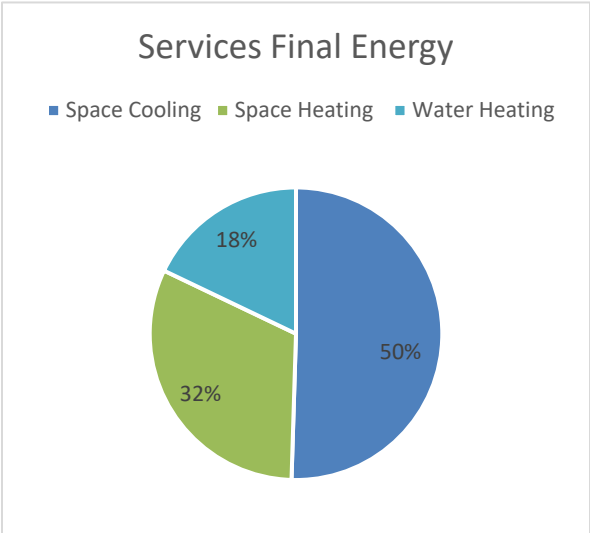


Figure 58 – Final energy consumption by end-use

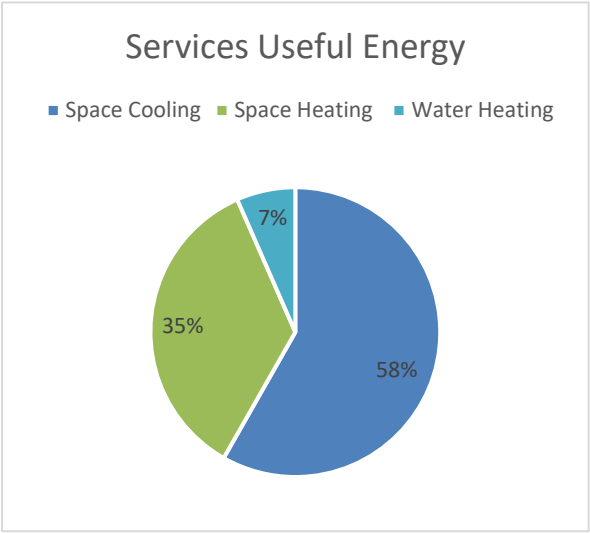


Figure 57 – Useful energy by end-use

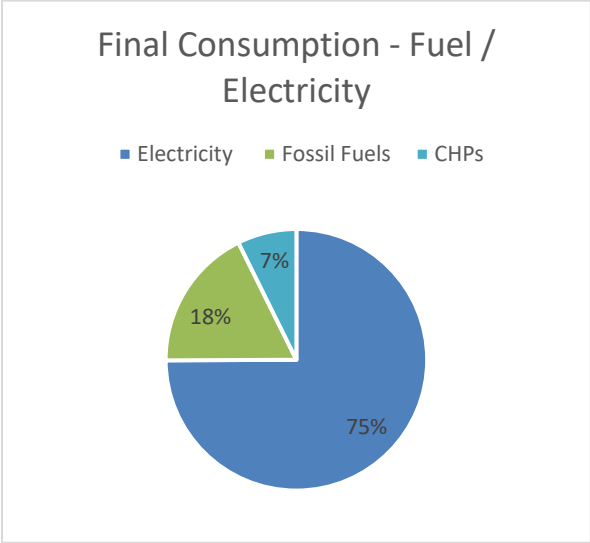


Figure 60 - Final energy consumption by source

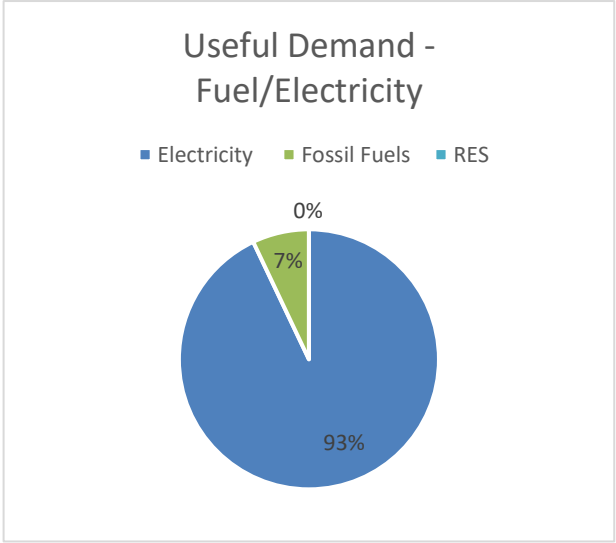


Figure 59- Useful energy by source

As evidenced in the figures below, the main predominant source of energy generation in the services sector is electricity, with a relatively much lower use of fossil fuels. It is to be noted that the use of renewable energy sources is very limited and is described in further detail in Section 1.2.1.5.3 hereunder.

### 1.2.1.5.1 Electrical Consumption

Electrical consumption in the Services Sector is very high, and as already explained, it is mostly used for space cooling purposes, with the use of heat pumps to convert electrical energy into space cooling. The table below depicts the final and useful electrical energy divided into the indicated three main different energy uses.

Table 43 – Final and Useful Electrical Energy in the Services Sector

Electricity	End Use		Final Energy	Useful Energy
			GWh/a	GWh/a
	Space Cooling	Heat pumps	372.29	1,044.94
	Space Heating	Heat pumps	200.34	598.01
	Water Heating	Boilers	49.67	45.37
	Total		622.31	1,688.31

The figures below show the electrical final energy for the different uses by the Services Sector, with a 59% use for space cooling and a relatively lower 32% for space heating and a 9% for water heating. When it comes to the energy demand, space cooling covers 61% whilst space heating and water heating cover 36% and 3% respectively.

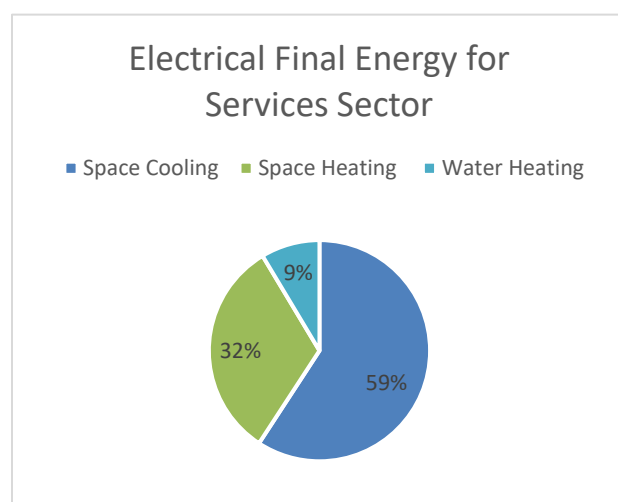


Figure 61 – Electrical final energy by end-use

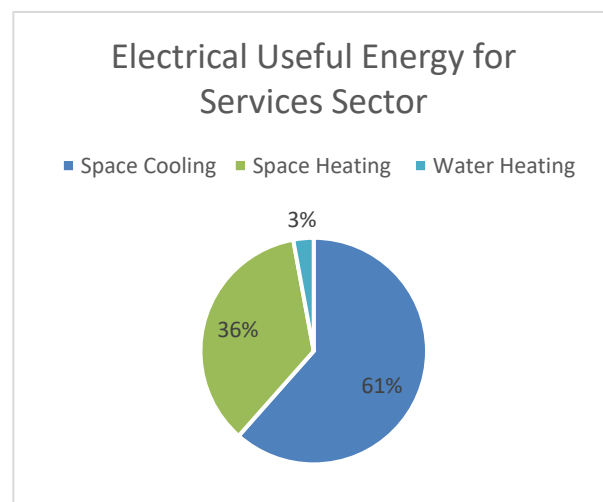


Figure 62- Electrical useful energy by end-use



### 1.2.1.5.2 Fuel Consumption

Fossil fuels in the Services Sector are mostly used for water heating purposes through fuel-fired boilers. The table below depicts the final and useful fuel energy divided into the indicated three main different energy uses. It should be noted that the space cooling in the Services Sector covers the post-cooling requirements for humidity-controlled spaces in the hospital sub-sector.

Table 44 – Fuel Consumption per sub-sector split into space cooling, space heating and water heating purposes<sup>42</sup>.

End Use			Final Energy	Useful Energy
			GWh/a	GWh/a
Fuel	Space Cooling	Boilers	20.91	19.24
	Space Heating	Boilers	43.53	39.36
	Water Heating	Boilers	85.75	71.21
	Total		150.19	129.81

The figures below show the percentage distribution of fossil fuels for different usage within the Services Sector.

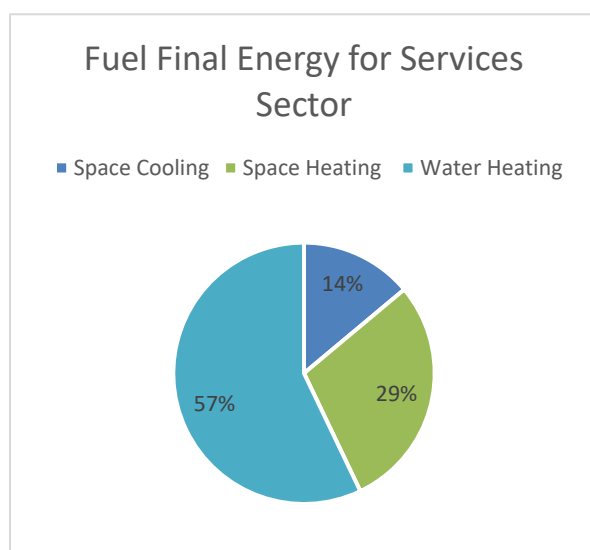


Figure 64 – Fuel final energy consumption by end-use

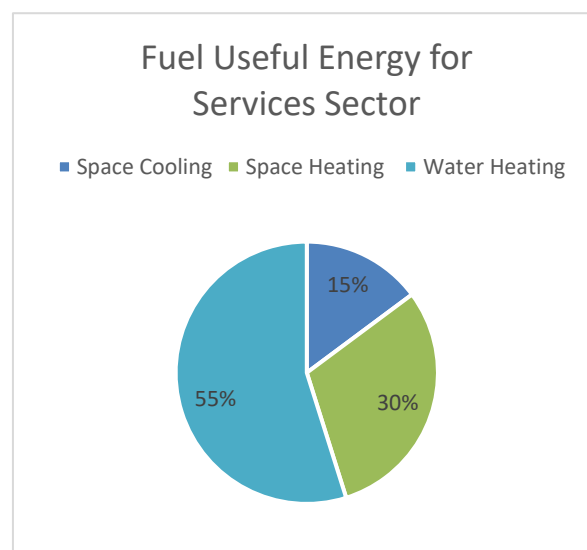


Figure 63-Fuel useful energy consumption by end-use

<sup>42</sup> Data extracted from EWA Fuel Survey.

Figure 65 below shows the fossil fuel consumption in the different Services sub-sectors according to the different usages.

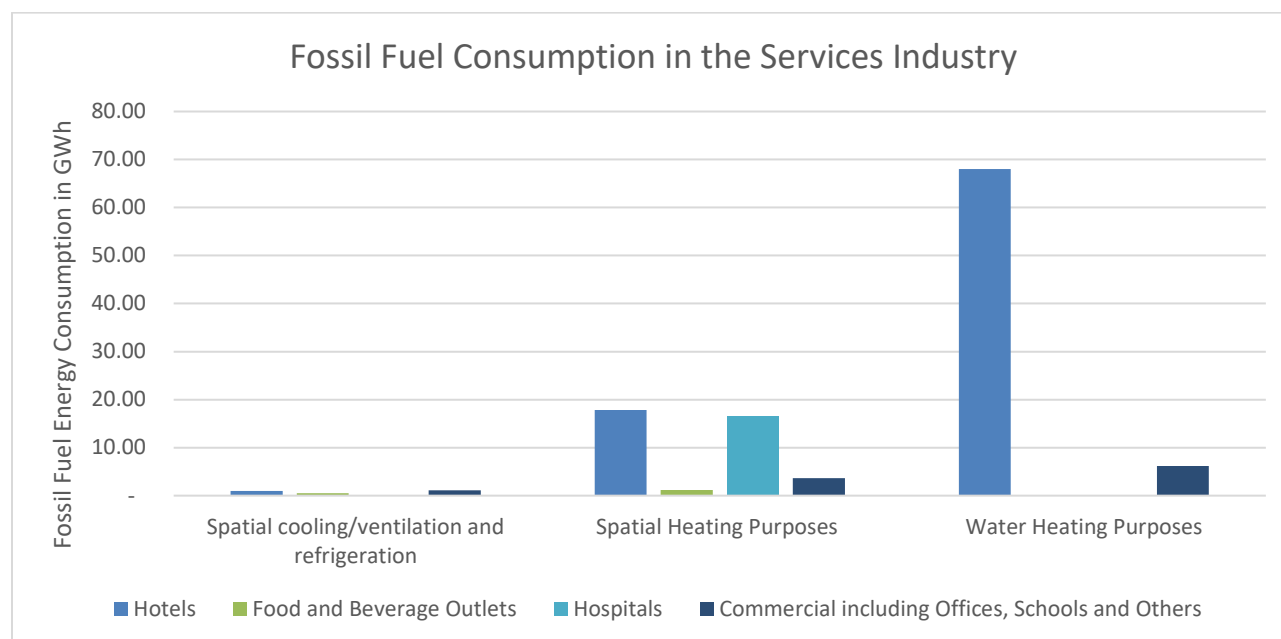


Figure 65 – Fossil Fuel Consumption in the Services Industry split by sub-sector and by end-use

#### 1.2.1.5.3 Renewable Energy Systems

Within the Services Sector, the renewable energy is mainly generated by heat pumps and combined heat and power machines.

#### Combined Heat and Power

In 2018, a total of four CHP (Combined Heat & Power) or cogeneration plants using biogas were licensed by the Regulator for Energy and Water Services as seen in the list below, all of which were in operation in 2018:

1. Wastserv Ltd Sant Antnin CHP – application GEN/APP/CHP/01/10, licensed on 01-Oct-2011 and consisting of two reciprocating engines of 1.021Mwe and 716kWe respectively.
2. Wasteserv Ltd Maghtab CHP – application GEN/APP/CHP/09/12, licensed on the 18-Oct-2012 and consisting of a reciprocating engine of 190kWe.
3. Water Services Corporation – Ta' Barkat Sewage Treatment Plant – application reference GEN/APP/CHP/05/11, licensed on the 10/6/2015 and consisting of 3 reciprocating engines with a total capacity 1.11Mwe.

4. Wasteserv Ltd Malta North MBT CHP – reference application GEN/APP/CHP/01/16, licensed on the 03-Feb-2017 and consisting of a reciprocating engine for a total of 1.523Mwe.

The total final thermal energy reported by EWA as being produced by the CHPs is **6.19GWh**.

## Heat pumps

Following consensus reached to consider heat pumps as a renewable energy source, in line with Article 2 of the Directive on the promotion of the use of renewable energy sources, Directive 2009/28/EC, Annex VII of the said Directive establishes the basic method for calculating renewable energy supplied by heat pumps. The said Annex sets out three parameters that are needed for the calculation of the renewable energy from heat pumps to be counted for the renewable energy targets:

- (a) the power system efficiency ( $\eta$  or eta);
- (b) the estimated amount of useful energy supplied from the heat pumps (Qusable);

the 'seasonal performance factor' (SPF).

The methodology for determining the power system efficiency ( $\eta$ ) was agreed in the Renewable Energy Statistics Working Party of 23 October 2009. The Commission Decision 2013/114/EU of 1 March 2013 establishing the guidelines for Member States on calculating renewable energy from heat pumps from different heat pump technologies set out how Member States should estimate the two remaining parameters of Qusable and the 'seasonal performance factor' (SPF), taking into consideration differences in climatic conditions, especially very cold climates. With these guidelines, Member States are enabled to calculate the amount of renewable energy supplied by heat pump technologies.

In the case of Malta, a value of 55.7GWh has been calculated as the total renewable energy derived from heat pumps in the Services Sector in 2018. <sup>43</sup>

Table 45 below shows the energy generated from the said renewable sources.

*Table 45 – Energy generated by renewable sources in the services sector*

End Use		Technology	Final Energy GWh/a	Useful Energy GWh/a
RES	Space Cooling			
	Space Heating	Ambient heat from heat pumps	55.7	
	Water Heating	CHPs	6.89	
	<b>Total</b>		<b>61.86</b>	

<sup>43</sup> Data from EWA.

### 1.1.3 Industry Sector

Although Malta is considered as an attractive destination for industrial investment due to its geographical location, modern infrastructure, adequate and flexible labour supply, it is pertinent to note that the GDP contribution of industry to Malta's economy is approximately 10%, below the EU average.<sup>44</sup> With the growth of export-orientated services, there was a decline of the manufacturing industry in Malta, with the major change being that in the clothing industry whilst the technology-based industries, such as the electronic components industry, increased their relative share of the sector.<sup>45</sup> Government's economic policies focus on assisting industrial players in tapping foreign markets and in restructuring their operations, while targeting new foreign direct investment in high quality, export orientated activities. The industry target sectors in Malta are quite diverse, ranging from electronics, pharmaceuticals, healthcare, plastics, rubber, aircraft maintenance and other similar relatively capital-intensive areas generating a higher value added per employee.

The industrial sector consists of a mixture of large enterprises and numerous smaller family-run companies, as well as subsidiaries of mainly European companies that account for most of Malta's export earnings.

The main sources of data about energy consumption for the industry sector in Malta for the base year 2018 have been obtained from the below entities:

- Enemalta Plc, which has provided the monthly energy consumption, according to geographical location;
- Energy and Water Agency (EWA), which provided the amount of fossil fuels, per type of fuel and NACE code used by the industry sector.

#### 1.1.3.1 Electrical Consumption for the Industry Sector

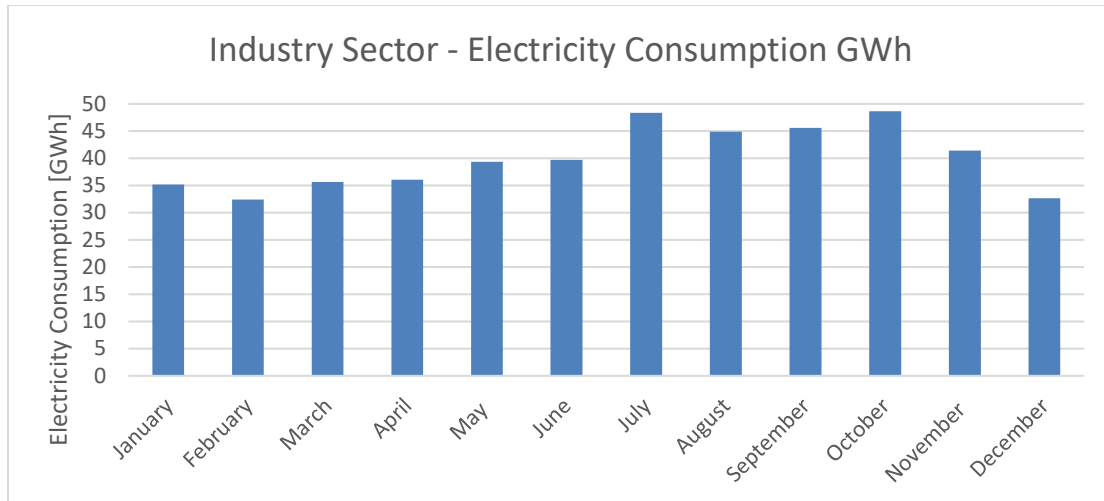
For the purposes of this study, the total electricity consumed monthly by the industry sector for the base year 2018 has been obtained from Enemalta plc, as can be shown in Figure 66 below. This data has been grossed up to reflect a total electricity consumed by the Industry Sector in 2018 amounts to 477.5GWh<sup>46</sup>.

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<sup>44</sup> Economic Vision for Malta 2014-2020, Malta Chamber of Commerce, Enterprise and Industry.

<sup>45</sup> The Maltese economy: structure and performance: University of Malta, published on the 20 July 2016

<sup>46</sup> Sectorial electricity consumption, Industry: Source EWA



*Figure 66 – Electricity Consumption in 2018 in the Industry Sector*

Given that it is being assumed that hot water generation and space heating requirements in the industry sector are being covered by means of fossil fuels, there is no need to remove the electricity demand attributed to hot water generation / space heating from the electricity consumption as part of this assessment. In the absence of actual and specific data for the electricity consumption for space cooling, the methodology explained below was used to be able to determine this consumption.

The monthly consumption was split into daily consumption and the minimum daily electricity consumption was determined. The lowest consumption was found to be in December at a daily value of 1.052GWh. In order to calculate the daily electrical baseload requirement, the daily minimum consumption was further reduced by 5% so as to take into account the space cooling required in the month with lowest consumption i.e. December, due to industrial processes which still require cooling during the winter months.

The baseload electrical consumption was then subtracted from the daily electrical consumption to calculate the daily electrical consumption for space cooling and this again grossed up to monthly values. Figure xxx below shows the distribution of the electrical consumption between the baseload requirements and space cooling requirements throughout the year.

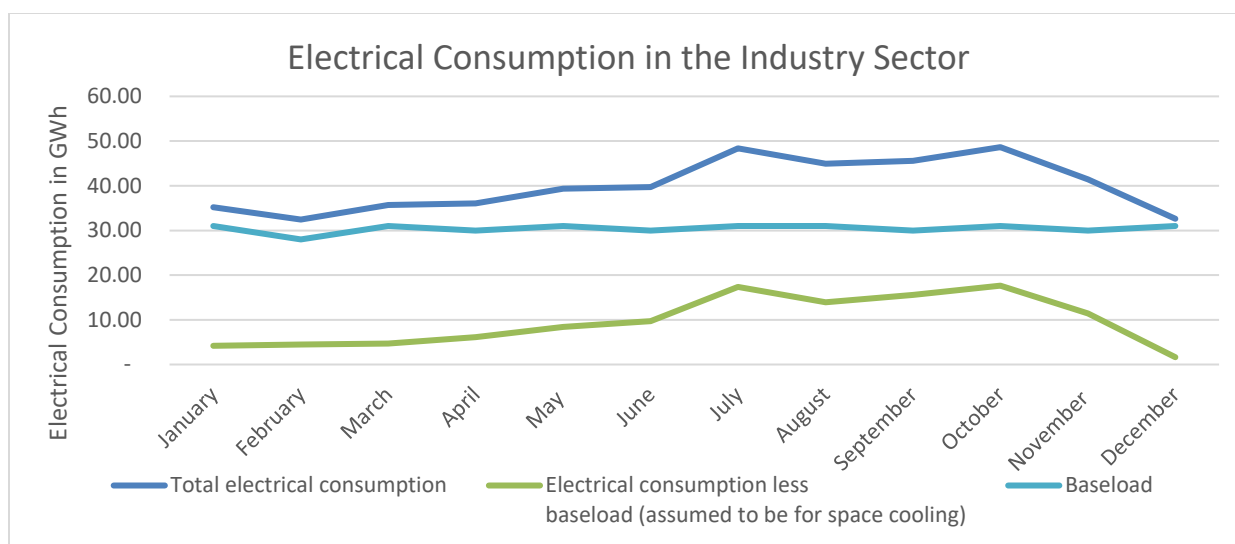


Figure 67 – Yearly profile of electrical energy distribution between energy use for baseload and space cooling for the Industry Sector.

On the basis of the above, Figure 67 shows the monthly electrical energy distribution in the industry sector in Malta for 2018.

For the calculation of the useful energy, an EER of 2.77 has been applied, which is a typical value of EER for air-cooled chillers.

Table 46 below shows the final energy consumption and useful energy requirements from electricity for the Industry Sector. It should be noted that for the purposes of this study, due to lack of energy data used for process cooling purposes, the value of energy consumed under space cooling is being assumed to include energy for process cooling in the industry sector.

Table 46 – Final and useful electrical energy for the industry sector

	End Use	Technology	Final Energy	Conversion Factor	Useful Energy
			GWh/a		GWh/a
Electricity	Space Cooling	Heat pumps	114.49	2.77	317.15
	Space Heating				
	Water Heating				
	<b>Total</b>		<b>114.49</b>		<b>317.15</b>

### 1.1.3.2 Fuel Consumption for the Industry Sector

Fossil fuel consumption data for the Maltese Industry Sector was obtained from EWA. This was split in consumption per end use as can be seen in Table 47 hereunder.

*Table 47 – Fossil Fuel Consumption for the Industrial Sector in 2018 according to different NACE codes, source EWA.*

Fuel Type	Purpose	Industry Sub-Sectors			
		Mining and Quarrying – GWh/a	Manufacturing – GWh/a	Construction – GWh/a	TOTAL GWh/a
Diesel	Space Cooling	-	-	-	-
	Space Heating	-	-	-	-
	Water Heating	-	-	-	-
Fuel Oil	Space Cooling	-	0.29	-	0.29
	Space Heating	-	-	-	-
	Water Heating	-	-	-	-
Gasoil	Space Cooling	-	4.97	-	4.97
	Space Heating	-	9.46	0.84	10.30
	Water Heating	0.71	5.08	0.29	6.08
Kerosene	Space Cooling	-	-	-	-
	Space Heating	-	-	-	-
	Water Heating	-	2.93	-	2.93
LPG	Space Cooling	-	0.68	0.01	0.68
	Space Heating	-	0.13	-	0.13
	Water Heating	-	1.93	-	1.93
Petrol	Space Cooling	-	-	-	-
	Space Heating	-	-	-	-
	Water Heating	-	-	-	-
<b>Total (GWh)</b>		<b>0.71</b>	<b>25.46</b>	<b>1.14</b>	<b>27.37</b>

Note: Diesel and Petrol are not included in the above table since the values are considered negligible.

The above data shows clearly that gasoil is the mostly used fossil fuel in the Industry Sector, with the second most used fuel being kerosene. Figure 68 below indicates the type of fuel used in different sub-sectors of the industry sector, by type, consumption and end use.

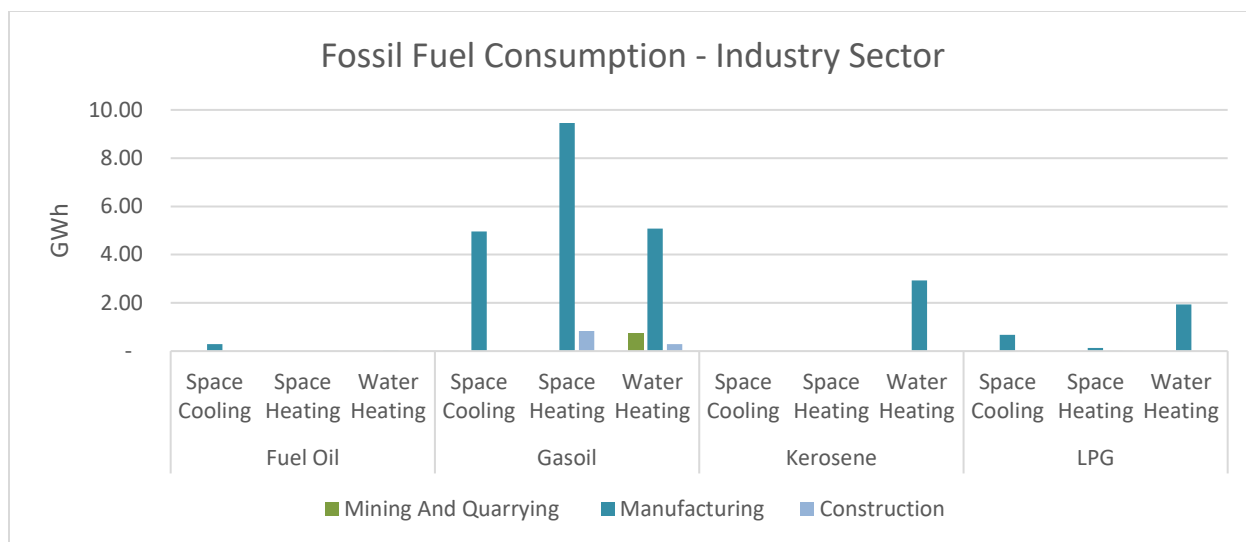


Figure 68- Fossil fuel distribution in the industry sector by industry type

For the purpose of this study, only the fossil fuel consumption for the manufacturing industry will be considered further, since this falls under the Nace Code C, thus bring it in parallel with the electricity consumption readings and data.

The figure below shows the different fuel types used in the Industry Sector (Manufacturing) in Malta in 2018, together with the respective percentage usage, showing gasoil to be the most common fuel used, with a 77% share of usage.

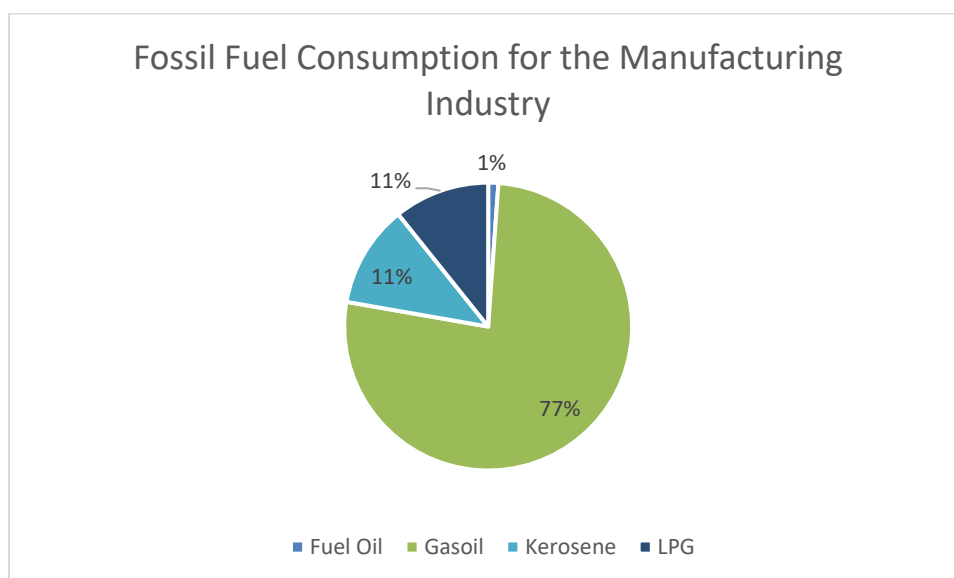


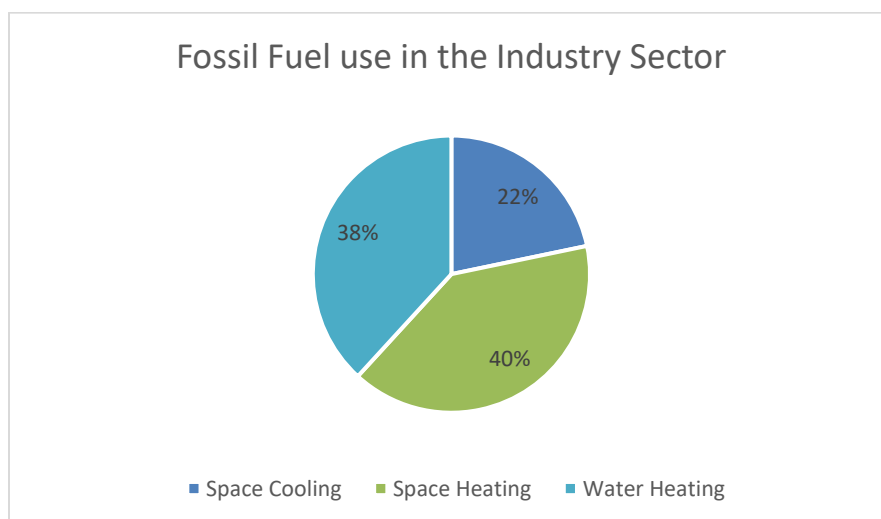
Figure 69 – Fossil Fuel Consumption for different fuel types



The distribution of fossil fuels for different usage in the Industry Sector is shown in the table below, showing that fuel-fired boilers are the most commonly used technology for this sector, for both space cooling and heating, as well as for water heating.

	End Use	Technology	Final Energy	Conversion Factor	Useful Energy
			GWh/a		GWh/a
Fuel	Space Cooling	Fuel Fired Boilers	5.94	0.85	5.05
	Space Heating	Fuel Fired Boilers	10.95	0.85	9.30
	Water Heating	Fuel Fired Boilers	10.43	0.85	8.87
	<b>Total</b>		<b>27.32</b>		<b>23.22</b>

The figure below shows the different purposes of fossil fuels usage in the Industry Sector in 2018, with the two most common being space heating and water heating. A relatively small amount of fuel is used for space cooling purposes mostly in manufacturing plants which require humidity controlled spaces for their manufacturing processes, which will use boilers to reheat air which has been cooled at dew point temperature to remove the humidity in air, as a result of the high humidity values which is common in the Maltese Island's climate.



*Figure 70 – Fossil Fuel use for space heating, cooling and water heating purposes*

### 1.1.3.3 Total Final and Useful Energy for Industry Sector

On the basis of the data outlined above and taking into consideration the methodologies and assumptions indicated above, the following is a quantification of the final and useful energy for the Industry sector for space heating and cooling as well as water heating as indicated in Table 48 below.

*Table 48 -Summary of the final and useful energy in the industry sector by energy source and use*

	End Use	Technology	Final Energy	Conversion Factor	Useful Energy
			GWh/a		GWh/a
Electricity	Space Cooling	Heat pumps	114.49	2.77	317.15
	Space Heating				
	Water Heating				
		Total	114.49		317.15
Fuel	Space Cooling	Fuel Fired Boilers	5.94	0.85	5.05
	Space Heating	Fuel Fired Boilers	10.95	0.85	9.30
	Water Heating	Fuel Fired Boilers	10.43	0.85	8.87
		Total	27.32		23.22
Total	Space Cooling		<b>120.43</b>		<b>322.20</b>
	Space Heating		<b>10.95</b>		<b>9.30</b>
	Water Heating		<b>10.43</b>		<b>8.87</b>
		<b>Total</b>	<b>141.81</b>		<b>340.37</b>
Others			<b>448.76</b>		

The figures below give a snapshot of the distribution of the final and useful energy consumption for the Industry Sector. As can be seen from the said figures, energy consumption is mostly used for space cooling.

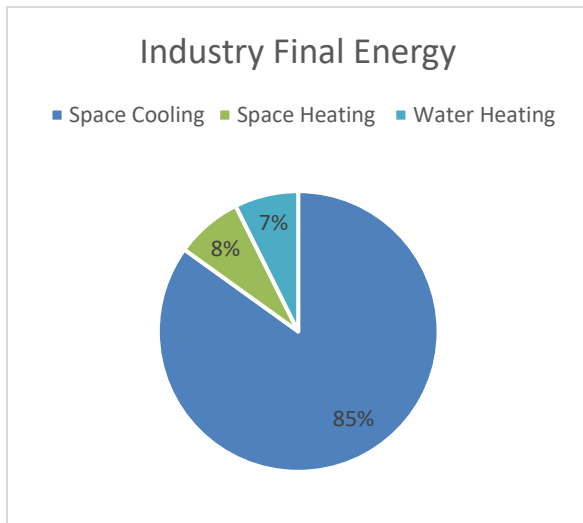


Figure 72- Final energy consumption by end-use

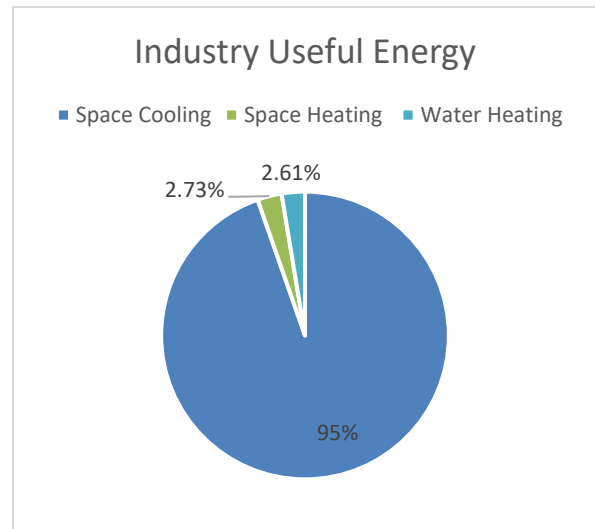


Figure 71- Useful energy consumption by end-use

Moreover, as evidenced in the figures below, electricity is the main energy generator in the Industry Sector.

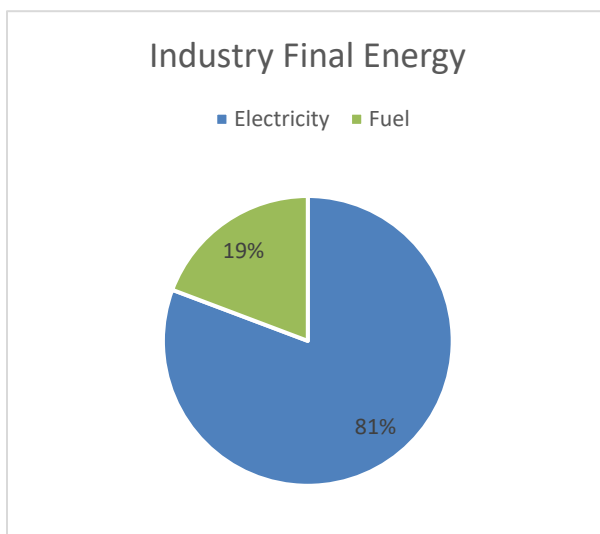


Figure 74- Final energy consumption by source

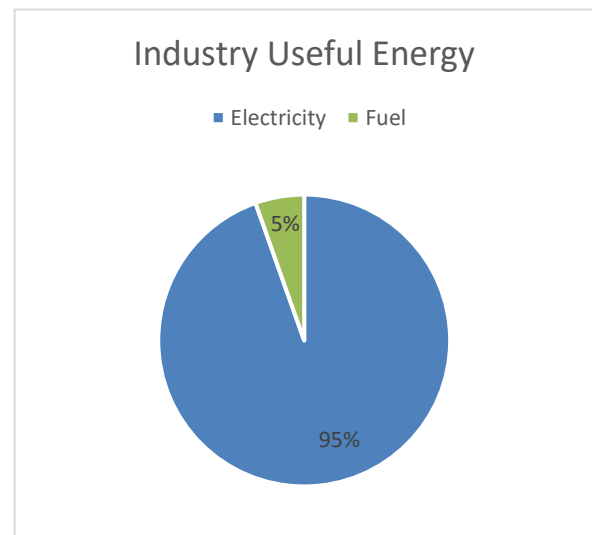


Figure 73- Useful energy consumption by source

## 1.1.4 Summary for Heating and Cooling Demand

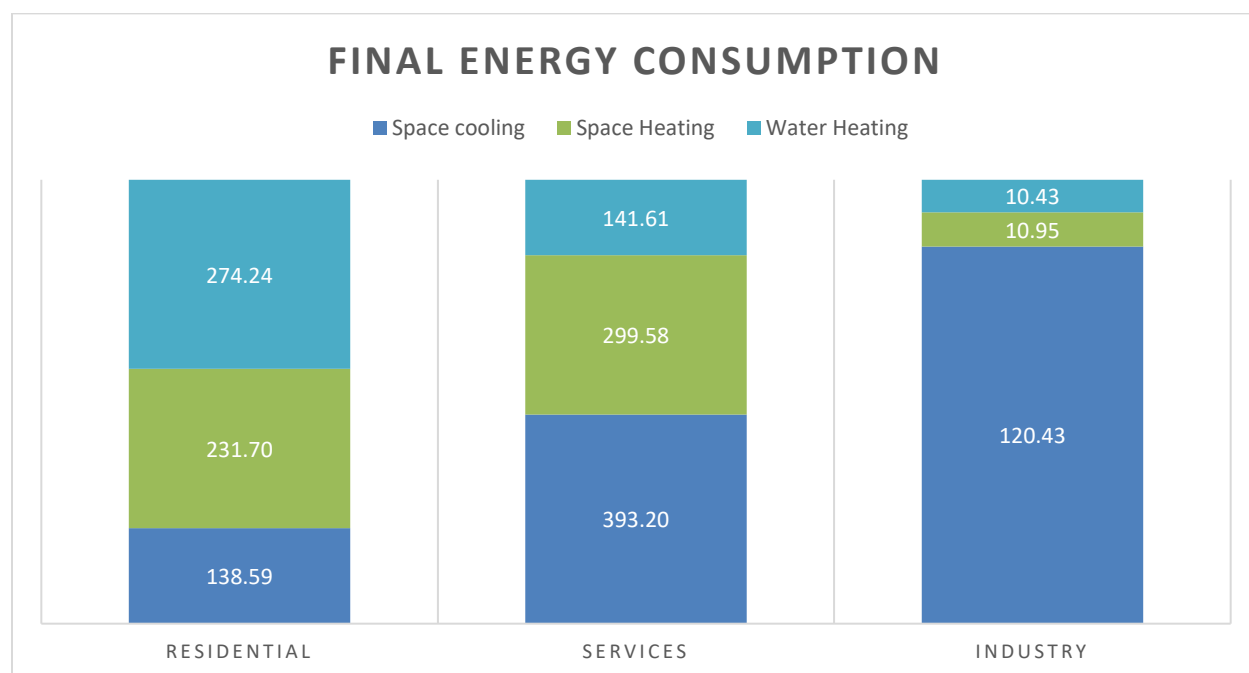
Following the detailed analysis of the Final Energy Consumption and the Useful Energy Consumption of a number of different sectors, the following is a consolidated summary of the results per sector. This conclusion reflects the three different types of usages, being space cooling, space heating and water heating, as analysed in this report.

The table below shows the Final Energy Consumption of the three different sectors and the resulting totals for the base year 2018.

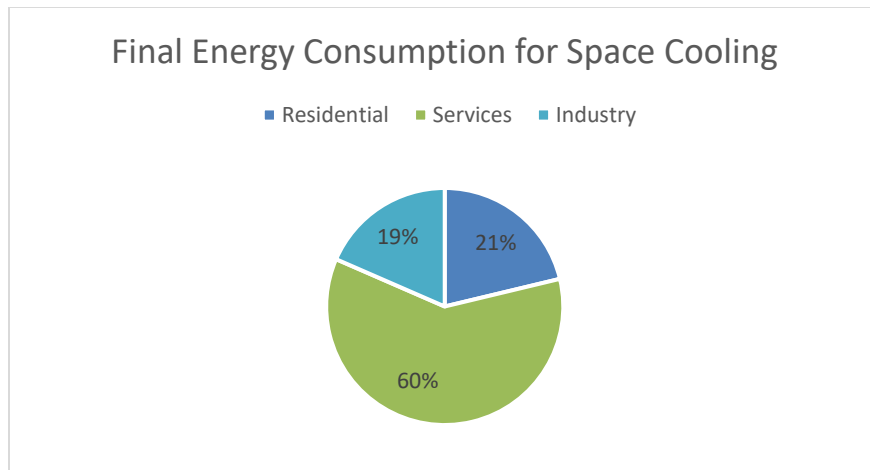
*Table 49 – Final Energy Consumption for the three sectors in 2018*

FINAL ENERGY	Sector	Space Cooling	Space heating	Water Heating	Total
		GWh/a	GWh/a	GWh/a	GWh/a
	Residential	138.59	231.70	274.24	644.54
	Services	393.20	299.58	141.61	834.39
	Industry	120.43	10.95	10.43	141.81
	<b>Total</b>	<b>652.22</b>	<b>542.23</b>	<b>426.29</b>	<b>1620.74</b>

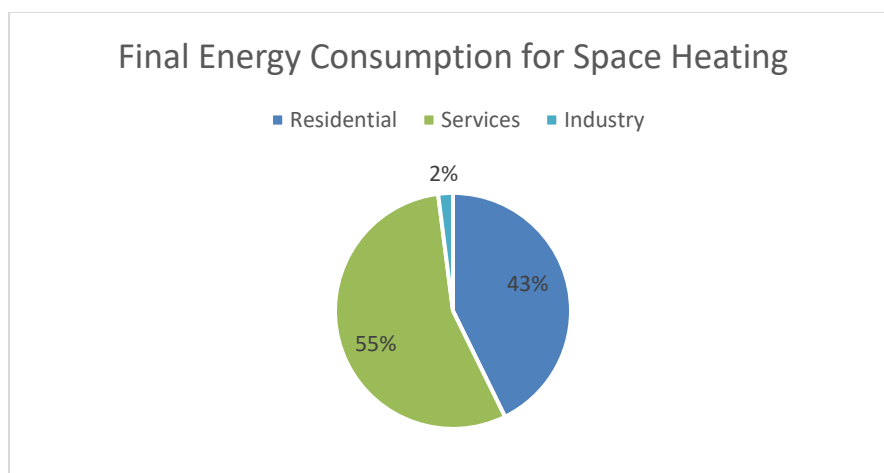
As a result of the analysis carried out for the different sectors, the below figure is another consolidated reflection of the Final Energy Consumption in GWh per annum for space cooling and heating and water heating, followed by charts indicating the Final Energy Consumption per use for each different sector.



*Figure 75 – Representation of the final energy consumption for the three different uses covering the residential, services and industry sectors.*



*Figure 76 – Final energy consumption for the three sectors for space cooling*



*Figure 77- Final energy consumption for the three sectors for space heating*

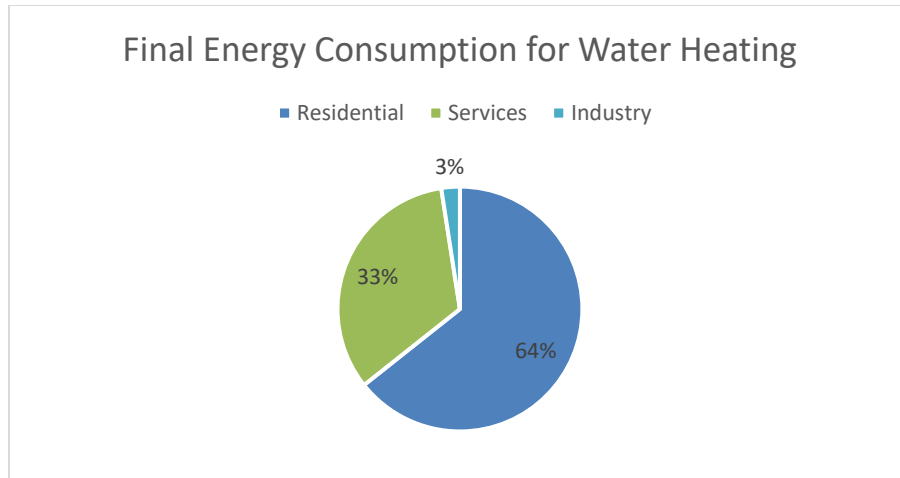


Figure 78- Final energy consumption for the three sectors for water heating

The table below shows the Useful Energy Demand of the three different sectors analysed in this report and the resulting totals for the base year 2018.

Table 50 – Useful Energy Demand for the three sectors in 2018

USEFUL ENERGY	Sector	Space Cooling	Space heating	Water Heating	Total
		GWh/a	GWh/a	GWh/a	GWh/a
	Residential	376.52	191.76	222.83	791.11
	Services	1064.18	637.37	116.58	1818.13
	Industry	322.20	9.30	8.87	340.37
	<b>Total</b>	<b>1762.90</b>	<b>838.43</b>	<b>348.28</b>	<b>2949.61</b>

As a result of the analysis carried out for the different sectors, the below figure is another consolidated reflection of the Useful Energy Consumption in GWh for space cooling and heating and water heating, followed by charts indicating the Useful Energy Consumption per use for each different sector.

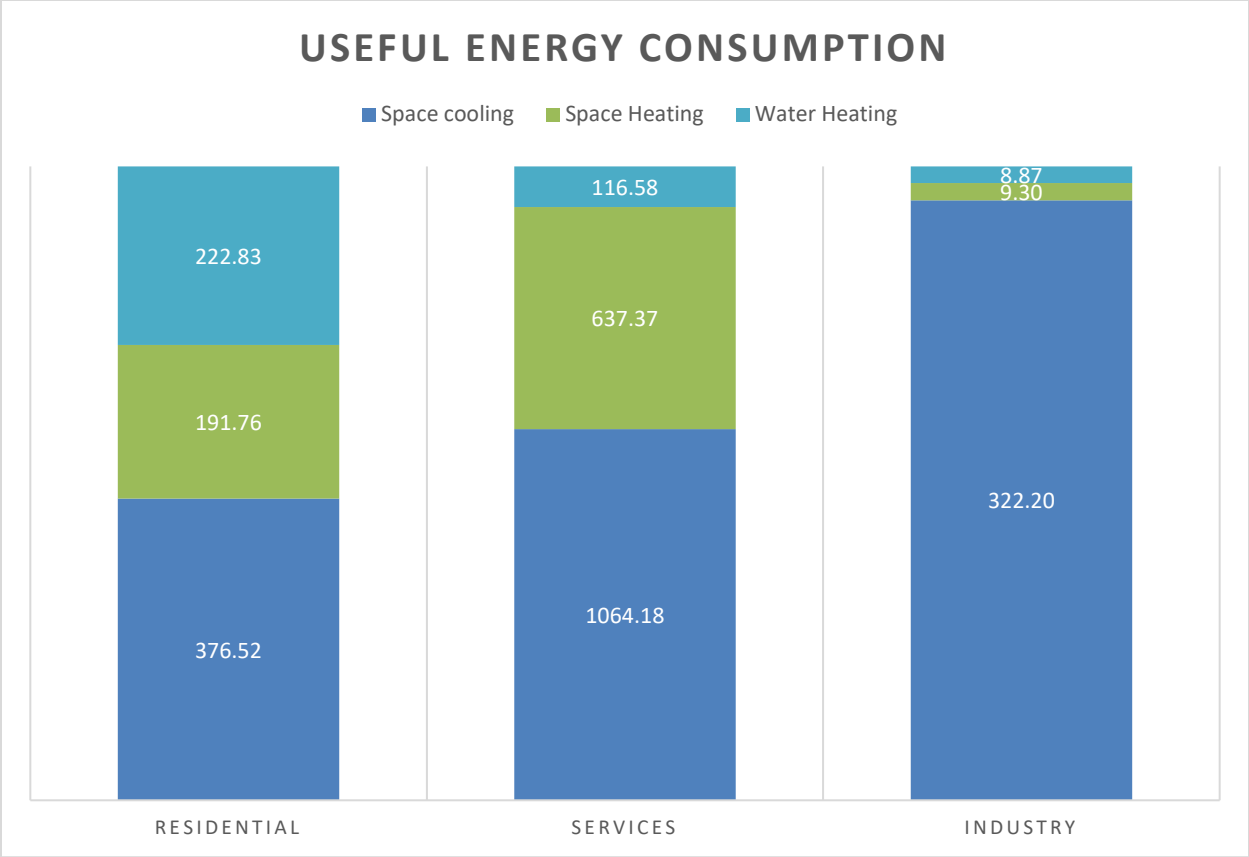


Figure 79 – Representation of the useful energy consumption for the three different uses covering the residential, services and industry sectors.

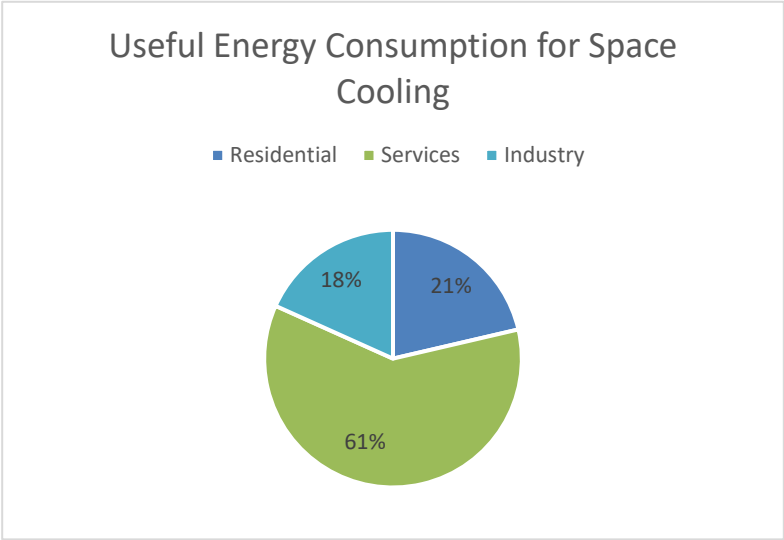


Figure 80 – Useful energy consumption distribution between different sectors for space cooling

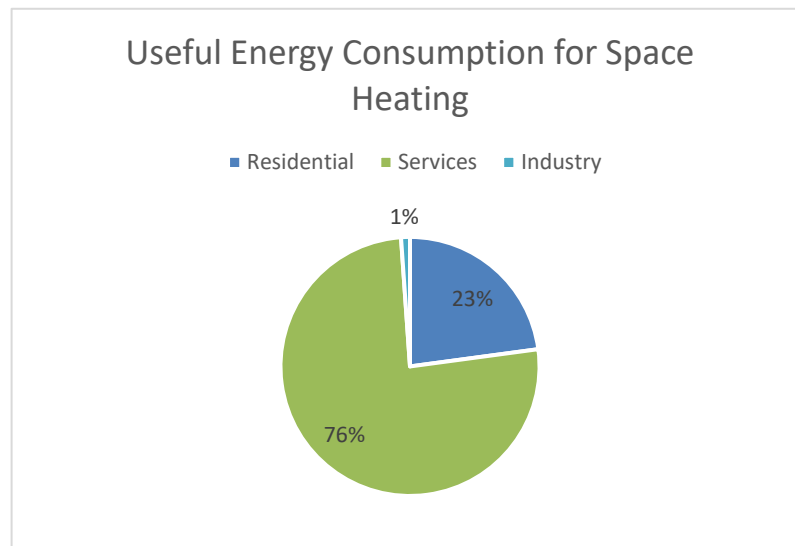


Figure 81 - Useful energy consumption distribution between different sectors for space heating

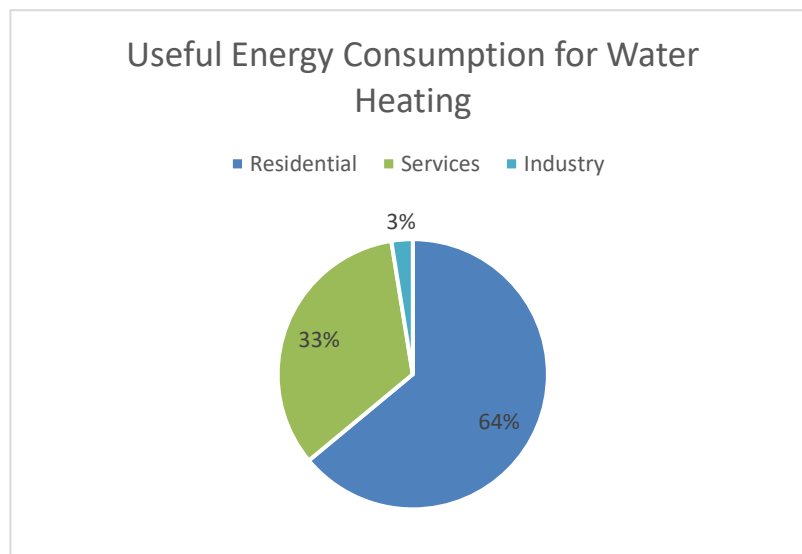


Figure 82 - Useful energy consumption distribution between different sectors for water heating



## 1.2 Identification of Current Heating and Cooling Supply

### 1.2.1 Identification by technology

In line with Part 1 of Annex VIII of the Commission Delegated Regulation (EU) 2019/826 of the 4<sup>th</sup> March 2019 amending Annexes VIII and IX to Directive 2012/27/EU of the European Parliament and the Council on the contents of comprehensive assessments of the potential for efficient heating and cooling, and with particular reference to point 2(a) of the said Annex, the table below is identifying and estimating in GWh per annum, by technology, the following:

- energy provided on-site in residential and service sites, distinguishing between energy derived from fossil fuel and renewable sources;
- energy provided on-site in non-service and non-residential sites (the industrial sector), distinguishing between energy derived from fossil fuel and renewable sources;

In both cases, the technologies being reported upon individually are i) heat only boilers, ii) high efficiency heat and power co-generation, iii) heat pumps, and iv) other on-site technologies and sources, in line with the above-mentioned Commission Delegated Regulation.

The values being indicated in the table below for energy provided on-site have been obtained through the analysis indicated in the previous chapter of this report.

Finally, it should be noted that in Malta, currently no energy is provided off-site through i) high efficiency heat and power co-generation, ii) waste heat and iii) other off-site technologies and source. Nonetheless, the Government of Malta has proposed plans to set up a new waste-to-energy thermal treatment plant which is expected to be commissioned in 2024. The share of the bio-origin content of the waste input is yet to be determined but given that the input stream is expected to be mainly refuse-derived fuel and rejects, the bio-fraction is expected to be minimal.

Table 51 - Energy provided on site for the three different sectors under study by means of fossil fuel sources and renewable energy sources

<b>Energy provided on-site</b>			Unit	Value
Residential sector	Fossil fuel sources	Heat only boilers	GWh/a	270.72
		Other technologies	GWh/a	226.62
		HECHP	GWh/a	
	Renewable energy sources	Heat only boilers	GWh/a	
		HECHP	GWh/a	
		Heat pumps	GWh/a	73.1
		Other technologies	GWh/a	74.10
Service sector	Fossil fuel sources	Heat only boilers	GWh/a	178.95
		Other technologies	GWh/a	593.54
		HECHP	GWh/a	
	Renewable energy sources	Heat only boilers	GWh/a	
		HECHP	GWh/a	6.19
		Heat pumps	GWh/a	55.7
		Other technologies	GWh/a	
Industrial sector	Fossil fuel sources	Heat only boilers	GWh/a	21.38
		Other technologies	GWh/a	120.43
		HECHP	GWh/a	
	Renewable energy sources	Heat only boilers	GWh/a	
		HECHP	GWh/a	
		Heat pumps	GWh/a	
		Other technologies	GWh/a	

## 1.2.2 Identifications of installations generating waste heat or cold

Reference is made again to Part 1 of Annex VIII of the Commission Delegated Regulation (EU) 2019/826 of the 4<sup>th</sup> March 2019 amending Annexes VIII and IX to Directive 2012/27/EU of the European Parliament and the Council on the contents of comprehensive assessments of the potential for efficient heating and cooling, and in particular to point 2(b) of the said Annex, which requires the identification of installations that generate waste heat or cold and their potential heating or cooling supply.

Due to the small size of the country, and the lack of heavy industry in Malta, gives rise to difficulties for the cogeneration, eventually associated to district heating or cooling. This is mainly due to low thermal loads and low heat/power ratios required as well as the fact that residences and industrial sites are not connected to a natural gas grid, which is non-existent in Malta.

It is for this reason that Malta is not in a position to report on the generation of waste heat or cold or the potential heating or cooling supply of the following installations:

- thermal power generation installations to supply waste heat exceeding 50MW
- combined heat and power installations with thermal input exceeding 20MW
- renewable energy installations with thermal input exceeding 20MW; and
- industrial installation with thermal input exceeding 20MW supply waste heat.

The planned new waste-to-energy thermal treatment plant which the Maltese Government is expected to commission in the coming year may give rise to possible generation of waste heat which could be used as a potential source of thermal heat supply. However, no data on this potential waste heat generation is yet available.

As regards waste incineration plants, Malta has a Thermal Treatment Facility (TTF) situated in Marsa consists of which uses heat to process abattoir waste, clinical waste and other hazardous waste streams. It also includes an autoclave plant that treats animal tissue waste prior to the incineration process. As a by-product, energy released from both processes is used to produce hot water for washing purposes. Moreover, the operation of the autoclave plant has the potential to achieve substantial savings in fuel used to operate the incinerator due to the extraction of tallow (animal fat) in the autoclaving process which is then used in the incinerator as fuel, thus creating resources from waste.

### 1.2.3 Share of energy from renewable sources and waste heat or cold

Reference is made again to Part 1 of Annex VIII of the Commission Delegated Regulation (EU) 2019/826 of the 4<sup>th</sup> March 2019 amending Annexes VIII and IX to Directive 2012/27/EU of the European Parliament and the Council on the contents of comprehensive assessments of the potential for efficient heating and cooling, and in particular to point 2(c) of the said Annex, which requires the reporting of shares of energy from renewable sources and from waste heat or cold in the final energy consumption of the district heating and cooling over the past 5 years in line with directive EU 2018/2011.

It should be noted Part 1 of this report, and specifically the sections covering the residential and services sectors, include references to the energy generation from renewable sources mainly through solar water heating, biomass, heat pumps and combined heat and power engines. A summary of such energy generation is being reproduced in Table 52 below.

Table 52 – Renewable energy generated in 2018 for the three different sectors

	Sector	Space Cooling	Space heating	Water Heating	Total
		GWh/a	GWh/a	GWh/a	GWh/a
RES	Residential	73.10	15.56	58.51	147.17
	Services	0.00	55.70	6.19	61.89
	Industry	0.00	0.00	0.00	0.00
	<b>Total</b>	<b>73.10</b>	<b>71.26</b>	<b>64.70</b>	<b>209.06</b>

## 1.3 Maps covering Heating and Cooling Demands in the National Territory

Reference is made again to Part 1 of Annex VIII of the Commission Delegated Regulation (EU) 2019/826 of the 4<sup>th</sup> March 2019 amending Annexes VIII and IX to Directive 2012/27/EU of the European Parliament and the Council on the contents of comprehensive assessments of the potential for efficient heating and cooling, and in particular to point 3 of the said Annex, which requires the provision of a map covering the entire national territory identifying heating and cooling demand areas following the analysis above.

Maps representing at territorial level the results obtained in the above chapters particularly from Table 12, Table 42 and Table 48, have been created considering the following different breakdowns:

- Final Energy Consumption for Space Heating, Cooling and Water Heating;
- Useful Energy Consumption for Space Heating, Cooling and Water Heating;
- Energy Sources (Electricity, Fossil Fuel, RES);
- Sectors of use being the Residential, Services and Industry Sectors;
- Geographical location subdivided into 68 separate areas as indicated in Figure 83 below representing the lower level (LAU2, formerly NUTS level 5) which consist of the 68 local councils.



*Figure 83 – Malta's geographical map sub-divided into the 68 LAU 2 areas*

For the residential sector the values attributed to each LAU were obtained from the electricity consumption in each respective LAU area based on the respective number of dwellings in each LAU area. The number of dwelling in each LAU area has been extracted from the NSO Malta Census of 2011. These figures have been then extrapolated to reflect the additional number of occupied dwelling by the year 2017 from the NSO Regional Statistics MALTA 2019 Edition. The extrapolated values which figures are shown in Annex 1 attached with this report. For the residential sector maps have been carried out for the final and useful energy consumption, different sources and different usage as explained above.

For the service sector the values attributed to each LAU were calculated based on the respective electricity consumption for each locality as provided in the data by Enemalta plc. The values for final and useful energy for space heating, cooling and water heating were then attributed to each LAU based on the ratio of the total electricity consumption and the energy for heating and cooling purposes. Maps for the final and useful energy consumption, different sources and different usage have been worked out.

For the industry sector the values attributed to each LAU have been based on the respective factory floor area in each LAU area as indicated in Table 53 below.

Table 53 – Total floor area of Industrial Estates<sup>47</sup>

Industrial Area	LAU	Total Floor Area [sq m]
Attard Ind Estate	Attard	21,104
Bulebel Ind Estate	Zejtun	257,842
Hal Far Ind Estate	Birzebbuga	515,599
Kirkop Ind Estate	Kirkop	30,231
Kordin Ind Estate	Paola	113,318
Luqa Industrial Estate	Luqa	39,603
Marsa Ind Estate	Marsa	212,592
Mosta Technopark	Mosta	26,291
Mrieהל Industrial Estate	Birkirkara	43,342
Safi Aviation Park	Safi	101,752
San Gwann Ind Estate	San Gwann	118,246
Ta' Qali Crafts Village	Attard	45,780
Ta' Dbiegi Crafts Village	Gharb	3,052
Xewkija Industrial Estate	Xewkija	56,254

Maps for the final and useful energy consumption, different sources and different usage have been worked out.

Another map showing the location of existing heating and cooling supply points, namely the location of the incinerator and autoclave plants in Malta has also been reproduced to cover point 3(b) of Annex VIII of the abovementioned Commission Delegated Regulation 2019/826. The said map does not include any references to district heating transmission installations, since they do not exist in Malta.

As regards 3(c) of Annex VIII of the abovementioned Commission Delegated Regulation 2019/826, a map is also being reproduced to show the location of the planned Waste-to-Energy plant which could possibly be a source of heating supply, according to information available to date. Again, to date, no information on planned projects which could potentially lead to district heating transmission is available.

The maps indicated above are found in Annex I attached to this report. The list of all the maps included in Annex 2 can be found below:

#### **Residential Sector:**

Final Energy Space Cooling – Electricity

Final Energy Space Heating – Electricity

Final Energy Water Heating – Electricity

Final Energy Space Heating – Fossil Fuels

<sup>47</sup> <https://indismalta.com/industrial-zones/bulebel-industrial-estate/> data retrieved on 13<sup>th</sup> November 2020.

Final Energy Space Heating – Solid Biomass

Final Energy Water Heating – Solar Thermal Water Heaters

**Industrial Sector:**

Final Energy Space Cooling – Electricity

Final Energy Space Heating – Fossil Fuels

Final Energy Water Heating – Fossil Fuels

**Service Sector:**

Final Energy Space Cooling – Electricity

Final Energy Space Heating – Electricity

Final Energy Water Heating – Electricity

Final Energy Space Heating – Fossil Fuels

Final Energy Water Heating – Fossil Fuels

Final Energy Water Heating – CHP

Location of the incinerator and autoclave plants

Location of the planned Waste-to-Energy plant

## 1.4 Forecast of Trends in Demand for Heating and Cooling for the next 30 years

In this section of Part I of this report, a forecast of demand for heating and cooling for the next 30 years, but with a more specific focus for the next 10 years, has been undertaken. This forecast is taking into account the impact of national policies and strategies relating to both energy efficiency as well as heating and cooling demands, reflecting the needs of the various sectors in Malta, mainly, the residential sector, the services sector and the industry sector. Moreover, it should be noted these forecasts were prepared in line with points 1 and 2 of Annex VIII of Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012 on energy efficiency to be able to determine current supply and demand.

### **Residential sector methodology**

The data related to the total heating and cooling demand in the residential sector up to 2030 is based on the data captured in the NECP which have been updated to take into account any possible effects from COVID-19. These projections reflect the results of a modelling tool developed for the assessment of policies and measures and the resulting generation of projections. These modelled scenarios have been based on specific assumptions regarding framework conditions, which include demographic and economic activity, technological trends, energy costs/prices and other relevant variables. In this respect, Malta has developed its own methodology and set of assumptions to forecast the macroeconomic indicators as part of this analysis. Such indicators include population figures, Gross Domestic Product, sectoral Gross Value Added, household size, number of households and disposable income. Such national indicators were developed by external consultants but endorsed by the Economic Policy Department within the Ministry for Finance, and were consistently used by various Ministries in Malta in several modelling exercises related to the development of the NECP. On the other hand, the policies and measures, either already implemented or which will be implemented at different points in time, are modelled as exogenous variables. The data obtained from the NECP reflects mainly the energy consumption and hence, in order to achieve the related energy demand, conversion factors such as COP and EER values have been taken into account. Such values have been tweaked with the aim of allowing for advances in heating and cooling technologies as well as the projected increase of heat pump installations in the residential sector.

In order to arrive at projections for 2050, the yearly percentage increase of ratio of heating and cooling demand per household between 2020 and 2030 was calculated and extrapolated onto the period up to 2050, together with the expected yearly additional number of households up to 2050.

Table 54 below shows the yearly forecasted heating and cooling demand for the residential sector between 2020 and 2030. Full details showing values with a 5-yearly forecast between 2020 and 2050 are included in Annex 3 of this report.



Table 54 – Projected heating and cooling demand between 2020 and 2030

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
<b>Total H&amp;C<sup>48</sup></b>	<b>899.0</b>	<b>923.1</b>	<b>947.6</b>	<b>971.9</b>	<b>996.0</b>	<b>1008.3</b>	<b>1037.9</b>	<b>1055.7</b>	<b>1074.0</b>	<b>1089.7</b>	<b>1106.7</b>
<b>RES<sup>49</sup></b>	<b>90.3</b>	<b>95.8</b>	<b>101.1</b>	<b>106.0</b>	<b>110.6</b>	<b>108.9</b>	<b>121.5</b>	<b>123.1</b>	<b>124.7</b>	<b>124.6</b>	<b>124.9</b>
Space Cooling	363.5	379.2	395.3	411.6	428.5	446.0	461.7	478.0	494.8	512.1	529.9
Space Heating	174.3	177.5	180.9	184.1	186.8	189.4	201.6	203.7	205.6	207.2	208.5
Water Heating	319.1	324.1	328.7	333.0	337.0	334.8	337.4	338.4	339.4	338.7	338.5

Figure 84 below shows the trends for the energy demand forecast in GWh for heating and cooling purposes between 2020 and 2050 based on the methodologies described above.

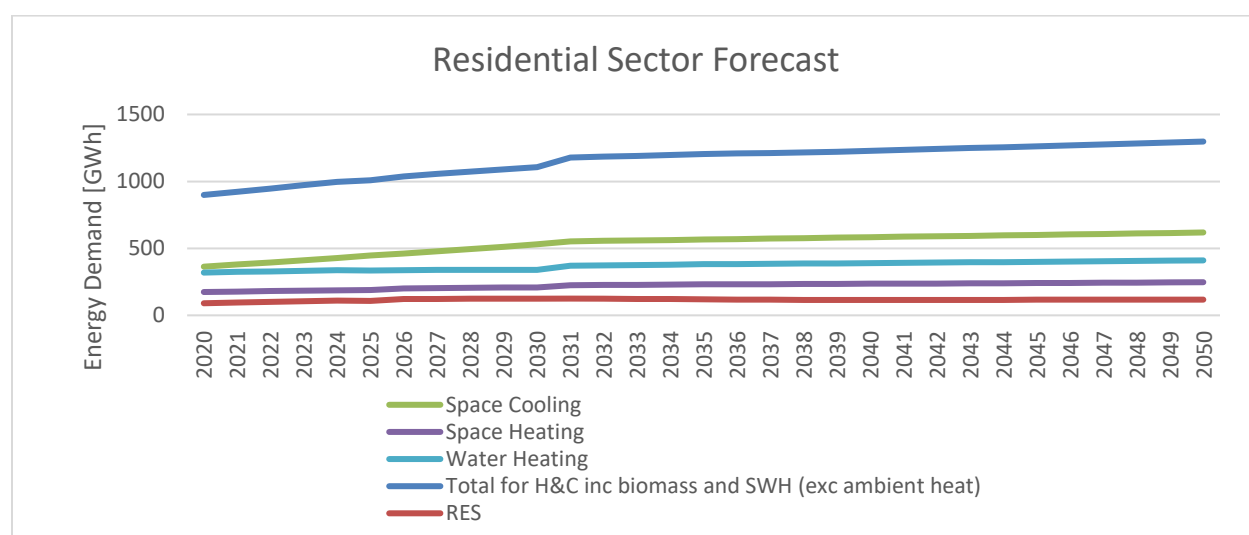


Figure 84 – Energy demand (useful) forecast for heating and cooling purposes between 2020 and 2050 for the residential sector

## Services sector methodology

The data reflecting the total final energy consumption and RES in the services sector is based on the NECP values up to 2030, values which have been obtained using the same methodology explained above. On the other hand, for the period between 2030 and 2050, the annual growth ratio for the total final energy consumption in the services sector was based on the Potencia<sup>50</sup> data trend for 2030-2050.

<sup>48</sup> The total values for H&C reported include the energy demand from solar water heating as well as biomass.

<sup>49</sup> The total values for RES reported include the energy demand from solar water heating, biomass, together with the energy from ambient heat

<sup>50</sup> POTENCIA model Central Scenario, JRC Science for Policy Report, 2019 - <https://ec.europa.eu/jrc/en/potencia>

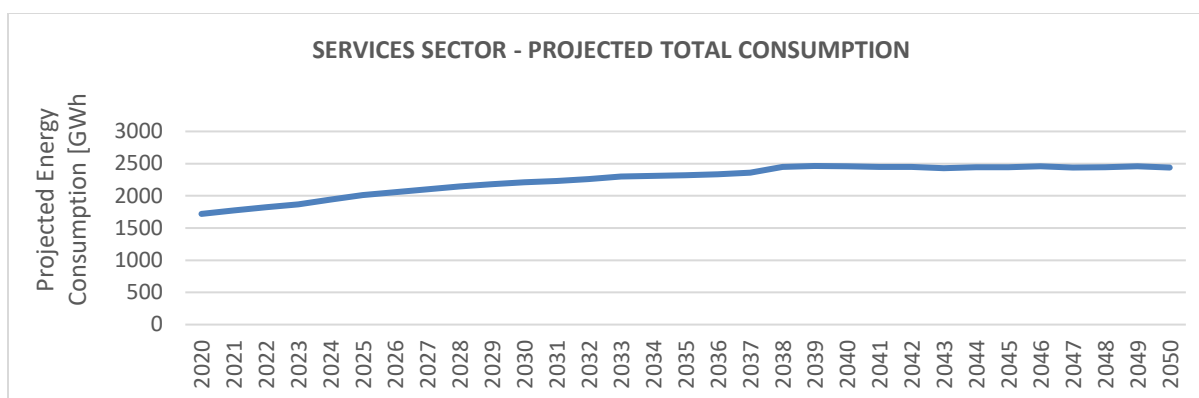


Figure 85 – Projected total energy consumption for services sector based on NECP values between 2020 and 2030, and Potencia growth rate values between 2030 and 2050.

In order to arrive at the percentage share for space cooling, space heating and water heating respectively for 2030 and 2050, the data related to energy use for such purposes in 2018 was used. Growth rate for each end-use was extrapolated from the NECP data to determine the values up to 2030. Subsequently the growth rate trend for each end-use from NECP was extrapolated up to 2050. The projections were based on this trend.

The data obtained from the NECP reflects mainly the energy consumption and hence, in order to achieve the related energy demand, conversion factors such as COP and EER values have been taken into account. Such values have been tweaked with the aim of allowing for advances in heating and cooling technologies as well as the projected increase of heat pump installations in the services sector.

Table 55 below shows the yearly forecasted heating and cooling demand for the services sector between 2020 and 2030. Full details showing values with a 5-yearly forecast between 2020 and 2050 are included in Annex 3 of this report.

Table 55 – Projected heating and cooling demand between 2020 and 2030

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
<b>Total H&amp;C<sup>51</sup></b>	<b>2105.8</b>	<b>2175.1</b>	<b>2236.9</b>	<b>2287.6</b>	<b>2329.2</b>	<b>2409.2</b>	<b>2457.1</b>	<b>2462.1</b>	<b>2512.9</b>	<b>2504.8</b>	<b>2538.8</b>
<b>RES (Ambient heat)</b>	<b>75.1</b>	<b>87.9</b>	<b>99.1</b>	<b>105.1</b>	<b>115.2</b>	<b>129.2</b>	<b>129.6</b>	<b>137.4</b>	<b>146.3</b>	<b>153.8</b>	<b>163.1</b>
Space Cooling	1229.1	1272.1	1307.0	1335.2	1356.0	1399.1	1426.5	1429.3	1458.9	1455.3	1476.3
Space Heating	731.3	755.0	776.5	794.1	809.2	837.6	854.1	855.5	872.8	869.4	880.4
Water Heating	145.3	148.0	153.4	158.3	164.0	172.4	176.5	177.3	181.2	180.2	182.2

Figure 86 below shows the trends for the energy demand forecast in GWh for heating and cooling purposes between 2020 and 2050 based on the methodologies described above.

<sup>51</sup> The total for H&C reported does not include energy from ambient heat.

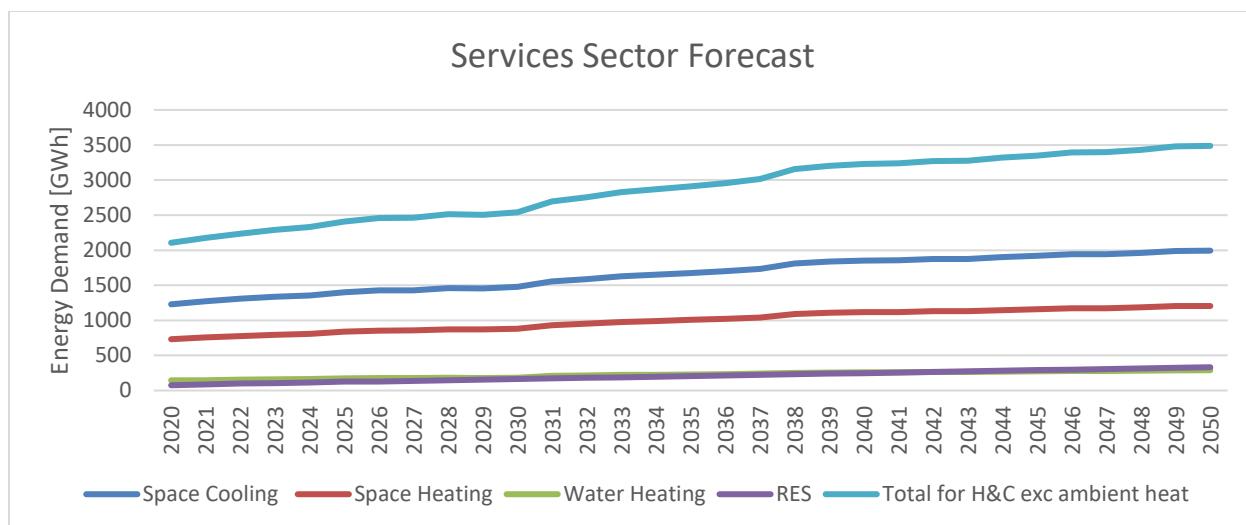


Figure 86 – Energy demand (useful) forecast for heating and cooling purposes between 2020 and 2050 for the services sector.

### Industry sector methodology

The data related to the total final energy consumption in the industry sector is based on the NECP projection values up to 2030. For the period between 2030 and 2050, the annual growth ratio for the total final energy consumption in the industry sector was based on the Potencia<sup>52</sup> data trend for 2030-2050.

In order to arrive at the percentage share for the heating and cooling, the 2018 data was used as a baseline and an assumption was made that there will be a reduction in the growth rate of 2.5% in terms of heating and cooling demand from year 2031 to 2050. This assumption is based on the fact that the growth rate for heating and cooling demand will stabilise itself and thus the share for heating and cooling demand from the total energy consumption will remain constant at a value of twenty percent. It is also being assumed that the percentage shares between space cooling, space heating and water heating will remain constant up to 2050 especially in view of the fact that the space heating and water heating allocations are very low when compared to the space cooling allocation. Thus, the trend for space cooling, space heating and water heating between 2020 and 2030 was extrapolated up to 2050.

The data obtained from the NECP reflects mainly the energy consumption and hence, in order to achieve the related energy demand, conversion factors such as COP and EER values have been taken into account. Such values have been tweaked in order to allow for advances in heating and cooling technologies in the industry sector as well as energy savings measures to be applied in the said sector in view of the energy audit regulations in place for non-SME's which form most of the industry sector in Malta.

Table 56 below shows the yearly forecasted heating and cooling demand for the industry sector between 2020 and 2030. Full details showing values with a 5-yearly forecast between 2020 and 2050 are included in Annex 3 of this report.

<sup>52</sup> POTEnCIA model Central Scenario, JRC Science for Policy Report, 2019 - <https://ec.europa.eu/jrc/en/potencia>

Table 56 - Projected heating and cooling demand between 2020 and 2030

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
<b>Total H&amp;C</b>	<b>376.6</b>	<b>381.9</b>	<b>387.2</b>	<b>392.3</b>	<b>397.2</b>	<b>402.1</b>	<b>407.0</b>	<b>411.7</b>	<b>416.3</b>	<b>420.8</b>	<b>425.3</b>
Space Cooling	356.5	361.6	366.5	371.3	376.0	380.7	385.2	389.7	394.0	398.3	402.6
Space Heating	10.3	10.4	10.6	10.7	10.9	11.0	11.1	11.3	11.4	11.5	11.6
Water Heating	9.8	10.0	10.1	10.2	10.3	10.5	10.6	10.7	10.8	11.0	11.1

Figure 87 below shows the trends for the energy demand forecast in GWh for heating and cooling purposes between 2020 and 2050 based on the methodologies described above.

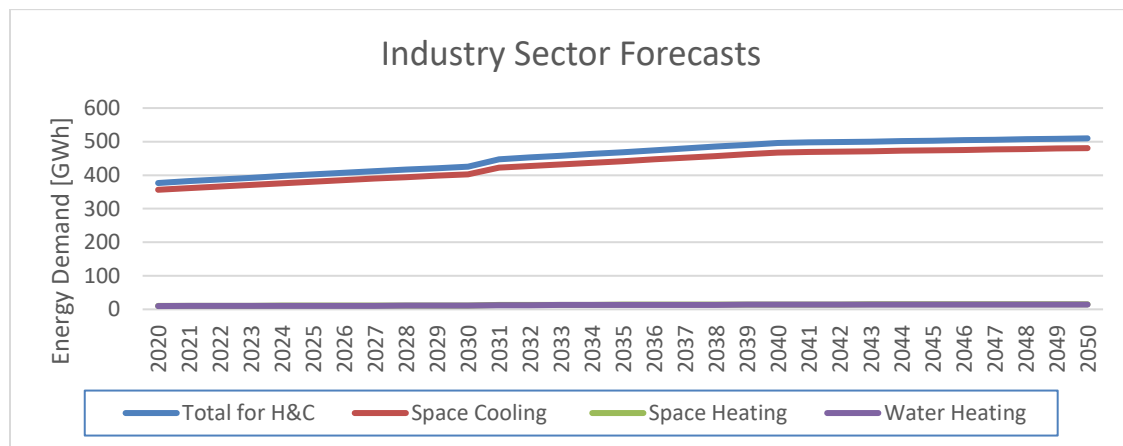


Figure 87- Energy demand (useful) forecast for heating and cooling purposes between 2020 and 2050 for the industry sector.

## Part II – Objectives, Strategy and Policy Measures

The context within which this part of the study is being carried out is with the aim of providing an overview on the role of efficient heating and cooling in the Maltese islands in order to eventually achieve GHG emission reduction, in line with existing policies as outlined in the NECP (Malta's 2030 National Energy and Climate Plan).

For the purpose of this study, current energy and climate policies and measures related to the two of the Energy Union dimensions will be described into detail, being the **decarbonisation dimension** and the **energy efficiency dimension**.

The current policy framework for energy and climate in the Maltese Islands is covered by the following key documents:

- The National Energy Policy, published in 2012;
- The National Renewable Energy Action Plan for 2020, published in 2017;
- The National Energy Efficiency Action Plan for 2020, published in 2017; and
- The National Energy and Climate Plan, published in 2019.

Other supporting documents amplify aspects of these policy frameworks and include measures designed to implement the various policies.

As a consequence of the changed priorities and of major projects undertaken in recent years, various measures arising out of the **Energy Policy** published in 2012 have been implemented, others superseded or rendered irrelevant. The need for an updated action plan covering the period 2015 to 2020 arose after reconsideration of the RES options triggered by technological, social and economic developments. The **2017 National Renewable Energy Action Plan** in fact includes a revision of the national RES perspective while remaining faithful to the underlying Energy Policy of 2012 and Malta's commitments to meet the 10% Renewable Energy Target by 2020 in line with Directive 2009/28/EC.

The most recent and detailed document from the list of key policy documents indicated above is Malta's **National Energy and Climate Plan (NECP)** published in December 2019, which has streamlined policy outcomes from all the said key documents. As indicated in this document, Malta's major policy measures and objectives are described under the five dimensions of the Energy Union in line with the Governance Regulation (EU) 2018/1999. The NECP, which serves as a strategic planning framework and policy document, sets out Malta's national objectives and contributions for 2030 under the five Energy Union dimensions summarised below:

- **Decarbonisation:** Malta's strategy under this dimension strives to promote the transition to a low-carbon economy primarily through the pursuit of upholding national GHG emission reduction commitments and by continuing to deploy all viable indigenous renewable energy sources. In the area of

renewable energy, Malta set out to continue its efforts to increase its RES share primarily by extending its current support framework for RES to the period until 2030.

- **Energy efficiency:** Malta's efforts in the area of energy efficiency post-2020 will seek to achieve cost efficient energy savings in the relative end-use sectors whilst taking into account the effective potential. The Government will also strive to continue decreasing the overall energy intensity of its economy and uphold its obligations under the Energy Efficiency Directive. Temperate climatic conditions and lack of energy-intensive industries mean that Malta has the second lowest final energy consumption per capita across all EU Member States.

- **Energy security:** Malta will continue to emphasize the commitment to achieve greater security of supply through diversification of energy sources and suppliers and reducing energy import dependency primarily through the deployment of indigenous renewable energy sources. The Government will also ensure that periodic contingency planning in the electricity, gas and oil sectors has been undertaken. Energy security will also be considered within the context of the long-term objective of decarbonisation of the energy system.

- **Internal energy market:** Malta's electricity grid is linked to the European grid via the 200 MW interconnector. The Government aims to ensure that the legal and regulatory frameworks result in affordable energy pricing, whilst encouraging competition within the limits imposed by the market size and structure. Social measures are also in place to support and protect energy poor and vulnerable consumers.

- **Research, innovation and competitiveness:** Malta endeavoured to boost research, innovation and competitiveness specifically in the area of energy and low-carbon technologies through the development the National Strategy for Research and Innovation in Energy and Water for 2021-2030, the main aim of which is to contribute to Malta's transition to a low-impact and decarbonised economy and increase the level of domestic support for R&I in Malta.

This strategy, which is the first one which holistically covers the five Energy Union dimensions and replaces previous sectoral reporting obligations under the 2020 framework, sets out Malta's national objectives and contributions for 2030 in these five dimensions and gives a description of the policies and measures which need to be implemented in order to reach these objectives. In fact the NECP serves as a strategic planning framework and policy document that will guide Malta's contribution to achieve the Energy Union's 2030 objectives and targets whilst identifying those objectives and measures necessary for their achievement during the period until 2030, with an outlook to 2040.

For the purposes of this report, this section will primarily focus on the **Decarbonisation and Energy Efficiency dimensions** since they are directly related to the heating and cooling demand. The small size and specific characteristics of Malta's energy system and market limit the range of measures which can be availed of to meet the country's energy savings obligations. In this context, one cannot but also take into consideration the absence of a natural gas network on the Maltese islands, as well as the lack of

district heating and cooling networks across the country which are rendered to be economically unfeasible.

## **Decarbonisation dimension**

### **National objectives and targets**

The decarbonisation dimension is sub-divided into **GHG emissions and removals** and **Renewable Energy**.

As indicated in Malta's National Energy and Climate Plan (NECP), 2019, as regards the objectives and targets related to **GHG emissions and removals**, Malta has, through the ratification of the Paris Agreement, re-affirmed its commitment to address climate issues and to contribute towards the European Union's collective target of 40% reduction of its GHG emissions by 2030 compared to 1990 levels. By 2030, Malta is bound to reduce its GHG emissions by 19% below its 2005 emissions pursuant to the Effort Sharing Regulation.

As regards **Renewable Energy**, after taking into consideration all the relevant circumstances affecting the deployment of renewable energy, Malta's contribution to the 2030 Union target in terms of the share of energy from renewable energy in gross final consumption is expected to amount to **11.5%** by 2030. Malta's RES contribution in the three reference years, 2022, 2025 and 2027 is expected to reach 10.3%, 11.0% and 11.6%, respectively. The contribution excludes RES ambient cooling captured by air-to-air heat pumps, as the Commission has not yet established a methodology for calculating renewable energy for cooling, as required by Directive EU 2018/2001 by December 2021.

It should also be pointed out that the European Green Deal has established an action plan<sup>53</sup> to boost the efficient use of resources by moving to a clean, circular economy and to restore biodiversity and decrease pollution. The EU aims to turn the goal of climate neutrality by 2050 into law, thus proposing a European Climate Law to turn this political commitment into a legal obligation. Thus, sectoral legislation related to GHG emissions, renewables and energy efficiency will be revised starting from June 2021 and sectoral targets for 2030 will be increased in line with the higher climate ambition

### **Key policies and measures for GHG emissions and removals**

The final National Energy and Climate Plan (NECP) has been drafted whilst the Low-Carbon Development Strategy (LCDS) for Malta is still under development. The latter has a timeframe up to 2050, as opposed to the NECP which sets out Malta's contribution to 2030 targets. Since the timelines of the two strategic documents were not running in parallel, additional policies and measures to those outlined in this section of the NECP could be included in the decarbonisation strategy. These would ultimately feature in a subsequent revision of the NECP, expected in 2025. This is in line with the possibility of updating the NECPs

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<sup>53</sup> A New Circular Economy Action Plan – For a cleaner and more competitive Europe. Available online: [https://eur-lex.europa.eu/resource.html?uri=cellar:9903b325-6388-11ea-b735-01aa75ed71a1.0017.02/DOC\\_1&format=PDF](https://eur-lex.europa.eu/resource.html?uri=cellar:9903b325-6388-11ea-b735-01aa75ed71a1.0017.02/DOC_1&format=PDF)

to reflect new policies and measures which Governments decide to embark on, acknowledging the need to further reduce climate emissions, and the socio-economic impact of such policies and measures.

## **Waste Management**

It should be noted that the overall share of GHG emissions from the waste sector is equivalent to <5% of the gross national emissions. The main gas emitted from waste management, mainly from disposal of solid waste to land, is methane.

Policies and measures charted out in the Waste Management Plan 2014-2020 have been further reinforced in the Waste Management Plan covering the time horizon between 2021-2030, published very recently in December 2020. The main objective for this new waste management plan is to maximise the resource value for waste through holistic waste management solutions and adopting a collaborative approach whilst fostering behavioural change, with the ultimate aim of leading Malta to achieve its ambitious 2030 targets. In relation to heating and cooling measures, this new waste management plan refers to the investment in waste treatment infrastructure, known as 'ECOHIVE'. This project will include the design, build and commissioning of a **waste-to-energy (WtE) facility** to treat an estimated 40% of MSW. The principal aim of this project is to further reduce landfilling of non-otherwise treatable or recyclable fractions. The development of this WtE facility in Malta to complement the existing waste management infrastructure has been identified as a necessity to attain targets, established in various EU directives. It should be noted that the energy generated from the waste treatment process under this project is envisaged to be used for heating and cooling purposes. The project is expected to be based on proven technologies for WtE plants, technically similar to many other WtE plants in Europe, with lower emissions generated in comparison to landfill activities.

Organic waste is expected to continue being treated through anaerobic digestion plants. Projections of renewable electricity and/or heat generated by the WtE plant from biodegradable waste content are based on projections of waste generation and are projected to remain largely constant. The Government is carrying out studies to assess the potential of increasing capacity of treatment of organic waste.

In view of the fact that bio-origin content of the waste input for the new waste-to-energy thermal treatment plant is yet to be determined, this new plant has not been considered for the scope of the Malta's RES share in the NECP.

This project is in fact one of the different measures being introduced under the new waste management plan intended to drive the country towards a circular economy with all waste streams being reutilised to their full potential, and ultimately move Malta away from over-reliance on landfilling, once and for all.



## Key policies and measures for Renewable Energy

Renewable energy deployment in Malta is limited due to the country's physical and spatial limitations, advancement in technology and resource availability. The island's geology and topology does not lend itself to the production of hydro or geothermal energy and the development of wave energy is still at research stage. The following are measures exploiting technically and economically indigenous RES sources.

### Solar PV

Without doubt, solar PV continues to be the most viable and robust form of indigenous sources of RES and has penetrated all sectors successfully. The Energy & Water Agency has indicated, following an assessment of Malta's technical potential for solar PV, that post-2020, there will be potential for further deployment of solar PV on rooftops and brownfield sites. Therefore, the Government intends to extend its current policy framework to cover the period from 2021-2030, adopting new measures where appropriate, aimed to increase the capacity of solar PV in Malta.

### Share of RES in Heating and Cooling

The share of RES in heating and cooling is made up of different technologies, which apart from the heat generated by the waste-to-energy plants, also include:

- solar water heaters;
- heat pump water heaters;
- air-to-air heat pumps; and
- biomass imports.

Given the high solar intensity prevalent in Malta, **Solar Water Heaters (SWH)** are considered a viable source of RES. However, the effectiveness of an ongoing grant scheme supporting the purchase of SWH and **Heat Pump Water Heaters (HPWH)** by households, has decreased in recent years, with consumers preferring PV systems, especially when technologies compete for limited roof space. In view of this, in 2018, the Government increased the maximum support level for SWHs to €700, capped at 50% of the eligible cost. Launched in 2017, the support scheme for HPWH was also extended and increased in 2018 to also provide a grant of 50% of eligible costs up to €700.

Post-2020, the existing financial support and incentives being offered are also expected to be revised with the aim of overcoming recently observed barriers. The Government aims to provide support for the installation of 800 renewable water heating technologies, namely solar water heaters and heat pump water heaters, each year from 2021-2030 in view of the fact that such systems are unlikely to be installed if grant schemes to promote uptake are not maintained

In parallel to the revamp of these schemes, the Government also plans to initiate an educational and awareness raising campaign aimed at attracting households to invest in such technologies by highlighting the benefits of SWHs/HPWHs. Still, one cannot but note that current trends which prioritise the development of high rises and multi-apartment buildings limit the technical potential of SWHs.

The number of **Air-to-air heat-pumps** in Malta is projected to increase without the need for policy intervention, in view of the fact that this is already a well-established technology in Malta and considered by many households to be essential for thermal comfort. The affordability of this technology combined with the continual rise in expectations of thermal comfort ensures sustained growth, also reflecting demographic changes. For instance, the number of heat pumps imported in 2016 and 2017 was above average due to increased activity in the construction sector in response to a significant influx of inwards migration. Split-unit heat pumps in the residential sector are projected to increase from 204,500 at the end of 2017 to 461,000 in 2030 and 556,000 in 2040. This increase is driven by a growth in the number of households, and the number of units per dwelling.

The abovementioned projections take into account current trends of installation and average unit size, as well as a saturation level with regards to the number of air-to-air units per household, depending on the type and size of dwelling. In the non-residential sector, installation of new heat-pumps is also expected to increase in line with the country's economic activity. The construction of new or modernisation of office spaces, hotels, and other commercial spaces will create a sustained demand for the importation of air conditioning systems employing heat pump technology. In all sectors, it is assumed that units will be replaced once they reach their end-of-life.

As regards **bioenergy**, it is assumed that the production of bioenergy from waste treatment facilities, both electricity and heat, and the use of biomass for space heating in the residential sector will remain largely stable between 2021 and 2030. Malta's landscape does not lend itself to provide the land area or resources required to cultivate energy crops and hence does not possess sustainable sources of biomass. Moreover, in view of Malta's low heating demand, it is deemed to be more beneficial to target increased efficiency in heating and cooling, rather than promoting biomass importation. Imported biomass in Malta primarily includes wood pellets, fuel wood in logs or briquettes, sawdust and wood charcoal, all of which is assumed to be consumed by the residential sector for heating purposes and for the coming years imports of biomass are expected to remain largely stable and to follow current trends.

## **Energy efficiency**

### **National objectives and targets**

The energy efficiency target for 2030 for the EU is 32.5%, measured with reference to the projections performed by PRIMES in 2007. Malta's indicative energy efficiency contribution to the 2030 target is an energy intensity level of 0.07 toe/'000€<sub>2005</sub> as compared to a level of 0.15 toe/'000€<sub>2005</sub> in 2005. The estimated Primary Energy Consumption by 2030 for Malta is 1,051 ktoe whilst the estimation for the Final Energy Consumption is 786 ktoe.

Article 7(1)(b) of the Energy Efficiency Directive provides the framework under which Malta has to comply with its energy savings obligations. Apart from Malta's small size of the energy market, Malta has its own specificities in that it depends on a single electricity distributor. Of notable importance is the fact that Malta has no natural gas network. Another important characteristic of the Maltese islands which should also be taken into consideration is the lack of district heating and cooling networks across the country, as

already indicated above. This is compounded by the limited number and size of fuel suppliers which significantly limits the range of measures which Malta can undertake to meet its energy savings obligations. Such limitations are recognised under the aforementioned Article 7(1)(b) of the revised Energy Efficiency Directive, whereby Malta is required to achieve new savings each year from 1 January 2021 to 31 December 2030 equivalent to 0.24% of annual final energy consumption averaged over the most recent three-year period prior to 1 January 2019.

As regards the milestones of the long-term strategy for the renovation of the national stock of residential and non-residential private and public buildings, Malta is aware of its commitments, in accordance with Article 2a of Directive 2010/31/EU. In line with this obligation, the first long-term renovation strategy which is still being prepared. . In view of this, no indicative milestones of the long-term renovation strategy are included as part of the NECP.

Another commitment which Malta has is the one arising from Article 5 of Directive 2012/27/EU which imposes an obligation to identify a total floor area to be renovated or equivalent annual energy savings to be achieved from 2021 to 2030. To date, this total floor area is not yet available.

The total floor area to be renovated or equivalent annual energy savings to be achieved from 2021 to 2030 under Article 5 on the exemplary role of public bodies' buildings of Directive 2012/27/EU is not available.

### **Key measures and policies for Energy efficiency**

Key measures and policies for the Energy efficiency dimension cover a number of Energy savings obligations and incentives for all energy end use sectors, through the following measures:

#### **Electricity tariffs supporting energy efficiency**

In view of the fact that Malta is striving to move towards the electrification for heating and cooling purposes, through air-to-air reversible heat pumps, it is worth noting that current electricity tariffs, which incorporate a built-in mechanism to promote end-use electrical energy savings, are expected to continue post-2020. These include a “rising block tariff” and an eco-reduction mechanism, which incentivize end-users to reduce consumption below an established threshold and deter high consumption by applying higher tariffs as consumption increases.

#### **Support schemes for the industry and services sectors, and households**

In view of the fact that the industry and services sectors are responsible for a significant portion of the total final energy consumption in Malta, a number of actions and schemes were designed to facilitate interventions in energy efficiency initiatives. Between 2014 and 2020, the Energy and Water Agency operated a ‘voluntary scheme’ whereby enterprises would report verified energy savings. This scheme is expected to continue post-2020 and shall be a prerequisite for access to support schemes provided by the Government. Such schemes-support projects for heating and cooling measures resulting from energy audits can be used to further provide tailor-made solutions for increased efficiency in heating and cooling

demand. Moreover, the Energy and Water Agency is also currently leading information dissemination programmes for decision-makers and engineers to create awareness on the need to invest in energy efficiency, the savings potential, the financial and/or operational benefits of energy efficiency measures, and how to build capacity in energy management.

In the case of SMEs, a scheme was setup in 2018 whereby such enterprises could benefit from grants to help them carry out Energy Audits of their premises/processes/plants/transport fleet. Infact currently the EWA is entrusted with the promotion of energy audits and managing support for enterprises in performing these audits, named '*Promotion of Energy Audits in Small and Medium Sized Enterprises Scheme*'. Under this scheme enterprises can apply for an energy audit to be carried out by a certified energy auditor in compliance with the current regulations. Once this is in place and has been vetted by the EWA, the enterprise in question will be able to obtain funding for such an energy audit under this scheme, up to a maximum value of €5,000. This scheme is expected to continue post 2020, subject to State aid regulations.

Moreover, the EWA has been entrusted with the development of Malta's National Strategy for Research and Innovation in Energy and Water. The Strategy document is intended to provide a high level framework for research activity in these two sectors for the period 2021-2030 in view of the fact that these two sectors bring together some of the most significant challenges being faced at national level, intensified by the rapid pace of economic and population growth and the increasing impacts of climate change. This scheme is closely linked to the European drive to expand and further R&I activities, as this is increasingly viewed as a cross-cutting measure necessary to enable Member States realise their national ambitions and the EU. The objectives of this strategy are the following:

- Strengthen and support R&I addresses national policy priorities and challenges; and/or boost national competitiveness and growth in a variety of sectors.
- Increase coordination and cooperation between the wide array of stakeholders in fields of energy and water, thereby ensuring that outcomes from R&I activities translate into tangible positive impacts

Although Malta has one of the lowest energy intensity figures for households within the EU, the Government still promotes energy efficiency in households and other small consumers. Of particular significance is the scheme known as the 'LEAP scheme' with a special focus on vulnerable and energy poor households aimed at reducing energy and water consumption through the replacement of old and inefficient appliances belonging to Maltese and Gozitan individuals classified as socially vulnerable persons. This scheme included a number of visits conducted in households falling under this category and apart from an assessment of the appliances being used, included also sharing useful tips on how to save energy and water on a daily basis. Under this scheme, which also includes the replacement of high energy consuming appliances used for heating and cooling purposes, it is estimated that there will be a reduction of approximately 48 metric tons of carbon dioxide, with the national savings expected to average around 106MWhrs annually - equal to approximately 27 households' worth of consumption.

## **Government leading by example**

Leading by example, the Government of Malta is implementing and planning to implement more projects and/or measures promoting energy efficiency and achieving energy savings. Funded under Operational Programme I 'Fostering a competitive and sustainable economy to meet our challenges' for the 2014-2020 Programming period, with the aim to shift towards a more low carbon and environmentally-friendly society,

the Government is implementing several projects, such as the introduction of energy efficient measures through the upgrading and retrofitting of the Administration Centre in Gozo and the introduction of an energy efficient lighting system together with heating, ventilation and air-conditioning (HVAC) system at the St. Vincent de Paul Residence (SVPR).

Moreover, households and enterprises will soon be able to benefit from a Financial Instrument with an allocation of €15M from EU funding which is expected to generate a portfolio of guaranteed loans of c. €54M to €60M. This is aimed to incentivise households and enterprises to carry out RES and EE measures. Examples of eligible measures include: insulation, windows and doors, other building-envelope related measures with impact on thermal performance; space heating, domestic hot water, ventilation systems, cooling, lighting, building and Energy management systems, connection to energy supplies, integrated renewable energy investments, charging stations for electric vehicles; renewable energy investments, such as photovoltaic farms not directly linked to building; electric vehicles (for corporates); other energy efficiency investments which aim at reduction of energy consumption; and water efficiency measures. To date, two commercial banks have been selected to implement this Financial Instrument, which is expected to be available on the market in Q1 2021.<sup>54</sup>

For the next Programming period spanning from 2021 to 2027, Malta is currently negotiating with the European Commission in order to secure more funding to continue investing in increase of RES and energy efficiency measures.

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<sup>54</sup>[https://eufunds.gov.mt/en/Operational%20Programmes/Monitoring%20Committees/Documents/OPI\\_OPII%20MC%2029%20Oct%202020/2.%20OPI\\_MC\\_10.2020\\_%20Presentation\\_Update%20on%20Implementation.pdf](https://eufunds.gov.mt/en/Operational%20Programmes/Monitoring%20Committees/Documents/OPI_OPII%20MC%2029%20Oct%202020/2.%20OPI_MC_10.2020_%20Presentation_Update%20on%20Implementation.pdf), retrieved on 22.11.2020

## Part III - Analysis of the Economic Potential for Efficiency in Heating and Cooling

### 3.1 Introduction and Methodology

Part III analyses the economic potential of the technologies to be proposed for the Maltese territory, as set out in Article 14(3) of the EED. The main aim of the analysis is to facilitate *“the identification of the most resource-and cost-efficient solutions to meeting heating and cooling needs”* of the entire national territory of the Maltese Islands, distinguishing between the energy derived from fossil and renewable sources where applicable.

With due consideration of the technologies listed in Part III to Annex VIII of Directive 2012/27/EU (EED), as revised by Delegated Regulation (EU) 2019/826, the following list of interventions were identified as a potential group of projects to be pursued in the context of the heating and cooling characteristics of Malta, separated into two target areas:

Sector	Intervention reference	Description of intervention	Cooling/heating target
Residential	R1	Replacing electrical water heating with heat pumps	Water heating
Residential	R2	Replacing LPG heaters with electric heat pumps	Space heating
Hotels	H1	Replacing fuel-fired boilers used for water heating with electric heat pumps	Water heating
Hotels	H2	Replacing boilers with condensing-type, high-efficiency boilers	Water heating
Hotels	H3	Replacing air-cooled chillers with air-cooled chillers including heat recovery	Water heating
Hotels	H4	Replacing water-cooled chillers with water-cooled chillers including heat recovery	Water heating

*Table 57 – Summary of the scenarios and cooling/heating target*

Each intervention is subject to a **financial feasibility analysis from the point of view of the investor**, followed by a **financial and economic analysis from the point of view of society**, assessing the effects of policy from the societal point of view. The following sections provide further detail on the composition of each part of the analyses.

### 3.1.1 Methodology for the Financial Analyses (investor point of view)

The financial analysis computes the financial performance indicators of the alternative interventions, to assess their profitability and financial sustainability from the point of view of the individual investor. Two types of investors are taken into consideration – household owners and hotel owners, with the latter further sub-categorised into 5&4-star hotel and 3&2-star hotel owners.

As requested in Annex VIII of the EED, the financial analysis (and the economic analysis) uses the **net present value** as criterion for the assessment. This follows the **Discounted Cash Flow (DCF)** method mentioned in section III (method for calculating the discounted net revenue of operations generating net revenue) of Commission Delegated Regulation (EU) No 480/2014. These are the rules followed:

- (i) Only cash inflows and outflows are considered. Depreciation, reserves, price and technical contingencies and other accounting items which do not correspond to actual flows are disregarded.
- (ii) The calculation of the present value of future cash flows is based on a financial discount rate (FDR) of **4%** in real terms, as per Art. 19(3) of Delegated Regulation EU No 480/2014. Due consideration was also taken of sub-articles (4) and (5), especially in relation to the FDR for households. The 4% rate is considered to be the best approximation of the cost of capital for all target groups in the energy efficiency sector.
- (iii) On the time horizon (or reference period), the EIB's publication *The Economic appraisal of Investment Projects at the EIB*<sup>55</sup> states that it "depends on the type of the project and can vary from less than 15 years for many energy efficiency investments up to 25 years for some investments concerning the building envelope". In turn, Annex I of Commission Delegated Regulation EU No 480/2014 suggests a timeframe of 15-25 years for energy projects.

Item (4) under Part I of Annex VIII to 2012/27/EU, amended by (EU) 2019/826, prescribes a 30-year perspective for the construction of cooling and heating demand forecasts. For consistency and completeness, the financial and economic analyses are projected over a **30-year reference period**.

The technical life of the principal technology installed is taken into account, in line with the respective technical life set on National Energy and Climate Plan (NECP, pg. 118).

- (iv) The analysis is carried out net of VAT for hotel owners, both on costs and revenues as this is recoverable by the project promoter. This is not the case of household owners, therefore VAT was included in the respective prices. This is in line with the provisions of the Annexes to Article 14 of Directive 2012/27/EU (hereafter simply referred to as "Article 14"), more

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<sup>55</sup> Included in the list of recommended literature in Annex II to the Commission Recommendation on the content of the comprehensive assessment of the potential for efficient heating and cooling under Article 14 of Directive 2012/27/EU.

specifically, Annex V (section 2) which states that “VAT on costs and revenues (unless this is recoverable by the project promoter);”

- (v) The analysis is carried out in constant (real) prices, with prices fixed at base-year 2020. No adjustment of prices is made for potential fluctuations in consumer price indices.
- (vi) Note on the forecast consumer price index (CPI). Here are the considerations on the cost components making up the financial and economic analyses of the applicable scenarios in this study:

Cost Component	Rationale	Consumer Price Index (CPI) applied
Investment costs – technology	Technology prices follow prices set in the NECP. No adjustment was made for the base year Y1. The reinvestment cost at the end of the technical life but within the reference period (2021-2050) is the same. This follows the assumption that the same technology will have its price deflated by technological obsolescence and competition. Costs were retained at current prices as a conservative approach.	0%
Investment costs – structural alterations	Costs are incurred in the base year 2021 only. No CPI applies.	0%
Operating and maintenance costs – Repairs and maintenance (labour and parts)	Costs of labour and parts are assumed to follow the mainstream CPI. These follow the Retail Price Index (RPI) trend observed between 2017 and 2020 (averaging 1.3%). <sup>56</sup> Since this component is not critical in the financial and economic performance of the scenarios considered, this CPI is ignored.	0%
Operating and maintenance costs – Electricity, Fuel costs	The specific RPI for the Water, Electricity, Gas and Fuels sector ranged between 0.02 <sup>57</sup> and -0.01 percentage points between 2017 and 2020. Considering EU/global decarbonization targets to be achieved during the reference period, possibly leading to a price deflation of fossil fuels (partly offset by inflation labour costs and other costs of production), a neutral rate of 0% is deemed applicable.	0%

*Table 58 – Considerations on the forecast Consumer Price Index*<sup>58</sup>

- (vii) Direct taxes (on capital, income or other) are considered only for the financial sustainability verification of the owner as mentioned in Annex V of Article 14 that “the financial analysis should take account of direct taxes on the prices of inputs” (page 20) but that economic

<sup>56</sup> Trend in Malta’s Retail Price Index of 1.18% (2017-2018), 1.73% (2018-2019), and 1.0% (2019-2020) (*Economic Survey 2018, Economic Survey 2019, Economic Survey 2020*, available at [www.mfin.gov.mt](http://www.mfin.gov.mt).)

<sup>57</sup> Economic Survey 2018,

<sup>58</sup> Guide to Cost-Benefit Analysis of Investment Projects, 2014, pg. 226



analysis should not include direct taxes on inputs (page 21); these being an internal transfer between operators in society.

- (viii) There is no case of owner-operator separation. Owners are assumed to be the operators, hence there is no risk of including internal transfers in the analysis.

As recommended by the European Commission in its *Guide to Cost-benefit Analysis of Investment Projects* (2014), the Cost-Benefit Analyses follow **an incremental approach**, where the alternative solutions are compared to the baseline (or business-as-usual) scenario. The latter takes into account the current status of heating and cooling in Malta as outlined in Part I and point 6 of Part II of Annex VIII of Directive 2012/27/EU (EED), as revised by Delegated Regulation (EU) 2019/826. It is the reference scenario, reflecting existing policy measures and national and EU legislation and is generally based on the energy efficiency and renewable energy “with existing measures” (WEM) scenarios developed for the National Energy and Climate Plan (NECP).

The current heating and cooling **demand** by residential, services, industry and other sectors and the respective demand changes for the projected time horizon are considered. This includes particular projections for the next 30 years considering changes in demand in buildings and different sectors of the industry and the impact of policy and strategies on demand management. Likewise, the identification and/or estimation of the **supply** of heating and cooling in Part I provides the basis of information on the existing technologies installed for the baseline scenario. Such data is the basis for the projection of operational, replacement and maintenance costs and revenues over the time horizon of the financial and economic analyses.

Capital investment costs under the baseline scenario represent the necessary reinvestment needed to replace present equipment and infrastructure at the end of its technical life with the same type, to ensure continuation of the existing level of heating and cooling service provision. This is added to the assessment, so that the financial analysis of the alternatives is net of the unavoidable replacement capital costs.

All technically feasible options shortlisted above are assessed on their respective profitability after taking into consideration:

- a. Initial Investment costs – these include the capital costs of all the fixed assets (plant, equipment, machinery, etc) and non-fixed assets (e.g. technical costs such as designs, planning, project management, technical assistance, supervision, etc). Such costs are assumed to be incurred by the household/investor in the first year of the reference period (Year 1). Cost breakdowns over the years are consistent with the physical realisation (technical lifetime) and the time-plan for implementation.

Estimates of these costs were obtained from the NECP (pg. 118) and primary market data sought by technical experts from the open market.

- b. Replacement costs – these include costs occurring during the reference period to replace short-life machinery/equipment. This is based on the technical life of the individual assets. Such costs are included under the ‘initial investment costs’ for presentation purposes.
- c. Residual value – reflects the capacity of the remaining service potential of fixed assets whose economic life is not completely exhausted.
- d. Operating and maintenance (O&M) costs – all the costs incurred to operate and maintain the new or upgraded service, to ensure adequate quality standards. These may be fixed or variable by nature and include such costs as:
  - i. Labour costs for the employer
  - ii. Materials needed for maintenance and repair of assets
  - iii. Consumption of raw materials
  - iv. Fuel costs
  - v. Electricity costs (inclusive of emission charges in tariff)
  - vi. Services purchased from third parties
  - vii. Quality control
  - viii. Waste disposal costs
- e. As recommended by the guide to the comprehensive assessment, the financial analyses takes into account the cost of CO2 emissions from installations covered by the EU emissions trading system (ETS) “as far as they represent real cash flows” (EU CION, 2014: 219). These values are internalized in the electricity tariff, and follow the projections provided by the European Commission for EU ETS carbon prices, as reproduced in the NECP<sup>59</sup>. The prices of natural gas and carbon over the reference period and the electricity tariffs used (base year 2020)<sup>60</sup> are shown in Annex I.
- f. Revenues – these are defined in Article 61 of (EU) Regulation 1303/2013 as “cash inflows directly paid by users for the goods and services provided by the operation, such as charges borne directly by users for the use of infrastructure, sale and rent of land or buildings, or payments for services”.

For the purposes of the financial analyses in this study, inflows for the investor are only in the form of government grants (subsidies) received, in partial reimbursement of the incremental cost between the baseline and the alternative technology. As stated in the EC Guide<sup>61</sup>, “*transfers or subsidies (e.g. transfers from state budgets) shall not be included within the operating revenues for the calculations of financial profitability because they are not directly attributable to the project operations. On the contrary, they shall be computed for the financial sustainability verification*”. However, given the nature of this project where the main financial decision making process is intended to show how consumer behavior (on the part of households and hoteliers) can be swayed towards the purchase of energy efficient equipment, the provision mentioned above against the inclusion of subsidies was overruled. As a matter of fact Annex V to Article 14 lists subsidies as one of the benefits to be included in the financial analysis (page 21). For the

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<sup>59</sup> NECP, pg. 115

<sup>60</sup> REWS, 2020, available at <https://www.rews.org.mt/#/en/a/13-regulated-electricity-tariffs>

<sup>61</sup> *Guide to Cost-benefit Analysis of Investment Projects*, European Commission (2014)

latter reason, such grants are being included in the financial analyses of this study, while they are removed for simulation in the risk and sensitivity analyses.

### 3.1.1.1 Existing Government Subsidies

#### *For Households*

Two separate schemes administered by the Regulator for Energy and Water Services (REWS) provide financial assistance to households for the installation of Solar Water Heater and Heat Pump Water Heater systems. Both schemes finance 50% of the costs including VAT (up to €700) to private homeowners.

The eligible costs include costs of solar hot water panels and storage tanks (where applicable), plus their fixing to the roof or ground, including VAT, but excluding (i) the cost of any extended warranty beyond the standard warranty that installers are required to provide free of charge; (ii) the cost of any other materials, works or other costs such as, but not limited to, any cost of plumbing at property; and (iii) costs of permits or certification.

#### *For Enterprises*

Government, through the joint collaboration of the Energy and Water Agency and Malta Enterprise, currently finances the **Investment Aid for Energy Efficiency Projects**. The objective of the scheme is to assist small, medium and large enterprises to invest in technologies aimed at improving energy efficiency, including:

- a. Investment in substitution or upgrading of equipment and installations to reduce energy consumption.
- b. Renovation or upgrading of equipment of existing installation for heating (or cooling) systems.
- c. The improvement of energy efficiency of existing illumination systems.

Projects must consist of an investment of at least ten thousand Euro (€10,000) and reach an estimated energy saving of at least 10%.

The eligible costs are the extra investment costs necessary to achieve the higher level of energy efficiency, determined as follows:

- i. where the costs of investing in energy efficiency can be identified in the total investment cost as a separate investment, this energy efficiency-related cost shall constitute the eligible costs;
- ii. in all other cases, the costs of investing in energy efficiency are identified by reference to a similar, less energy efficient investment that would have been credibly carried out

without the aid. The difference between the costs of both investments identifies the energy efficiency-related cost and constitutes the eligible costs.

The aid intensities are 50% for small, 40% for medium and 30% for large enterprises.

### 3.1.2 Methodology for the Economic Analyses (societal point of view)

The economic analysis addresses the social costs and benefits of the investments pursued by the private investor (household, hotel). This is done by converting market prices to **shadow prices** to reflect the social opportunity cost of goods and services. The following assumptions and adjustments apply:

- i. Geographic boundaries – all economic analyses in this study cover the territory of the Maltese Islands, and not beyond.
- ii. Fiscal corrections on inputs and outputs – taxes and subsidies are a transfer of benefits from one operator to another in society, so prices of inputs are net of any direct or indirect taxes. Corrections mainly consist of the reversal VAT (in the case of households), excise duties (in the case of LPG, diesel, gasoil in the baseline or alternative investments) and government subsidies. There are no outputs from the scenarios considered, so no tariffs (hence no subsidies) apply.
- iii. Conversion from market to shadow prices for inputs and outputs. For inputs (e.g. fuel), commonly acceptable methods for border prices are used, in line with the recommendation given in the EC's *Guide to Cost-Benefit Analysis of Investment Projects*.
- iv. Evaluation of non-market impacts and corrections for externalities. The external costs and benefits of the proposed technologies in terms of GHG emissions (mainly CO<sub>2</sub>) and health and safety outcomes.

As recommended by Annex VI to the Commission Recommendation on the content of the comprehensive assessment, the assessment of environmental value is based on data available on environmental damage factors of each unit of energy consumed. Conversion factors (from EWA, other local sources and general literature) are used to estimate how environmental value changes with the alternative technologies from the baseline scenario.

Likewise, the valuation of GHG emissions and climate change impact are based on a damage-cost approach that provides higher values per ton of emissions. Comparison is made against the baseline scenario on the basis of greenhouse gas emission reductions and primary energy savings (in GWh per year). The proposed interventions are not deemed to have a significant impact on the share of renewables in the national energy mix.

For simplification purposes, **CO<sub>2</sub> emissions only** are considered in the CBA. Although considered in the calculations performed, **other GHG emissions and pollutants** were deemed to be relatively marginal in comparison to CO<sub>2</sub>, hence ignored.

- v. Further to this and as recommended by Annex I to the Commission Recommendation on the content of the comprehensive assessment (part 4.2), the economic analysis also assessed the benefits of the alternative heating and cooling solutions on the energy system, including the flattening of the energy demand curve.
- vi. The **social discount rate** used is **5%**. This is the European Commission benchmark according to Annex III of the Implementing Regulation on the application form and CBA methodology for major projects in Cohesion countries (including Malta).

In the assessment of the economic impact of the alternative solutions proposed, this study takes into consideration the typical benefits and valuation methods associated with energy efficiency projects related in the *EC Guide to CBA of Investment Projects* (2014), namely:

Economic benefit	Valuation method	Counterfactual
Increase of efficiency for consumption	Variation in economic costs of the energy source/fuel	Business as usual
Increase of comfort	Variation in economic costs of the energy source/fuel	Economic energy cost sustained to maintain a 'thermal comfort' temperature through the without-the-project technology/system of energy production
Reduction of GHG emissions	Shadow price of GHG emissions	Business as usual
Reduction of air pollutant emissions	Shadow price of air pollutants	Business as usual

*Table 59 – Typical benefits and valuation methods of energy-efficient consumption projects (EC, 2014)<sup>62</sup>*

Whereas *increase of efficiency for consumption* and *reductions in GHG and air pollutant emissions* are directly related to the alternative scenarios considered, there is no increase in thermal comfort from the alternative technologies proposed. The levels of space or water cooling and heating obtained from the proposed projects are the same as those obtained from the baseline scenario, therefore no calculations are performed on this matter. Additionally, the valuation of air pollutant emission reductions – although not negligible in terms of the improved welfare to society – are not considered substantial in comparison to the value of CO<sub>2</sub> emission reductions. Hence, calculations mainly concentrate on the latter valuations.

At the outset it should be mentioned that the Government of Malta holds a major shareholding interest in the sole energy operator and distributor in Malta, Enemalta plc, such that the profitability of the entity is of direct interest to the Government as an investor and in ensuring security of energy supply for the Maltese society. However, this study considers these as merely costs saved from one sector of society (i.e. energy generation and distribution), which are further reinvested into other sectors of the economy by

<sup>62</sup> Guide to Cost-Benefit Analysis of Investment Projects, 2014, pg. 226

the citizens (i.e. energy efficient technologies); and hence are not taken into consideration in the economic analysis.

Therefore, the main external benefits from energy efficiency are based on:

- i. **CO<sub>2</sub> emissions avoided**
- ii. **Primary energy cost savings.**

CO<sub>2</sub> emissions are calculated through conversion factors applied to the energy consumed in the baseline and alternative scenarios. For electricity, this depends on the projected mix of fuels used in electricity generation in Malta, taking into consideration three possible scenarios of decarbonization by 2050. These and the factors for the other fuels or vehicles used in this study are the following:

Fuel	Emission factor	Source
Electricity - Scenario 1	Constant energy mix between 2021 and 2050, where the emission factor does not change (constant at 0.381 kg/kWh <sup>63</sup> )	EWA
Electricity – Scenario 2	Constant energy mix until 2030 (constant at 0.381 kg/kWh), decreasing linearly up to a 50% reduction (0.1905 kg/kWh) between 2031 and 2050	EWA
Electricity – Scenario 3	Constant energy mix until 2030 (constant at 0.381 kg/kWh), decreasing linearly up to a 100% reduction between 2031 and 2050 (i.e. reaching 0 kg/kWh by 2050)	EWA
LPG	0.227160 kg/kWh	EIB <sup>64</sup>
Diesel	0.266760 kg/kWh	EIB
Light Commercial Vehicles (LCV)	0.241 kg CO <sub>2</sub> e/ vkm	EIB

*Table 60 – CO<sub>2</sub> Emission Factors*

The shadow price of CO<sub>2</sub> emissions follows the progression of the EU Emissions Trading System (ETS) outlined in the NECP, as in this table:

<sup>63</sup> Source: EWA

<sup>64</sup> EIB Methodologies for the Assessment of Project GHG Emissions and Emission Variations, July 2020

Year	Carbon Price	Carbon Price
	EU ETS CION/PRIMES Assumptions	
	€ 2016/t CO <sub>2</sub>	
<b>2021</b>	€17.0704	€0.0171
<b>2022</b>	€18.6223	€0.0186
<b>2023</b>	€20.1741	€0.0202
<b>2024</b>	€21.7260	€0.0217
<b>2025</b>	€23.2778	€0.0233
<b>2026</b>	€25.5539	€0.0256
<b>2027</b>	€27.8299	€0.0278
<b>2028</b>	€30.1060	€0.0301
<b>2029</b>	€32.3821	€0.0324
<b>2030</b>	€34.6581	€0.0347
<b>2031</b>	€36.4169	€0.0364
<b>2032</b>	€38.1757	€0.0382
<b>2033</b>	€39.9344	€0.0399
<b>2034</b>	€41.6932	€0.0417
<b>2035</b>	€43.4520	€0.0435
<b>2036</b>	€45.1073	€0.0451
<b>2037</b>	€46.7626	€0.0468
<b>2038</b>	€48.4179	€0.0484
<b>2039</b>	€50.0732	€0.0501
<b>2040</b>	€51.7285	€0.0517
<b>2050</b>	€51.7285	€0.0517

Table 61 – EU ETC Carbon Prices 2021-50 (NECP, EWA)

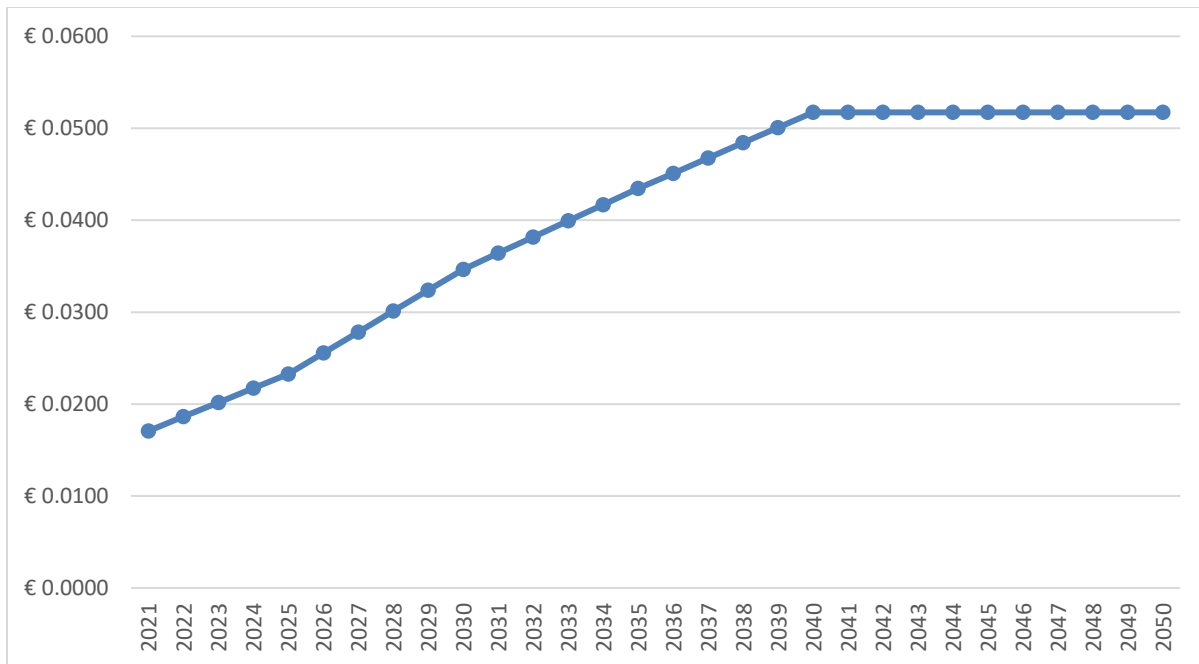


Figure 88 - Progression of the Carbon Price, € / kg CO<sub>2</sub>

Primary energy savings are expressed in terms of the border price of natural gas, LPG or other fuel saved, in line with EC recommendations, net of excise duties and taxes. It is acknowledged that Annex VIII (EED), Art III, item 8, states that *the assessment and decision-making should take into account costs and energy savings from the increased flexibility in energy supply and from a more optimal operation of the electricity networks, including avoided costs and savings from reduced infrastructure investment, in the analysed scenarios*. However, in line with the *maximin* approach that underpins this study, the CIF of (avoided) fuel was taken as a proxy for fuel savings.

In the same prudent spirit “homogeneity of output” was assumed such that the output from the baseline and alternative technologies is **the useful energy produced**. Put differently, the value placed by consumers of the output from the technologies is assumed to be the same, since the useful energy produced will be equivalent, irrespective of the baseline and alternative scenarios. It may be debated that consumers also place a value on procuring an output which is greener than another. However, this consumer surplus is not considered significant relative to the other costs and benefits, so it does not feature in the calculations of the economic net present value.



## 3.2 Financial and Economic Analyses of the Alternative Scenarios

This section analyses the financial and economic potential of different technologies for heating and cooling installed in two key areas identified in the previous parts of this study – residential and hotels.

For each solution proposed, an individual cost benefit analysis is conducted to determine:

- i. the financial performance from the investor's point of view and
- ii. the consolidated economic impact of the implementation of the solution by multiple operators in society.

### 3.2.1 Residential Sector

#### 3.2.1.1 Residential Scenario 1 (R1) - Replacing electrical water heating with heat pumps

##### *Description, rationale and key assumptions*

This scenario considers the replacement of electric water heaters with electric heat pumps in private households. The key parameters of the scenario are summarized here:

TECHNOLOGY DATA	Baseline: Electric Water Heaters	Alternative: Heat Pumps
Units per household	1	1
Efficiency losses per annum	0.01	0.009
Technical Life (years)	10	20
Price per unit (€)	€253	€2,000
Structural alterations in Y1 (€)	€0	€100
ENERGY DATA		
Useful energy demand – water heat. only (kWh, 2021)	1079	1079
Coefficient of Performance (COP)	0.9	4.0
Annual electricity consumption (kWh, 2021)	1199	270
Electricity tariff - Residential (weighted) inc. VAT	€0.117	€0.117

*Table 62 – Key parameters of Scenario R1*

Prices in this scenario are inclusive of VAT, as VAT is not recoverable by the household. It is assumed that during the reference period, the technologies are replaced with an identical technology at the end of their technical life<sup>65</sup>. Considering the small size of the local market and the inherent uncertainty around the real price of the technology, the price of heat pumps shown above is deemed to be the closest approximation to the current market price in Malta.

For the financial analysis from the perspective of the individual household owner, the main investment cost is incurred in Y1 (2021), assuming the current electric water heater installed in the household has reached the end of its technical life and is due for replacement with either the baseline or alternative technology. The alternative scenario includes a one-time cost for structural changes to the household, in Y1. Operating and maintenance costs include electricity costs based on the weighted tariff in Table 62 and repairs and maintenance costs based on the assumptions in Annex 4 attached to this report. Electricity costs are subject to annual increases due to the technology efficiency losses indicated above.

A Government incentive of €700 is assumed to be granted only in the first year of investment, Y1 (2021).

### *Results from the Financial Analysis*

Table 63 summarizes the outcome from the financial analysis (household owner perspective), which is strongly affected by significant incremental investment and reinvestment costs in Y1 (PV=€1747) and Y21 (PV=€581) respectively, partially offset by the residual value.

<b>2021-2050 - NPV</b>	<b>Electric water heater</b>	<b>Heat pump</b>	<b>Incremental</b>
Investment Costs	(539)	(2,913)	(2,373)
Residual Value	-	321	321
Operating & Maintenance costs	(2,889)	(1,010)	1,879
Government subsidy	-	700	700
FNPV	(3,428)	(2,902)	526
FRR			9.3%

*Table 63 – Scenario R1 – Financial NPV (30 years, 2021-50)*

Figure 89 shows the progression of the cumulative net cash flows, suggesting a payback period on the initial investment of 11 years.

<sup>65</sup> The technical life of the technologies considered in this study were taken from the NECP (pg. 118). The technical life of electric water heaters was considered to be 10 years.

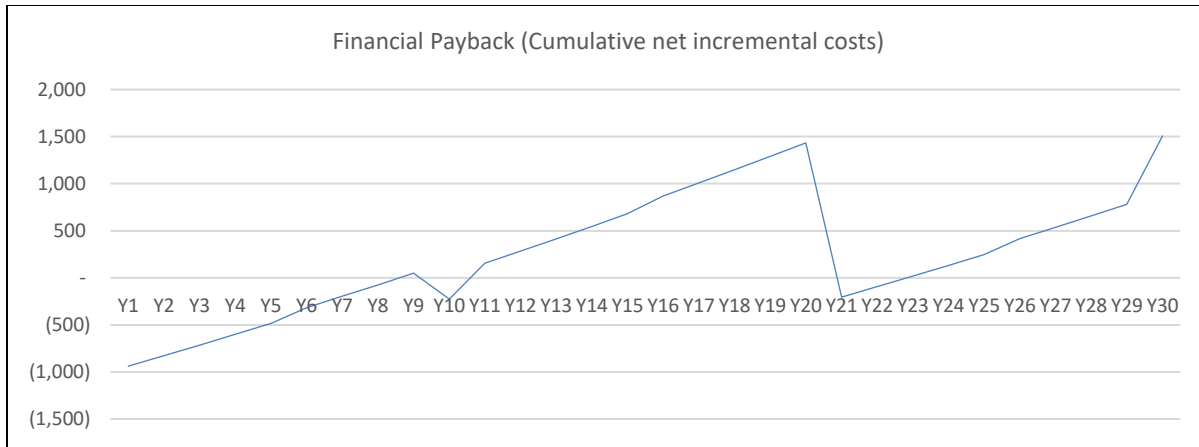


Figure 89 - Residential 1: Cumulative incremental cash flows and Payback undiscounted - 2021-2050 (€)

### Results from the Economic Analysis (Benchmark Scenario)

Table 64 shows the relevant population and household data.

	2020	2025	2030	2035	2040	2045	2050
Population of Malta and Gozo <sup>66</sup>	478,809	519,286	547,083	562,704	571,232	575,561	577,741
Total number of households <sup>67</sup>	180,003	192,328	210,416	216,425	219,704	221,368	222,207

Table 64 – Population and household data

The economic analysis for this scenario evaluates the change in welfare under three demand scenarios, considering different technology penetration levels in households. The first context considers a constant of 800 changeovers annually, leading to a 27% penetration of all households by 2050, while the second and third consider more optimistic 50% and 100% take-ups. Table 65 splits the number of households cumulatively in ten-year periods for the three scenarios.

Demand Scenario	Changeovers by 2050	by 2020	by 2030	by 2040	by 2050	% by 2050
R1-A	800 households annually by 2050	36,494	44,494	52,494	60,494	27%
R1-B	50% of all households by 2050	36,494	44,494	77,799	111,103	50%
R1-C	100% of all households by 2050	36,494	44,494	133,350	222,207	100%

Table 65 – Demand for Heat Pumps for water heating in households: three scenarios 2021-2050

The **Benchmark Scenario (BM)** is based on demand scenario R1-A. The other two are simulated in the Sensitivity Analysis in Section 3.2.1.1 below. The other variable in the economic analysis is the **level of CO<sub>2</sub>**

<sup>66</sup> NECP

<sup>67</sup> NECP and EWA

**emissions** considering the three energy decarbonization scenarios in the generation of electricity in Malta. These are reproduced here for ease of reference:

Fuel	Emission factor
Electricity - Scenario 1	Constant energy mix between 2021 and 2050, where the emission factor does not change (constant at 0.381 kg/kW <sup>68</sup> )
Electricity – Scenario 2	Constant energy mix until 2030 (constant at 0.381 kg/kW), decreasing linearly up to a 50% reduction (0.1905 kg/kW) between 2031 and 2050
Electricity – Scenario 3	Constant energy mix until 2030 (constant at 0.381 kg/kW), decreasing linearly up to a 100% reduction between 2031 and 2050 (i.e. reaching 0 kg/kW by 2050)

*Table 66 – Electricity CO<sub>2</sub> emissions – three scenarios*

The Benchmark Scenario considers **carbon emissions based on the current energy mix for electricity** (Electricity – Scenario 1), constant across the whole reference period. The economic performance is summarized here:

<b>2021-2050 – ENPV, €</b>	<b>INCREMENTAL (€)</b>
Financial Costs	(3,871,842)
Financial Revenues	-
Economic Costs	
<i>Fiscal Corrections</i>	(3,257,160)
Economic Benefits	
<i>Energy savings</i>	7,687,637
<i>CO<sub>2</sub> Emissions avoided</i>	2,509,833
ENPV	3,068,469
ERR	8.1%
B/C RATIO	1.66

*Table 67 – Scenario R1-A – Economic NPV (30 years, 2021-50)*

<sup>68</sup> Source: EWA

## Sensitivity Analysis

### Sensitivity Analysis (Part 1) – Combination of demand levels and electricity decarbonization scenarios

The ENPVs for each combination of demand and emissions scenario considered in the CBA are summarized in Table 68. The respective effects on the primary energy savings and carbon emissions are presented in Figure 90.

Incremental ENPV (€), 2021-50	Demand 1 [800 till 2050]	Demand 2 [50% till 2050]	Demand 3 [100% till 2050]
CO <sub>2</sub> - Scenario 1 (constant)	3,068,469- BM <sup>69</sup>	3,086,232	3,125,228
CO <sub>2</sub> - Scenario 2 (grad-50%)	2,464,447	1,416,606	(883,713)
CO <sub>2</sub> - Scenario 3 (grad-100%)	1,860,425	(253,021)	(4,892,654)

Table 68 – Residential R1 – Sensitivity of ENPV to demand and CO<sub>2</sub> (30 years, 2021-50)

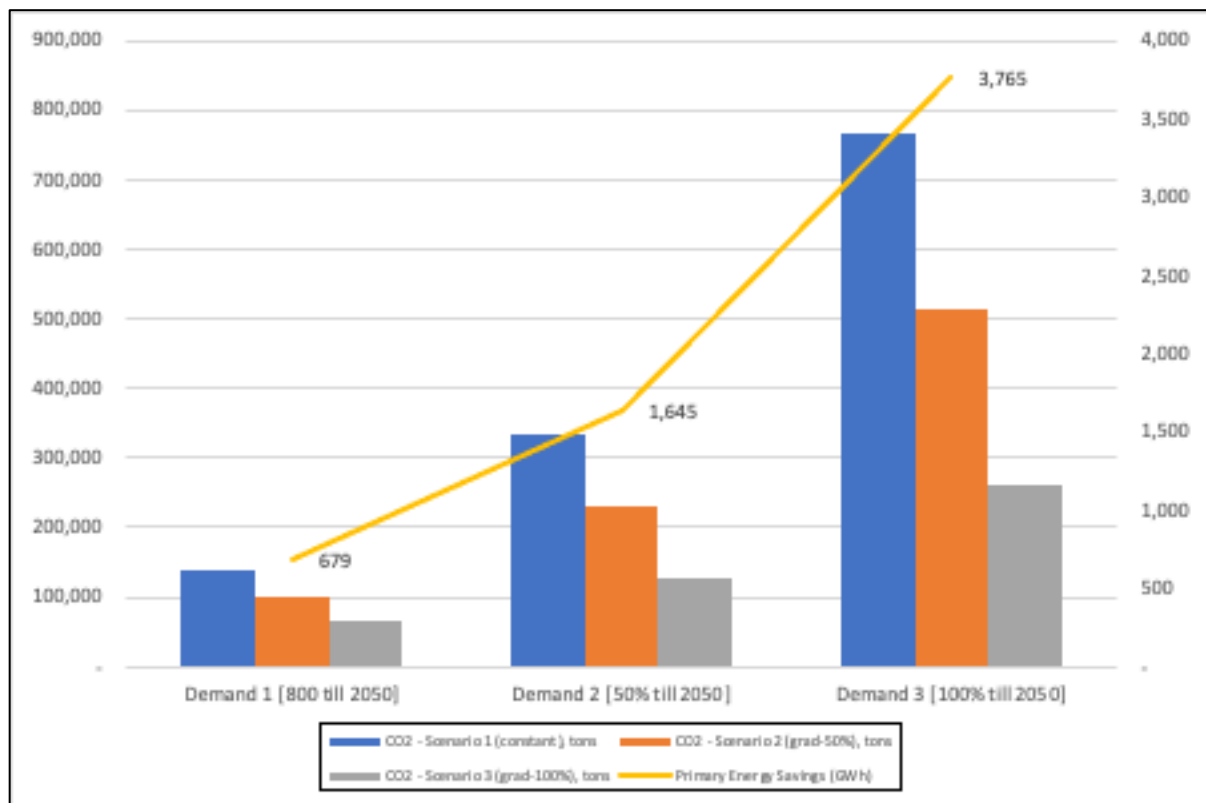


Figure 90 - Residential R1 – CO<sub>2</sub> Emissions avoided (tons) and Primary energy savings (GWh)

<sup>69</sup> BM = Benchmark Scenario

The trajectory of CO<sub>2</sub> emissions avoided under each of the three demand scenarios is explained by the evolution of the emission factors under the three possible electricity decarbonization settings between 2021 and 2050, as shown in the following figure.

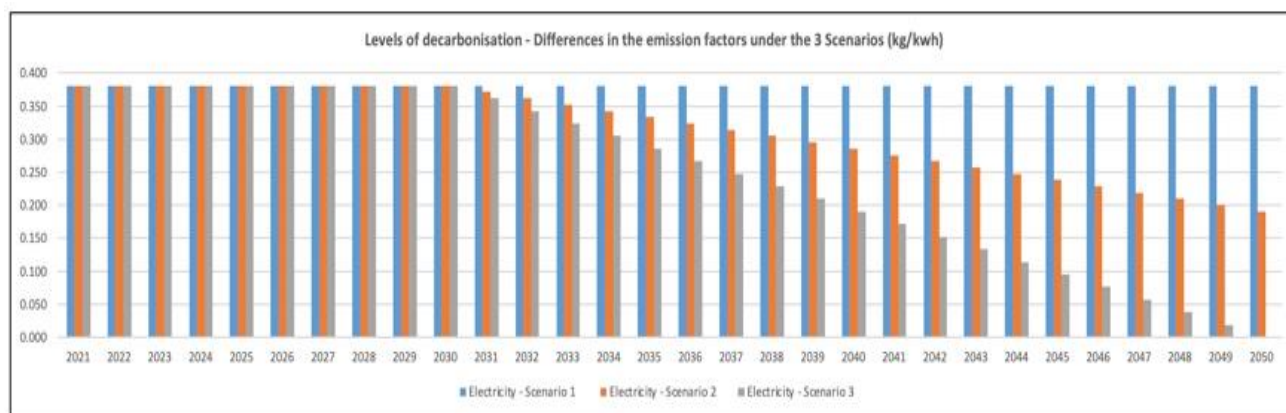


Figure 91 - CO<sub>2</sub> Emission factor progression in the three supply decarbonisation scenarios (kg/kWh)

An identical and constant emission factor value of 0.381 kg/kW features until 2030, which is maintained under demand scenario 1 after 2030, but diminishes progressively and constantly under demand scenarios 2 and 3, reaching 0.1905kg/kW (or 50% less) and 0 kg/kW (or 100% less) respectively by 2050.

Therefore, the returns in terms of emissions avoided per kWh of electricity consumed reduces constantly under CO<sub>2</sub> scenario 2, and at double its pace under CO<sub>2</sub> scenario 3. This explains the downward, stepped shape of emissions avoided under each demand scenario. This also partially contributes to the diminishing ENPVs in Table 68.

#### Sensitivity Analysis (Part 2) – Sensitivity to changes in major variables

This part of the analysis examines the reaction of the financial and economic values determined in the economic analysis above to a positive or negative change in a critical variable. The analysis below is carried out by changing one variable at a time and determining the effect of that change on the NPV. As a general rule, in accordance with the CBA Guide (EU CION, 2014: 67), ‘critical’ variables are those for which a variation of  $\pm 1\%$  of the value adopted in the base case (i.e. the benchmark scenario<sup>70</sup>) gives rise to a variation of more than 1% in the value of the NPV. Four variables are analysed, namely:

<sup>70</sup> The benchmark scenario BM = an uptake of the alternative technology 800 annually until 2050 and the retention of the current electricity energy mix

- i. Primary energy prices and electricity tariffs<sup>71</sup>
- ii. Investment cost of the alternative technology<sup>72</sup>
- iii. Government subsidies<sup>73</sup>
- iv. EU ETC Carbon Price<sup>74</sup>

The independent variables are isolated and measures to remove deterministic interdependencies (e.g. splitting a variable in its independent components) are taken. The following table summarizes the critical elements for scenario R1 in red, those which are not critical are in green:

Variable	Variation of the FNPV due to a $\pm 1\%$ variation	Criticality judgement	Variation of the ENPV due to a $\pm 1\%$ variation	Criticality judgement
Primary energy prices & Electricity tariffs	4.18%	Critical	7.67%	Critical
Alternative technology investment cost	5.70%	Critical	9.22%	Critical
Government subsidies	1.33%	Critical	N/A	N/A
EU ETS Carbon Price	N/A	N/A	0.82%	Not critical

*Table 69 – Residential R1 – Sensitivity Analysis: Critical and non-critical variables*

The FNPV is highly sensitive to changes in the main cost drivers – investment costs and the electricity costs. The appeal of scenario Residential 1 is based on the potential to improve energy efficiency, but is burdened by relatively heavy initial investment costs and reinvestment costs. Government subsidies are therefore also critical to ensure feasibility for the investor.

Similarly, economic welfare is closely linked to the level of primary energy and electricity prices and the price the alternative technology. As a matter of fact, when higher levels of demand coincide with a completely decarbonized supply of energy, the ENPV turns negative (see Table 68 above and the following Table 70), mainly due to the financial costs invested by a larger population in alternative technology not being offset by the resulting energy savings and reduction in emissions.

<sup>71</sup> BM in the Financial Analysis of each respective scenario in the Annexes.

<sup>72</sup> BM in the Financial Analysis of each respective scenario in the Annexes.

<sup>73</sup> BM = €700 capping for Residential 1; No subsidy on Residential 2; 30% \* the difference in cost between the alternative and the baseline technology for Services 1, 2, 3 and 4.

<sup>74</sup> BM in Annex 1

<b>2021-2050 – ENPV, €</b>	<b>CO<sub>2</sub> - Scenario 3 (grad-100%) &amp; Demand 3 [100% till 2050]</b>	<b>BENCHMARK SCENARIO</b>
Financial Costs	(50,564,914)	(3,871,842)
Financial Revenues	-	-
Economic Costs		
<i>Fiscal Corrections</i>	3,865,512	(3,257,160)
Economic Benefits		
<i>Energy savings</i>	36,657,931	7,687,637
<i>CO<sub>2</sub> Emissions avoided</i>	5,148,818	2,509,833
ENPV	(4,892,654)	3,068,469

Table 70 – Residential R1 – Sensitivity Analysis: Comparison Benchmark vs Worst-performing Scenario

To understand the impact of different estimations of opportunity cost, a separate assessment examines the responsiveness of the key indicators to an increase and decrease in the Financial Discount Rate and the Social Discount Rate by 1 point over the benchmark rates of 4% and 5% respectively. The results are shown here:

<b>Financial Discount Rate</b>	<b>ENPV</b>	<b>Social Discount Rate</b>	<b>ENPV</b>
3%	€607	4%	€4,596,440
4% - BM	€526	5% - BM	€3,068,469
5%	€386	6%	€1,851,036

Table 71 – Residential R1 – Sensitivity Analysis: Effect of different FDR and SDR

As a final assessment of sensitivity, all four variables were separately tested to identify the minimum change allowed before FNPV or ENPV turn negative. Switching values of less than 100% are considered critical, with a higher risk of changing the financial or economic feasibility of the scenario. The below confirms the high sensitivity of both NPVs to changes in the energy prices and investment costs.



	<b>FNPV - BM</b>	<b>ENPV - BM</b>
	€526	€3,068,469
	Minimum change for <b>FNPV</b> to become negative	Maximum change for <b>ENPV</b> to become negative
Primary energy prices & Electricity tariffs	-24%	-14%
Alternative technology investment cost	18%	11%
Government subsidies	-76%	N/A
EU ETS Carbon Price	N/A	-123%

*Table 72 – Residential R1 – Sensitivity Analysis: Switching Values*

The relatively low switching value of primary energy prices and electricity in relation to ENPV is determined by various factors. Firstly, the benefits of the alternative solution in the context of the Benchmark Scenario (demand scenario at 800 per annum and CO<sub>2</sub> emissions held constant until 2050) are mainly driven by its ability to generate savings in primary energy. A change in the unit price of energy has a significant effect on its economic performance.

Another important determinant is the timing of cash flows. ENPV is the summation of investments occurring gradually from Y1 to Y30. The first set of 800 investments occurs in Y1 (undiscounted); the next set of 800 occurs in Y2 (discounted) and repeated uniformly over the remaining years, with progressively higher discounting. Energy savings, on the other hand, are lower in the early years when take-up and discounting are relatively low, but cumulatively higher in the later years when discounting is comparatively higher. The effect of this can be seen from the difference in loss in value between discounted and undiscounted financial cash flows (fiscally corrected) and energy savings below.

	Undiscounted	Discounted	% value loss
Cumulative financial costs, 2021-50	9,159,427	7,129,002	22%
Cumulative energy savings, 2021-50	18,634,913	7,687,637	59%
			37%

*Table 73 - Residential R1 – Sensitivity Analysis: Effect of discounting*

59% of the valuation of energy savings is lost to discounting, compared to only 22% lost in the value of investment, reinvestment and O&M costs. This is further illustrated in the following figures, showing how the surplus (orange shade) is eroded with the introduction of time value discounting, and thus explaining why energy prices are so crucial for ENPV.<sup>75</sup>

<sup>75</sup> CO<sub>2</sub> emissions avoided – which are not affected by critical variable under review here (energy prices), and therefore ignored – complete the ENPV calculation.

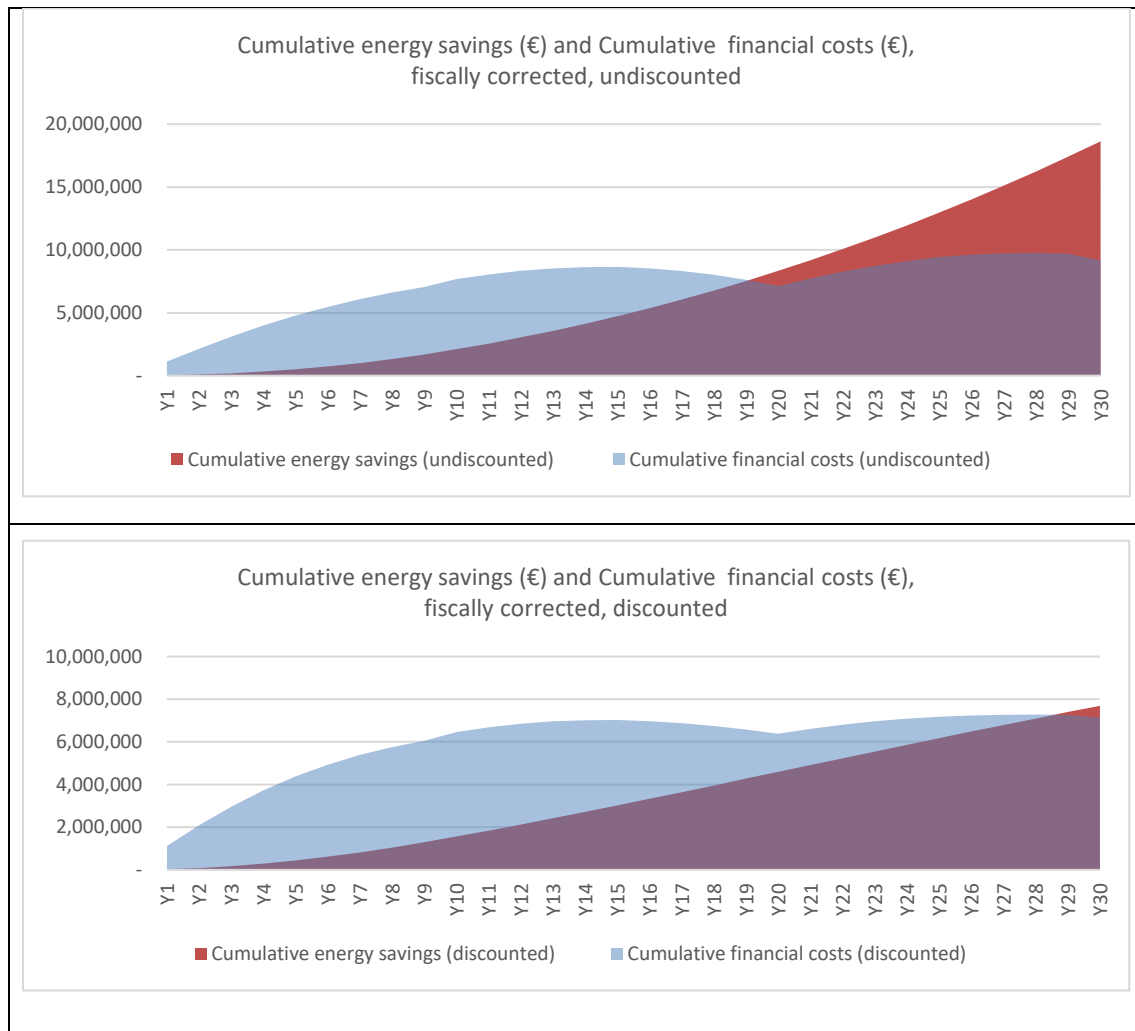


Figure 5 - Residential R1 – Sensitivity Analysis: Effect of discounting and the criticality of energy prices on ENPV

FNPV, on the other hand, has one major investment cost incurred in Y1 when discounting is zero and O&M occurring from Y2 to Y30, with one major reinvestment in Y20. The 'lifeline' of FNPV in the financial analysis is linear, starting from Y1 to Y30. It takes a slightly higher percentage change in electricity prices to shift FNPV to negative, compared to ENPV.

### 3.2.1.2 Residential Scenario 2 (R2) - Replacing LPG space heaters with heat pumps

#### *Description, rationale and key assumptions*

This scenario considers the replacement of LPG heaters with heat pumps for spatial heating in households, with the following key parameters:

TECHNOLOGY DATA	Baseline: LPG Heaters	Alternative: Heat Pumps
Units per household	1	1
Price per unit (€)	€156	€720
ENERGY DATA		
Useful energy demand - space heating only (kWh, 2021)	269	269
Coefficient of Performance (COP)	0.9	4
Final Energy consumption (kWh, 2021)	298	67
LPG demanded per household per annum (kg)	21.9	N/A
Weighted LPG cylinder price (residential)	€16	N/A
Number of cylinders purchased by households p.a. (space heating only)	1.7	N/A
Electricity tariff - Residential (weighted) inc. VAT	N/A	€0.12

*Table 74 – Key parameters of Scenario R2*

Prices in this scenario are inclusive of VAT, as this is not recoverable by the household. No investment cost is incurred in Y1 (2021), as the majority of households in Malta<sup>76</sup> already own an air-conditioning unit. This was therefore assumed as a sunk cost. Given the lengthy duration of the reference period, one reinvestment cost is introduced in Y20. Operating and maintenance costs include the cost of LPG cylinders (baseline) and electricity costs (alternative) based on the weighted price and tariff in Table 74 and repairs and maintenance costs based on the assumptions in Annex 4 attached with this report.

As noted in the NECP, the penetration of heat pumps for space cooling or heating has been self-sustaining in the past years. No Government incentives are therefore being considered under this scenario.

<sup>76</sup> More than 70% (source: EWA), but mostly use air-conditioners for cooling purposes only, despite their multi-functionality.

## Results from the Financial Analysis

This case shows a positive return over the 30-year period, as shown in the following tables. No FRR is returned due to the late timing of the cash outflow and the predominance of positive cash flows over all the remaining 29 years.<sup>77</sup>

2021-2050 - NPV	LPG heater	Heat pump	Incremental
Investment Costs	(74)	(342)	(268)
Residual Value	25	115	90
Operating & Maintenance costs	(534)	(150)	385
Government subsidy	-	-	-
FNPV	(583)	(376)	207
FRR (C)			-

Table 75 - Scenario R2 – Financial NPV (30 years, 2021-50)

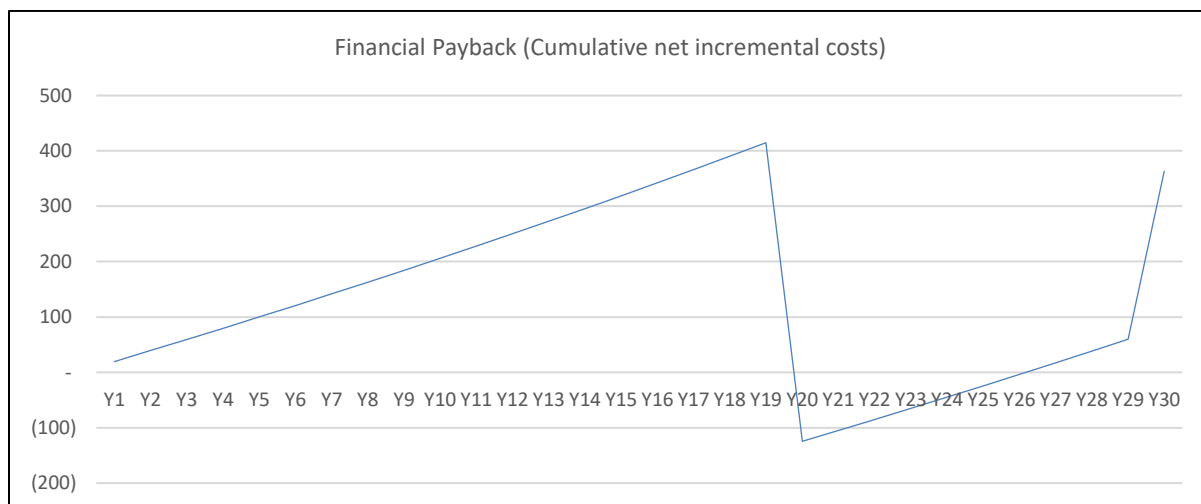


Figure 92 - Residential 2: Cumulative incremental cash flows and Payback undiscounted - 2021-2050 (€)

<sup>77</sup> No initial investment costs in Y1 and only net cash inflows are registered across the reference period.

## Results from the Economic Analysis

From the analysis in Part I of this report, 12% of the useful energy for space heating in Maltese residences is produced from fuel heaters. Assuming 20% of households do not need additional space heating within the insulation capacity of their building envelope, the following are the figures at the start and end of the reference period, with existing measures:

	Y1 - 2021	Y30 - 2050
Total households	192,328	222,207
% of households with no space heating needs	20%	20%
Number of households with no space heating needs	38,466	44,441
Number of households with space heating needs	153,862	177,765
% households using LPG heaters for space heating	12%	12%
<b>Number of households using LPG heaters (baseline)</b>	<b>17,824</b>	<b>20,594</b>

*Table 76 – Stock of households using LPG heaters in Y1 (2021) and Y30 (2050), with existing measures*

The demand trajectory for the whole reference period is based on the same three demand scenarios used in the under Scenario R1. The number of households switching to heat pump space heating annually is summarized here:

Demand Scenario	Changeovers by 2050	by 2030	by 2040	by 2050	% by 2050
R2-A	800 households annually by 2050	8,000	16,000	20,594	100%
R2-B	50% of all households by 2050	8,000	9,002	10,297	50%
R2-C	100% of all households by 2050	8,000	14,150	20,594	100%

*Table 77 – Demand for Heat Pumps for space heating in households: three scenarios 2021-2050*

The same three decarbonization scenarios in Table 66 are applied to the alternative scenario. The baseline emissions are based on the constant CO<sub>2</sub> emissions from LPG. Table 78 presents the results assuming constant CO<sub>2</sub> emissions from electricity and demand scenario R2-A.

<b>2021-2050 – ENPV, €</b>	<b>INCREMENTAL (€)</b>
Financial Costs saved	1,730,221
Financial Revenues	-
Economic Costs	
<i>Fiscal corrections</i>	(736,401)
Economic Benefits	
<i>Primary Energy savings</i>	1,336,009
<i>GHG Emissions avoided</i>	290,076
ENPV	2,619,906
ERR (C)	-

*Table 78 – Scenario R2 – Economic NPV (30 years, 2021-50)*

## *Sensitivity Analysis*

### *Sensitivity Analysis (Part 1) – Combination of demand levels and electricity decarbonization scenarios*

The ENPV for each combination of demand and emissions scenario considered in the CBA are summarized in Table 79. The respective effects on the primary energy savings and carbon emissions are presented in Figure 93.

<b>Incremental ENPV, 2021-50</b>	<b>Demand 1 [800 till 2050]</b>	<b>Demand 2 [50% till 2050]</b>	<b>Demand 3 [100% till 2050]</b>
CO <sub>2</sub> - Scenario 1 (constant)	2,619,906 - BM	1,462,414	2,356,848
CO <sub>2</sub> - Scenario 2 (grad-50%)	2,664,992	1,486,154	2,397,365
CO <sub>2</sub> - Scenario 3 (grad-100%)	2,710,078	1,509,893	2,437,882

*Table 79 – Residential R2 – Sensitivity of ENPV to demand and CO<sub>2</sub> (30 years, 2021-50)*

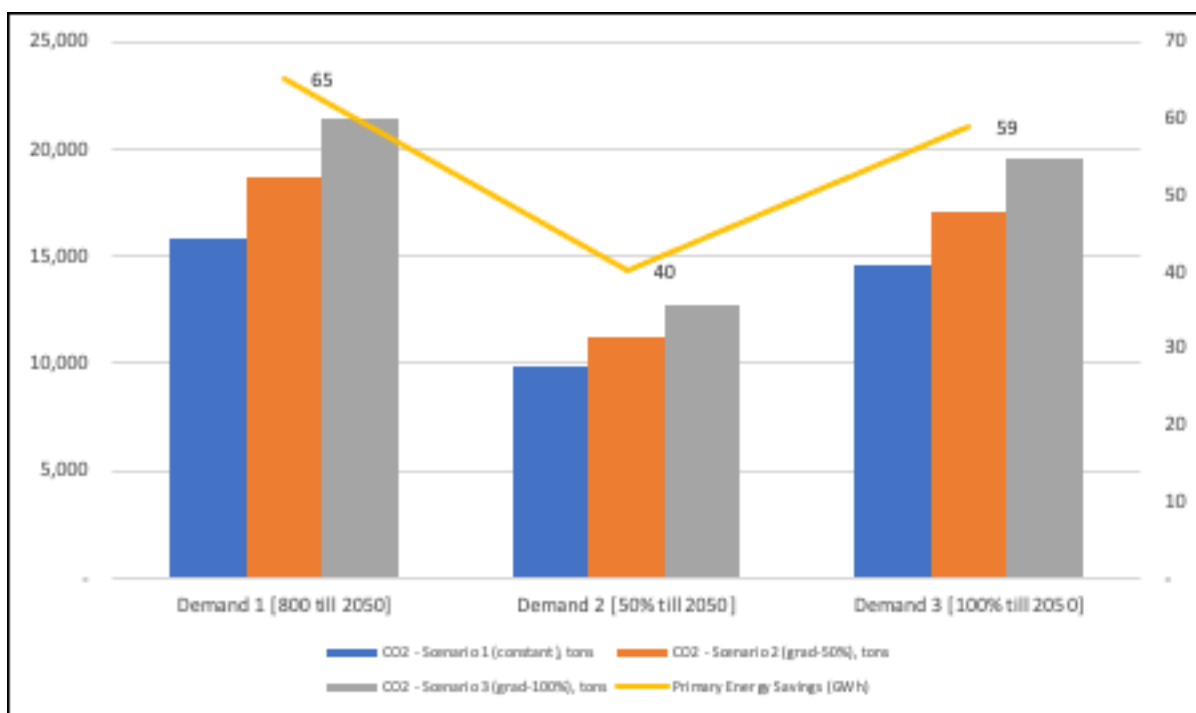


Figure 93 - Residential R2 – CO<sub>2</sub> Emissions avoided (tons) and Primary energy savings (GWh)

Take-up under demand scenarios 1 reaches 100% by 2046, slightly earlier than scenario 3 where it is reached in 2050. This accounts for the difference in energy savings and emissions avoided.

Unlike the residential scenario R1, the CO<sub>2</sub> emissions avoided are higher when decarbonization levels reach 100% by 2050 (scenario 3). This is due to the fact that the stock of CO<sub>2</sub> emissions eliminated from LPG consumption is replaced by a lesser amount of CO<sub>2</sub> emissions from electricity. In fact, taking demand 1 as an example in the next table (corresponding to the first cluster of columns on the left of Figure 93), CO<sub>2</sub> scenario 3 eliminates 81% of the baseline emissions, compared to 60% and 71% under CO<sub>2</sub> scenarios 1 and 2.

		<b>Baseline CO<sub>2</sub> emissions, 2021-50 (tons)</b>	<b>Alternative CO<sub>2</sub> emissions, 2021-51 (tons)</b>	<b>CO<sub>2</sub> emissions avoided 2021-50 (tons)</b>	<b>% of emissions avoided</b>
CO <sub>2</sub> - Scenario 1 (constant)	Emission factor (constant at 0.381 kg/kW[1])	26,242	10,380	15,862	60%
CO <sub>2</sub> - Scenario 2 (grad-50%)	Emission factor at 0.381 kg/kW until 2030; 2031-50 decreasing to 0.1905 kg/kW in 2050	26,242	7,639	18,603	71%
CO <sub>2</sub> - Scenario 3 (grad-100%)	Emission factor at 0.381 kg/kW until 2030; 2031-50 decreasing to 0 kg/kW in 2050.	26,242	4,898	21,344	81%

*Table 80 – Residential R2 – Sensitivity Analysis – Comparison on CO<sub>2</sub> emissions, 2021-50)*

### *Sensitivity Analysis (Part 2) – Sensitivity to changes in major variables*

The critical variables are in red below:

<b>Variable</b>	<b>Variation of the FNPV due to a ± 1 % variation</b>	<b>Criticality judgement</b>	<b>Variation of the ENPV due to a ± 1 % variation</b>	<b>Criticality judgement</b>
Primary energy prices & Electricity tariffs	1.85%	Critical	1.74%	Critical
Alternative technology investment cost	1.09%	Critical	0.62%	Not critical
Government subsidies	N/A	N/A	N/A	N/A
EU ETS Carbon Price	N/A	N/A	0.11%	Not critical

*Table 81 – Residential R2 – Sensitivity Analysis: Critical and non-critical variables*

No Government grants apply to this scenario R2, hence its non-applicability to ENPV. Both FNPV and ENPV are sensitive to changes in the prices of electricity and LPG, albeit to a lesser extent than in the other residential scenario. FNPV is also responsive to changes in the cost of the technology, in view of the reinvestment in Y20. This is not critical for ENPV though.



The impact of varying FDR and SDR is shown below:

Financial Discount Rate	FNPV	Social Discount Rate	ENPV
3%	€231	4%	€2,994,038
4% - BM	€207	5% - BM	€2,619,906
5%	€190	6%	€2,305,580

*Table 82 – Residential R2 – Sensitivity Analysis: Effect of different FDR and SDR*

The switching values in this scenario are the following:

	FNPV - BM	ENPV - BM
	€207	€2,619,906
	Minimum change for <b>FNPV</b> to become negative	Maximum change for <b>ENPV</b> to become negative
Primary energy prices & Electricity tariffs	-54%	-57%
Alternative technology investment cost	92%	161%
Government subsidies	N/A	N/A
EU ETS Carbon Price	N/A	-904%

*Table 83 – Residential R2 – Sensitivity Analysis: Switching Values*

### 3.2.2 Services (Hotels) Sector

The financial analyses of each scenario under the hotels sector are categorized under two headings – 3&2-Star Hotels and 5&4-Star Hotels. The economic analyses and sensitivity analyses are consolidated by scenario on a national level.

The key hotel data applicable to all four scenarios are presented here:

HOTEL DATA	5&4-Star Hotels	3&2-Star Hotels
Number of rooms per hotel	225	75
Beds per room	2	2
Nights per annum	365	365
Maximum bednights per hotel p.a.	164,250	54,750
Hotel occupancy p.a. - %	65%	65%
Hotel occupancy p.a. - bednights	106,763	35,588

*Table 84 – Key hotel data*

The following are the CO<sub>2</sub> emission factors used in this section:

Fuel	Emission factor	Source
Electricity - Scenario 1	Constant energy mix between 2021 and 2050, where the emission factor does not change (constant at 0.381 kg/kW <sup>78</sup> )	EWA
Electricity – Scenario 2	Constant energy mix until 2030 (constant at 0.381 kg/kW), decreasing linearly up to a 50% reduction (0.1905 kg/kW) between 2031 and 2050	EWA
Electricity – Scenario 3	Constant energy mix until 2030 (constant at 0.381 kg/kW), decreasing linearly up to a 100% reduction between 2031 and 2050 (i.e. reaching 0 kg/kW by 2050)	EWA
LPG	0.227160 kg/kWh	EIB <sup>79</sup>
Diesel	0.266760 kg/kWh	EIB

*Table 85 – CO<sub>2</sub> emission factors for the hotel scenarios*

<sup>78</sup> Source: EWA

<sup>79</sup> EIB Methodologies for the Assessment of Project GHG Emissions and Emission Variations, July 2020

### 3.2.2.1 Hotels Scenario 1 (H1) - Replacing electrical water heating with heat pumps

#### *Description, rationale and key assumptions*

Hotels Scenario 1 consists of the replacement of fuel-fired boilers used for water heating with electric heat pumps. The following table presents the key parameters of the scenario:

	3&2-Star Hotels		5&4-Star Hotels	
INVESTMENT DATA	Baseline - LPG Heaters	Alternative - Heat Pumps	Baseline - LPG Heaters	Alternative - Heat Pumps
Thermal power required per ROOM (KW)	1		1	
Thermal power required per HOTEL (KW)	75		225	
Thermal power per boiler (KW)	50	N/A	125	N/A
Boilers installed	2	N/A	2	N/A
Thermal power installed (KW)	100	100	250	250
Spare thermal power installed (KW)	25	25	25	25
Price per KW installed (NECP) (exc. VAT)	€38	€250	€38	€250
Technical Life	20	23	20	23
Capital expenditure years	Y1, Y21	Y1, Y24	Y1, Y21	Y1, Y24
Efficiency losses per annum	0.01	0.009	0.01	0.009
Maintenance - routine (annual)	5%	5%	5%	5%
Maintenance - major (every 10 years)	10%	10%	10%	10%

ENERGY DATA	Baseline - LPG Heaters	Alternative - Heat Pumps	Baseline - LPG Heaters	Alternative - Heat Pumps
Useful energy for water heating DEMANDED per bednight (kWh)	3.0	3	3.0	3.0
Coefficient of performance (COP)	0.85	4.0	0.85	4.0
Final Energy consumed for water heating per bednight (kWh)	3.5	0.75	3.5	0.75
Fuel - Weighted cost per kWh of final energy (exc. VAT)	€0.06	N/A	€0.06	N/A
Electricity tariff - Weighted cost per kWh, Non-residential (exc. VAT)	N/A	€0.12	N/A	€0.12

Table 86 – Key investment and energy parameters of Scenario H1

Prices in this scenario are exclusive of VAT, as this is recoverable. It is assumed that during the reference period, the technologies are replaced with an identical technology at the end of their technical life<sup>80</sup>.

For the financial analysis, the main investment cost is incurred in Y1 (2021), assuming the current boiler has reached the end of its technical life and is due for replacement with either the baseline or alternative technology. Both scenarios include dismantling costs in Y1 and in the replacement year. Operating and maintenance costs include the following:

- For the baseline, fuel costs based on the weighted price in Table 30 above and repairs and maintenance costs, based on the calculations and assumptions in Annex I;
- For the alternative technology scenario, electricity costs based on the weighted tariff in Table 30 (details in Annex I) and repairs and maintenance costs based on the assumptions in Annex I.

Electricity and fuel costs are subject to annual increases due to the technology efficiency losses indicated in Table 86.

This scenario includes a Government incentive equivalent to the difference between the costs of the baseline and the alternative technologies, in line with the existing *Investment Aid for Energy Efficiency Projects* scheme by Malta Enterprise (see section 3.1.1.1). The most conservative aid intensity of 30% was assumed and the subsidy is granted in the first year of investment only (Y1, 2021).

<sup>80</sup> The technical life of the technologies considered in this study were taken from the NECP (pg. 118).

## Results from the Financial Analysis

### Scenario H1: 5&4-Star Hotels

2021-2050 - NPV	BOILERS	HEAT PUMP	INCREMENTAL
Investment Costs	(21,118)	(92,858)	(71,740)
Residual Value	1,523	13,941	12,418
Operating & Maintenance costs	(421,951)	(235,781)	186,170
Government Subsidy	-	15,900	15,900
FNPV	(441,545)	(298,797)	142,748
FRR			35.8%

Table 87 - Scenario H1, 5&4-Star Hotels – Financial NPV (30 years, 2021-50)

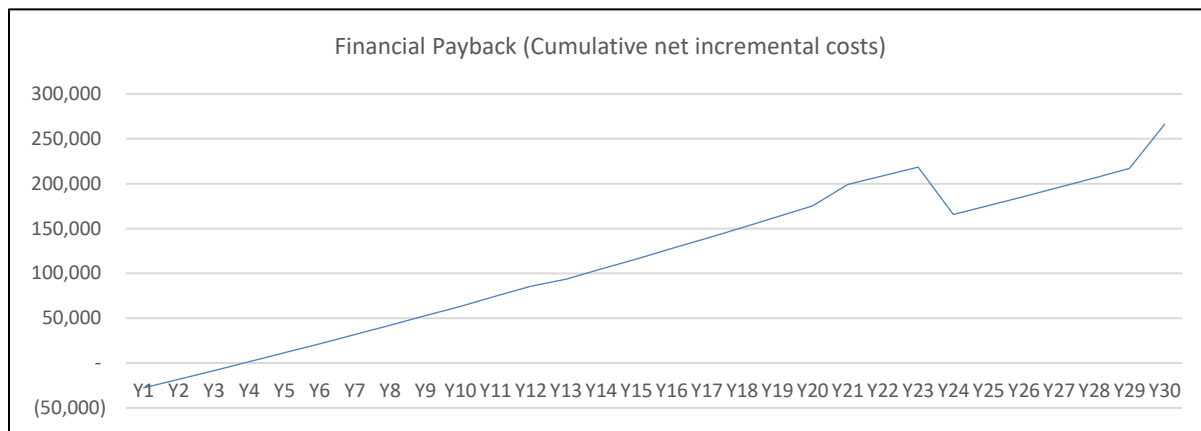


Figure 94 - Services H1: Cumulative incremental cash flows and Payback undiscounted - 2021-2050 (€) – 5&4-Star hotels (€)

### Scenario H1: 3&2-Star Hotels

2021-2050 - NPV	BOILERS	HEAT PUMP	INCREMENTAL
Investment Costs	(12,816)	(40,143)	(27,327)
Residual Value	609	5,577	4,967
Operating & Maintenance costs	(141,241)	(82,470)	58,771
Government Subsidy	-	6,360	6,360
FNPV	(153,448)	(110,677)	42,771
FRR			26.5%

Table 88 - Scenario H1, 3&2-Star Hotels – Financial NPV (30 years, 2021-50)

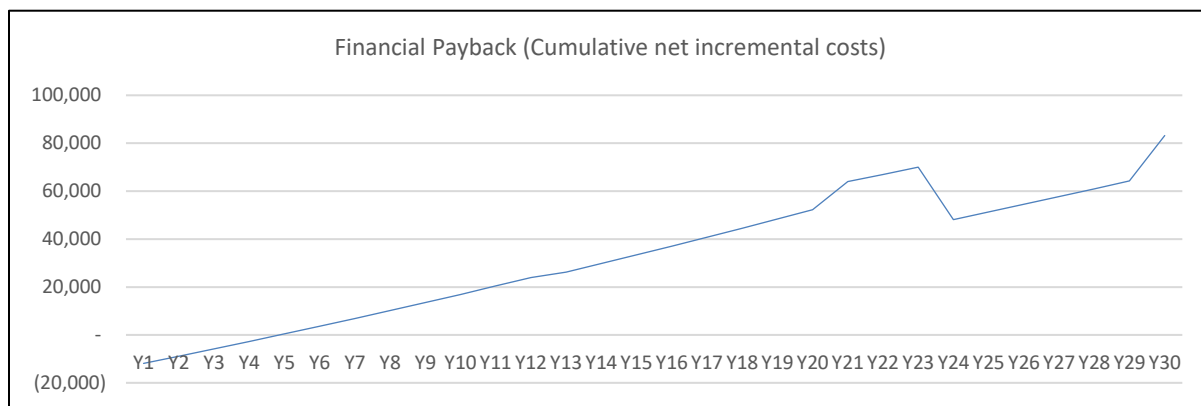


Figure 95 - Services H1: Cumulative incremental cash flows and Payback undiscounted - 2021-2050 (€) – 3&2-Star hotels (€)

The results above confirm that the alternative scenario outperforms the baseline for both hotel categories, with a strong positive financial return and swift payback in the early years of investment (Y2).

### Results from the Economic Analysis

Table 89 shows statistical data on hotel establishments in 2018, the basis year used in this study:

Type of accommodation	Establishments	Bedrooms	Bed-places	Max bednights p.a.
5-star	13	3,169	6,192	2,260,080
4-star	43	8,290	19,000	6,935,000
3-star	51	4,660	10,776	3,933,240
2-star	17	646	1,426	520,490
<b>Total</b>	<b>124</b>	<b>16,765</b>	<b>37,394</b>	<b>13,648,810</b>

Table 89 – Statistical data on hotels in Malta and Gozo, NSO, 2018<sup>81</sup>

The stock of hotel establishments is assumed to remain constant at 2018 levels throughout the reference period, taking into account the surplus bednights currently available, especially in the shoulder and off-peak seasons (average annual occupancy was 65% in 2018) and the carrying capacity of tourism which might be approaching saturation levels during the period.

The population of hotels using boilers is equal to the whole population of hotels, therefore 124. This economic analysis is performed on the basis of three demand scenarios – a pessimistic take up of 25% up to 2050, a moderate take-up of 50% and the most optimistic take-up of 100%. The rate of changeovers to be executed over the reference period is distributed equally over the 30 years. This is a simplification measure adopted to minimize the timing impact on the cash flows, since a high volume of investment in the earlier years would have a more adverse effect on the NPV than investment later in the reference period.

Penetration by 2050	Demand scenario 1-25%		Demand scenario 2 - 50%		Demand scenario 3 - 100%	
	<i>Pessimistic – BM</i>		<i>Moderate</i>		<i>Optimistic</i>	
Establishment type	Changeovers p.a.	Total by 2050	Changeovers p.a.	Total by 2050	Changeovers p.a.	Total by 2050
5-star	0.11	3.25	0.22	6.5	0.43	13
4-star	0.36	10.75	0.72	21.5	1.43	43
3-star	0.43	12.75	0.85	25.5	1.70	51
2-star	0.14	4.25	0.28	8.5	0.57	17
<b>Total</b>	<b>1.03</b>	<b>31</b>	<b>2.07</b>	<b>62</b>	<b>4.13</b>	<b>124</b>

Table 90 – Annual Demand scenarios

<sup>81</sup> Collective Accommodation Establishments: Q4/2018, available at

[https://nso.gov.mt/en/News\\_Releases/View\\_by\\_Unit/Unit\\_C3/Tourism\\_Statistics/Documents/2019/News2019\\_032.pdf](https://nso.gov.mt/en/News_Releases/View_by_Unit/Unit_C3/Tourism_Statistics/Documents/2019/News2019_032.pdf)

The pessimistic demand scenario and the Electricity - Scenario 1 for CO<sub>2</sub> emissions (“BM - Benchmark Scenario”) are used in the following economic analysis in Table 91.

<b>2021-2050 – NPV, €</b>	<b>INCREMENTAL (€)</b>
Financial Costs saved	675,339
Financial Revenues	-
Economic Costs	
<i>GHG Emissions avoided</i>	384,423
<i>Fiscal Corrections</i>	(713,521)
Economic Benefits	
<i>Energy savings</i>	3,209,308
ENPV	3,555,549
ERR	76.7%
B/C Ratio	11.8

*Table 91 – Scenario H1 – Economic NPV (30 years, 2021-50)*

### *Sensitivity Analysis*

#### *Sensitivity Analysis (Part 1) – Combination of demand levels and electricity decarbonization scenarios*

The ENPV for each combination of demand and emissions scenario considered in the CBA are summarized in Table 92. The respective effects on the primary energy savings and carbon emissions are presented in Figure 96.

<b>Incremental ENPV, 2021-50</b>	<b>Demand 1 [25% till 2050]</b>	<b>Demand 2 [50% till 2050]</b>	<b>Demand 3 [100% till 2050]</b>
CO <sub>2</sub> - Scenario 1 (constant)	3,555,549	7,111,098	14,222,196
CO <sub>2</sub> - Scenario 2 (grad-50%)	3,601,444	7,202,889	14,405,778
CO <sub>2</sub> - Scenario 3 (grad-100%)	3,647,340	7,294,680	14,589,360

*Table 92 – Services H1 - Sensitivity of ENPV to demand and CO<sub>2</sub> (30 years, 2021-50)*



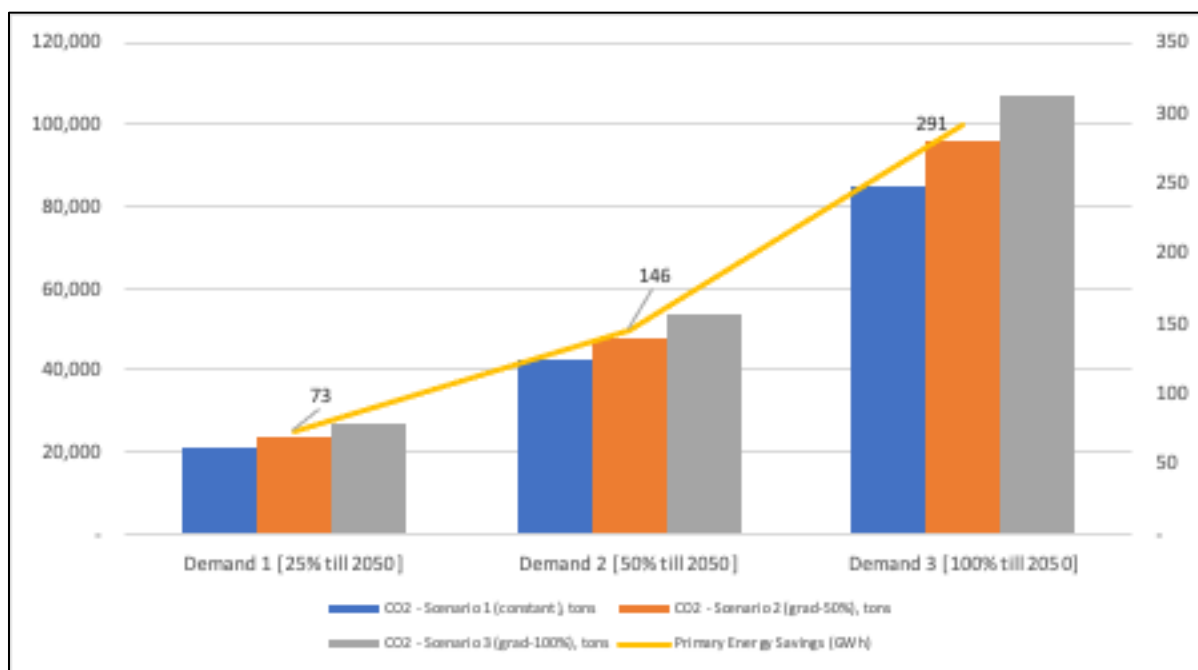


Figure 96 -Services H1 – CO<sub>2</sub> Emissions avoided (tons) and Primary energy savings (GWh)

As in residential scenario R2 (section 3.2.1.2 – Sensitivity Analysis), here we are assessing the replacement of fuel emissions from the baseline with electricity emissions from the alternative technology. The CO<sub>2</sub> emissions avoided are higher when decarbonization levels reach 100% by 2050 (scenario 3). This is due to the fact that the stock of CO<sub>2</sub> emissions eliminated from LPG/gasoil consumption is replaced by a lesser amount of CO<sub>2</sub> emissions from electricity.

#### Sensitivity Analysis (Part 2) – Sensitivity to changes in major variables

##### i. Critical variables

Variable	5&4-STAR		3&2-STAR			
	Variation of the FNPV due to a ± 1 % variation	Criticality judgement	Variation of the FNPV due to a ± 1 % variation	Criticality judgement	Variation of the ENPV due to a ± 1 % variation	Criticality judgement
Primary energy prices & Electricity tariffs	1.65%	Critical	1.84%	Critical	0.59%	Not critical
Alternative technology investment cost	0.79%	Not critical	1.06%	Critical	0.45%	Not critical
Government subsidies	0.11%	Not critical	0.15%	Not critical	N/A	N/A
EU ETS Carbon Price	N/A	N/A	N/A	N/A	0.11%	Not critical

Table 93 – Services H1 – Sensitivity Analysis: Critical and non-critical variables

ii. Switching Values

	5&4-STAR	3&2-STAR	
	FNPV - BM	FNPV - BM	ENPV - BM
	€142,748	€42,771	€3,555,549
	Minimum change for <b>FNPV</b> to become negative	Minimum change for <b>FNPV</b> to become negative	Maximum change for <b>ENPV</b> to become negative
Primary energy prices & Electricity tariffs	-61%	-55%	-170.0%
Alternative technology investment cost	126%	95%	224%
Government subsidies	-900%	-680%	N/A
EU ETS Carbon Price	N/A	N/A	-925.0%

Table 94 – Services H1 – Sensitivity Analysis: Switching Values

iii. Impact of different FDR and SDR

	5&4-STAR	3&2-STAR		
Financial Discount Rate	FNPV	FNPV	Social Discount Rate	ENPV
3%	€165,099	€50,051	4%	€4,242,144
4% - BM	€142,748	€42,771	5% - BM	€3,555,549
5%	€124,168	€36,734	6%	€2,997,194

Table 95 – Services H1 – Sensitivity Analysis: Effect of different FDR and SDR

### 3.2.2.2 Hotels Scenario 2 (H2) - Replacing conventional boilers with condensing-type, high-efficiency boilers

#### *Description, rationale and key assumptions*

Hotels Scenario 2 consists of the replacement of boilers with condensing-type, high-efficiency boilers. The following table presents the key parameters of the scenario:

INVESTMENT DATA	3&2-Star Hotels		5&4-Star Hotels	
	Baseline: Boiler @ 85% efficiency	Alternative: Boiler @ 97% efficiency	Baseline: Boiler @ 85% efficiency	Alternative: Boiler @ 97% efficiency
Thermal power required per ROOM (KW)	1	1	1	1
<b>Thermal power required per HOTEL (KW)</b>	<b>75</b>	<b>75</b>	225	225
Thermal power per boiler (KW)	50	50	125	125
Boilers installed	2	2	2	2
<b>Thermal power installed (KW)</b>	<b>100</b>	<b>100</b>	<b>250</b>	<b>250</b>
Spare thermal power installed (KW)	25	25	25	25
Price per KW installed (NECP) (exc. VAT)	€38	€70	€38	€70
Technical Life	20	20	20	20
Capital expenditure years	Y1, Y21	Y1, Y21	Y1, Y21	Y1, Y21
Efficiency losses per annum	0.01	0.01	0.01	0.01
Maintenance - routine (annual)	5%	5%	5%	5%
Maintenance - major (every 10 years)	10%	10%	10%	10%
Prices are	exc. VAT	exc. VAT	exc. VAT	exc. VAT

<b>ENERGY DATA</b>	<b>Baseline: Boiler @ 85% efficiency</b>	<b>Alternative: Boiler @ 97% efficiency</b>	<b>Baseline: Boiler @ 85% efficiency</b>	<b>Alternative: Boiler @ 97% efficiency</b>
Useful energy for water heating DEMANDED per bednight (kWh)	3.0	3.0	3.0	3.0
Final Energy consumed for water heating per bednight (kWh)	3.5	3.1	3.5	3.1
Fuel - Weighted cost per kWh of final energy (exc. VAT)	€0.06	€0.06	€0.06	€0.06
Fuel cost for water heating per bednight (exc. VAT)	€0.20	€0.18	€0.20	€0.18

*Table 96 - Key investment and energy parameters of Scenario H2*

Prices in this scenario are exclusive of VAT, as this is recoverable. It is assumed that during the reference period, the technologies are replaced with an identical technology at the end of their technical life

For the financial analysis, the main investment cost is incurred in Y1 (2021), assuming the current boiler has reached the end of its technical life and is due for replacement with either the baseline or alternative technology. Both scenarios include dismantling costs in Y1 and in the replacement year. Operating and maintenance costs include electricity costs based on the weighted price and repairs and maintenance costs, based on the calculations and assumptions in Annex 4 attached to this report.

Fuel costs are subject to annual increases due to the technology efficiency losses indicated in Table 96.

This scenario includes a Government incentive equivalent to the difference between the costs of the baseline and the alternative technologies, in line with the existing *Investment Aid for Energy Efficiency Projects* scheme by Malta Enterprise (see section 3.1.1.1). The most conservative aid intensity of 30% was assumed and the subsidy is granted in the first year of investment only (Y1, 2021).

## Results from the Financial Analysis

### Scenario H2: 5&4-Star Hotels

2021-2050 - NPV	BOILER - 85%	BOILER - 95%	INCREMENTAL
Investment Costs	(21,118)	(32,769)	(11,651)
Residual Value	1,523	2,806	1,283
Operating & Maintenance costs	(390,383)	(363,793)	26,590
Government Subsidy	-	2,400	2,400
FNPV	(409,978)	(391,356)	18,622
FRR			59.2%

Table 97 - Scenario H2, 5&4-Star Hotels – Financial NPV (30 years, 2021-50)

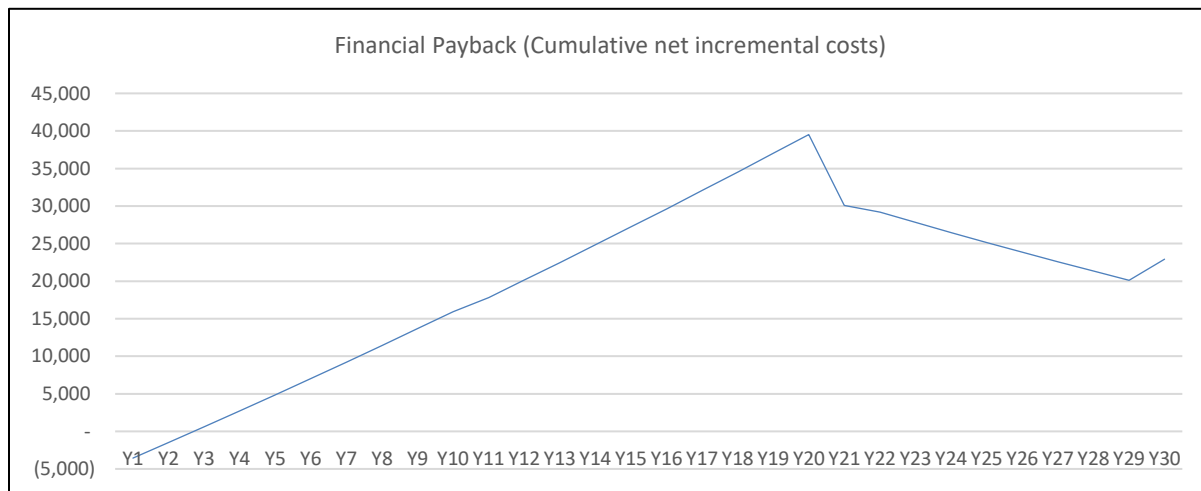


Figure 97 - Services H2: Cumulative incremental cash flows and payback undiscounted - 2021-2050 (€) – 5&4-Star hotels (€)

## Scenario H2: 3&2-Star Hotels

2021-2050 - NPV	BOILER - 85%	BOILER - 95%	INCREMENTAL
Investment Costs	(12,816)	(17,477)	(4,660)
Residual Value	609	1,122	513
Operating & Maintenance costs	(130,732)	(122,353)	8,380
Government Subsidy	-	960	960
FNPV	(142,939)	(137,747)	5,192
FRR			42.7%

Table 98 - Scenario H2, 3&2-Star Hotels – Financial NPV (30 years, 2021-50)

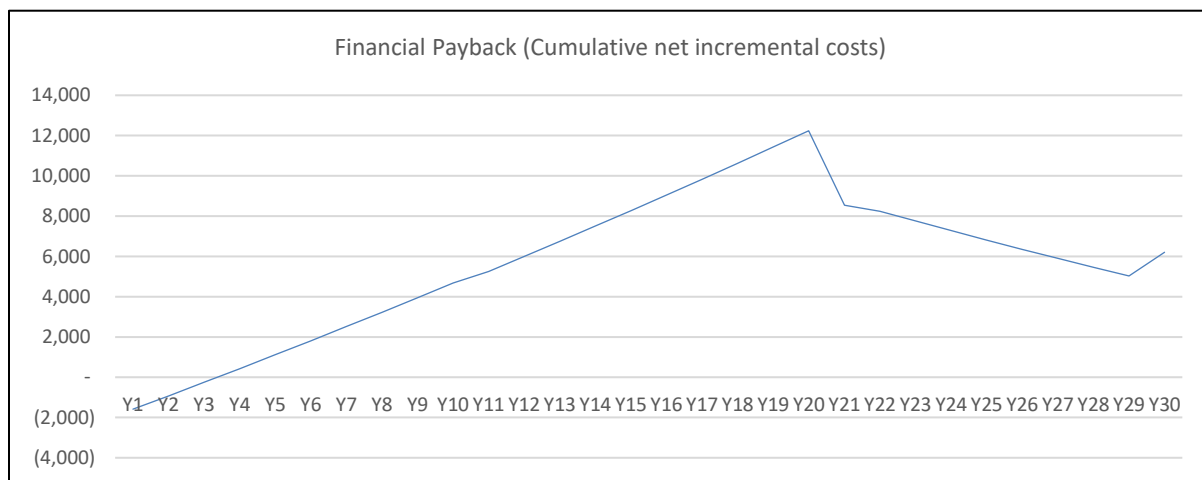


Figure 98 - Services H2: Cumulative incremental cash flows and payback undiscounted - 2021-2050 (€) – 3&2-Star hotels (€)

The results above confirm that the alternative scenario outperforms the baseline for both hotel categories, with a strong positive financial return and swift payback in the early years of investment (Y4, Y5).

### Results from the Economic Analysis

This economic analysis is performed on the basis of three demand scenarios, from a pessimistic take up of 25% up to 2050 to the most optimistic penetration of 100%. The rate of changeovers to be executed over the reference period are distributed equally over the 30 years.

Penetration by 2050	Demand scenario 1 – 25%		Demand scenario 2 - 50%		Demand scenario 3 - 100%	
	<i>Pessimistic</i>		<i>Moderate</i>		<i>Optimistic</i>	
Establishment type	Changeovers p.a.	Total by 2050	Changeovers p.a.	Total by 2050	Changeovers p.a.	Total by 2050
5-star	0.11	3.25	0.22	6.5	0.43	13
4-star	0.36	10.75	0.72	21.5	1.43	43
3-star	0.43	12.75	0.85	25.5	1.70	51
2-star	0.14	4.25	0.28	8.5	0.57	17
<b>Total</b>	<b>1.03</b>	<b>31</b>	<b>2.07</b>	<b>62</b>	<b>4.13</b>	<b>124</b>

Table 99 – Annual Demand scenarios

The pessimistic demand scenario is used in the following economic analysis in Table 100.

2021-2050 – NPV, €	INCREMENTAL (€)
Financial Costs saved	152,634
Financial Revenues	-
Economic Costs	
<i>Fiscal Corrections</i>	(84,765)
Economic Benefits	
<i>Energy savings</i>	432,414
<i>GHG Emissions avoided</i>	65,538
ENPV	565,820
ERR	102.8%
B/C Ratio	30.4

Table 100 – Scenario H2 – Economic NPV (30 years, 2021-50)

## Sensitivity Analysis

### Sensitivity Analysis (Part 1) – Combination of demand levels and electricity decarbonization scenarios

The ENPV for each level of demand are summarized in Table 101.

	Incremental ENPV (€) 2021-50
Demand 1 [25% till 2050]	565,820 - BM
Demand 2 [50% till 2050]	1,131,641
Demand 3 [100% till 2050]	2,263,282

Table 101 – Scenario H2 - Economic NPV, three demand scenarios (30 years, 2021-50)

The respective effects on the carbon emissions and primary energy savings are illustrated below.

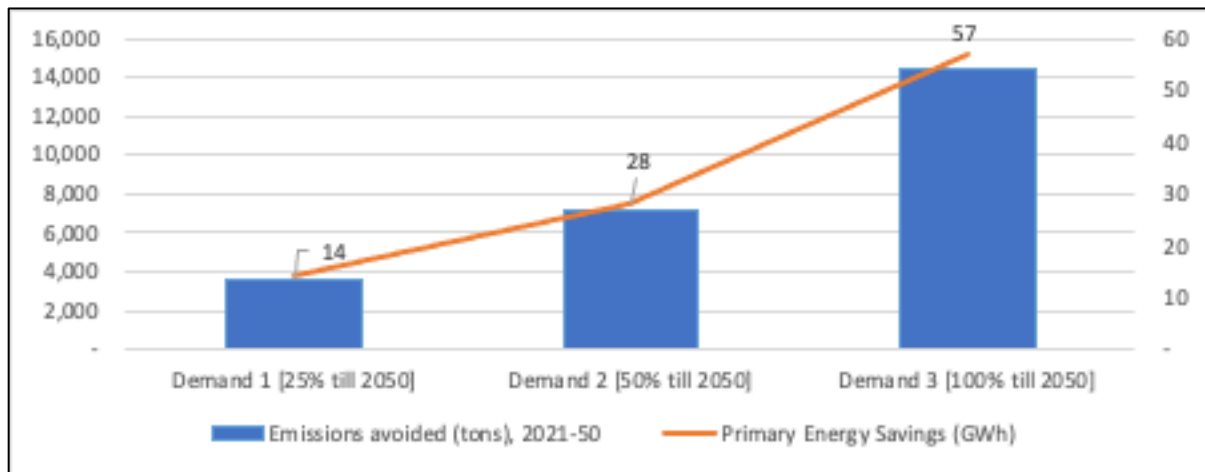


Figure 99 - Hotels H2 – CO<sub>2</sub> Emissions avoided (tons) and Primary energy savings (GWh)



## Sensitivity Analysis (Part 2) – Sensitivity to changes in major variables

### i. Critical variables

	5&4-STAR		3&2-STAR			
Variable	Variation of the FNPV due to a $\pm 1$ % variation	Criticality judgement	Variation of the FNPV due to a $\pm 1$ % variation	Criticality judgement	Variation of the ENPV due to a $\pm 1$ % variation	Criticality judgement
Primary energy prices & Electricity tariffs	1.82%	Critical	2.17%	Critical	0.77%	Not critical
Alternative technology investment cost	1.81%	Critical	2.60%	Critical	0.81%	Not critical
Government subsidies	0.13%	Not critical	0.18%	Not critical	N/A	N/A
EU ETS Carbon Price	N/A	N/A	N/A	N/A	0.12%	Not critical

Table 102 – Services H2 – Sensitivity Analysis: Critical and non-critical variables

### ii. Switching Values

	5&4-STAR	3&2-STAR	
	FNPV - BM	FNPV - BM	ENPV - BM
	€18,622	€5,192	€565,820
	Minimum change for <b>FNPV</b> to become negative	Minimum change for <b>FNPV</b> to become negative	Maximum change for <b>ENPV</b> to become negative
Primary energy prices & Electricity tariffs	-56%	-47%	-130.0%
Alternative technology investment cost	39%	56%	123%
Government subsidies	-550%	-776%	N/A
EU ETS Carbon Price	N/A	N/A	-864%

Table 103 – Services H2 – Sensitivity Analysis: Switching Values

iii. *Impact of different FDR and SDR*

	5&4-STAR	3&2-STAR		
Financial Discount Rate	FNPV	FNPV	Social Discount Rate	ENPV
3%	€19,739	€5,483	4%	€669,582
4% - BM	€18,622	€5,192	5% - BM	€565,820
5%	€17,522	€4,896	6%	€480,920

*Table 104 – Services H2 – Sensitivity Analysis: Effect of different FDR and SDR*

### 3.2.2.3 Hotels Scenario 3 (H3) - Replacing air-cooled chillers with air-cooled chillers including heat recovery

#### *Description, rationale and key assumptions*

Hotels Scenario 3 consists of the replacement of *air-cooled chillers* with *air-cooled chillers including heat recovery*. The following table presents the key parameters of the scenario:

	3&2-Star Hotels		5&4-Star Hotels	
INVESTMENT DATA	Baseline: Air-cooled chillers <u>without</u> HR	Alternative: Air-cooled chillers <u>with</u> HR	Baseline: Air-cooled chillers <u>without</u> HR	Alternative: Air-cooled chillers <u>with</u> HR
Chiller model installed	< 200kW chiller	< 200kW chiller	> 200kW chiller	> 200kW chiller
Chiller with Heat Recovery - Price per unit installed (exc. VAT)	€50,000	€59,000	€68,000	€79,000
Number of chillers in establishment	1	1	1	1
Repairs and Maintenance	5%	5%	5%	5%
Replacement	10%	10%	10%	10%
Efficiency losses	0.01	0.01	0.01	0.01
ENERGY DATA	Baseline: Air-cooled chillers <u>without</u> HR	Alternative: Air-cooled chillers <u>with</u> HR	Baseline: Air-cooled chillers <u>without</u> HR	Alternative: Air-cooled chillers <u>with</u> HR
Useful energy for SPACE COOLING DEMANDED per bednight p.a. (kWh)	3.0	3.0	3.0	3.0
Useful energy for SPACE HEATING DEMANDED per bednight p.a. (kWh)	1.6	1.6	1.6	1.6
EER (air-cooled) - SPACE COOLING	3.00	4.33	3.0	4.33
Final Energy for SPACE COOLING DEMANDED per bednight p.a. (kWh)	1.0	1.0	1.0	1.0

Final Energy for SPACE HEATING DEMANDED per bednight p.a. (kWh)	0.5	0.5	0.5	0.5
RENEWABLE ENERGY FOR WATER HEATING per bednight (kWh) - from sp cooling	0.0	1.3	0.0	1.3
RENEWABLE ENERGY FOR WATER HEATING per bednight (kWh) - from sp heat	0.0	0.0	0.0	0.0
Weighted electricity tariff - Non-residential exc. VAT	€0.1165	€0.1165	€0.1165	€0.1165
Fuel - Weighted cost per kWh of final energy (exc. VAT)	N/A	€0.057	N/A	€0.057

*Table 105 - Key investment and energy parameters of Scenario H3*

Prices in this scenario are exclusive of VAT, as this is recoverable. It is assumed that during the reference period, the technologies are replaced with an identical technology at the end of their technical life.

For the financial analysis, the main investment cost is incurred in Y1 (2021), assuming the current boiler has reached the end of its technical life and is due for replacement with either the baseline or alternative technology. Both scenarios include dismantling costs in Y1 and in the replacement year. Operating and maintenance costs include electricity costs based on the weighted price for non-residential users (same in both baseline and alternative scenarios), fuel costs based on the weighted average for non-residential users (see Annex 4) and repairs and maintenance costs based on the calculations and assumptions in Annex 4.

Electricity and fuel costs are subject to annual increases due to the technology efficiency losses indicated in Table 105.

This scenario includes a Government incentive equivalent to the difference between the costs of the baseline and the alternative technologies, in line with the existing *Investment Aid for Energy Efficiency Projects* scheme by Malta Enterprise (see section 3.1.1.1). The most conservative aid intensity of 30% was assumed and the subsidy is granted in the first year of investment only.

## Results from the Financial Analysis

### Scenario H3: 5&4-Star Hotels

2021-2050 – NPV, €	Baseline: Air-cooled chillers without HR	Alternative: Air-cooled chillers with HR	Incremental
Investment Costs	(103,986)	(120,807)	(16,821)
Residual Value	10,902	12,666	1,764
Operating & Maintenance costs	(496,480)	(320,511)	175,969
Subsidy	-	3,300	3,300
FNPV	(589,564)	(425,353)	164,211
FRR			- 82

Table 106 - Scenario H3, 5&4-Star Hotels – Financial NPV (30 years, 2021-50)

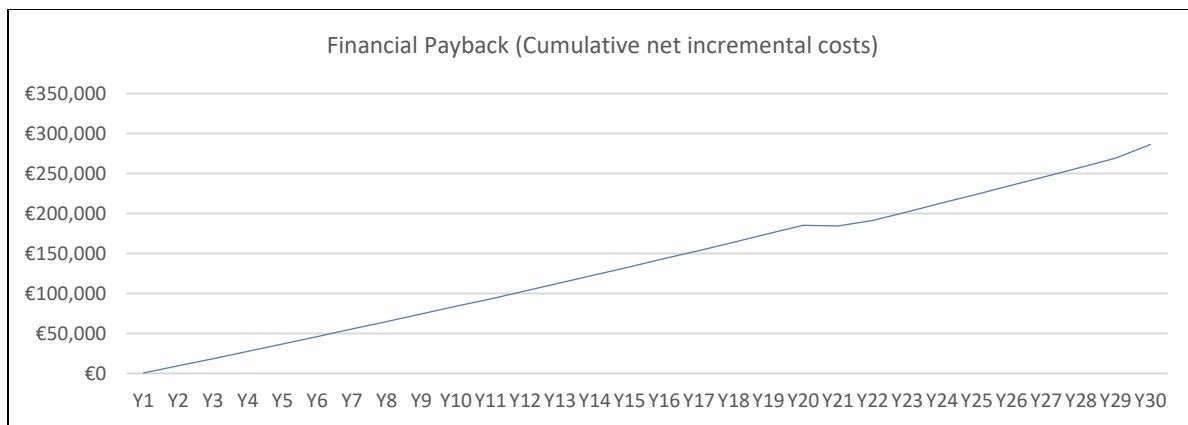


Figure 100 - Services H3: Cumulative incremental cash flows and payback undiscounted - 2021-2050 (€) – 5&4-Star hotels (€)

<sup>82</sup> No negative net financial cash flows over the 30 years, therefore IRR returns no value.

### Scenario H3: 3&2-Star Hotels

2021-2050 – NPV, €	Baseline: Air-cooled chillers without HR	Alternative: Air-cooled chiller with HR	Incremental
Investment Costs	(76,460)	(90,223)	(13,763)
Residual Value	8,016	9,459	1,443
Operating & Maintenance costs	(190,994)	(138,031)	52,964
Subsidy	-	2,700	2,700
FNPV	(259,438)	(216,095)	43,344
FRR			67.3%

Table 107 - Scenario H3, 3&2-Star Hotels – Financial NPV (30 years, 2021-50)

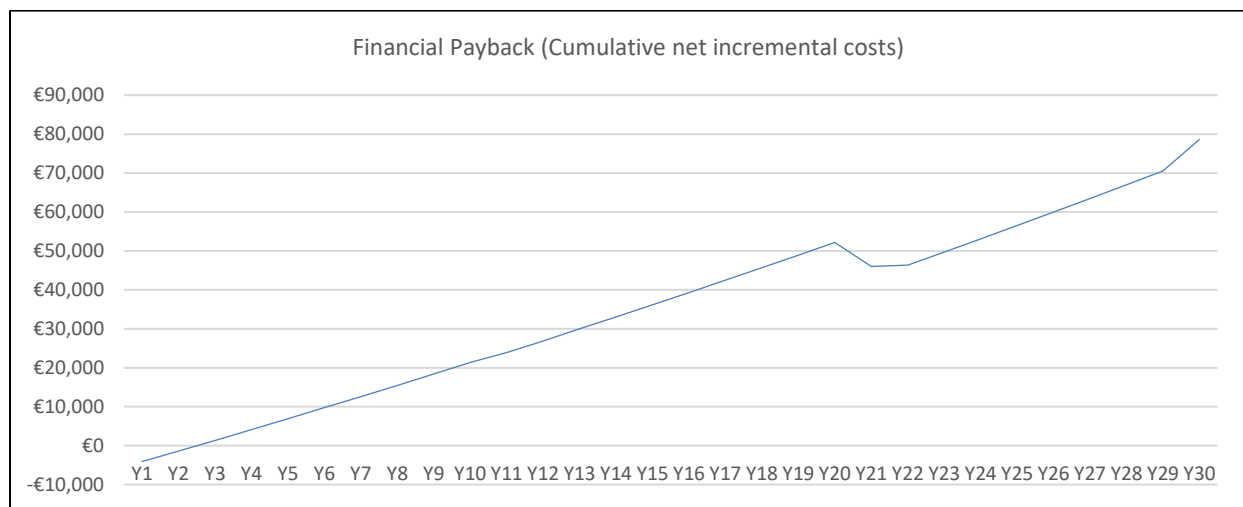


Figure 101 - Services H3: Cumulative incremental cash flows and payback undiscounted - 2021-2050 (€) – 3&2-Star hotels (€)

### Results from the Economic Analysis

Research during this study, summarized in the next table, estimates that 15% of the 124 hotels use air-cooled chillers for their air-conditioning needs. This amounts to 18 establishments, which is the population for this economic analysis.

Establishment type	VRV	Air Cooled Chiller	Water Cooled Chiller	Splits
	<b>65%</b>	<b>15%</b>	<b>12%</b>	<b>8%</b>
5-star	8	2	2	1
4-star	28	6	5	3
3-star	33	8	6	4
2-star	11	3	2	1
Totals	<b>80</b>	<b>18</b>	<b>15</b>	<b>10</b>

Table 108 – Air-conditioning technologies in hotels in Malta, 2018

Three different demand scenarios were considered for this technological alternative, on account of the perceived popularity of a technology which is highly beneficial in terms of renewable energy, at a relatively low additional investment cost. Three different paces of penetration are considered here: the fastest and more optimistic assumes all 18 hotels would be switching to the alternative by 2030; while the moderate and pessimistic scenarios assume full take-up by 2040 and 2050 respectively. The rate of changeovers to be executed over the reference period were distributed equally over the 30 years, as follows:

Establishment type	Demand Scenario 1 [100% till 2030]	Demand Scenario 2 [100% till 2040]	Demand Scenario 3 [100% till 2050]
	<i>Optimistic</i>	<i>Moderate</i>	<i>Pessimistic</i>
	<i>number of changeovers p.a.</i>	<i>number of changeovers p.a.</i>	<i>number of changeovers p.a.</i>
	<b>2021-30</b>	<b>2031-40</b>	<b>2041-50</b>
5-star	0.19	0.10	0.06
4-star	0.64	0.32	0.21
3-star	0.76	0.38	0.25
2-star	0.25	0.13	0.08
<b>Total p.a.</b>	<b>1.84</b>	<b>0.92</b>	<b>0.61</b>

Table 109 – Annual Demand scenarios - ACC (H3)

The ENPV for the pessimistic demand scenario (Benchmark Scenario) is given in the next table.

As a background explanation of the technology, a chiller produces a base load of chilled water, which is common to both baseline and alternative technologies. Therefore, no CO<sub>2</sub> emission gains result from this process. The added value of the alternative technology compared to the baseline lies in its capacity to

recover the heat rejected from the condenser, which would otherwise have been lost to the atmosphere. This is ‘free energy’ for the generation of hot water which otherwise would have to be heated by fuel-fired boilers.

2021-2050 – NPV, €	INCREMENTAL (€)
Financial Costs saved ( <i>benefit</i> )	700,294
Financial Revenues	-
Economic Costs	
<i>Fiscal Corrections</i>	(177,188)
Economic Benefits	
<i>Energy savings</i>	680,951
<i>GHG Emissions avoided</i>	149,319
ENPV	1,353,377
ERR	910.9%
B/C RATIO	49.6

Table 110 – Scenario H3 – Economic NPV (30 years, 2021-50)

### Sensitivity Analysis

#### Sensitivity Analysis (Part 1) – Combination of demand levels and electricity decarbonization scenarios

The ENPV for each level of demand are summarized in Table 111.

	Incremental ENPV €, 2021-50
Demand 1 [100% till 2030]	2,527,323
Demand 2 [100% till 2040]	1,869,214
Demand 3 [100% till 2050]	1,353,377

Table 111 – Scenario H3 - Economic NPV, three demand scenarios (30 years, 2021-50)

The respective effects on the primary energy savings and carbon emissions are illustrated below. The higher levels of emissions avoided, and energy saved occur in the faster uptake demand scenario (i.e. scenario 1). The earlier the technology changeovers are made, the larger the volume of savings registered by 2050.



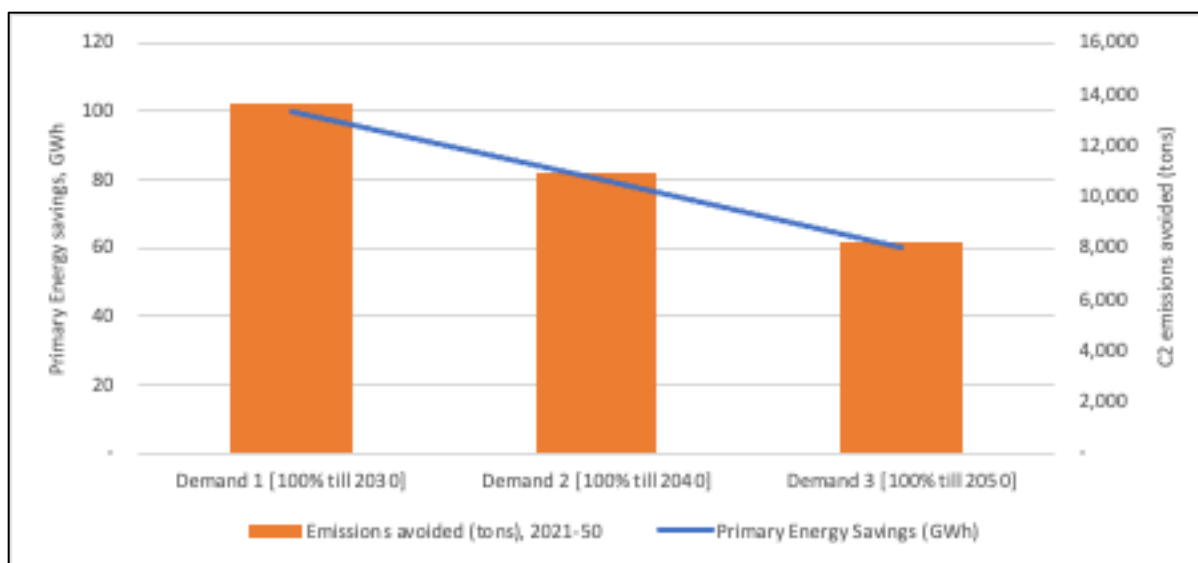


Figure 102 - Hotels H3 – Primary energy savings (GWh) and Emissions avoided (tons), under three demand scenarios

## Sensitivity Analysis (Part 2) – Sensitivity to changes in major variables

### i. Critical variables

Variable	5&4-STAR		3&2-STAR		Variation of the ENPV due to a $\pm 1$ % variation	Criticality judgement
	Variation of the FNPV due to a $\pm 1$ % variation	Criticality judgement	Variation of the FNPV due to a $\pm 1$ % variation	Criticality judgement		
Primary energy prices & Electricity tariffs	1.14%	Critical	1.45%	Critical	1.16%	Critical
Alternative technology investment cost	0.97%	Not critical	2.75%	Critical	1.03%	Critical
Government subsidies	0.02%	Not critical	0.06%	Not critical	N/A	N/A
EU ETS Carbon Price	N/A	N/A	N/A	N/A	0.11%	Not critical

Table 112 – Services H3 – Sensitivity Analysis: Critical and non-critical variables

### ii. Switching Values

5&4-STAR	3&2-STAR	
FNPV - BM	FNPV - BM	ENPV - BM

	€164,211	€43,344	€1,353,377
	Minimum change for <b>ENPV</b> to become negative	Minimum change for <b>ENPV</b> to become negative	Maximum change for <b>ENPV</b> to become negative
Primary energy prices & Electricity tariffs	-88%	-70%	-87.0%
Alternative technology investment cost	103%	37%	98%
Government subsidies	-4980%	-1606%	N/A
EU ETS Carbon Price	N/A	N/A	-907%

Table 113 – Services H3 – Sensitivity Analysis: Switching Values

iii. Impact of different FDR and SDR

	<b>5&amp;4-STAR</b>	<b>3&amp;2-STAR</b>		
<b>Financial Discount Rate</b>	<b>ENPV</b>	<b>ENPV</b>	<b>Social Discount Rate</b>	<b>ENPV</b>
3%	€186,359	€49,691	4%	€1,596,799
4% - BM	€164,211	€43,344	5% - BM	€1,353,377
5%	€145,811	€38,087	6%	€1,154,594

Table 114 – Services H2 – Sensitivity Analysis: Effect of different FDR and SDR

### 3.2.2.4 Hotels Scenario 4 (H4) - Replacing water-cooled chillers with water-cooled chillers including heat recovery

#### *Description, rationale and key assumptions*

Hotels Scenario 4 consists of the replacement of *water-cooled chillers* with *water-cooled chillers including heat recovery*. The following table presents the key parameters of the scenario:

INVESTMENT DATA	5&4-STAR		3&2-STAR	
	Baseline: Water-cooled chillers <u>without</u> HR	Alternative: Water-cooled chillers <u>with</u> HR	Baseline: Water-cooled chillers <u>without</u> HR	Alternative: Water-cooled chillers <u>with</u> HR
Chiller model installed	> 200kW chiller	> 200kW chiller	< 200kW chiller	< 200kW chiller
Chiller with Heat Recovery - Price per unit installed (exc. VAT)	€90,000	€102,500	€58,000	€68,000
Number of chillers in establishment	1	1	1	1
Repairs and Maintenance	5%	5%	5%	0%
Replacement	10%	10%	10%	0%
Efficiency losses	0.01	0.01	0.01	0.01

ENERGY DATA	Baseline: Air-cooled chillers <u>without</u> HR	Alternative: Air-cooled chillers <u>with</u> HR	Baseline: Air-cooled chillers <u>without</u> HR	Alternative: Air-cooled chillers <u>with</u> HR
Useful energy for SPACE COOLING DEMANDED per bednight p.a. (kWh)	3.5	3.5	3.5	3.5
Useful energy for SPACE HEATING DEMANDED per bednight p.a. (kWh)	1.7	1.7	1.7	1.7
EER (air-cooled) - SPACE COOLING	4.20	6.10	4.20	6.10
Surplus heat from space cooling for WATER HEATING	0.0	1.90	0.0	1.90
Final Energy for SPACE COOLING DEMANDED per bednight p.a. (kWh)	0.8	0.8	0.8	0.8

Final Energy for SPACE HEATING DEMANDED per bednight p.a. (kWh)	0.4	0.4	0.4	0.4
RENEWABLE ENERGY FOR WATER HEATING per bednight (kWh) - from sp cooling	0.0	1.90	0.0	1.1
RENEWABLE ENERGY FOR WATER HEATING per bednight (kWh) - from sp heat	0.0	0.00	0.0	0.0
Weighted electricity tariff - Non-residential exc. VAT	€0.1165	€0.1165	€0.1165	€0.1165
Fuel - Weighted cost per kWh of final energy (exc. VAT)	N/A	€0.057	N/A	€0.057

*Table 115 - Key investment and energy parameters of Scenario H4*

Prices in this scenario are exclusive of VAT, as this is recoverable. It is assumed that during the reference period, the technologies are replaced with an identical technology at the end of their technical life.

For the financial analysis, the main investment cost is incurred in Y1 (2021), assuming the current boiler has reached the end of its technical life and is due for replacement with either the baseline or alternative technology. Both scenarios include dismantling costs in Y1 and in the replacement year. Operating and maintenance costs include electricity costs based on the weighted price for non-residential users (same in both baseline and alternative scenarios), fuel costs based on the weighted average for non-residential users (see Annex 4) and repairs and maintenance costs based on the calculations and assumptions in Annex 4.

Electricity and fuel costs are subject to annual increases due to the technology efficiency losses indicated in Table 115.

This scenario includes a Government incentive equivalent to the difference between the costs of the baseline and the alternative technologies, in line with the existing *Investment Aid for Energy Efficiency Projects* scheme by Malta Enterprise (see section 3.1.1.1). The most conservative aid intensity of 30% was assumed and the subsidy is granted in the first year of investment only.

## Results from the Financial Analysis

### Scenario H4: 5&4-Star Hotels

2021-2050 – NPV, €	Baseline: Water-cooled chillers <u>without</u> HR	Alternative: Water-cooled chillers <u>with</u> HR	Incremental
Investment Costs	(137,629)	(156,744)	(19,115)
Residual Value	14,429	16,433	2,004
Operating & Maintenance costs	(438,271)	(232,483)	205,788
Subsidy	-	3,750	3,750
FNPV	(561,470)	(369,043)	192,427
FRR			- 83

Table 116 - Scenario H4, 5&4-Star Hotels – Financial NPV (30 years, 2021-50)

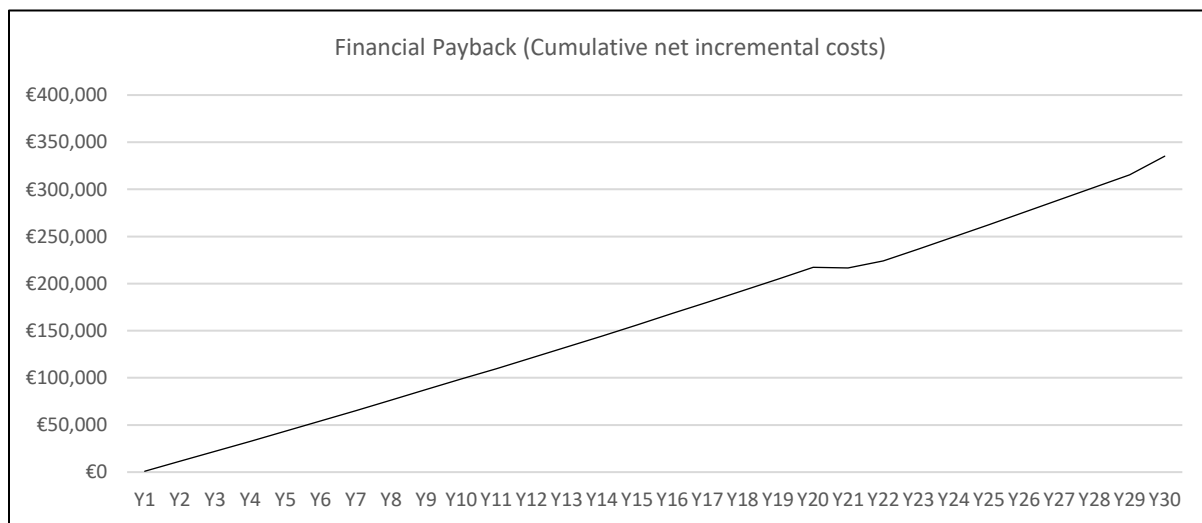


Figure 103 - Services H4: Cumulative incremental cash flows and payback undiscounted - 2021-2050 (€) – 5&4-Star hotels (€)

<sup>83</sup> No negative net financial cash flows over the 30 years, therefore IRR returns no value.

### Scenario H3: 3&2-Star Hotels

2021-2050 – NPV, €	Baseline: Water-cooled chillers <u>without</u> HR	Alternative: Water-cooled chillers <u>with</u> HR	Incremental
Investment Costs	(88,694)	(103,986)	(15,292)
Residual Value	9,299	10,902	1,603
Operating & Maintenance costs	(172,213)	(109,802)	62,411
Revenues	-	3,000	3,000
FNPV	(251,608)	(199,886)	51,723
FRR			74.3%

Table 117 - Scenario H4, 3&2-Star Hotels – Financial NPV (30 years, 2021-50)

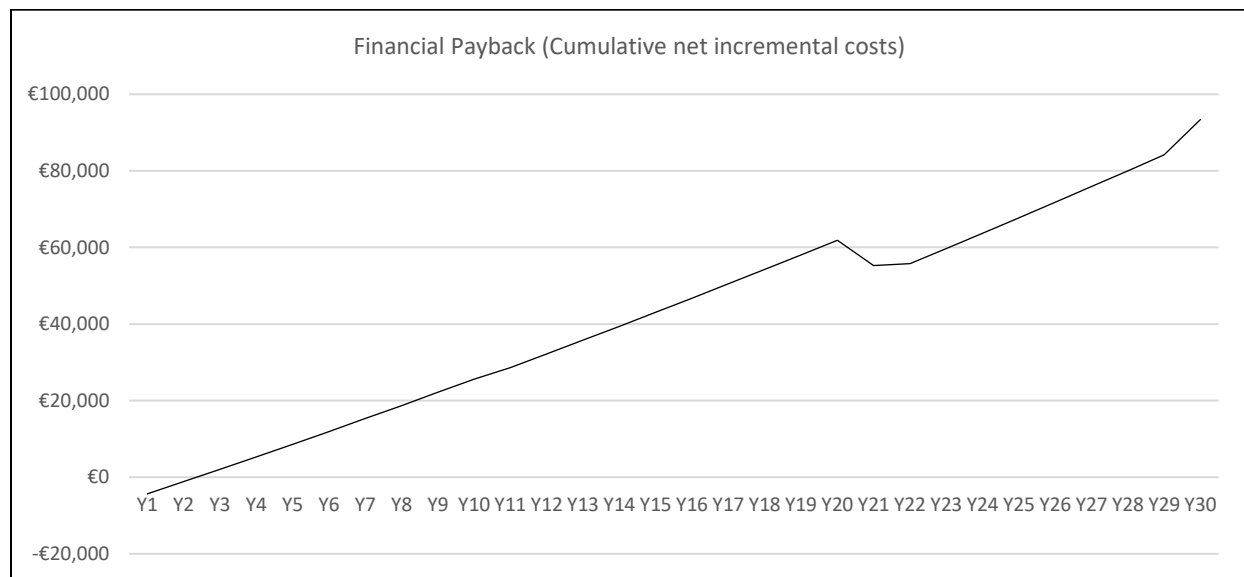


Figure 104 - Services H4: Cumulative incremental cash flows and Payback undiscounted - 2021-2050 (€) – 3&2-Star hotels (€)

### Results from the Economic Analysis

Research during this study, summarized in the next table, estimates that 12% of the 124 hotels use water-cooled chillers for their air-conditioning needs. This amounts to 15 establishments, which is the population for this economic analysis.

Establishment type	VRV	Air Cooled Chiller	Water Cooled Chiller	Splits
	<b>65%</b>	<b>15%</b>	<b>12%</b>	<b>8%</b>
5-star	8	2	2	1
4-star	28	6	5	3
3-star	33	8	6	4
2-star	11	3	2	1
Totals	<b>80</b>	<b>18</b>	<b>15</b>	<b>10</b>

Table 118 – Air-conditioning technologies in hotels in Malta, 2018

As in the previous scenario, three different paces of penetration are considered here: the fastest and more optimistic assumes all 15 hotels would be switching to the alternative by 2030; while the moderate and pessimistic scenarios assume full take-up by 2040 and 2050 respectively. The rate of changeovers to be executed over the reference period are distributed equally over the 30 years, as follows:

Establishment type	Demand Scenario 1 [100% till 2030]	Demand Scenario 2 [100% till 2040]	Demand Scenario 3 [100% till 2050]
	<i>Optimistic</i>	<i>Moderate</i>	<i>Pessimistic</i>
	<i>number of changeovers p.a.</i>	<i>number of changeovers p.a.</i>	<i>number of changeovers p.a.</i>
	<b>2021-30</b>	<b>2021-40</b>	<b>2021-50</b>
5-star	0.16	0.08	0.05
4-star	0.52	0.26	0.17
3-star	0.62	0.31	0.21
2-star	0.21	0.10	0.07
<b>Total p.a.</b>	<b>1.51</b>	<b>0.75</b>	<b>0.50</b>

Table 119 – Annual Demand scenarios - WCC (H4)

The ENPV for the pessimistic demand scenario (Benchmark Scenario) is given in the next table. CO<sub>2</sub> emissions from electricity under the baseline and alternative scenarios are the same, therefore cancel

each other out. CO<sub>2</sub> emission reductions are solely from the avoided fuel consumption from the heat recovery for water heating, as explained in section 3.2.2.3 in the previous technology scenario H3.

2021-2050 – NPV, €	INCREMENTAL (€)
Financial Costs saved ( <i>benefit</i> )	674,794
Financial Revenues	-
Economic Costs	
<i>Fiscal Corrections</i>	(168,902)
Economic Benefits	
<i>Energy savings</i>	651,204
<i>GHG Emissions avoided</i>	142,797
ENPV	1,299,893
ERR	1227.6%
B/C RATIO	50.8

*Table 120 – Scenario H4 – Economic NPV (30 years, 2021-50)*

## *Sensitivity Analysis*

### *Sensitivity Analysis (Part 1) – Combination of demand levels and electricity decarbonization scenarios*

The ENPV for each level of demand are summarized in Table 121.

	Incremental ENPV €, 2021-50
Demand 1 [100% till 2030]	2,426,969
Demand 2 [100% till 2040]	1,794,921
Demand 3 [100% till 2050]	1,299,893

*Table 121 – Scenario H4 - Economic NPV, three demand scenarios (30 years, 2021-50)*

The respective effects on the primary energy savings and carbon emissions are illustrated below. The higher levels of emissions avoided and energy saved occur in the faster uptake demand scenario (i.e.



scenario 1). The earlier the technology changeovers are made, the larger the volume of savings registered by 2050.

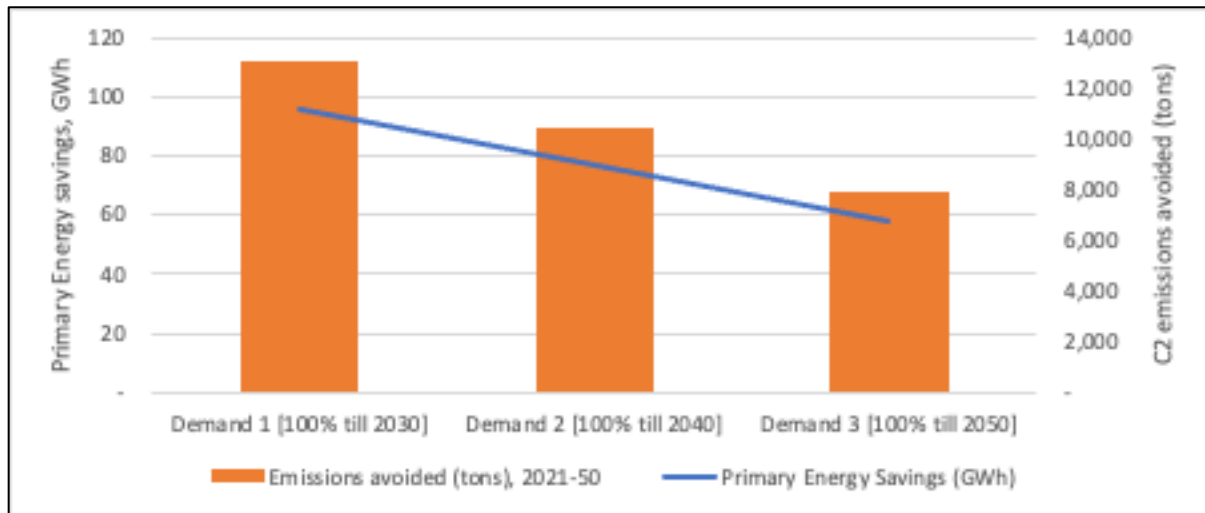


Figure 105 - Hotels H4 – Primary energy savings (GWh) and Emissions avoided (tons), under three demand scenarios

## Sensitivity Analysis (Part 2) – Sensitivity to changes in major variables

### i. Critical variables

Variable	5&4-STAR		3&2-STAR		Variation of the ENPV due to a ± 1 % variation	Criticality judgement
	Variation of the FNPV due to a ± 1 % variation	Criticality judgement	Variation of the FNPV due to a ± 1 % variation	Criticality judgement		
Primary energy prices & Electricity tariffs	1.14%	Critical	1.42%	Critical	1.15%	Critical
Alternative technology investment cost	1.08%	Critical	2.66%	Critical	1.11%	Critical
Government subsidies	0.02%	Not critical	0.06%	Not critical	N/A	N/A
EU ETS Carbon Price	N/A	N/A	N/A	N/A	0.11%	Not critical

Table 122 – Services H4 – Sensitivity Analysis: Critical and non-critical variables

ii. Switching Values

	5&4-STAR	3&2-STAR	
	FNPV - BM	FNPV - BM	ENPV - BM
	€192,427	€51,723	€1,299,893
	Minimum change for <b>FNPV</b> to become negative	Minimum change for <b>FNPV</b> to become negative	Maximum change for <b>ENPV</b> to become negative
Primary energy prices & Electricity tariffs	-88%	-71%	-87.0%
Alternative technology investment cost	93%	38%	90%
Government subsidies	-5130%	-1730%	N/A
EU ETS Carbon Price	N/A	N/A	-911%

Table 123 – Services H4 – Sensitivity Analysis: Switching Values

iii. Impact of different FDR and SDR

	5&4-STAR	3&2-STAR		
Financial Discount Rate	FNPV	FNPV	Social Discount Rate	ENPV
3%	€218,233	€59,231	4%	€1,533,515
4% - BM	€192,427	€51,723	5% - BM	€1,299,893
5%	€170,911	€45,501	6%	€1,109,107

Table 124 – Services H2 – Sensitivity Analysis: Effect of different FDR and SDR

### 3.3 Summary – Financial and Economic indicators, Energy savings and CO<sub>2</sub> Emissions of the Benchmark Scenario

For ease of reference, the below table summarises the findings of the technical and economical analysis described in Part III of this report which take several scenarios across different sectors into consideration. The FNPV, the FRR, the ENFV and the ERR of each scenario is also being provided, as well as the financial and economic payback of each proposed intervention. Important to note that the CO<sub>2</sub> Emission Scenario post 2030 is based on the constant one.

Government Subsidies	Value	No. of households 2021-30
Households (2021-30)	€700	800
Government subsidy for hotels and industry (2021-30)	30%	of incremental cost between baseline and alternative

			SOCIETY		INDIVIDUAL			SOCIETY			
			Primary Energy savings (GWh)	CO <sub>2</sub> Emissions reduced (tons)	FNPV	FRR	Financial Payback	ENPV	ERR	B/C ratio	Economic Payback
			Total - 2021-2050		€	%	year	€	%	Ratio	year
<b>RESIDENTIAL 1</b>	Replacing electrical water heating with heat pumps	Uptake - Scenario 1 [800 till 2050]	679	138,360	526	9.3%	Y11	3,068,469	8.1%	1.66	Y17
<b>RESIDENTIAL 2</b>	Replacing LPG heaters with electric heat pumps	Uptake - Scenario 1 [800 till 2050]	65	15,862	207	-	-	2,619,906	-	6.87	-

<b>SERVICES 1 - 5&amp;4-STAR HOTELS</b>	<b>Replacing fuel-fired boilers used for water heating with electric heat pumps</b>	Uptake - Scenario 1 [25% till 2050]	73	21,193	142,748	35.8%	Y4	3,555,549	77%	11.80	Y1
<b>SERVICES 1 - 3&amp;2-STAR HOTELS</b>	<b>Replacing fuel-fired boilers used for water heating with electric heat pumps</b>	Uptake - Scenario 1 [25% till 2050]			42,771	26.5%	Y5				
<b>SERVICES 2 - 5&amp;4-STAR HOTELS</b>	<b>Replacing boilers with condensing-type, high-efficiency boilers</b>	Uptake - Scenario 1 [25% till 2050]	14	3,612	18,622	59.2%	Y3	565,820	103%	30.43	Y1
<b>SERVICES 2 - 3&amp;2-STAR HOTELS</b>	<b>Replacing boilers with condensing-type, high-efficiency boilers</b>	Uptake - Scenario 1 [25% till 2050]			5,192	42.7%	Y4				
<b>SERVICES 3 - 5&amp;4-STAR HOTELS</b>	<b>Replacing air-cooled chillers with air-cooled chillers including heat recovery</b>	Uptake - Scenario 3 [100% till 2050]	60	8,231	164,211	-	Y1	1,353,377	911%	49.56	Y2
<b>SERVICES 3 - 3&amp;2-STAR HOTELS</b>	<b>Replacing air-cooled chillers with air-cooled chillers including heat recovery</b>	Uptake - Scenario 3 [100% till 2050]			43,344	67.3%	Y3				

<b>SERVICES 4 - 5&amp;4-STAR</b>	<b>Replacing water-cooled chillers with water-cooled chillers including heat recovery</b>	Uptake - Scenario 3 [100% till 2050]	58	7,871	192,427	-	Y1	1,299,893	1228%	50.79	Y2
<b>SERVICES 4 - 3&amp;2-STAR</b>	<b>Replacing water-cooled chillers with water-cooled chillers including heat recovery</b>	Uptake - Scenario 3 [100% till 2050]			51,723	74.3%	Y3				

*Table 125 – Summary of the Benchmark Scenario*

## Part IV – Analysis of the Economic Potential for Efficiency in Heating and Cooling

By way of conclusion, this part of the report will be focusing on additional and future policy measures in heating and cooling that may be adopted up to 2050, as a result of the assessment carried out in the previous sections of this report as well as on the basis of the cost benefit analysis carried out as part of this report.

In view of Malta's renewable targets up to 2030 and support to the EU wide commitment to decarbonize by 2050, the energy system in Malta and Maltese society as a whole will need to prioritize energy efficiency in heating and cooling. This will indirectly (and in parts directly) contribute towards the achievement of the said targets. In this scenario, it is crucial that Malta identifies the optimal balance between investments aimed at reducing heating and cooling demand and providing more efficient, sustainable and affordable supply solutions.

From a policy point of view, national and local authorities can play a major role to create the market framework and instruments which can help to incentivize investment in different sector for energy efficient heating and cooling technologies, to achieve decarbonization goals in buildings, towns and industries.

Following the results assessed in Part I and III of this report, this section outlines several strategies, policies and measures which Malta can realistically adopt in the coming years. In view of the results of the technical and economical analysis of the various scenarios, as per the Table 125 in Part III above, as well as the data on heating and cooling gathered in Part I of this report, below are recommendations being proposed as future policy measures. These recommendations, together with their assessed impact, go over and above policies set out in the 2030 National Energy and Climate Plan.

It should be noted that in 2015, a comprehensive assessment on the potential for the application of high efficiency cogeneration and efficient district heating and cooling in Malta was delivered to the European Commission in accordance with Article 14(1) of Directive 2012/27/EU. This report determined that district heating systems are not cost-effective solutions for Malta due to the fact that the final energy consumption for heating purposes in Malta is relatively low compared to what is needed to justify the considerable investment required for district heating networks. Indeed, despite the increase in final energy consumption for heating and cooling foreseen for 2030 and 2050, the final heating demand is likely to remain below the necessary threshold that render such technologies economically feasible. It is for this reason that the scenarios explored in Part III of this report do not consider the possible use of district heating networks. Scenarios and technologies also take into consideration the lack of a natural gas grid. Additionally, CHPs were also not prioritized as technologies to be assessed in this report, since the recommendation for potential use outlined in the 2015 report, was met with significant challenges during its implementation. In an effort to overcome these challenges and incentivize the uptake of high efficient CHP units, in 2016 the government released a scheme whereby enterprises were eligible for aid through

tax credits. To date, the uptake was nil, mainly due to spatial requirements for on-site fuel storage (mainly LPG) and applicable international standards. Such challenges brought about by spatial constraints, along with Malta's ambition to contribute to the EU wide commitment of decarbonizing by 2050, led to the prioritization of more relevant technologies to Malta's heating and cooling specificities, as analyzed in the Part III scenarios of this report.

### **Residential Sector**

**Increasing the amount of financial aid offered in schemes to incentivise the installation of Solar Water Heaters or Heat Pump Water Heaters in the residential sector.** From the financial analysis carried out it was noted that the ENPV value is positive, thus confirming that the installation of a heat pump system to replace an electrical water heater for a household is economically feasible. However, the pay-back period for such a system resulted to be very long (17 years), discouraging the general household to go for a heat pump system for hot water production. Such a long pay back period is a result of the high investment cost for a heat pump system when comparing with the investment cost of a standard electric water heater.

It is thus being recommended that the grant under the current solar water and heat pump water heater scheme is capped to a higher amount than €700 as shown in the sensitivity analysis for the residential sector carried out in Part III of this report. This would not only promote energy efficient equipment and reduce the heating demand in households, but also contribute towards the 2030 renewable targets and support the EU-wide ambition to decarbonise by 2050.

**A nation-wide information campaign to disseminate information of the advantages of utilising reversible air-to-air heat pumps for space heating over LPG gas heaters in the residential sector.** Based on information gathered in the technical assessment of this study, households already meet a significant portion of their cooling demand through the use of high efficiency air to air reversible heat pumps. Utilising the same technology for heating proves to not only be more financially feasible but, in general, also more efficient in terms of energy consumption in relation to the energy demand, than the use of LPG gas heaters for space heating in the residential sector. The use of an information campaign that promotes efficient heating through the use of this technology could help encourage a transition towards the electrification of heating in the households sector. To assess the long-term effects of this measure, it also being recommended that further detailed analysis on the effects and feasibility of the electrification of heating and cooling in the domestic sector by 2050 be carried out.

Preparation of **policies/supporting schemes** for the **design and implementation of residential buildings in line with nearly zero energy building (NZEB) standard**, including RES systems and installations providing sustainable heating and cooling.

More emphasis on **energy audits** targetting the residential sector by continuing the support of the *household visits scheme* currently administered by the Energy and Water Agency. This scheme provides the opportunity to households to benefit from free home visits by training technical staff

who provide professional advice to implement practical energy efficiency solutions to lower energy bills.

### **Services Sector**

Promotion and dissemination of information in favour of **heat recovery measures on air-cooled and water-cooled chillers (mostly within the hotels sub-sector)** to promote the benefits of such technologies. This technology maximizes energy efficiency while allowing direct control of both the hot and chilled water temperatures. The heat recovery chiller produces a base load of chilled water while generating hot water from the heat rejection recovered from the condenser which otherwise would be lost to the atmosphere. This energy can be used as 'free energy' for the generation of hot water which can have various uses, especially in the hotels sub-sector.

Another important scenario carried out for the services sector, and in particular the hotels sub-sector, focused on the use of heat pumps for water heating purposes. In fact, from the cost benefit analysis carried out for the purpose of this study, it is clear that such a **transition from the use of fuel fired boilers for water heating to heat pumps** would be both economically and financially feasible, resulting in positive ENPV and FNPV. Moreover, as already mentioned above, the use of heat pumps would not only promote energy efficient equipment and reduce the heating demand in the services sector, but will also significantly contribute towards the 2030 renewable targets and the EU-wide commitment to decarbonise by 2050.

Replacement of old **boilers** with new **condensing** ones for **the tertiary sector, especially the hospitality sub-sector**.

It should also be noted that currently, through the joint collaboration of the EWA and Malta Enterprise, small, medium and large enterprises can benefit under an Investment Aid scheme for energy efficiency projects through a grant of 30% of the investment cost of such energy efficiency measures. Given that the study carried out in Part III of this report shows a positive FNPV and ENPV for the different scenarios analysed under the services sector, the existing percentage grant value is enough to support all recommendations enlisted above. However, it is recommended that more efforts should be made to **create more awareness about this already existing scheme to the applicable beneficiaries**.

**Public bodies following green procurement policies** resulting in the purchase of products and acquisition of services with high energy performance.

**Public buildings designed for high energy efficiency** and in line with **nearly zero energy building (NZEB) standard** whenever building and/or renovating already existing public buildings.



National and local authorities to adopt **efficient heating and cooling criteria in their regulatory instruments** to regulate **the design, building and renovation of buildings in the industry and tertiary sector**.

More emphasis on **energy audits** targeting all **businesses and entities** within the services sector including SMEs which can lead to use of current EWA schemes Promotion of Energy Audits in Small and Medium Sized Enterprises Scheme' and Malta Enterprise Energy Efficiency Schemes which have been described in further detail in Part II of this report.

It is being strongly recommended that the present scheme *is* extended further into the coming years together with an advertising campaign to continue promoting such a scheme on a national level.

The implementation of energy savings measures resulting from energy audits can contribute to an eventual reduction in the final energy consumption for heating and cooling whilst in some cases also assist in contributing towards the EU-wide commitment to decarbonize by 2050.

The implementation of a **Waste-to-Energy (WtE) project** through which the **energy generated from the waste treatment process** is envisaged to be used for **heating and cooling purposes** needed for the **same process within the project**. Moreover, as per the definition in Directive (EU) 2018/2001, such heat cannot be classified as 'waste-heat' due to the lack of a district heating network. For this reason, the recommendation would be to assess all possibilities for heat recovery onsite within the process.

## **Industry Sector**

Malta does not have an energy and carbon-intensive industry as can be evidenced from the fact that Malta's share of final energy consumption in industry is also significantly lower than the EU average. Hence, currently Malta's long-term targets for the decarbonisation of energy and carbon-intensive industrial sectors are still being assessed. To this day, there are no specific 2050 objections related to the promotion of clean energy technologies for industry. It is precisely due to the small size and extremely diverse nature of the industry sector in Malta, and the resulting relatively small energy consumption of this sector, that a 'one-size-fits-all' approach cannot be adopted for heating and cooling measures for this sector. Therefore, rather than policies specifically targeting the whole industry sector, emphasis should be made on specific individual energy audits which serve to identify particular and specific energy saving measures related to the type of industry concerned.

Moreover, it should be noted that the existing low thermal loads and heat demands in the industry sector do not make district heating and cooling solutions feasible in Malta. As indicated above, co-generation units are not being proposed as recommend technologies for the industry sector, particularly in view of the lack of a natural gas grid and spatial restrictions required for LPG. Taking all the aforementioned restrictions into consideration, finding solutions to improve efficiency in heating and cooling or to achieve long-term decarbonisation within this sector might require innovative solutions. It is recommended that work to achieve such innovative solutions are identified as high-level priority areas for R&I activities for Malta. This could be complimented by further promotion of the R&I Grant Scheme for research and innovation in energy and water launched in 2020 to further incentivize local research in this area as described in further detail in Part II of this report.

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