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Methodology to estimate the decarbonization potential at neighbourhood level. Case study LIlla Perduda and Benicalap in Valencia, Spain

Master's Thesis

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Final Master Thesis

METHODOLOGY TO ESTIMATE THE DECARBONIZATION POTENTIAL AT NEIGHBORHOOD LEVEL. CASE STUDY: BENICALAP AND L'ILLA PERDUDA IN VALENCIA, SPAIN

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ABSTRACT

In line with the Sustainable Development Goals (SDGs) that the United Nations adopted in the 2030 Agenda, the European Union and many national, regional, and local governments have included decarbonization plans in their policies. However, for planning these new politics is required to reach the lowest levels of spatial planning, such as neighborhoods, to be able to make a realistic analysis of the decarbonization potential and the implementation and evaluation of effective measures to decarbonize an area. This project aims to develop a methodology to estimate the decarbonization potential at neighborhood level and thus contribute to achieving the SDGs. This methodology could help local governments target decarbonization measures in the neighborhoods that make up the cities, focusing on analyzing the areas of Benicalap and L'Illa Perduda located in the city of Valencia. Cities are responsible for more than 70% of the total emissions our planet produces today, even though these land-use planning figures cover only 3% of global land occupation, and this is the reason for focusing on this.

To carry out the methodology, state-of-the-art is elaborated, based on the information obtained, an emissions inventory is worked on, and these emissions are quantified. The emissions inventory is carried out through the analysis by sectors such as energy, transport, consumption, and others. Subsequently, lines of action are proposed with their respective measures for neutralizing these emissions in the different sectors, which are developed and analyzed from a technical, economic, environmental, and social perspective.

Once the lines of action are developed, an emissions balance is drawn up, evaluating the contribution that each of the focal points of action makes to the decarbonization of the neighborhood, assessing whether it is possible to achieve the objective of neighborhoods with zero emissions, or if not, including future guidelines to achieve it.

With the analysis of the measures applied, a reduction of around 50% would be achieved in 2030, considering that only a few measures of a wide range have been developed. One of the proposed actions that contribute more to reducing GHG emissions is installing solar photovoltaic panels on the rooftops, followed by the implementation of sustainable transport in the neighborhoods.

RESUMEN

En línea con los Objetivos de Desarrollo Sostenible (ODS), aprobados por la Organización de las Naciones Unidas en la Agenda 2030, la Unión Europea y muchos gobiernos nacionales, regionales y locales han incluido planes de descarbonización en sus políticas. Sin embargo, para desarrollar estas políticas es necesario alcanzar los niveles más bajos de planificación espacial, como los barrios, para poder realizar un análisis realista del potencial de descarbonización y la implementación y evaluación de medidas efectivas para descarbonizar un área. El objetivo de este trabajo es desarrollar una metodología para estimar el potencial de descarbonización a nivel de barrio y de esta manera contribuir al logro de los ODS. Esta metodología ayudará a los gobiernos locales a establecer las medidas de descarbonización en los barrios que conforman las ciudades, centrándose en analizar los barrios de Benicalap y L'Illa Perduda localizados en la ciudad de Valencia. Las ciudades son las responsables del más del 70% del total de las emisiones totales generadas en nuestro planeta en la actualidad, a pesar de que estos territorios cubren solo el 3% de la superficie terrestre, y esta es la razón para enfocarse en ellas.

Para llevar a cabo la metodología, inicialmente el estado del arte es elaborado, a partir de la información obtenida se realiza un inventario de emisiones y se cuantifican las mismas. El inventario de emisiones se lleva a cabo a través del análisis por sectores como energía, transporte, consumo y otros. Posteriormente, se proponen líneas de acción con sus respectivas medidas para la neutralización de estas emisiones en los diferentes sectores, que son desarrolladas y analizadas desde una perspectiva técnica, económica, ambiental y social.

Una vez desarrolladas las líneas de acción, se elaborará un balance de emisiones, evaluando la contribución de cada uno de los puntos de acción en la descarbonización del barrio, verificando si es posible alcanzar el objetivo de barrios con cero emisiones, o en caso contrario, incluyendo futuras pautas para conseguirlo.

Considerando las medidas implementadas se ha conseguido una reducción de alrededor de un 50% para el 2030, este valor se ha obtenido teniendo en cuenta que sólo unas pocas medidas de un amplio abanico han sido desarrolladas. Una de las medidas que más contribuye a la reducción de las emisiones de gases de efecto invernadero es la instalación de paneles fotovoltaicos en los tejados, seguida de la propuesta de implementación del transporte sostenible en los barrios.

RESUM

En línia amb els Objectius de Desenrotllament Sostenible (ODS) , aprovats per l'Organització de les Nacions Unides en l'Agenda 2030, la Unió Europea i molts governs nacionals, regionals i locals han inclòs plans de descarbonització en les seues polítiques. No obstant això, per a desenrotllar estes polítiques és necessari aconseguir els nivells més baixos de planificació espacial, com els barris, per a poder realitzar una anàlisi realista del potencial de descarbonització i la implementació i avaluació de mesures efectives per a descarbonitzar una àrea. L'objectiu d'este treball és desenrotllar una metodologia per a estimar el potencial de descarbonització a nivell de barri i d'esta manera contribuir a l'èxit dels ODS. Esta metodologia ajudarà als governs locals a establir les mesures de descarbonització en els barris que conformen les ciutats, centrant-se a analitzar els barris de Benicalap i L'Illa Perduda localitzats en la ciutat de València. Les ciutats són les responsables del més del 70% del total de les emissions totals generades en el nostre planeta en l'actualitat, a pesar que estos territoris cobrixen només el 3% de la superfície terrestre, i esta és la raó per a enfocar-se en elles.

Per a dur a terme la metodologia, inicialment l'estat de l'art serà elaborat, a partir de la informació obtinguda es realitzarà un inventari d'emissions i es quantificaran les mateixes. L'inventari d'emissions es durà a terme a través de l'anàlisi per sectors com a energia, transport, consum i altres. Posteriorment, es proposaran línies d'acció amb les seues respectives mesures per a la neutralització d'aquestes emissions en els diferents sectors; aquestes línies d'acció seran desenvolupades i analitzades des d'una perspectiva tècnica, econòmica, ambiental i social.

Una vegada desenrotllades les línies d'acció, s'elaborarà un balanç d'emissions, avaluant la contribució de cada un dels punts d'acció en la descarbonització del barri, verificant si és possible aconseguir l'objectiu de barris amb zero emissions, o en cas contrari, incloent futures pautes per a aconseguir-ho.

Considerant les mesures que s'han implementat s'ha aconseguit una reducció d'al voltant d'un 50% per al 2030, aquesta dada tenint en compte que només unes poques mesures d'un ampli ventall s'han desenvolupat. Una de les mesures que més contribueix a la reducció de les emissions de gasos d'efecte d'hivernacle és la instal·lació de panells fotovoltaics en les teulades, seguida de la proposta d'implementació del transport sostenible en els barris.

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ACRONYMS

CAPEX	Capital expenditure
CND	Carbon Neutral District
CO_2	Carbon Dioxide
DGT	Dirección General de Tráfico
EMT	Empresa Municipal de Transportes
EU	European Union
GHG	Greenhouse gases
IMD	Intensidad Media Diaria
KPI	Key Performance Indicators
OPEX	Operational expenditure
PV	Photovoltaic
REE	Red Eléctrica de España
SDG	Sustainable Development Goals
SECAP	Sustainable Energy and Climate Action Plan

1 INTRODUCTION

1.1 Background

Since the middle of the 20th century, the level of carbon dioxide (CO_2) has increased and particularly in the past four decades, the rise of CO_2 emissions has been exponential [1], [2]. This increase is related to the fact that different negative environmental consequences of that emission, such as climate change and air pollution, are increasing.

The increase of CO_2 emissions is directly related with the increase in global temperature that has grown considerable in the last few decades. Trying to reduce these it was proposed in the Paris Agreement, signed in 2015 by a total of 196 countries, to develop and initiate different actions and policies to achieve the limitation of increase the temperature more than 1,5 degrees comparing with preindustrial levels [5]. More recently, in November 2021 take place the Conference of the Parties (COP26) in Glasgow where several goals were proposed emphasizing the Paris Agreement with the necessity to secure global net zero by mid-century and keep the range of 1,5 degrees [6].

Cities have an important role in all these emissions and the consequences of that because they are responsible for 70% of the total emissions in the world, considering that they only fill 3% of the total surface [7]. For these reasons, innovative programs, proposals, and actions should be focused on cities. The city of Valencia has followed the guidelines of European programs and today this city is included in the program "100 Climate-neutral Cities by 2030" [8]. Also, this city has published the Sustainable Energy and Climate Action Plan (SECAP) [9] as part as the Covenant of Mayors for Climate and Energy [10].

1.2 Contribution to Sustainable Development Goals

Different programs and actions are focus on this problem related to greenhouse gas (GHG) emissions. The United Nations planned the Agenda for Sustainable Development, composed of 17 Sustainable Development Goals (SDG) to promote development while reducing the negative impact on the planet [3].

The proposed project planned in this document plays a key role as other alternative projects in achieving SDG [4]. The implementation of Carbon Neutral Districts, such as this project, impacts several SDGs, mainly in SDG 7 affordable and clean energy, SDG 8 decent work and economic growth, SDG 11 sustainable cities and communities and SDG 13 climate action.

1.3 Motivation and justification

Research and interest in analyzing and developing strategies in cities to fight climate change and reduce its impacts have increased in recent years. These strategies have gone in different directions, but one of the most relevant has been the achievement of carbon neutrality by a defined year that depends on the city and its sustainable objectives.

The goal of developing carbon neutrality in an area has been focused on cities because, despite the urban figures that have less area occupied, they are responsible for more than three-quarters global CO_2 emissions.

In line with this, the present study is focused on the planning and development of carbon neutrality in the city of Valencia. More precisely, the selected zones in the city of Valencia have been two neighborhoods, Benicalap and L'Illa Perduda. Selecting smaller zones inside the hole city is more effective to analyze in detail the initial situation and propose measures adapted to the characteristics of each zone.

1.4 Objectives

This master thesis aims to develop a methodology to estimate the decarbonization potential at neighborhood level and the road map to achieve it in two specific neighborhoods of the city of Valencia: Benicalap and L'Illa Perduda.

This research study's specific main goals are:

- Develop a GHG emissions inventory considering the different activity sectors in the neighborhoods.
- Build a methodology to estimate and analyze the decarbonization potential in specific city zones, the neighborhoods.
- Search for and propose measures to reduce GHG emissions and quantify the impact of each measure on the initial GHG inventory to analyze the final situation.
- Realize a carbon balance by years considering the actions proposed.
- Analyze and detail future actions and directions to follow to improve and complete the carried out study.

1.5 Methodology and structure

This document is divided into nine defined chapters to organize the information developed in this study.

This first chapter, the introduction, includes the background, the motivation and justification to carry out this study, the general and specific objectives, and this section about the organization of the different chapters in the document.

The second chapter is about state-of-the-art, which includes concepts about carbon neutrality, GHG emissions in cities, and current initiatives proposed in other countries to achieve carbon neutrality in neighborhoods.

The third one exposes in a summary section the tools used during the realization of this study and the reason and purpose of its use.

The next chapter includes schemes and explanations about the methodology developed and followed in this study with the main steps presented.

The fifth chapter is dedicated to presenting the results of applying the methodology to the neighborhoods of Benicalap and L'Illa Perduda in the city of Valencia.

The sixth chapter is related to the carbon balance and the analysis of the initial and final situation concerning GHG emissions.

The next chapter is a detailed analysis of the general proposal, including all the different lines of development and evaluated considering various aspects such as social, economic, sensitivity, and policy and legal.

Chapter eight exposes the study's main conclusions, and chapter nine, the bibliography used to elaborate on this study.

Finally, a set of annexes with detailed information is used to develop this work and clarify some aspects of the carried out work.

2 STATE OF THE ART

2.1 Definition of Carbon Neutral Neighborhood

Before talking about Carbon Neutral Neighborhoods, the definition of Carbon Neutrality should be presented. Carbon neutrality is achieving a net zero balance between emitting and absorbing carbon from the atmosphere in carbon sinks. The idea of removing carbon oxide from the atmosphere is known as carbon sequestration [11].

The concept of a Carbon Neutral Neighborhood is the idea of applying carbon neutrality in a limited area of a city; in the case of this project, the zones of Benicalap and L'Illa Perduda have been selected due to the reason mentioned in the introduction about the key role of the cities in the global world GHG emission.

Implementing this new system in a city supposes the necessity to change many aspects of the current society: policies, markets, business models, education, etc. The European Union (EU) reports emphasizes the changes that the development of this new neighborhoods will have in society with new models of city governance, new roles for the citizens, new roles for innovation, new ways of funding and financing, etc. being necessary to evaluate the scale of this changes [8].

In line with this approach to achieving carbon neutrality in cities, a wide range of new cities categories have emerged, such as sustainable city, smart city, eco-city, low carbon city, resilient city, green city, and carbon neutral city [12]. Each of the city categories harbors a different view of what the city is and how it works, with respect to the role of citizens and the way they relate to the governance of the city, with respect to the interactions between the city and its natural environment, and with respect to the role of urban infrastructure systems and services in the city's economy and livability. Considering all the previous categories that have similar aspects in common but specific approaches and objectives, for this reason in this work the category selected to develop in the neighborhood is the carbon neutral neighborhood.

2.2 Questions to be developed to plan a carbon-neutral neighborhood

Considering the vital role of these new neighborhoods in the cities, it is crucial to analyze the future prospects, the city objectives and other topics related to carbon neutrality in the city of Valencia. The following questions are the key to propose the better plan [13]:

- What does a carbon neutrality plan in your city focus on?
- What does carbon neutrality mean for your city?
- What are the targets set by the city to achieve the carbon neutrality outcomes desired?
- Do you think the city could have been more ambitious when setting those targets?
- What tangible benefits do you see for your city in implementing these plans?
- To implement those plans, what are the main stakeholder groups that the city wants to engage?
- Are those stakeholders willing to collaborate?
- What are the main obstacles hindering the implementation of the plans so far?

- What could support your city to speed up the implementation of the plans? (Tools, methodologies, expert knowledge, policies, etc.)
- What are the next steps to be taken by the city?

2.3 GHG inventory

In this work, the main item is to quantify GHG emissions. To understand the types of emissions, it is important to present the kinds of emissions considered in the GHG emissions studies. Firstly, the emissions are divided into two types: direct and indirect emissions. Direct emissions are from sources owned or controlled by the reporting party. Indirect emissions are produced because of activities of the reporting party but take place at sources owned by another party [14].

Therefore, the emission types are divided into three scopes. The scope one includes all the direct emissions, and scopes two and three are represented by indirect emissions [15]. The scopes, their definitions, and some examples are presented in Table 2.1.

Table 2.1 Emissions scopes.

Emission type	Scope	Definition	Examples
Direct emissions	Scope 1	Emissions from operations that are owned or controlled by the reporting party	Fuel consumption in reporting party facilities Fuel consumption in reporting party vehicles
Indirect emissions	Scope 2	Emissions from the generation of purchased or acquired electricity, steam, heating, or cooling consumed by the reporting party	Purchase electricity
Indirect emissions	Scope 3	All indirect emissions not represented in Scope 2 that are a consequence of the activities of the reporting party but occur from sources not owned or controlled by the company	Purchase goods and services Travels outside of the district

2.4 Defining the lines to achieve carbon neutrality

Focusing on achieving carbon neutrality in the neighborhoods, the consulted studies give a guideline of three main steps that will be applied in the following order [16]:

- Energy reduction of the current consumptions in the economy sectors implementing energy efficiency measures, balancing out the needs of the different sectors, building infrastructure, energy use, transport, and mobility, etc.

- Energy flexibility and synergies mean dealing with the problem of not having supply and demand simultaneously.
- Energy production by renewable sources to cover the remaining demand.
- Sequestration of CO_2 emissions by the implementation of green zones in the cities.

In [17] a more detailed guide with steps was developed and will be applied in this project. The steps are referred to in Figure 2.1:

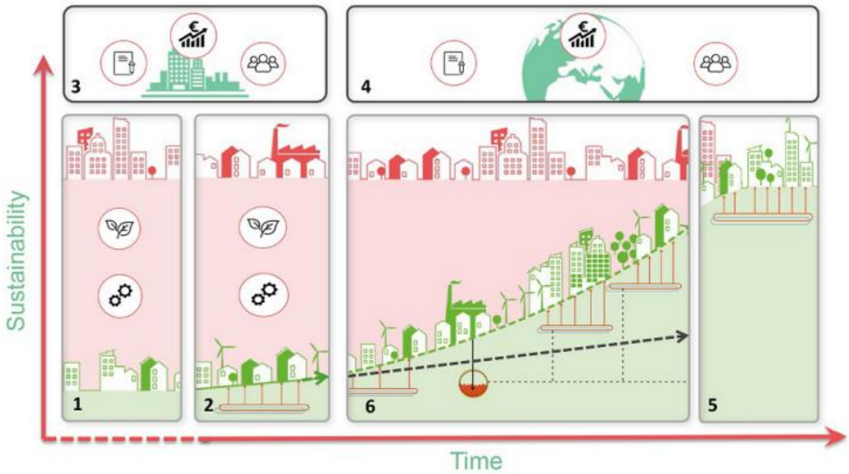

Figure 2.1 Steps to approach for neighborhood energy transition [17].

- Step 1: Energy analysis mapping the current situation.
- Step 2: Analyze current plans and trends based on predictions.
- Step 3: Analysis of society and stakeholders mapping the political, legal, social, and economic climate.
- Step 4: Scenario for the future considering external influencing variables.
- Step 5: Future decarbonization vision with targets and plans.
- Step 6: Roadmap with energy interventions and actions, with an ambitious timeline for a rapid upscaling fight the urgency of climate mitigation and adaptation.

3 TOOLS

In this part of the document the tools used to develop this project are presented and explained the reason of its use.

3.1 QGIS

This tool has been used to estimate the building surface available to implement solar photovoltaic (PV) installations in the rooftops of the buildings.

The procedure followed to achieve the surface results is developed and explained in annex D of the Calculation of rooftop surface for PV panels installation, and the QGIS maps used to obtain this data are shown in Figure 3.1 and Figure 3.2.

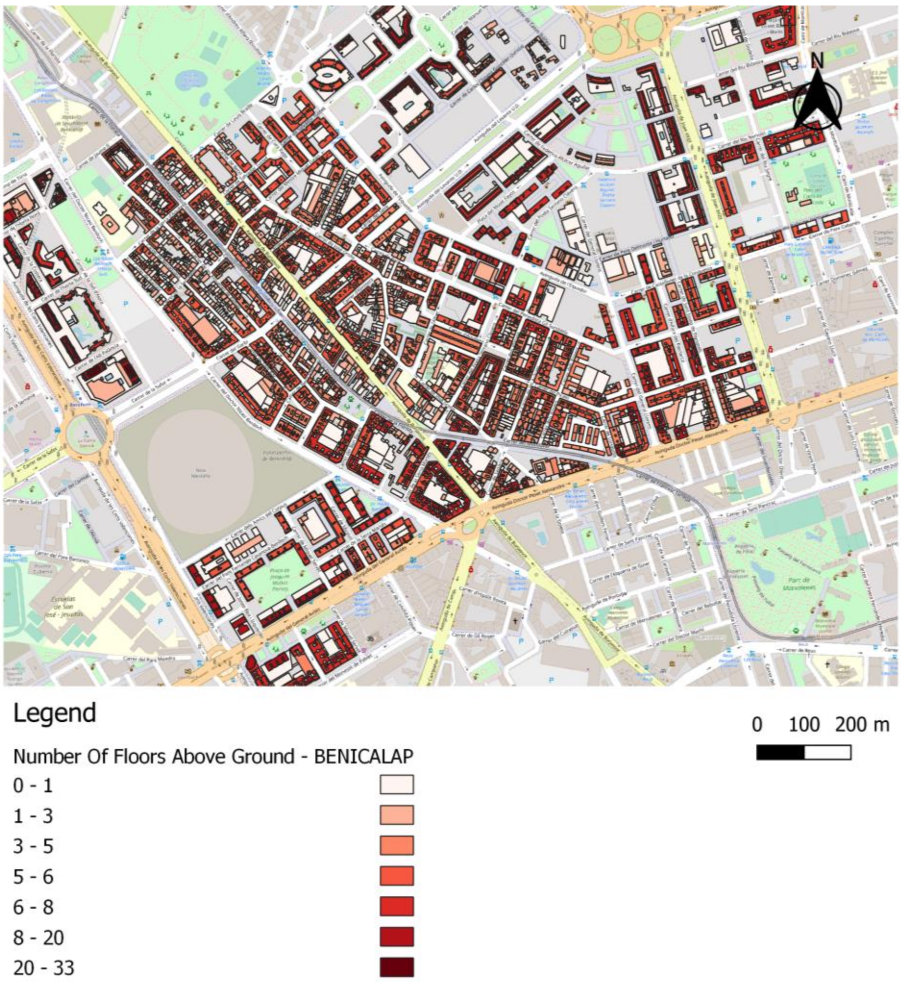

Figure 3.1 QGIS map from Benicalap with the polygons classified by number of floors above ground. Elaborated from QGIS.

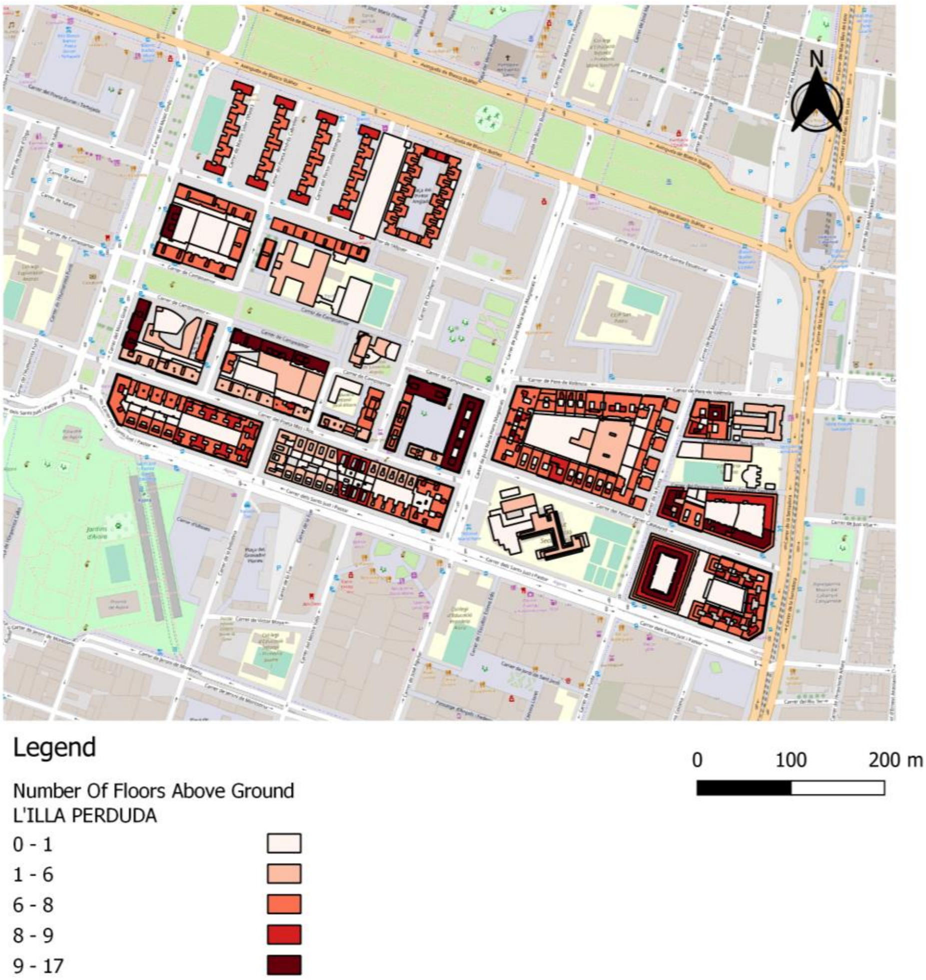

Figure 3.2 QGIS map from L'Illa Perduda with the polygons classified by number of floors above ground. Elaborated from QGIS.

The values of total surface obtained from QGIS for the neighborhoods are included in annex D Calculation of rooftop surface for PV panels installation.

3.2 Excel

Excel tool has been used during all the steps of this project. The main tasks developed with this tool have been the next ones:

- Gather and organize the different information searched for the followed steps and analysis of this work.
- Make calculations about the GHG inventory with the initial data gathered and the equations planned to calculate the total emissions by the different sectors based on the methodology presented in chapter 4 METHODOLOGY.
- Present the different results obtained from the GHG inventory and work with this data to create useful graphs to analyze and summarize the final GHG results.

- Develop calculations about the planned measures to reduce GHG emissions: such as the catalog of green zones in the neighborhoods and its contribution to reduce the initial emissions.
- Analyze using graphs the information obtained from implementing the planned CO_2 reduction measures.
- Combine the initial emissions with the emissions saved with the actions planned for the future from now to 2030 and calculate the final emissions for each year.
- Detail and calculate the initial data to introduce in Homer to simulate the scenarios in Homer and estimate the total PV power installed and the generation of this system.

3.3 Google Earth

This tool has been used to estimate some distances, such as the distance of the lines of public transport traveled in the neighborhood, and to have a global vision of some aspects of the neighborhood in a map. In Figure 3.3 and Figure 3.4 are presented the different lines of public transport in Benicalap and L'Illa Perduda, respectively. These lines have been used to calculate the distance traveled by each trip and route.

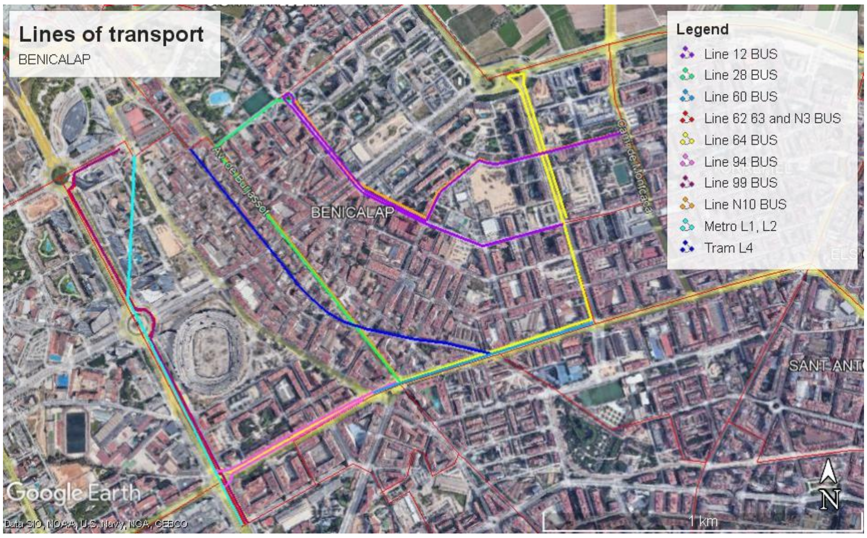

Figure 3.3 Lines of public transport in Benicalap. Elaborated from Google Earth.

Figure 3.4 Lines of public transport in L'Illa Perduda. Elaborated from Google Earth.

Also, this tool has been used to evaluate the useful area on the rooftops of the buildings to estimate the PV potential in a sample of the neighborhood. The results can be extrapolated to all the areas of the neighborhoods, in this case, Benicalap and L'Illa Perduda. The useful area is going to be compared with the total area previously calculated with QGIS, but in this case, with a new layer in QGIS with only the surface of study, as shown in Figure 3.5 and Figure 3.6. Inside this layer, a more detailed analysis could be done because of the small dimensions of the sample, and some of the area of the roofs of the building that appear in the next images are not considered in the comparative process.

Figure 3.5 Sample zone of Benicalap selected to analyze the surface potential for installing PV panels. Elaborated from QGIS.

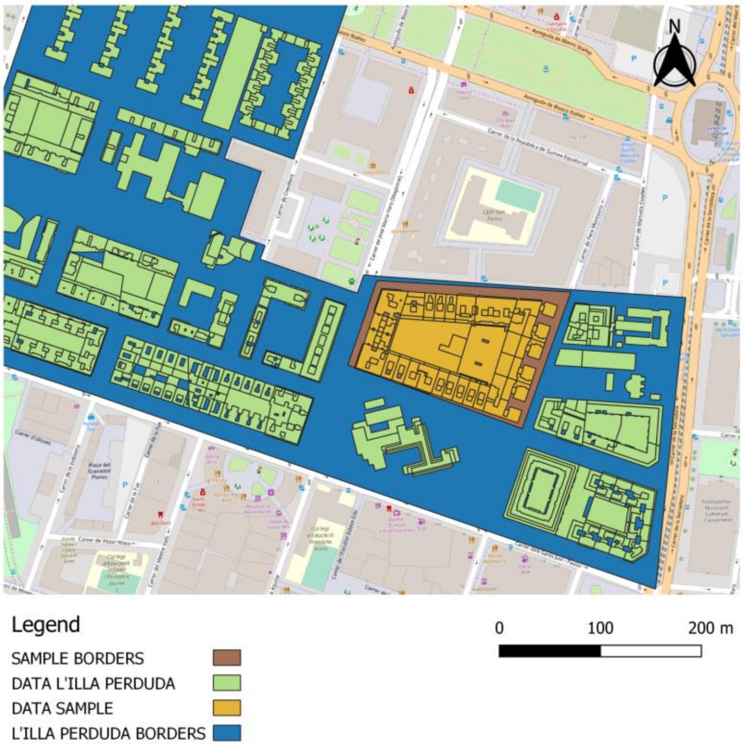

Figure 3.6 Sample zone of L'Illa Perduda selected to analyze the surface potential for installing PV panels. Elaborated from QGIS.

The useful area considered, avoiding small zones, zones with shadows, and other zones not appropriate to install PV panels are detailed in Figure 3.7 and Figure 3.8. for Benicalap and L'Illa Perduda, respectively.

Figure 3.7 Sample zone to estimate the useful area in Benicalap. Elaborated from Google Earth.

Figure 3.8 Sample zone to estimate the useful area in L'Illa Perduda. Elaborated from Google Earth.

In annex D, the Calculation of PV installationand the comparison of the surfaces between QGIS and Google Earth has been developed and presented the results about the useful area in neighborhoods.

3.4 Datadis

This online tool has been used to obtain the daily electricity consumption values in the different neighborhoods, Benicalap and L'Illa Perduda. The process developed to obtain the hourly values is explained next.

The daily data has been obtained from the platform Datadis [18], which provides electrical data consumption and the number of clients. This data is collected from the area of a user's zip code.

From this platform, the daily values (kWh/day) have been obtained for each main sector, residential, industrial, and public services for 2019. The year selected is 2019 because of the current pandemic and post-pandemic situation, and the strong influence of this fact on electricity consumption and at it will be shown in the energy price chapters.

The zip code is corresponded approximately with a district but sometimes a neighborhood or even a district includes various zip codes, in this case Benicalap is located inside the 46025 code and L'Illa Perduda in 46022 zip code both in the city of Valencia [19].

To calculate the more exactly value of a neighborhood and considering an homogeneous consumption by the houses and commerce of an entire zip code, the consumption is the division of the daily consumption of each sector by the number of clients in each sector (kWh/client), and this value should be multiply for the real number of households for the case of the residential sector, the real number of industries for the industrial sector and the real number of commerce for the services sector. This real value has been considered from the statistics of the Ayuntamiento de Valencia [20].

These values are obtained per day, but for a more detailed analysis, the values per hour should be calculated using standard consumption curves for a typical day and considering these patterns. These curves are obtained from [21].

3.5 PVGIS

PVGIS (Photovoltaic Geographical Information System) is an online tool developed by JRC (Joint Research Centre) of Ispra (Italia) from the European Commission, which has a database about the solar resource.

To obtain the solar information is necessary to introduce in the tool, the geographic location, the azimuth, the PV panels installation angle and with this data the values about irradiation are obtained. In this case these values are used to include it in the simulations with Homer.

3.6 Homer

HOMER (Hybrid Optimization Model for Multiple Energy Resources) is a software developed by National Renewable Energy Laboratory and improved and distributed by Homer Energy. It has been used to dimension and evaluates the neighborhood's photovoltaic potential as one measure to try to reduce emissions associated with electricity consumption. The data used to create the model in Homer is included in annex E of Calculation of PV installation, and the process is detailed in 5.4.2 PV GENERATION.

4 METHODOLOGY

The methodology developed and followed to obtain and present a carbon-neutral neighborhood roadmap for Benicalap, and L'Illa Perduda is detailed in this chapter.

4.1 General procedure

The procedure developed and carried out for this study is indicated in Figure 4.1, a scheme with all the steps followed to achieve the results obtained and expressed in this document, based on [22].

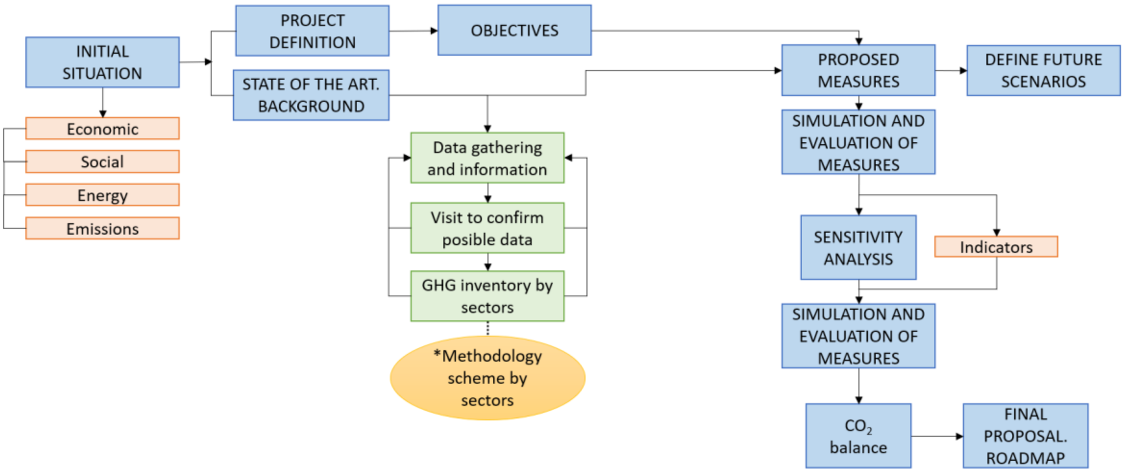

Figure 4.1 Scheme of general procedure methodology.

Then, the different steps included in this methodology will be presented and explained:

<u>**PROJECT DEFINITION AND OBJECTIVES**</u>

The first step is defining the project and the planned objectives to achieve during the study. To define this step and the main project scope and objectives it is important to plan some questions to bear in mind to define it, such as *"What do carbon neutrality plans in your city focus on? What does carbon neutrality mean for your city? What real benefits do you see for your city in implementing these plans? To implement those plans, what are the main stakeholder groups that the city needs to engage?"* [13].

In this case, carbon neutrality is the direction that the work should have, and base on that a series of points were considered:

- The area of the city of Valencia is selected to apply the methodology and the scale of this surface. In this case, the selected part of the city is included in the neighborhoods category: Benicalap and L'Illa Perduda, two different parts of Valencia with differentiated features, situated in the districts of Benicalap and Algirós respectively.
- The CO_2 emissions that will be considered related to the different scopes previously mentioned. In the case of this study, it has been considered only the emissions related to the operation (OPEX) of the neighborhood and not the one concerned with its construction (CAPEX). For example, in the case of a building, it will be considered the

CO_2 emitted from the consumption of energy, goods, etc. but not the CO_2 emissions due to building construction, the production of the materials, etc.

STATE-OF-THE-ART

Having defined the project and the lines to follow, a detailed review of the state-of-the-art in different topics, related all of them with carbon neutrality was carried out. The documents included and reviewed in this step were from research articles, review articles, government documents related with studies, statistics from the Valencia City Council or the Valencian Community and reports from the European Community or other institutions.

Based on that, a good concept about carbon neutrality application in the cities was constructed. The mainly topics searched has been carbon neutrality, sustainable cities, energy efficiency in buildings, natural-based solutions, circular economy, involve stakeholders in programs, PV generation in rooftops, etc.

ANALYSIS OF THE INITIAL SITUATION

With the information obtained from the elaboration of the state-of-the-art and the concepts clears, the next step is to analyze the initial situation of the place where the project will be applied. In the case of this specific study a set of initial information was gathered and evaluated:

- Main characteristics of the neighborhoods: total surface, use of the land, population, and characteristics of the population (age, sender, job, etc.), transport system, green areas, and other data that with the progress of the study has been considered important and useful.
- In some case, and when it is possible a visit to the neighborhoods was executed to understand the characteristics and evaluate the data collected by the different sources.
- Energy consumption divided by sectors: residential, industry and services.
- GHG inventory by sectors. Obtain data from the characteristics of the sectors in both neighborhoods, the emissions per type of sectors and other aspects to been able to develop this inventory.

PROPOSED MEASURES AND FUTURE SCENARIOS

Considering the initial situation of the neighborhoods and using the concepts extracted from the development of the state-of-the-art related with the possible measures to reduce CO_2 emissions a list of measures has proposed to make a multilevel analysis about economic, technical, social and environmental impact on the initial situation.

The summary of the list of measures is:

- Renewable generation based on PV generation.
- Evolution of the transport fleet both for private and public transport to a sustainable transport.
- Implementation of natural based solutions.
- Energy efficiency measures in public lighting.

SIMULATION OF THE MEASURES

Considering the proposed measures is necessary to analyze the impact and contribution to the CO_2 reduction of the initial situation that each measure can produce. In that way, it will be possible to concreate which measure has a greater impact as it is more important to develop, but all of this not only considering the CO_2 reduction but also the economic impact, the social affection, etc. And with all these data priories the different measures in a temporal line.

SENSITIVITY ANALYSIS

With the previous results obtained from the simulation of the proposed measures, the sensitivity analysis for this study has been carried out. In this case, the variables or aspects considered changeable in this analysis and that have been included as important to evaluate the impact of this change in the project has been:

- Energy price.
- Increase of consumption.
- Increase of electric vehicles.

CO_2 BALANCE

One of the main reasons of this study is to evaluate the impact of different measures proposed in the literature to achieve carbon neutrality in cities, and for this, a CO_2 balance has been carried out. Starting from the initial situation and considering a curve estimated for the CO_2 emissions during the next years and considering the CO_2 reduction based on the proposed measures a CO_2 balance has been presented in this document for the next years until 2030.

FINAL PROPOSAL WITH ROADMAP

Being analyzed the initial situation, the measures proposed and the impact of the measures in CO_2 reduction a roadmap for both neighborhoods has been planned to conduct these zones of the city to carbon neutral zones.

In Figure 4.2 is detailed the Figure 4.1 but including more information about the different steps explained before.

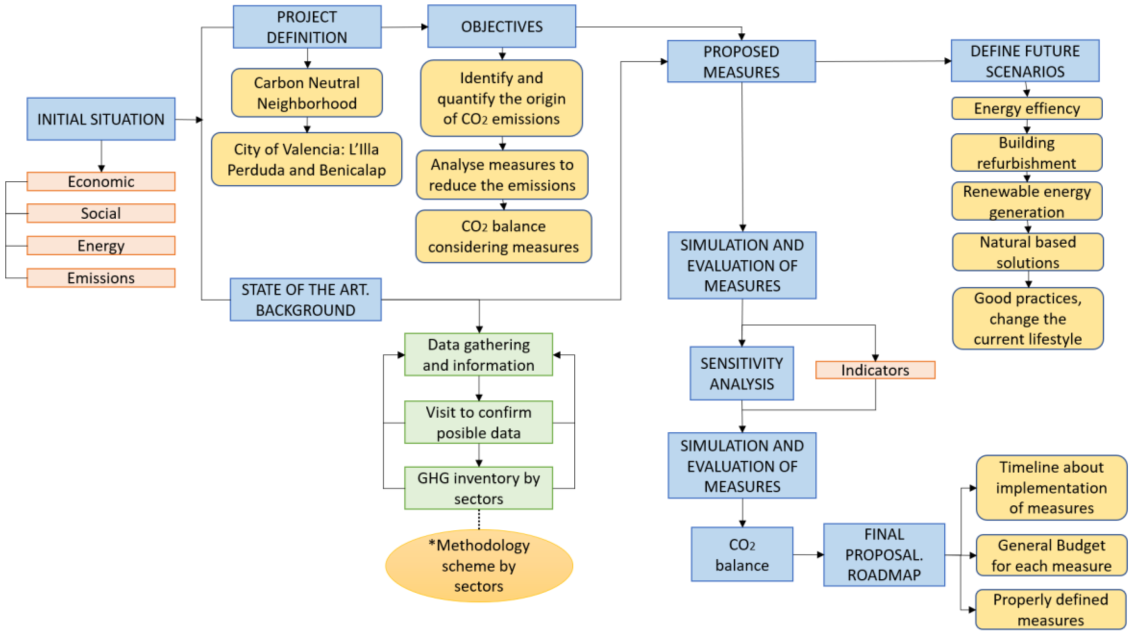

Figure 4.2 Detailed scheme of general procedure methodology.

4.2 GHG Inventory

The GHG Inventory has been developed in this work, dividing all the emissions emitted today in diverse groups to calculate this in detail. The groups included in this document are buildings (electricity and gas consumption), transport, consumption of goods, waste, and public lighting.

4.2.1 Building

To estimate the initial emissions coming from the operation of the different building it has been used the information of the total consumption of electricity and gas for the city of Valencia and after that, this data has been extrapolated to Benicalap and L'Illa Perduda using factors from Table 10.1 and Table 10.2.

The total consumption of the city of Valencia is presented in Table 4.1 [20].

Table 4.1 Total consumption in MWh in the city of Valencia for 2021.

Electricity consumption	2217453	MWh
Gas consumption	850045	MWh

Considering the mentioned factors, both neighborhoods' electricity and gas consumption has been detailed in Table 4.2.

Table 4.2 Total consumption in MWh in Benicalap for 2021.

	Benicalap		L'Illa Perduda	
Electricity consumption	116476,48	MWh	24093,84	MWh
Gas consumption	44650,44	MWh	9236,20	MWh

With the previous data, the yearly electricity and gas consumption has been estimated, but for a detailed study, daily data has been obtained from the platform Datadis [18]. This platform provides data on electrical consumption and the number of clients from the zip code area the user selects. The process carried out to obtain these values is included in Figure 4.3.

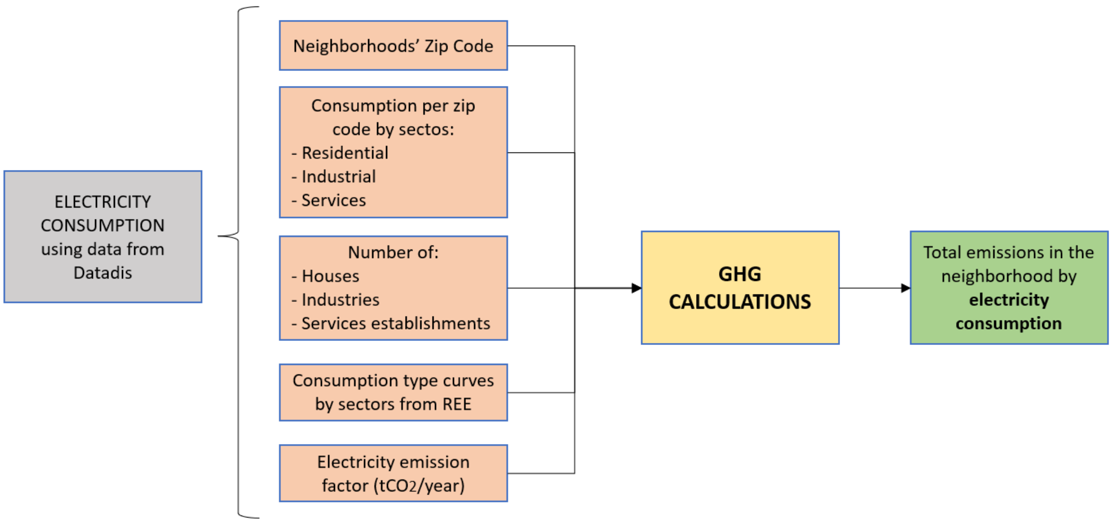

Figure 4.3 Scheme for electricity consumption calculations.

With the previous analysis developed with Datadis and explained in detail in 3.4 Datadis, the annual electricity consumptions by sectors are obtained and is detailed in 5.3.1 Building.

4.2.2 Transport

To calculate the emissions generated by the different means of transport, it has been divided in two groups: private transport and public transport. The scheme of the information used to calculate GHG emissions related with private transport is included in Figure 4.4 and with public transport in Figure 4.5.

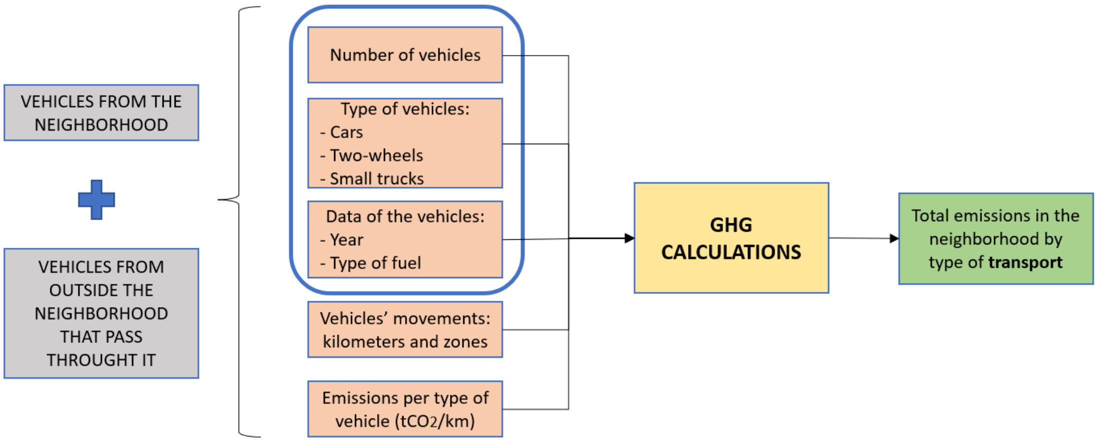

Figure 4.4 Scheme information used to calculate GHG emissions from private transport.

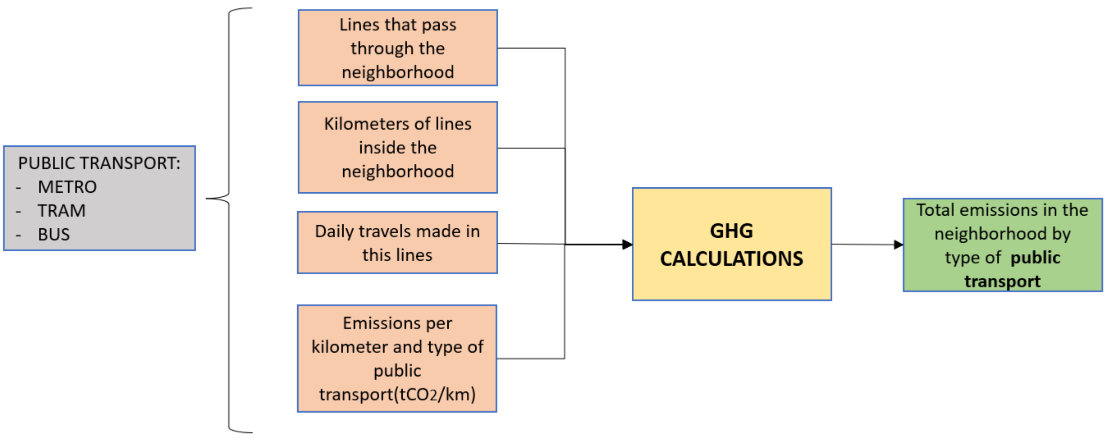

Figure 4.5 Scheme information used to calculate GHG emissions from public transport.

Private transport

To determine the current situation of private transport in the city of Valencia and, more specifically in Benicalap and L'Illa Perduda, the private vehicles will be small trucks, passenger cars, two-wheelers and bicycles.

To evaluate the emissions, first the number of each type of private transport in the city of Valencia was obtained from Dirección General de Tráfico (DGT) [23]. These vehicles are calculated in base of the European Regulation that groups the vehicles in various groups depending on the year of matriculation. In Table 4.3 is detailed the range of years that are included in each group.

Table 4.3 Range of years in the transport European Regulations [24].

	CARS	**MOTORCYCLE**
REGULATION	Years	Years
Pre Euro	<1992	<1999
Euro 1	1992-1995	1999-2002
Euro 2	1996-1999	2003-2005
Euro 3	2000-2004	2006-2015
Euro 4	2005-2009	2016-2019
Euro 5	2010-2014	>2020
Euro 6	>2015	

Based on that regulation, the data used to calculate the emissions has been:

- Total of each mean of transport vehicles grouped due to the regulation in each neighborhood.
- Total kilometers travelled for each vehicle depending on the type and year.
- Emissions per kilometer depending on the type and year of the vehicle.

The different calculations are detailed in annex F of Transport calculations for GHG inventory.

Another emission that should be considered due to the use of private transport is the ones coming from the vehicles that are not considered as private vehicles in the neighborhood but pass through it and emit GHG in the area.

These emissions have been calculated using the IMD (Intensidad Media Diaria de Vehículos) available for the main streets in Valencia in [25], the kilometer of each of these avenues and the general emissions per kilometer considered for this calculation.

The calculations of these emissions are detailed in annex F of Transport calculations for GHG inventory, and the final values of emissions of CO_2 are presented in 5.3.2 Transport.

Public transport

The public transport of the city of Valencia is composed by four main means of transport: seven metro lines, four tram lines, a wide range of bus lines, which will be detailed for each neighborhood analyzed, and Valenbisi service that is the bicycle-sharing service. The detailed data of this public transport calculations is in annex F Transport calculations for GHG inventory and the final results are detailed in 5.3.2 Transport.

In this case, the metro and tram system are only included in one of the neighborhoods studied, Benicalap, and the bus system is present in both neighborhoods. The activity of the public transport, including metro, tram and bus is calculated considering the distance of each of the lines that pass through the neighborhood, the number of trips performed per type of day, weekday, weekend, and holiday and the emissions related with each mean of transport.

Table 10.43, Table 10.44, Table 10.46 and Table 10.48 includes the total distance of the lines for both neighborhoods.

Valencia has a total of 2750 bicycles [26] divided into 277 stations in all the city and 5502 locking points. Based on the map of all the stations in the city, the bicycles in Benicalap are 66 in total and in L'Illa Perduda are 27.

4.2.3 Consumption of goods

The consumption of goods in society nowadays is very remarkable because it could be qualified as consumerist [27] and the purchase and use of a higher number of necessary goods supposes an increment in the CO_2 emissions related to these process that could be reduced implementing good practices in the consumption of goods. The goods considered in this inventory are food, clothes, and other manufactured products.

Table 4.4 details the yearly mean consumption per capita of Spain.

Table 4.4 Yearly mean consumption of food [28].

CONSUMPTION OF FOOD		
Oil:	9,26	kg/cap
Olives:	2,96	kg/cap
Rice:	5,05	kg/cap
Beverages:	152,23	kg/cap
Wine:	6,29	kg/cap
Cereals:	1,60	kg/cap
Cookies:	4,98	kg/cap
Coffee & infusions:	1,63	kg/cap
Beef:	3,98	kg/cap
Lamb:	1,40	kg/cap
Other meat:	40,67	kg/cap
Chocolate:	3,21	kg/cap
Fresh fruit:	86,40	kg/cap
Processed fruit & vegetables:	12,62	kg/cap
Dried fruit:	3,74	kg/cap
Fresh vegetables:	60,92	kg/cap
Egg:	8,59	kg/cap
Milk:	62,65	kg/cap
Dairy products:	33,45	kg/cap
Legumes:	3,39	kg/cap
Bread & pastry:	37,07	kg/cap
Flour:	2,55	kg/cap
Pasta:	4,51	kg/cap
Potato:	27,39	kg/cap
Fish:	21,37	kg/cap
Ready-to-eat:	15,05	kg/cap
Rest:	8,10	kg/cap

The previous inventory of food consumption is based on the "Informe del Consumo de Alimentación en España 2020" [28] where a total of 27 type of food categories were estimated for the Spanish society consumption.

To calculate the emissions produced by this consumption is necessary to consider the CO_2 emission factors for each previous item included. This information is included in Table 4.5. In the case of clothes and other manufactured products the information is directly included in annual tCO_2e/cap.

Table 4.5 Emissions by type of consumption per capita [29].

EMISSIONS BY TYPE OF CONSUMPTION:		
FOOD		
Oil:	0,00601	t CO_2e/kg
Olives:	0,00220	t CO_2e/kg
Rice:	0,00266	t CO_2e/kg
Beverages:	0,00063	t CO_2e/kg
Wine:	0,00200	t CO_2e/kg
Cereals:	0,00053	t CO_2e/kg
Cookies:	0,00053	t CO_2e/kg
Coffee & infusions:	0,00139	t CO_2e/kg
Beef:	0,02605	t CO_2e/kg
Lamb:	0,03384	t CO_2e/kg
Other meat:	0,00512	t CO_2e/kg
Chocolate:	0,00230	t CO_2e/kg
Fresh fruit:	0,00050	t CO_2e/kg
Processed fruit & vegetables:	0,00281	t CO_2e/kg
Dried fruit:	0,00142	t CO_2e/kg
Fresh vegetables:	0,00047	t CO_2e/kg
Egg:	0,00339	t CO_2e/kg
Milk:	0,00139	t CO_2e/kg
Dairy products:	0,00886	t CO_2e/kg
Legumes:	0,00066	t CO_2e/kg
Bread & pastry:	0,00098	t CO_2e/kg
Flour:	0,00098	t CO_2e/kg
Pasta:	0,00198	t CO_2e/kg
Potato:	0,00020	t CO_2e/kg
Fish:	0,00650	t CO_2e/kg
Ready-to-eat:	0,00522	t CO_2e/kg
Rest:	0,00251	t CO_2e/kg
CLOTHES	0,3	t CO_2e/cap
MANUFACTURED PRODUCTS	1,3	t CO_2e/cap

Combining the previous values, the CO_2 emissions per capita has been calculated and detailed in Table 4.6. To calculate the emissions related with consumption in both neighborhoods this value and the total population of each one has been considered.

Table 4.6 tCO_2 per capita and per year related to consumption of goods.

TYPE OF CONSUMPTION	tCO_2e/year (per capita)
Food	1,35
Clothes	0,3
Manufactured products	1,3

These total emissions for Benicalap and L'Illa Perduda are presented in 5.3.3 Consumption of goods.

4.2.4 Waste

Other emissions considered in this inventory are related to the generation and management of waste. First, the total waste generation in the neighborhoods per waste type has been identified and presented in Table 4.7. The data used to include these values is obtained from [20] and scaled to the neighborhoods using the downscaling factors from Table 10.1 and Table 10.2.

After that, it is necessary to divide the waste type into management categories. In this case, the categories considered has been landfilling, recycling, energy generation and composting [30], and the values of tons for each neighborhood are presented in Table 4.8, based on the percentage of each category [30].

Table 4.7 Annual waste generation in the neighborhoods per capita and in total.

TYPE OF WASTE	kg/cap	Tons in Benicalap	Tons in L'Illa Perduda
Municipal solid waste	323,44	13417,3	2775,4
Organic	26,94	1117,6	231,17
Glass	16,40	680,52	140,77
Paper	22,43	930,46	192,47
Plastic and light packaging	17,41	722,22	149,40
Vegetal oil	0,04	1,66	0,34
Batteries	0,003	0,13	0,03
TOTAL	406,67	16869,8	3489,6

Table 4.8 Amount of waste divided by waste management category.

	%	Tons in Benicalap	Tons in L'Illa Perduda
Landfilling	56,70%	9565,2	1978,6
Recycling	18,30%	3087,2	638,60
Energy generation	13,50%	2277,4	471,10
Composting	11,50%	1940	401,31

Considering the previous values, and the emission factors for each type of waste management category the total emissions associated with waste generation and management are detailed in Table 4.9 the total emissions have been calculated and are detailed in 5.3.4 Waste.

Table 4.9 Emissions associated with waste management by categories.

	tCO_2e/t_{waste}
Landfilling	0,27
Recycling	0,042
Energy generation	-
Composting	0,038

It is important to consider the emissions that are included in each of the waste management category:

- Recycling: transport to recycling facility and sorting of recycled materials at material recovery facility.
- Landfilling: include transport to landfills, equipment uses at landfills, and fugitive landfill CH_4 emissions. Landfill CH_4 is based on typical landfill gas collection practices and average landfill moisture conditions.
- Composition: include transport to composting facility, equipment uses at composting facility and CH_4 and N_2O emissions during composting.

4.2.5 Public Lighting

The public lighting installed in streets, gardens, parks, monuments, and other public elements are responsible of a part of the CO_2 emissions from the neighborhoods.

Based on the Valencia City Hall [21], the total electricity consumption from public lighting is known and detailed in Table 4.10.

Table 4.10 Characteristics of the public lighting in the city of Valencia.

PUBLIC LIGHTING IN THE CITY OF VALENCIA	
Point of light	101858
Consumption (MWh)	36715

Also, this analysis and data is included in this source [20], divided in the different districts of the city of Valencia, in this case the ones that interest are Benicalap and Algirós, which data is included in Table 4.11.

Table 4.11 Characteristics of the public lighting in the district of Benicalap and Algirós.

DISTRICT	BENICALAP	ALGIRÓS
Point of light	4002	4503
Consumption (MWh)	2025	1912

To adapt these values of the district to the selected neighborhoods, the downscaling factors from Table 10.3 and Table 10.4 respectively for Benicalap and L'Illa Perduda has been considered, in this case the factors used and being more adequate due to the type of distribution of public lighting has been the area. The final data of consumption and emissions for both district is detailed in point 5.3.5 Public Lighting.

5 CASE STUDY BENICALAP AND L'ILLA PERDUDA

5.1 Presentation of Benicalap and L'Illa Perduda"

The methodology developed in this study will be applied to the neighborhoods of Benicalap and L'Illa Perduda in the Spanish city of Valencia. These two neighborhoods are included in two different districts of the nineteen that compose this city. The districts are Benicalap and Algirós, respectively.

5.1.1 Benicalap

Benicalap is the biggest neighborhood of the district with the same name that is composed together with the neighborhood of Ciudad Fallera. This area is in the north of the city of Valencia, and its general data is included in Table 5.1. The geographical location of this neighborhood is represented in Figure 5.1.

Table 5.1 Basic data of Benicalap [31].

Population (number on inhabitants)	41483
Surface (km^2)	1,72
Density of population (inhab/km^2)	24132

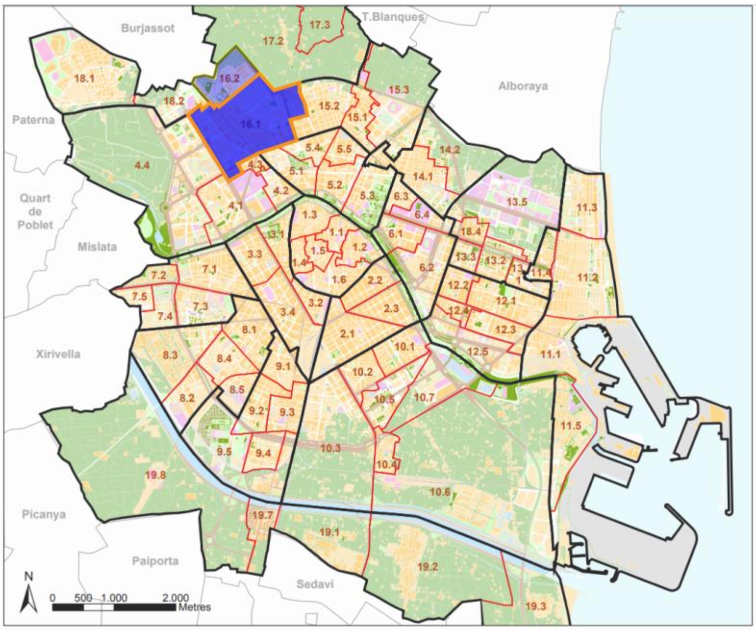

Figure 5.1 Geographical location of Benicalap. Modified from [32].

It is important to evaluate and analyze the initial situation of the different neighborhoods to been able to transform the area in a carbon neutral neighborhood proposing different measures adapted to the characteristics of the neighborhood and study the evolution of the initial situation until the final situation. For this purpose, the social, economic and energy aspect will be analyzed and summary.

Social situation

The social situation of Benicalap is defined on the base of Figure 5.2 and Figure 5.3. In contrast with L'Illa Perduda, Benicalap has an average age lower where it is a high percentage of people in the range of 10 to 34 years despite the range of age with more people is from 40 to 50 years. Related to the educational level a 40% of the working population has a high school degree, and a 35% a school graduates or equivalent.

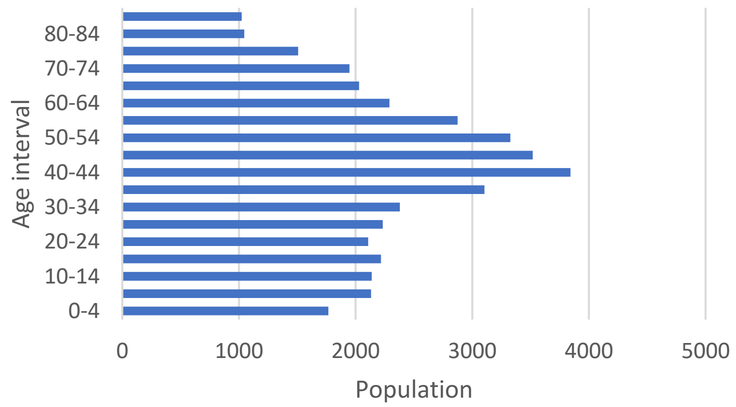

Figure 5.2 Age distribution of the population of Benicalap.

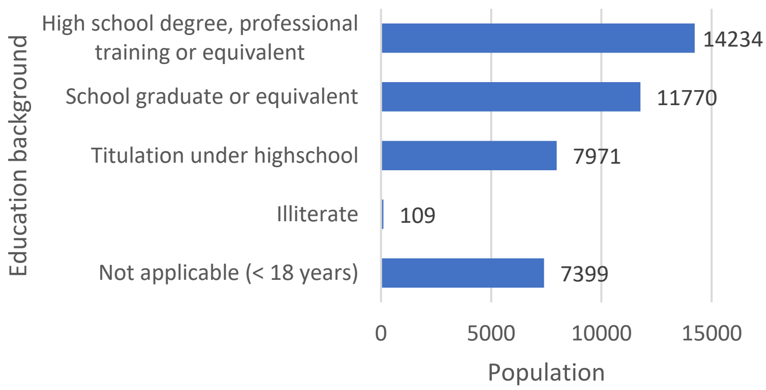

Figure 5.3 Education background of the population of Benicalap.

Economic situation

The economic system in Benicalap is based on the services sector, followed by professional activities and construction, as detailed in Figure 5.4.

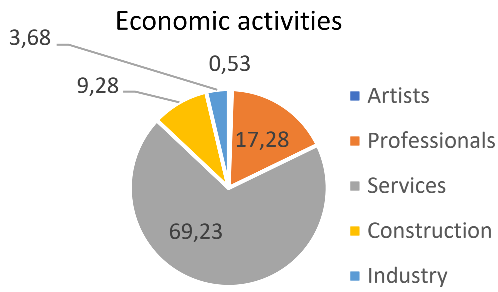

Figure 5.4 Distribution of economic activities in Benicalap.

Regarding the characteristics of the houses in the neighborhood, Figure 5.5 presents the year of construction of these buildings, being the majority age range from 1961-1980. The total number of houses in Benicalap is 18968, and the total number of buildings that holds all the houses is 1053.

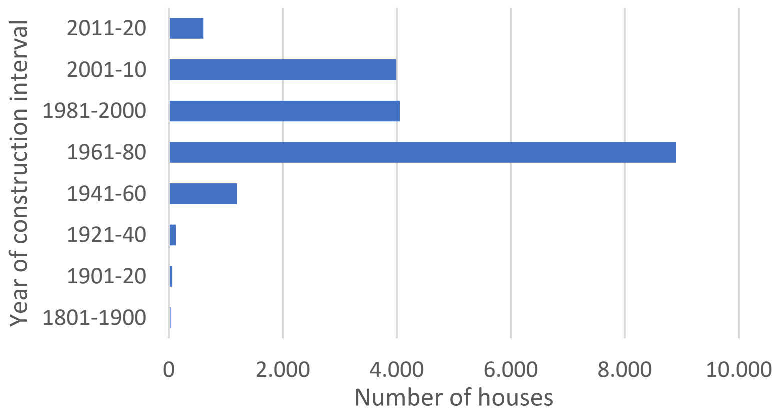

Figure 5.5 Number of houses due to its age in Benicalap.

Energy situation

The energy situation in Benicalap is represented in the electricity consumption in Figure 5.6 and the gas consumption is around 44650,44 MWh. The higher consumption in terms of electricity is the residential sector, followed by the services sector, the second sector in economic activities, and finishing with the industrial sector.

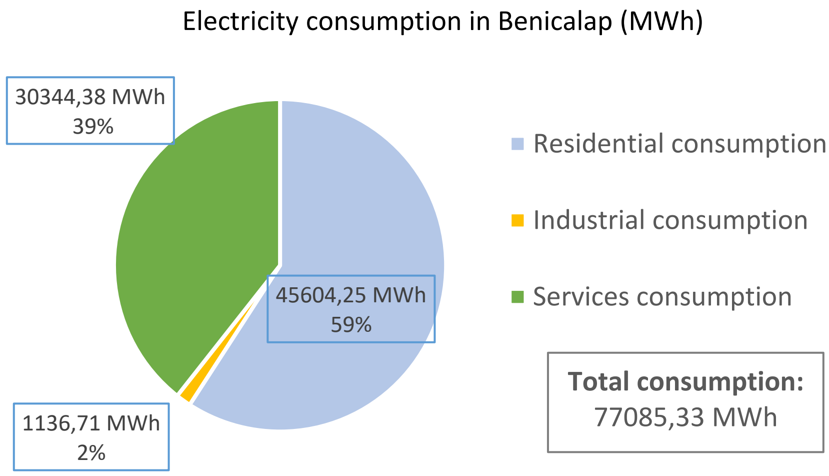

Figure 5.6 Electricity consumption in Benicalap by sectors.

5.1.2 L'Illa Perduda

L'Illa Perduda is one of the five neighborhoods that conform to the district of Algirós, which is represented in Figure 5.7. It is one of the smallest neighborhoods in the district, with a surface of 23 Ha. The general data of the neighborhood is included in Table 5.2.

Table 5.2 Basic data of L'Illa Perduda [31].

Population (inhab)	8581
Surface (km^2)	0,23
Density of population (inhab/km^2)	36987

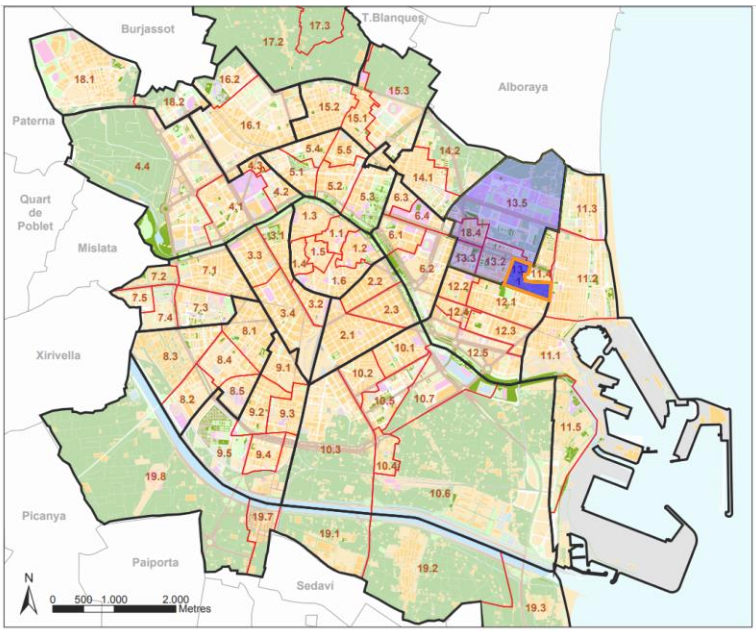

Figure 5.7 Geographical location of L'Illa Perduda. Modified from [32].

Social situation

The first data analyzed for L'Illa Perduda is the social characteristics of the population that live in this area of the city. As it is presented in Figure 5.8 and Figure 5.9, population is concentrated in the range of age from thirties to seventies and it is important to emphasize that 45% of people in age of working have a high school degree or equivalent.

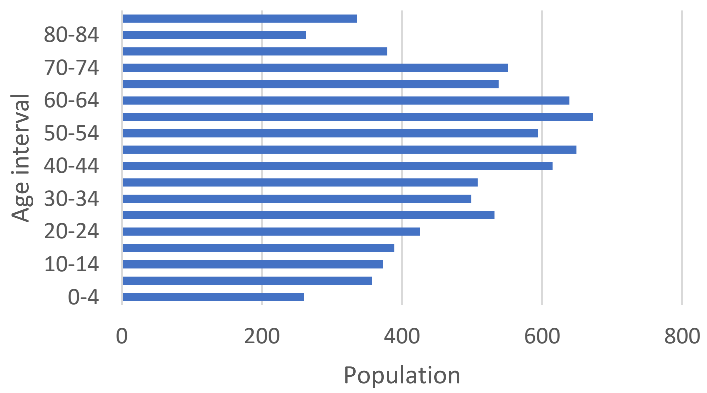

Figure 5.8 Age distribution of the population of L'Illa Perduda.

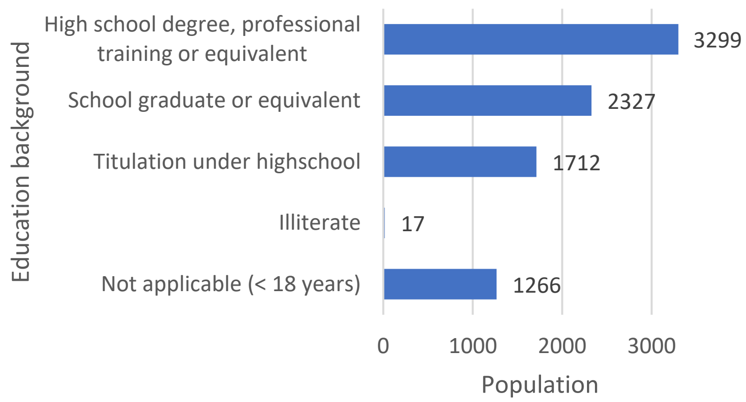

Figure 5.9 Education background of the population of L'Illa Perduda.

Economic situation

As shown in Figure 5.10, more than 70% of the people in the neighborhood work in the services sector.

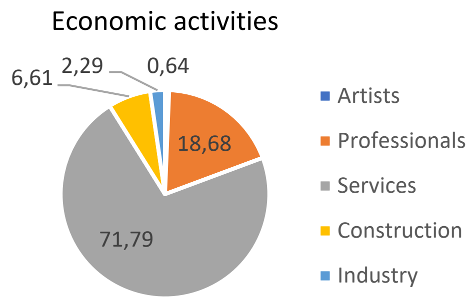

Figure 5.10 Distribution of economic activities in L'Illa Perduda.

Searching for the information about the years of construction of the buildings of this neighborhood the data obtained is included in Figure 5.11 and the predominant year of construction is between 1961 and 1980. The total number of houses in L'Illa Perduda is 4194 and the total number of buildings that holds all the houses is 155.

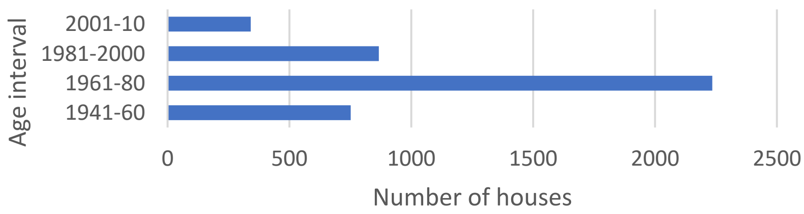

Figure 5.11 Number of houses due to its age in L'Illa Perduda.

Energy situation

The energy situation in L'Illa Perduda is represented in terms of electricity consumption in Figure 5.12 and the gas consumption is around 9236,2 MWh.

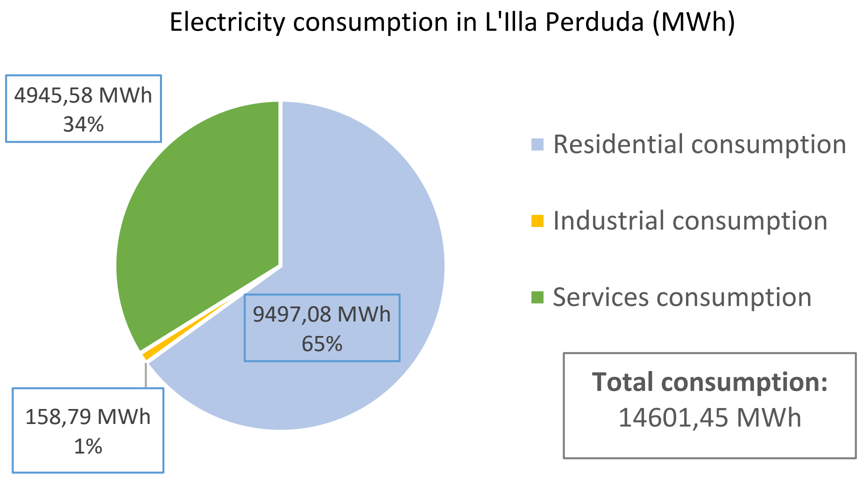

Figure 5.12 Electricity consumption in L'Illa Perduda by sectors.

5.2 Justification of the selection of this neighborhood

The choice of the neighborhood has been carried out by analyzing different criteria about technical, urban, environmental, economic, and social aspects such as the renewable energy resources, the annual thermal and electricity consumption, the total green areas, the GHG emissions, the fuel poverty, etc. for different neighborhoods of the city.

For the specific case of the city of Valencia, it is based on [33] the different zones are evaluated based on several criteria grouped in fifth different aspects mentioned, selected to evaluate the potential of the different districts about the ability to been transformed into a carbon neutrality area. For all these criteria, some of them has been selected for a group of experts and are evaluated in the different zones to obtain the results. These final criteria selected has been renewable energy potential, energy efficiency potential, renewable energy resources, annual thermal and electricity consumption, area of public buildings, green areas, mobility, GHG emissions, air pollution, investment, current projects, interest, community organization, cooperative projects, urban sustainable initiatives, fuel poverty and population. Considering these variables and the data available for each district for the analysis of each one, a value of CN potential has been calculated.

In this work the area of Benicalap is proposed as one of the most outstanding districts for the location of a Carbon Neutral District (CND), so it is probably more achievable to develop a type of this new neighborhood in Benicalap (in blue) than in L'Illa Perduda (in orange) that is classified with a medium position between all the districts in Valencia as presented in Figure 5.13.

The difference between the methodology presented in [33] and the one developed in this work is that this previous one is based on statistical data used to determine a score for each of the criteria, for example, in the case of quantifying the carbon neutral potential regarding green zones, a graph with the area of green zones of each district is available. Based on this data, a score is determined for each district and, in the same way, with other data for the rest of the criteria. In contrast, the methodology explained in this work is more detailed, started knowing a previous idea about the carbon neutral potential of one district compared to the other ones from the mentioned document [33], that gives a normalized score and not shows detailed data about this carbon neutral potential; a very detailed analysis has been developed with specific numbers for each neighborhood selected. This analysis includes the realization of the GHG inventory, the implementation of measures to reduce these emissions, and confirming if the initial decarbonization potential estimated by the previous document is in the right way. But to assess the conclusion of that document, it will be necessary to develop this method in the rest of the neighborhood or district to compare the results.

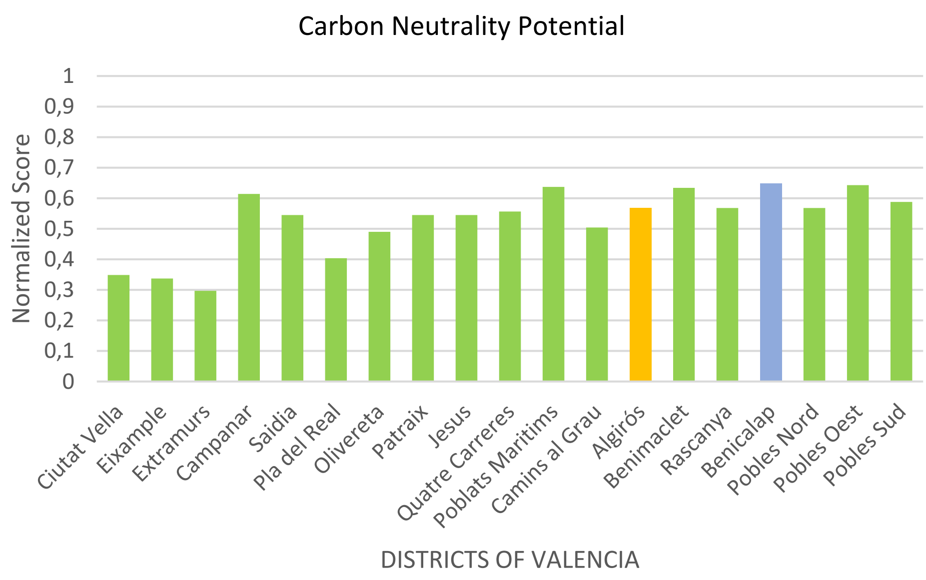

Figure 5.13 Carbon neutral potential in the district of Valencia, based on [33].

Each criteria allows to identify the districts' strengths and weaknesses in the different areas and propose measures to improve or maintain the negative and positive characteristics.

The values of these indicators and other ones considered to calculate the CND potential are included in Figure 5.14.

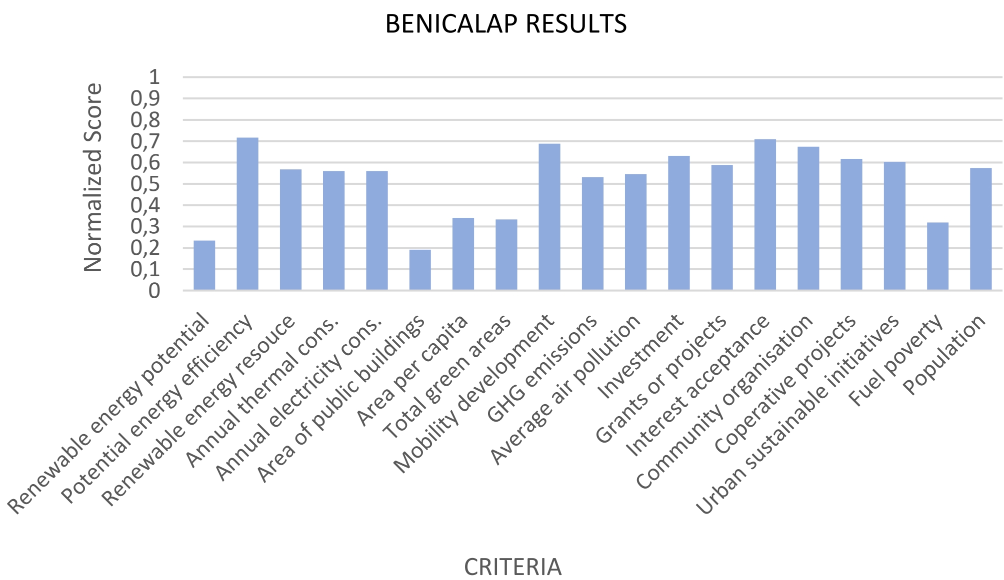

Figure 5.14 Evaluation of the different criteria for the district of Benicalap, based on [33].

In the case of Benicalap, it is a neighborhood characterized by the high potential for improving the energy efficiency of buildings and activities and for its low potential of renewable energy resources. Related to urban areas, it has a low area of green zones and public buildings related to other neighborhoods. About the social aspect, the indicator of fuel poverty is in the medium of the city of Valencia.

In the case of l'Illa Perduda, one of the neighborhoods inside the district of Algirós there is a bigger potential of renewable resources than in Benicalap and the fuel poverty level is lower than in most neighborhoods, as shown in Figure 5.15.

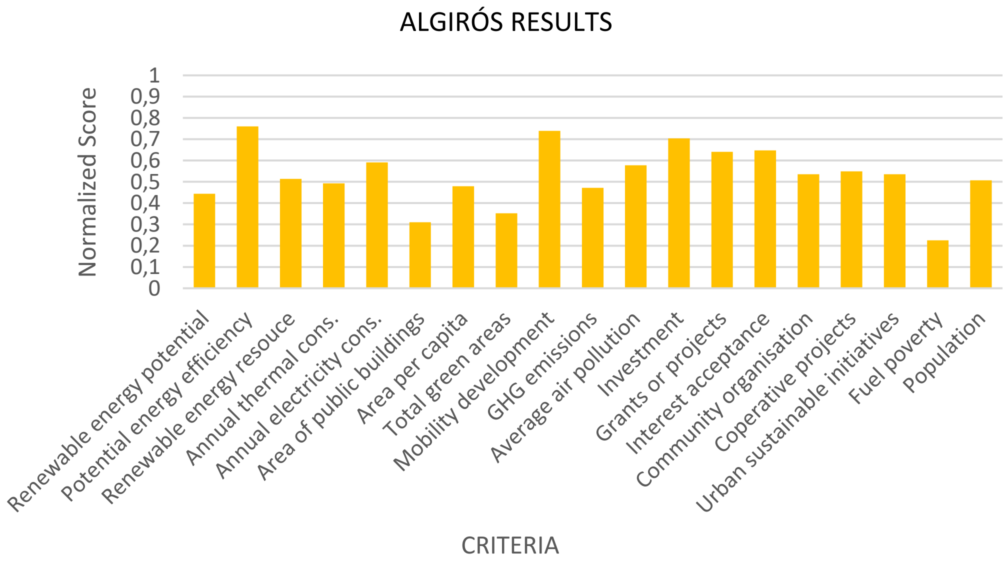

Figure 5.15 Evaluation of the different criteria for the district of Algirós, based on [33].

5.3 GHG Inventory results

The GHG inventory methodology for Benicalap and L'Illa Perduda is detailed in section 4.2 GHG Inventory. In this section the results obtained from data of the point mentioned and the summary of the GHG emissions including the emissions of all the CO_2 emissions by sectors and scopes of emissions will be presented.

5.3.1 Building

The final values of electricity consumption for both neighborhoods are included in Table 5.3.

Table 5.3 Electricity consumption in Benicalap and L'Illa Perduda.

Electricity consumption by sectors (MWh/year) in Benicalap			
Residential	Industry	Services	Total
45604,25	1136,71	30344,38	77085,33
Electricity consumption by sectors (MWh/year) in L'Illa Perduda			
Residential	Industry	Services	Total
9497,08	158,79	4945,58	14601,45

5.3.2 Transport

Private transport

The values of emissions coming from private vehicles are detailed in Table 5.4 and

Table 5.5.

Table 5.4 Private vehicle emissions in Benicalap.

Private vehicles inside Benicalap	18641,47	tCO_2e
Private vehicles from outside Benicalap but passing through it	15580,17	tCO_2e
TOTAL	**34221,17**	**tCO_2e**

Table 5.5 Private vehicles emissions in L'Illa Perduda.

Private vehicles inside L'Illa Perduda	1928,05	tCO_2e
Private vehicles from outside L'Illa Perduda but passing through it	2563,16	tCO_2e
TOTAL	**4491,21**	**tCO_2e**

Public transport

Table 5.6 presents the emissions results obtained for public transport in both neighborhoods.

Table 5.6 CO_2 emissions from public transport.

Benicalap	3367,65	tCO_2e/year
L'Illa Perduda	169,08	tCO_2e/year

5.3.3 Consumption of goods

The total emissions produced by the types of consumption for Benicalap and L'Illa Perduda are presented in Table 5.7. These values of emissions are obtained by combining the data from Table 4.6 and the number of people living in the neighborhood from Table 5.2 and Table 5.1.

Table 5.7 CO_2 emissions from Benicalap and L'Illa Perduda due to consumption of food, clothes, etc.

TYPE OF CONSUMPTION	BENICALAP (tCO_2e/year)	L'ILLA PERDUDA (tCO_2e/year)
Food	56042,3	11592,7
Clothes	12444,9	2574,3
Manufactured products	53927,9	11155,3
TOTAL	**122415,1**	**25322,3**

5.3.4 Waste

The total emissions related to waste management are presented in Table 5.8.

Table 5.8 Emissions associated with waste management in Benicalap and L'Illa Perduda.

	tCO_2e/year in Benicalap	tCO_2e/year in L'Illa Perduda
Landfilling	2582,6	534,23
Recycling	129,66	26,82
Energy generation	0,00	0,00
Composting	73,72	15,25
TOTAL	**2786**	**576,3**

5.3.5 Public Lighting

The characteristics of public lighting for both zones are detailed in Table 5.9. Also, the emissions associated with this electricity consumption are included in this table using the electricity emission factor to calculate this from Table 10.5.

Table 5.9 Characteristics of the public lighting in Benicalap and L'Illa Perduda and its associated CO_2 emissions.

NEIGHBORHOOD	BENICALAP	L'ILLA PERDUDA
Point of light	3306	354
Consumption (kWh)	1568219,7	150393
CO_2 emissions (tCO_2e)	269,73	25,87

5.3.6 Summary of GHG emissions inventory

Being presented all the calculations for the different sectors of the GHG inventory developed and considered for this work, one of the main steps to have a vision of the initial situation of the neighborhoods is to sum up the values of all emitting sectors and analyze the impact of each one in the global emissions inventory.

In Figure 5.16 is detailed the percentage that each sector represents to the global GHG inventory for the neighborhood of Benicalap and in Figure 5.17 the same data for the neighborhood of

L'Illa Perduda and the Table 5.10, detail the total emissions represented in these figures for both neighborhoods.

Table 5.10 Total CO_2 emissions divided by sectors of emissions in Benicalap and L'Illa Perduda.

	tCO_2e in Benicalap	%	tCO_2e in L'Illa Perduda	%
Private and commercial transport	33127,88	17,97%	4378,08	12,53%
Electricity. Residential sector (tCO_2)	7843,93	4,25%	1633,50	4,68%
Electricity. Industry sector (tCO_2)	195,51	0,11%	27,31	0,08%
Electricity. Services sector (tCO_2)	5219,23	2,83%	850,64	2,43%
Gas	8974,74	4,87%	1856,48	5,31%
Solid urban waste management	2785,98	1,51%	576,30	1,65%
Public and municipal transport	3367,64	1,83%	169,08	0,48%
Municipal buildings, equipment and facilities	179,94	0,10%	95,87	0,27%
Public lighting	269,73	0,15%	25,87	0,07%
Consumption of goods	122415,13	66,39%	25322,28	72,48%
TOTAL (tCO_2e)	**184379,72**	100,00%	**34935,40**	100,00%

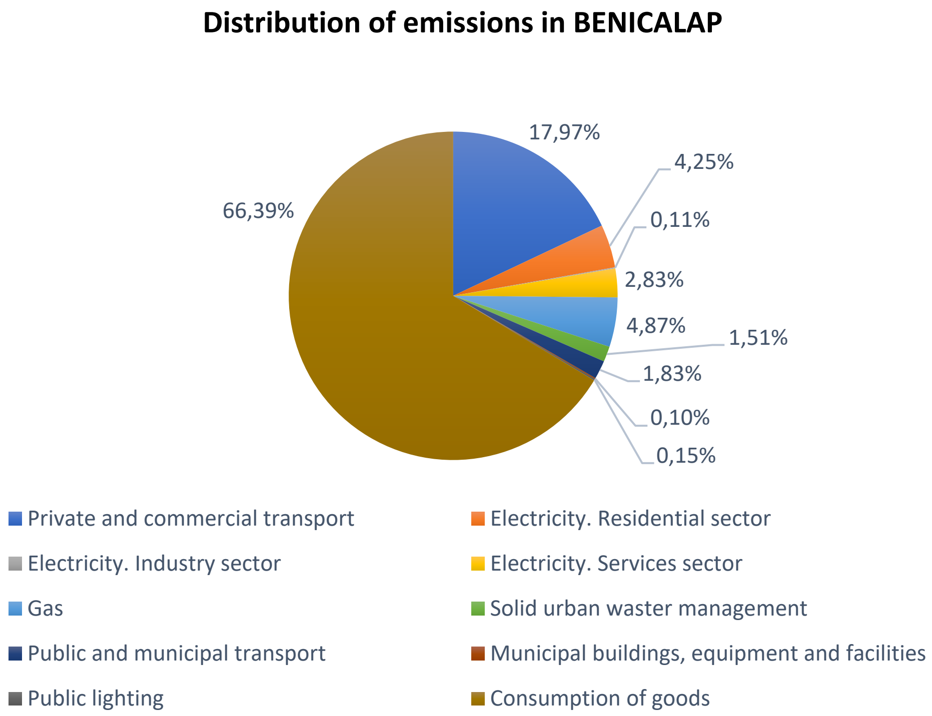

Figure 5.16 Summary of GHG inventory for Benicalap.

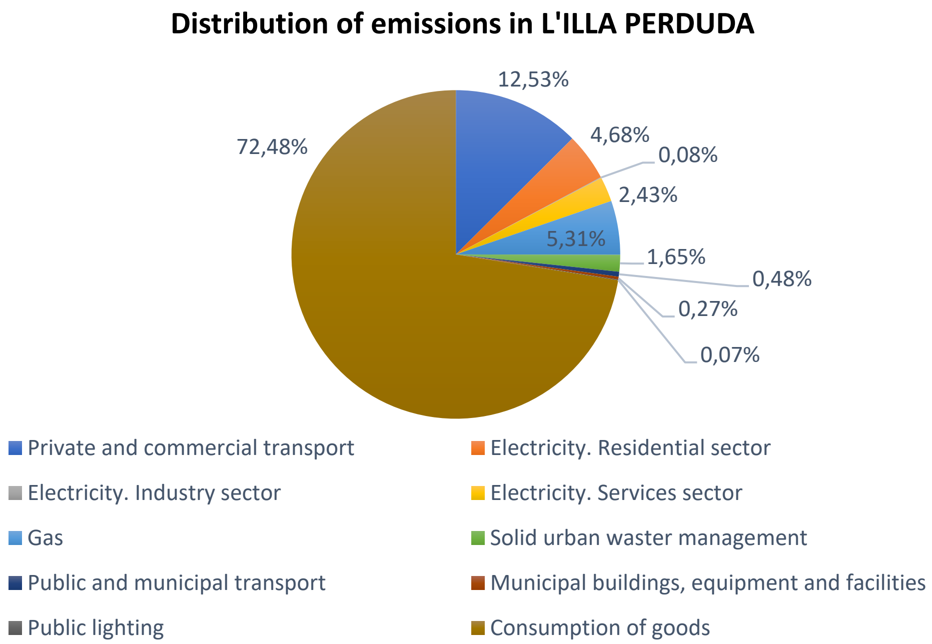

Figure 5.17 Summary of GHG inventory for L'Illa Perduda.

Comparing the percentages obtained for both cases, they are very similar, with small differences related with the characteristics of the neighborhoods, but the sectors that contribute in a higher way with the GHG emissions are the one related with consumption of goods (66,39% for Benicalap and 72,48% for L'Illa Perduda), followed by the correspondent with buildings and private transport (17,97% for Benicalap and 12,53% for L'Illa Perduda), that are the bigger issuers without considering the scope 3.

Considering that the measures proposed in this work has been focused on scopes 1 and 2, the next graphs Figure 5.18 and Figure 5.19 with the percentages of emissions only considering scopes 1 and 2 for Benicalap and L'Illa Perduda are presented.

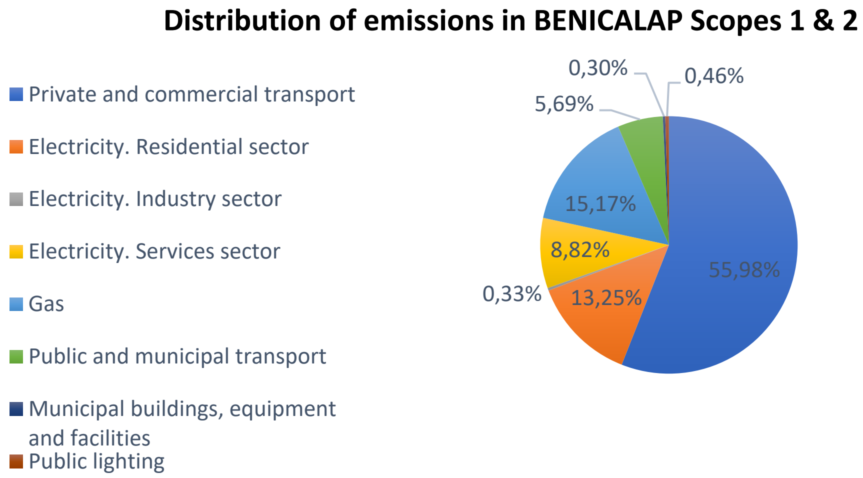

Figure 5.18 Summary of GHG inventory for Benicalap for scopes 1 and 2.

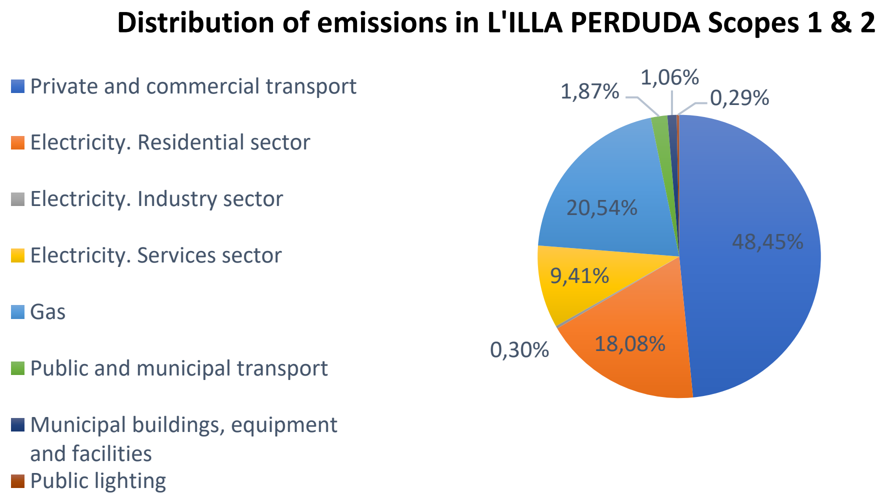

Figure 5.19 Summary of GHG inventory for L'Illa Perduda for scopes 1 and 2.

It is interesting to analyze the emissions by dividing the three scopes of emissions previously explained, in Table 5.11 and Table 5.12 the emissions divided in scope 1, scope 2 and scope 3 are presented, and the total percentages of each of this type of emissions is included in Figure 5.20 and Figure 5.21.

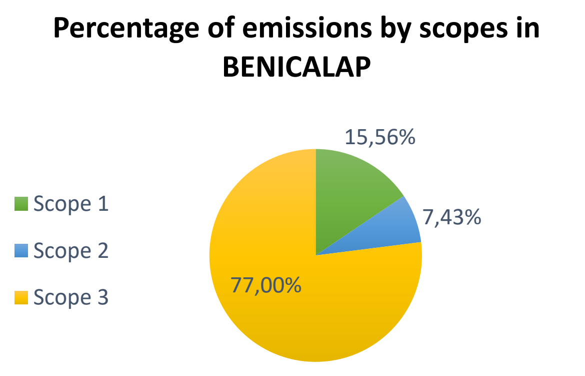

Figure 5.20 CO_2 Emissions divided by scopes in the neighborhood of Benicalap.

Table 5.11 Emissions inventory (tCO_2e) divided in the three scopes of emissions for Benicalap.

	Scope 1	Scope 2	Scope 3	TOTAL	%
Private and commercial transport	17547,71		15580,17	33127,88	17,97
Electricity. Residential sector		7843,93		7843,93	4,25
Electricity. Industry sector		195,51		195,51	0,11
Electricity. Services sector		5219,23		5219,23	2,83
Gas	8974,74			8974,74	4,87
Solid urban waste management			2785,98	2785,98	1,51
Public and municipal transport	2168,60		1199,04	3367,64	1,83
Municipal buildings, equipment and facilities		179,94		179,94	0,10
Public lighting		269,73		269,73	0,15
Consumption of goods			122415,13	122415,13	66,39
TOTAL	28691,05	13708,35	141980,32	**184379,72**	
%	15,56	7,43	77		

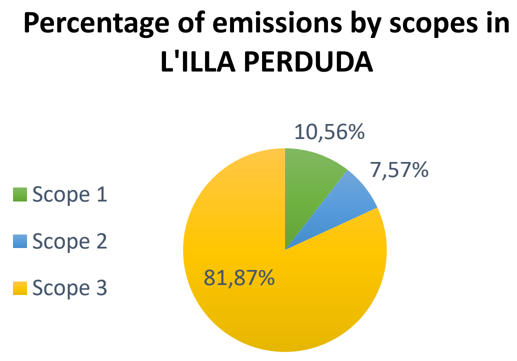

Figure 5.21 Emissions divided by scopes in the neighborhood of L'Illa Perduda.

Table 5.12 Emissions inventory (tCO_2e) divided in the three scopes of emissions for L'Illa Perduda.

	Scope 1	Scope 2	Scope 3	TOTAL	%
Private and commercial transport	1814,92		2563,16	4378,08	12,59
Residential sector		1633,50		1633,50	4,70
Industry sector		27,31		27,31	0,08
Services sector		850,64		850,64	2,45
Gas	1856,48			1856,48	5,34
Solid urban waste management			576,30	576,30	1,66
Public and municipal transport				0,00	0,00
Municipal buildings, equipment and facilities		95,87		95,87	0,28
Public lighting		25,87		25,87	0,07
Consumption of goods			25322,28	25322,28	72,84
TOTAL	3671,40	2633,19	28461,74	**34766,33**	
%	10,56	7,57	81,87		

Considering these values of emissions distributed in sectors, the future measures proposed to be implemented and that will contribute to reduce these emissions will be developed taking this into account and being aware of the impact that this will produce in the final GHG situation.

5.4 Development of defined lines to achieve carbon neutrality

Having developed the GHG inventory of the current emissions, the objective of this project is to propose different measures to reduce carbon emissions and approach to carbon neutrality.

5.4.1 NATURAL BASED SOLUTIONS

First, it is necessary to expose what Natural Based Solutions (NBS) are. As indicated in [34], NBS are means of bringing nature back into cities, following the example of natural ecosystems and achieving environmental, social, and economic benefits to improve urban sustainability.

Another aspect to consider in the analysis of natural solutions is the type of urban areas in which the project is proposed. Due to [35], the different zones are grouped in types depending on a variety of characteristics as land use, the type of buildings, etc. The urban zones are classified in urban zones with high density, urban zones with low density, urban zones of community equipment and new development urban zones. Considering the characteristics of Benicalap and L'Illa Perduda both neighborhoods can be considered as urban zones with high density that have a high surface occupied by buildings and a low surface with vegetal zones, been in the majority, alone trees or small garden. The recommendation in a wide range of studies, such as [35] and [36], in these type of zones is to increase the vegetation in buildings, focusing on court blocks, terraces, roofs, and facades. In the case of Benicalap, an area in the north of the neighborhood can be included in the group of urban zones with low density because the area of green zones is higher than in the rest. And the plan in this area is to increase the density of the current green zones with autochthonous species, apart from create new green zones in free spaces.

To propose a solution based on natural solutions, it is necessary to determine the base and current situation of this solution in the neighborhoods.

Using the Geoportal of the city of Valencia [37] there is one section with information about the green zones in this city, including the name of the green zone, the neighborhood which it belongs and the surface in square meters. Working with this date it is possible to calculate the total green zone area of one neighborhood, in case of Benicalap and L'Illa Perduda the total surface is included in Table 5.13.

In the case of Benicalap there is a total of 39 green zones in all the areas, including parks, gardens, green zones in sidewalks, etc., as included in the map in Figure 5.22. The total area that covers these zones is 135228 m^2, representing 7,87% of the entire surface of the neighborhood.

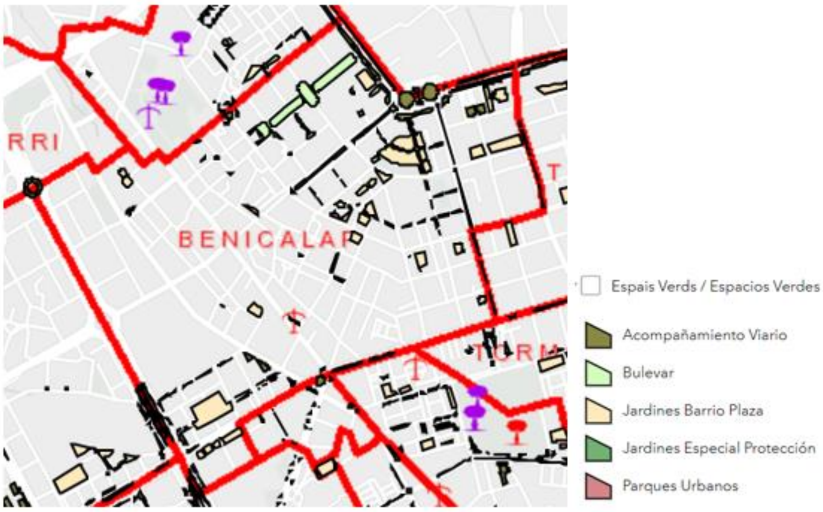

Figure 5.22 Current Green Zone in Benicalap [37].

In L'Illa Perduda, there is a total of 9 green zones in all the area, including all the types of green zones mentioned in the case of Benicalap and detailed in Figure 5.23. The total area that covers these zones is 49233 m^2, representing 21,22% of the total surface of the neighborhood. Compering this number, the ratio of green zones in L'Illa Perduda is higher than in Benicalap, which implies that in the initial situation, L'Illa Perduda presents an absorption potential related to natural zones better than Benicalap.

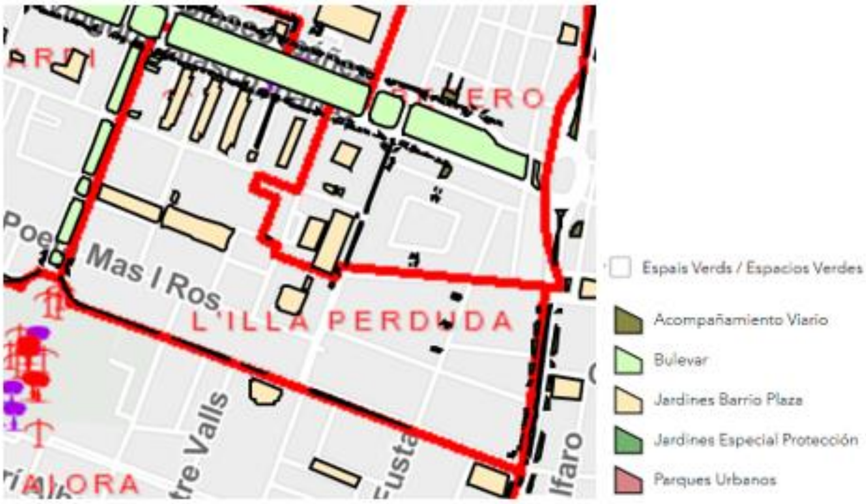

Figure 5.23 Current Green Zones in L'Illa Perduda [37].

Considering the previous green area and in the base of data from the chapter about environmental data of the Ayuntamiento de Valencia [20] it is possible to estimate the different types of trees that are planted in the green zones considering the surface in each neighborhood compared with the total surface of the city. Using this trees inventory and the CO_2 absorption factor for each tree and the age of each one it is possible to estimate the absorption potential of the green zones in Benicalap and L'Illa Perduda. But considering that it is not easy, and the data is not available about the age of the plants, this potential has been calculated using an absorption factor calculated for the green zones in the city of Valencia [38].

Due to [38] the abortion factor for the green zones in Valencia is 1,58 tons of CO_2e/ha. Considering the green area surfaces calculated in Table 5.13, the value of the absorption of CO_2 in Benicalap and L'Illa Perduda is possible to calculate and is expressed in Table 5.13.

Table 5.13 Green surface in the neighborhoods studied and CO_2 absorption factor.

Neighborhood	Green surface (m^2)	% Green zones	Current CO_2 absorption (tCO_2e/year)
Benicalap	135228	7,87	21,37
L'Illa Perduda	49233	21,22	7,78

Analyzing the initial situation of green areas in the neighborhoods is necessary to quantify two different concepts, first of all the increase of CO_2 absorption in the next years for the present inventory and considering that in the future, these green zones won't be extended. This is necessary because the older the trees, the more CO_2 absorption factor it has. And in second place, it is crucial to identify the potential green zones in the neighborhood and estimate the absorption potential when these green areas are developed.

To estimate the increase of CO_2 absorption in current green zones of the neighborhoods situated in Valencia and considering that the data available is the CO_2 absorption value for the green zones as a whole [39], but not divide this value according to the different species presented and also considering that it is available [20] the quantity and type of vegetation that exist in the city of Valencia, the following calculation has been carried out.

The process starts searching for the curve of the variability of accumulated absorption for the more common vegetation in Valencia (Figure 5.24) and based on that, suppose a tendential curve for the green zones considered as a group, pondering the value of the curve of each tree depending on the percentage of this tree respect to the total trees in Valencia. The data of the tendential curve is obtained from one study developed by the MITECO and the National Forest Inventory [39].

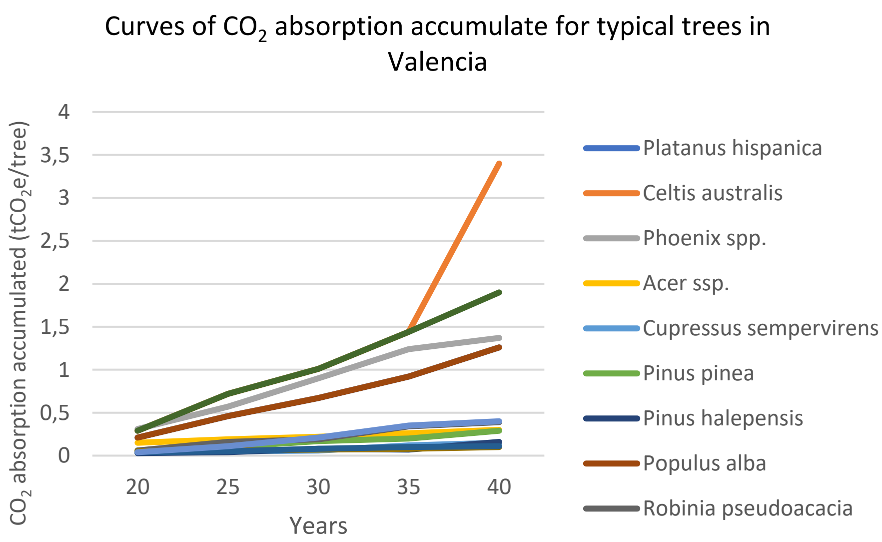

Figure 5.24 CO_2 absorption accumulated curve. Based on [34].

Considering the previous curve and using an exponential tendency curve, all the values for the different years have been calculated to estimate the curve for all the years from zero to forty years for the green zones (Figure 5.25).

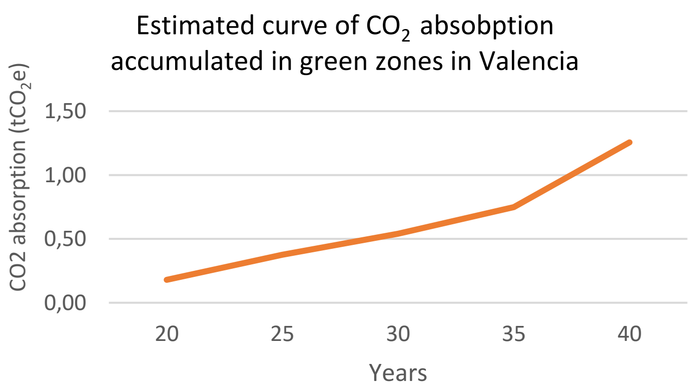

Figure 5.25 CO_2 absorption curve in green zones in Valencia.

Based on these values and considering that the values calculated and included in Table 5.13 are calculated for a period of 15 years, the CO_2 absorption for these values is in year 15 in the CO_2 curve.

The results obtained for the next years considering only the current green zones in both neighborhoods, are included, and graphed in Figure 5.26 and Figure 5.27. The data presented in the figures is the accumulated CO_2 absorption, the mean value of CO_2 absorbed per year in Benicalap is 5,2 tCO_2e/year, and in a range between 2,2 and 10,2 tCO_2e/year and in L'Illa Perduda the mean value of CO_2 absorbed per year is 1,8 tCO_2e/year, and in a range between 0,8 and 3,5 tCO_2e/year.

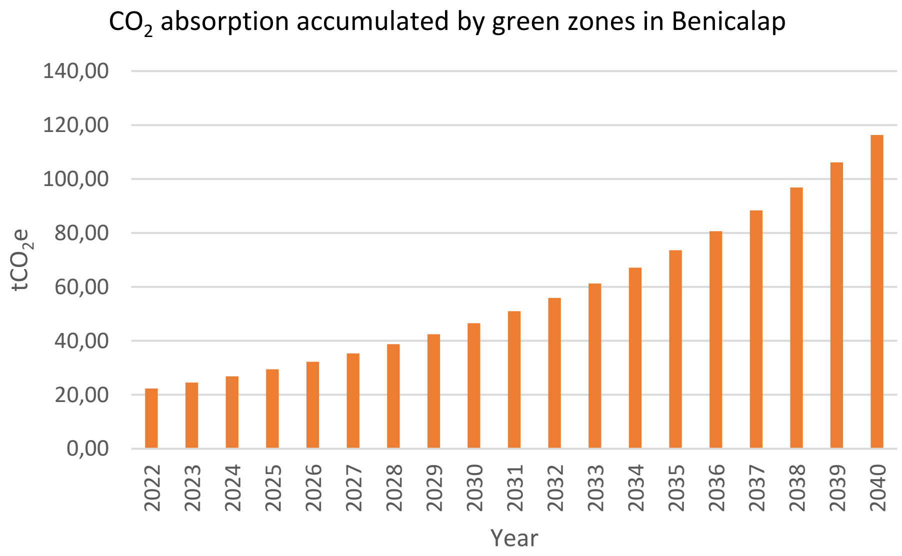

Figure 5.26 Tons of CO_2 accumulated by current green zones in Benicalap in the next years.

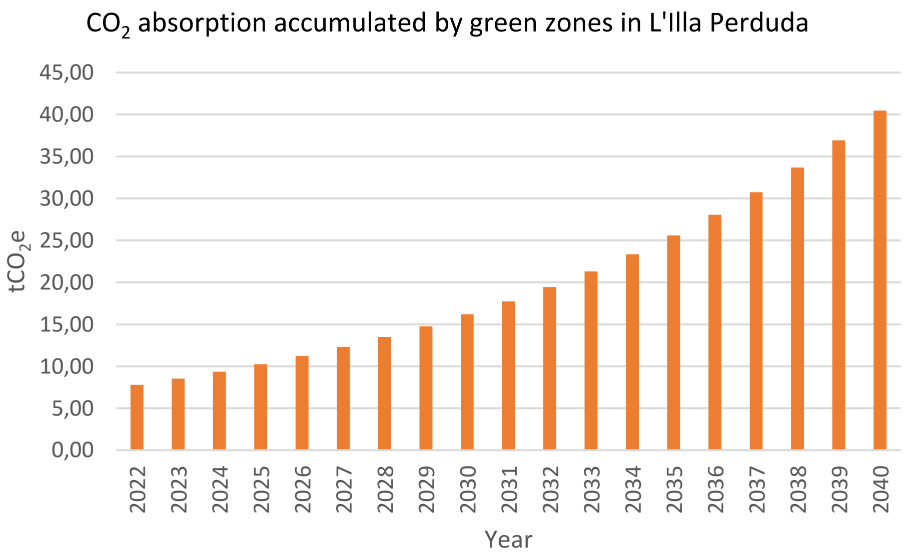

Figure 5.27 Tons of CO_2 absorption accumulated by current green zones in L'Illa Perduda in the next years.

To estimate the potential green areas, it has been calculated using the application Google Earth to identify the areas without buildings or other types of construction and free of plants or gardens or with a low density of plants and in a bad state of conservation (the areas indicated in Figure 5.22 and Figure 5.23 are not considered). After that, with a visit to the zone, these areas have been reaffirmed like good and profitable future green zones or discard from the list. But are not only proposals about areas with vegetation in the ground it is necessary to look for other solutions to implement natural solutions in the buildings, parking, or industries, etc. These new concepts of natural solutions will be proposed in the next paragraphs.

In case of Benicalap, as in Figure 5.28 in green color, there are a wide range of areas with the previous characteristics mentioned that will be transformed in parks, gardens, or similar proposals that, in general, today are unpaved zones where many cars are parked. In total an area of 83300 m^2 is identified as future potential green zones, but it is impossible to fill out these areas because of the garden designs or even because it is important to reserve areas for other uses such as car parks or future infrastructures. Due to that it will be considered only a 70% of these potential zones as future green zones and for this reason the future green area will be 58310 m^2.

Figure 5.28 Potential green zones in Benicalap.

In the case of L'Illa Perduda is more difficult as detailed in Figure 5.29 to find these types of zones mainly because this neighborhood is very small, and the majority of the surface is covered by buildings and courtyards that today have a few percentages of area with trees. The proposal for this neighborhood should be conducted to improve the current green zones and to evaluate the increase of green areas in sidewalks but respecting the pedestrians' zones. In total an area of 9600 m^2 is identified as future potential green zones, but as mentioned in the case of Benicalap a percentage of reduction, in this case, a 60% is applied, and the final proposed green zones will be 5760 m^2. The difference in the percentages is related to the characteristics of the zones selected because in Benicalap is easier to transform the zones because there are like zones without use and in the case of L'Illa Perduda the surface of the neighborhood is small, and the potential areas are more difficult to transform in green zones.

Figure 5.29 Potential Green Zones in L'Illa Perduda.

The same process applied to calculate the CO_2 absorbed in the current green zones is applied to new green areas but considering that the year of life that these zones has been considered in 3 years and not in 15 years as in the current zones because the new zones will include younger vegetation than existing green areas.

The implementation of these measure has been divided in five steps, dividing the total surface in five phases of 20% of the total surface and implementing that year by year. In that way from the starting year planned 2024 and the final 2028 all the new planned green areas will be implemented.

The values of CO_2 absorbed in these new proposed zones are presented in Figure 5.30 and Figure 5.31. The data presented in the figures is the accumulated CO_2 absorption, the mean value of CO_2 absorbed per year in Benicalap is 2 tCO_2e/year, and in a range between 1,1 and 2,9 tCO_2e/year and in L'Illa Perduda the mean value of CO_2 absorbed per year is 0,2 tCO_2e/year, and in a range between 0,1 and 0,3 tCO_2e/year.

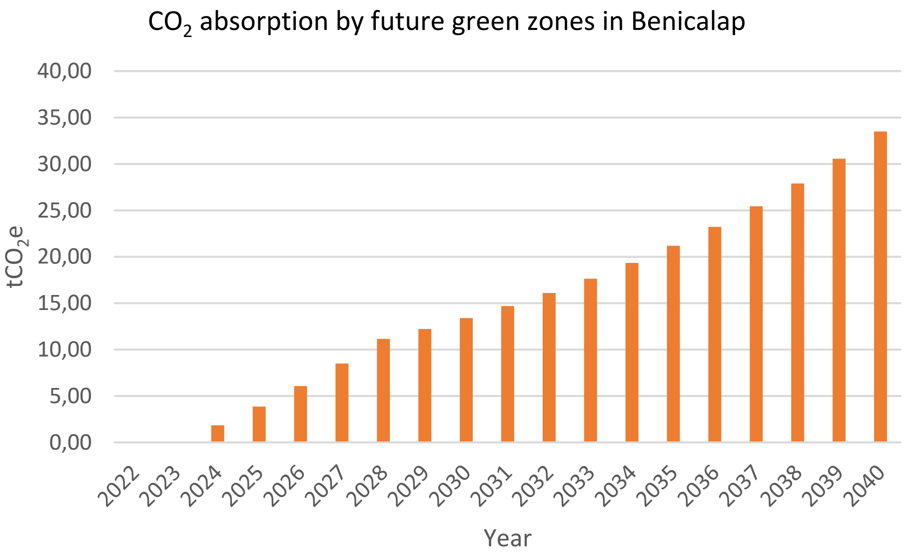

Figure 5.30 Tons of CO_2 absorption accumulated by proposed green zones in Benicalap in the next years.

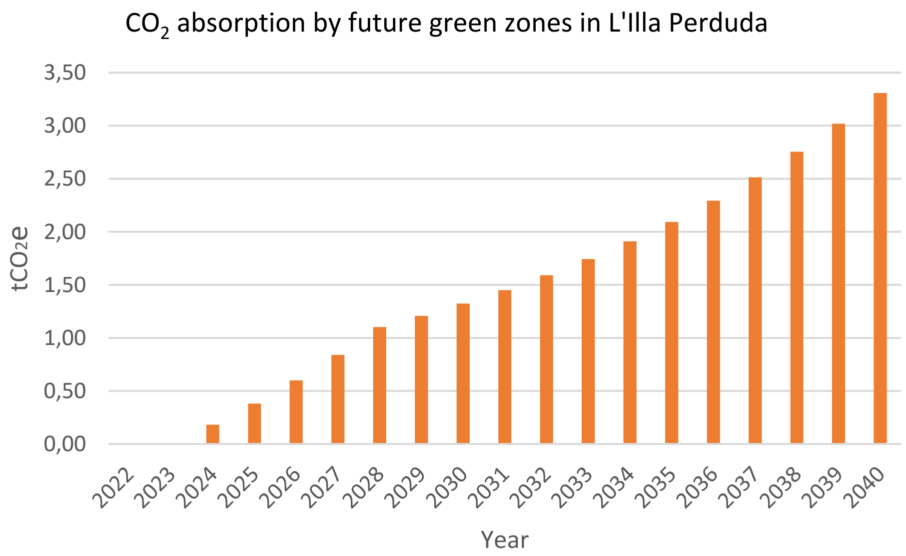

Figure 5.31 Tons of CO_2 absorption accumulated by proposed green zones in L'Illa Perduda in the next years.

The total absorption in Benicalap and L'Illa Perduda, considering the current green zones and the planned green areas, is graphed in Figure 5.32 and Figure 5.33. The data presented in the figures is the accumulated CO_2 absorption, the mean value of CO_2 absorbed per year in Benicalap is 7,1 tCO_2e/year, and in a range between 2,2 and 13,1 tCO_2e/year and in L'Illa Perduda the mean value of CO_2 absorbed per year is 2 tCO_2e/year, and in a range between 0,8 and 3,8 tCO_2e/year.

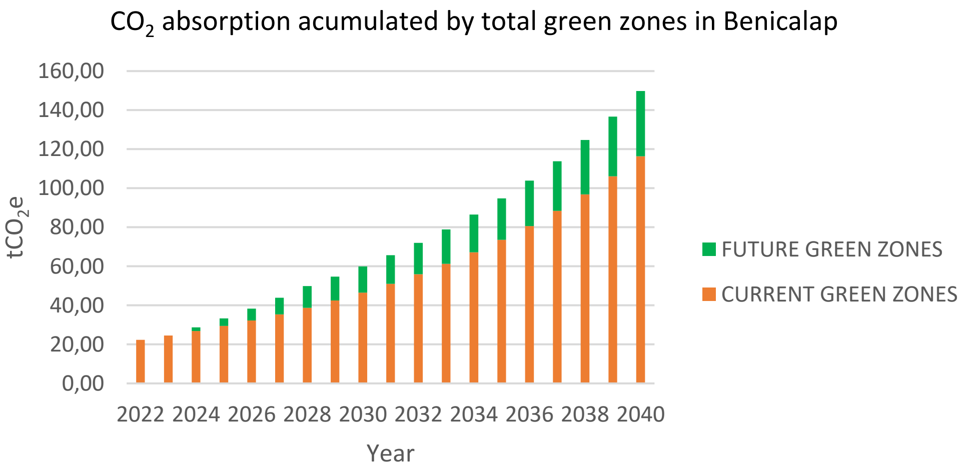

Figure 5.32 Tons of CO_2 accumulated by total green zones in Benicalap in the next years.

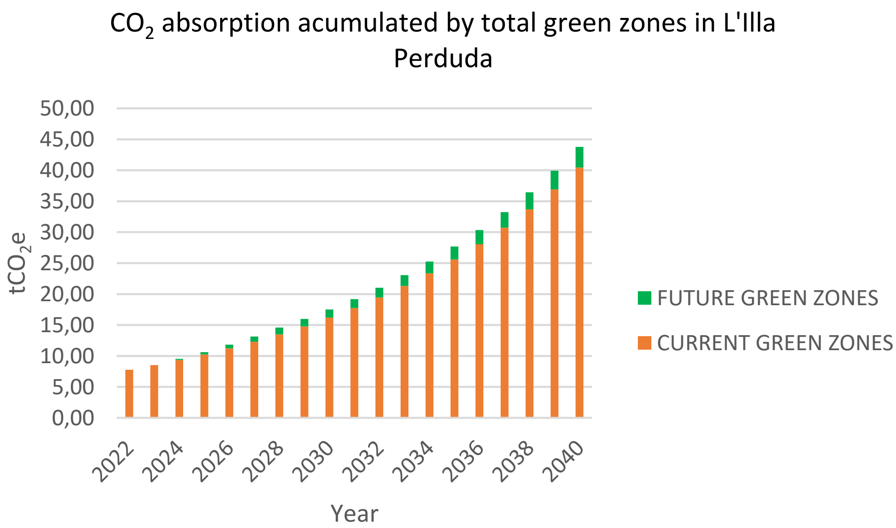

Figure 5.33 Tons of CO_2 accumulated by current green zones in L'Illa Perduda in the next years.

There are many other options apart from the naturalization of common spaces in the neighborhood to develop NBS in the neighborhoods and a few of them will be presented but not quantified in the next paragraphs (Figure 5.34).

These options are mainly related with the roof of the different buildings and the facades, in this case this measure has not been developed because the rooftops of the buildings are planned to use to install PV panels. In the future, a more detailed analysis about the more appropriate use of each roof should be developed to give them different uses and make more efficient all the measures.

The green rooftops can be green roofs, urban garden with different crops, rainwater harvesting systems, etc. And the facade is an outside wall covered with the right plants and selecting the correct wall.

Another option is to include green street furniture for example in wide sidewalks that have space to implement that system. Another system to include NBS that is not only green proposals is to create water micro-climates in squares or gardens.

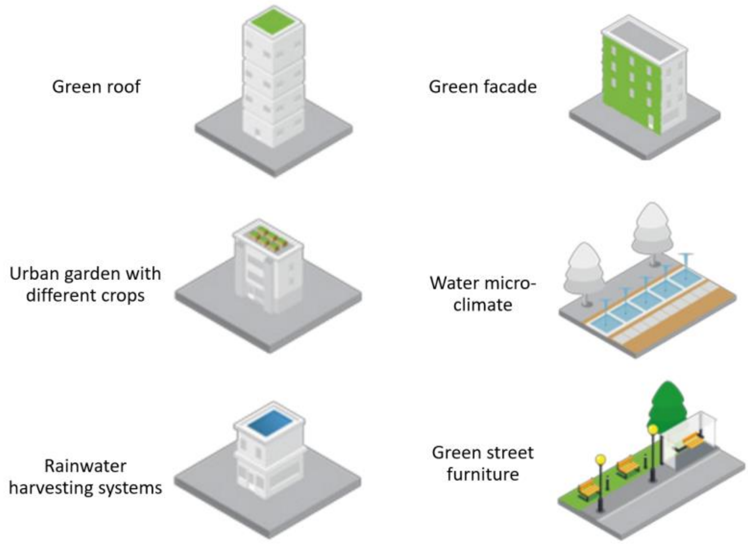

Figure 5.34 Alternatives NBS to implement in future steps in the neighborhoods. Based on [35].

5.4.2 PV GENERATION

PV systems on the neighborhoods' roofs have been proposed as one measure to decarbonize the city's electricity consumption.

The quantity of energy generated by the potential PV installations has been calculated using the software Homer, with the process explained in annex E Calculation of PV installation.

To obtain a more efficient system for both districts, the simulations have been carried out with the information included in annex E Calculation of PV installation and sensitivity analysis of the power, as in Table 10.25 and Table 10.26.

Ten simulations for each neighborhood have been developed, considering five different percentages of the useful area and two different inclinations. The main results obtained are in Table 10.28 for Benicalap and in Table 10.29 for L'Illa Perduda.

With all these results, one option has been selected to implement in this work applying two filters, the first filter used was applied in base of the useful surface percentages from Google Earth, so despite a wide range of simulations having been developed and implemented, the first filter only two options remain for each neighborhood. In the case of Benicalap, the simulations with a 38% useful surface and two inclinations 15º and 35º and in the case of L'Illa Perduda, the simulations with a 42% useful area and with two inclinations 15º and 35º.

After this first filter, the final selection has been based on the higher production of photovoltaic energy and comparing the payback between the two options. The PV production and capital cost is detailed in Table 5.14 for the two cases of simulation for each neighborhood.

It is important to mention that the installation of the total system of PV panels starts in 2023, and for 2025 the 50% of the total installation is working and for 2030 the 100% of the installation is producing electricity.

Table 5.14 Basic data of simulation of Benicalap considering the second filter.

Inclination (°)	PV Production (MWh)	Total capital cost (M€)
	Benicalap	
15	90315	56,70
35	62516	37,26
	L'Illa Perduda	
15	16858	10,58
35	12684	7,56

In this case, for both neighborhoods the option selected is the one with an inclination of 15º because notwithstanding the initial investment is higher, the total photovoltaic energy production is higher because with the smaller inclination angle, the distance between rows of panels is smaller and in consequence, the number of PV panels that can be installed is higher. Figure 5.35, Figure 5.36, Figure 5.37, and Figure 5.38 show hourly data of different values about the simulation of the final PV installation of Benicalap and L'Illa Perduda.

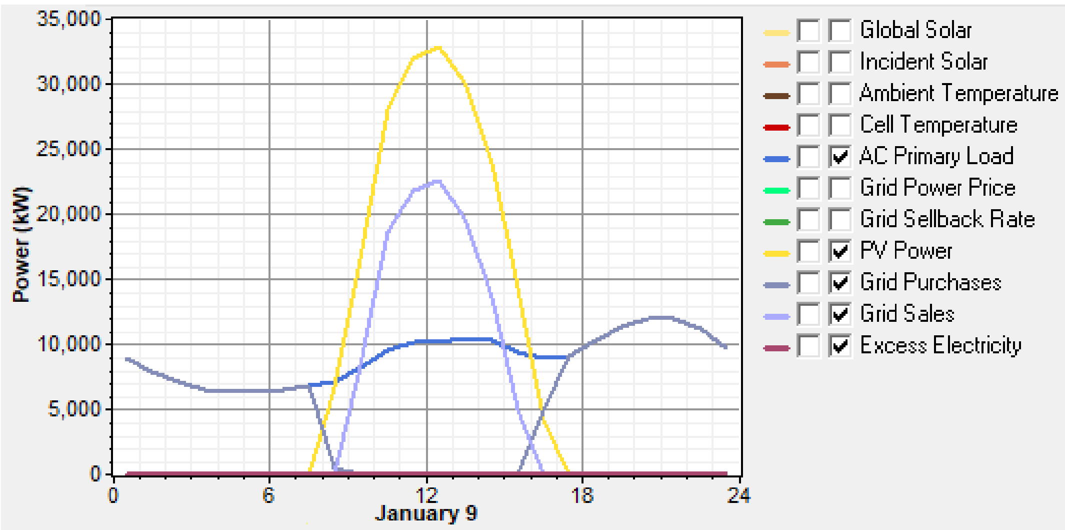

Figure 5.35 Simulation for Benicalap with an inclination of 15° for one day of January.

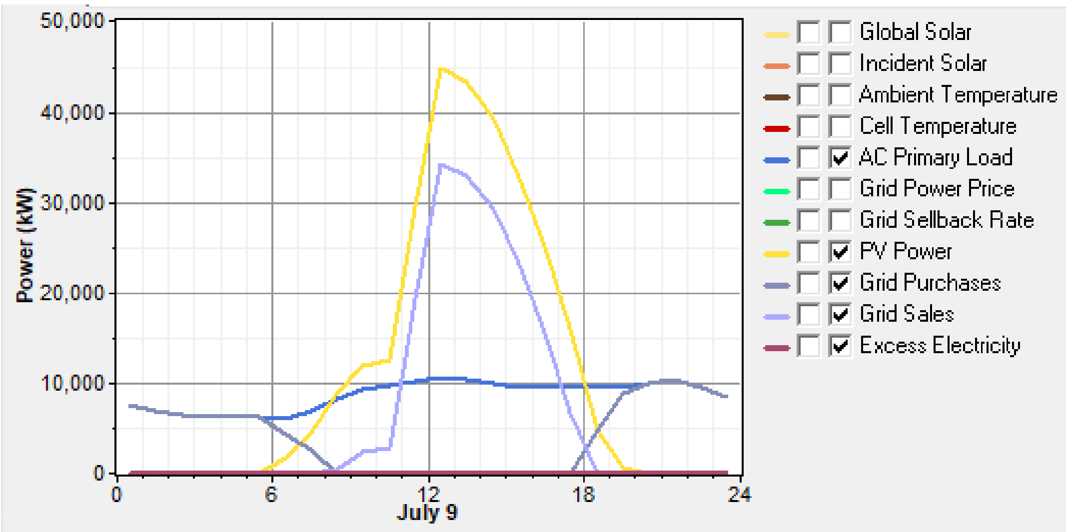

Figure 5.36 Simulation for Benicalap with an inclination of 15° for one day of July.

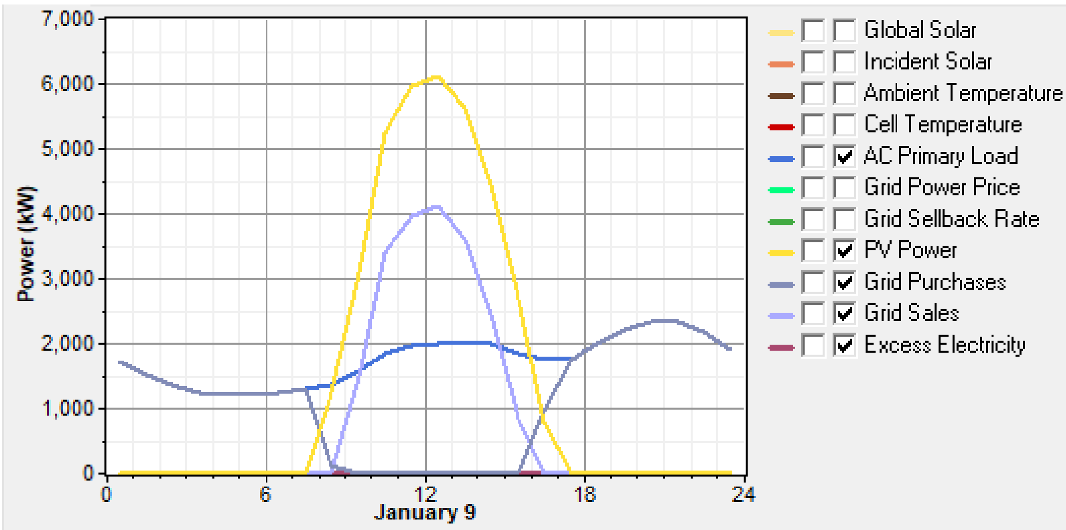

Figure 5.37 Simulation for L'Illa Perduda with an inclination of 15° for one day of January.

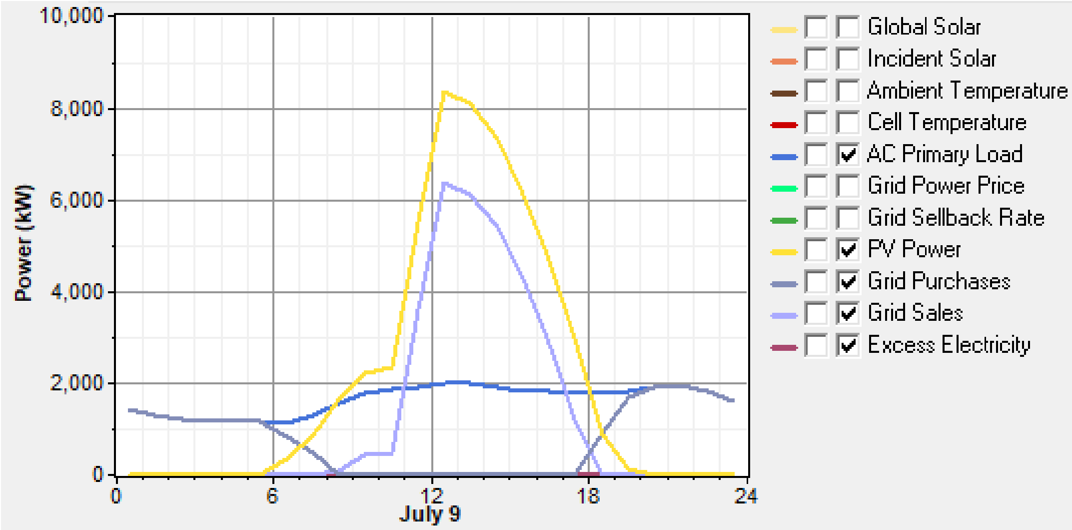

Figure 5.38 Simulation for L'Illa Perduda with an inclination of 15° for one day of July.

Having presented the data of the selected installation for both neighborhoods, the CO_2 savings from electricity for 2025 and 2030 has been calculated and presented in Table 5.15.

Table 5.15 Electricity CO_2 emissions for Benicalap and L'Illa Perduda with the new PV installation.

NEIGHBOURHOOD	BENICALAP	L'ILLA PERDUDA
YEAR	tCO_2/year	tCO_2/year
2020	0	0
2025	5915,6	1104,2
2030	9754	1820,7

5.4.3 SUSTAINABLE TRANSPORT

As observed in the previous GHG inventory, one of the main sectors responsible for GHG emissions in the neighborhoods is the transport sector, and more precisely the private and commercial transport, but not leaving out the measures in public transport.

Therefore, basis on that and the necessity to reduce these emissions, a series of measures will be proposed based on the "Plan de Movilidad Urbana Sostenible" of Valencia [40]. One of these objectives that will be proposed and developed are:

- Apply measures with the objective of the decarbonization of the transport system.
- Enhance the pedestrian's movements when the distance allows it.
- Increase the cycle paths and the number of public bicycles available to promote cycle movements.
- Promote public transport instead of private transport, with the analysis of the current system and the potential of zones with worst connections.
- Promote the increase of electric vehicles both in public and private transport.

ELECTRIC VEHICLE MEASURE:

With the objective of evaluating the GHG emissions savings with the penetration of the electric vehicle, the first step is to analyze the future increase of this type of vehicle.

In the case of electric vehicles, this increase is based on "Plan de impulso del vehículo eléctrico y despliegue de la infraestructura de recarga en la Comunitat Valenciana" [41] the prediction of electric vehicles in the Valencian Community is detail in Table 5.16, except the value for 2020 that is obtained from the statistical base of the city of Valencia in the chapter of transport [20]. To extrapolate these values to the city of Valencia a downscaling factor has been calculated based on the total population of the Valencian Community and the total population of the city of Valencia. The value obtained is 15,64% but considering that Valencia is one of the main cities in the zone, a wide quantity of installations to charge and better infrastructure to operate with an electric car will be there, the previous percentage has been modified to 25%. In Table 5.16 is included the prediction of the number of electric vehicles in the city of Valencia.

Table 5.16 Prediction of the future number of electric vehicles in the city of Valencia [41].

Year	Number of EV in Valencian Community	Number of EV in the city of Valencia	PERCENTAGE OF EV in the Valencian Community (%)
2020	20300	5075	0,6
2025	78100	19525	2,2
2030	260000	65000	7

Considering the previous values for the city of Valencia and using the factors from annex A Downscaling factors related with population in Table 10.1 and Table 10.2 the data for the electric vehicles in Benicalap and L'Illa Perduda has been calculated and detailed in Table 5.17.

Table 5.17 Prediction of the future number of electric vehicles in the neighborhoods.

Year	Number of vehicles electric in Benicalap	Number of electric vehicles in L'Illa Perduda
2020	267	56
2025	1026	213
2030	3413	707

The calculations developed to estimate the CO_2 emissions avoided with the implementation of the electric vehicle are detailed in annex H Calculation for electric vehicle measure.

The penetration of the electric vehicle in cities imply a removal of old cars to these new electric ones, because for considered the previous CO_2 emissions related with electric transport, the CO_2 emissions included in the initial analysis has been withdrawn from the CO_2 inventory. It has been assumed the same removal of cars as the new penetration of electric vehicles, in other words a relation 1:1.

Table 5.18, Table 5.19 and Table 5.20 include the change produced in the emissions related with public transport with the change indicated before.

Table 5.18 Tons of CO_2 emissions after substituting old cars for new electric ones.

Year	tCO_2 emissions initial situation Benicalap	tCO_2 emissions removal old vehicles Benicalap	tCO_2 emissions initial situation L'Illa Perduda	tCO_2 emissions removal old vehicles L'Illa Perduda
2025	16070	15377	1662	1590
2030	16070	13651	1662	1412

Table 5.19 Tons of CO_2 emissions after the substitution of old two wheels vehicles for new electric ones.

Year	tCO_2 emissions initial situation Benicalap	tCO_2 emissions removal old vehicles Benicalap	tCO_2 emissions initial situation L'Illa Perduda	tCO_2 emissions removal old vehicles L'Illa Perduda
2025	298,4	289,5	30,9	29,9
2030	298,4	269,5	30,9	27,8

Table 5.20 Tons of CO_2 emissions after the substitution of small trucks vehicles for new electric ones.

Year	tCO_2 emissions initial situation Benicalap	tCO_2 emissions removal old vehicles Benicalap	tCO_2 emissions initial situation L'Illa Perduda	tCO_2 emissions removal old vehicles L'Illa Perduda
2025	1179	1140	122	119,2
2030	1179	1049	122	112,9

Planning only these measures about the penetration of the electric vehicle in the private transport as is present above is not enough to significantly reduce the emissions related with transport. For this reason, is necessary to apply politics and raise awareness about the use of public transport or active mobility what is presented next.

ELECTRIC BUS MEASURE:

The next values have been considered to evaluate the fleet of public buses from the EMT Valencia, based on news about the new vehicles acquired in the last three years. Most of the fleet is composed by combustion vehicles and other hybrid buses that has appear in a very important percentage, and a few numbers of electrics, that is the point in which is important to focus and to improve. The total EMT buses has been obtained from [42] but the more updated report is from 2020, and the main sustainable transport implemented are from this year, so basis on news and the prediction from "Hoja de ruta para la estrategia energética de Valencia 2020-2030" [43] the next future prediction has been considered and detailed in Table 5.21. This report [43] considers that in 2025 the 25% of all the public vehicles will be electric and that in 2030 a

50% of the fleet will be electric but considering the current situation and the prediction of the EMT float the next values included in Table 5.21 has been used.

Table 5.21 Prediction of future number of public buses in Valencia.

Year	Combustion BUSES	Hybrid BUSES	Electric BUSES	Hydrogen BUSES
2020	324	164	0	0
2025	240	200	50	0
2030	0	250	100	5

It has been considered that the distribution of this fleet of buses in all the neighborhoods of the city of Valencia is developed in a proportional way for all the zones, and not given prioritization to some specific neighborhoods. Other possible analysis it has been to consider that the selected neighborhoods are pilot project and in 2030 all the transport system is electric, but in this study the first case has been selected, because is consider more realistic.

Based on the total kilometers traveled by public buses in the neighborhoods and calculated and detailed in Table 10.43 and Table 10.44 and defining a consumption of 3 kWh/km, the next emission values has been obtained for electric buses and included in Table 5.22 and Table 5.23.

Table 5.22 CO_2 emissions associated with electric buses in Benicalap.

Year	Electric BUSES in Valencia	kWh/year	tCO_2/year
2020	0	0	0
2025	50	111228,4	6,26
2030	100	222456,8	11,45

Table 5.23 CO_2 emissions associated with electric buses in L'Illa Perduda.

Year	Electric BUSES in Valencia	kWh/year	tCO_2/year
2020	0	0	0
2025	50	15684,4	0,88
2030	100	31368,8	1,61

The same process has been carried out to calculate the emission produced by hybrid buses, considering that this hybrid buses are diesel-electric, and the results obtained are detailed in Table 5.24 and Table 5.25.

Table 5.24 CO_2 emissions associated with hybrid buses in Benicalap.

Year	Hybrid BUSES in Valencia	Yearly km travelled by hybrid buses	tCO_2/year
2020	164	121609,7	3,27
2025	200	148304,5	3,51
2030	250	185380,7	4,01

Table 5.25 CO_2 emissions associated with hybrid buses in L'Illa Perduda.

Year	Hybrid BUSES in Valencia	Yearly km travelled by hybrid buses	tCO_2/year
2020	164	17148,3	0,46
2025	200	20912,6	0,49
2030	250	26140,7	0,56

BALANCE OF THE IMPLEMENTATION OF ELECTRIC TRANSPORT:

Finally, to sum up all the previous values obtained a balance and evaluation of the evolution of the emissions related with transport and applying the measures proposed is presented in Table 5.26 and Table 5.27 respectively for private and public transport. As comparing both tables it is notable that the decrease of emissions in the case of public transport is higher than in the case of private transport, because the statistics consider that a higher penetration of public electric vehicle will take place, mainly because this cost and ideas depends on the Ayuntamiento de Valencia and is easily to implement than private transport that depends on a high number of citizens.

Table 5.26 tCO_2 emissions evolution related with private transport in Benicalap and L'Illa Perduda.

Year	BENICALAP tCO_2 due to private transport	L'ILLA PERDUDA tCO_2 due to private transport
INITIAL SITUATION	34221,6	4491,2
2025	30134	3928,4
2030	26934,9	3531,4

Table 5.27 tCO_2 emissions evolution related with public transport in Benicalap and L'Illa Perduda.

Year	BENICALAP tCO_2 due to public transport	L'ILLA PERDUDA tCO_2 due to public transport
INITIAL SITUATION	1199	169,1
2025	617,1	87,02
2030	382	53,87

INCREASE CYCLE PATHS AND NUMBER OF PUBLIC BYCICLES:

The cycle path in 2020 is detailed for the whole city of Valencia in Figure 5.39 and in the case of the neighborhoods in Figure 5.40 and Figure 5.41.

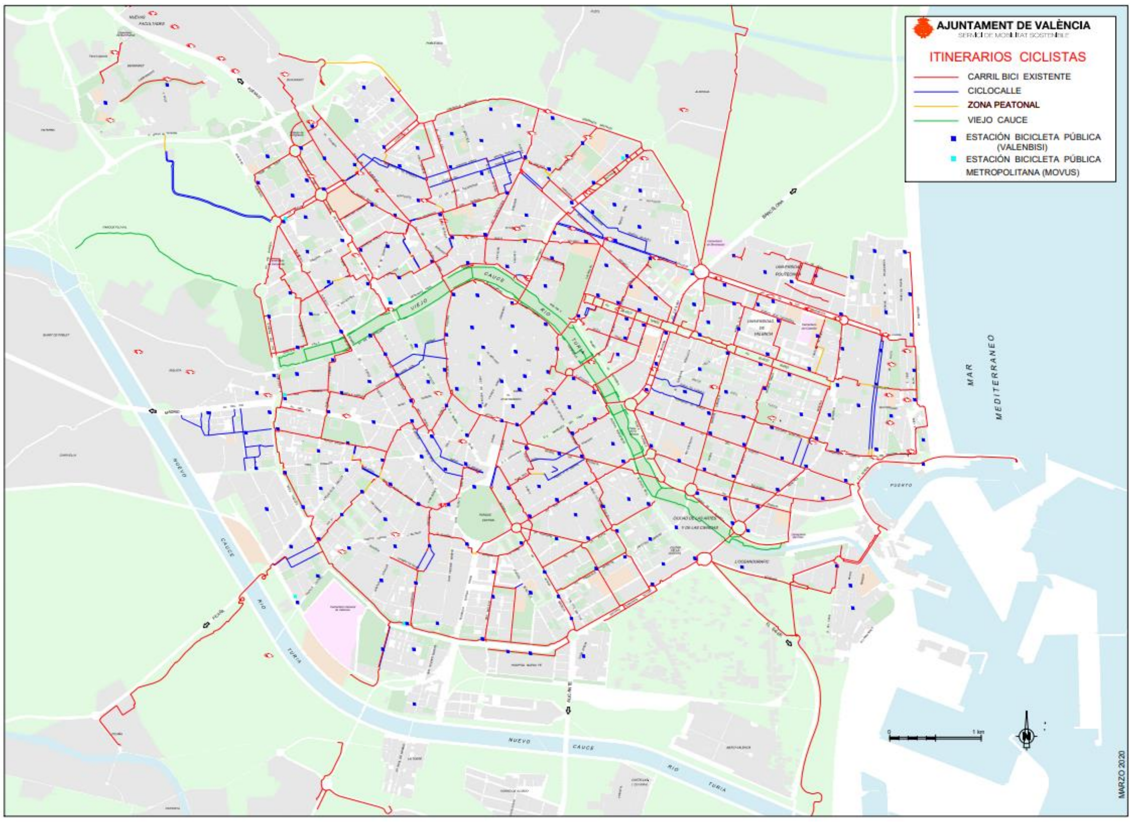

Figure 5.39 Map of the cycle paths in the city of Valencia.

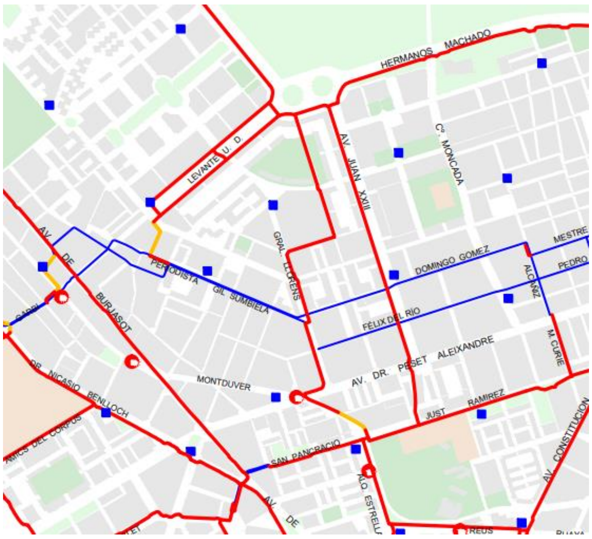

Figure 5.40 Situation of the cycle path in Benicalap.

Figure 5.41 Situation of the cycle path in L'Illa Perduda.

The total number of locking points in Benicalap is 133 and in L'Illa Perduda is 55. Considering the total Valenbisi bicycles and the total locking points, the proportion of bicycles per locking point is 50%, so considering this value the total public bicycles in Benicalap is around 66 and in L'Illa Perduda is 22.

Considering these values of bicycles and the total population of the neighborhoods, the relation between them is 629 persons/bicycle in Benicalap and 390 persons/bicycle in L'Illa Perduda.

These values can be raised to the value of 100 persons/bicycle with the objective to promote the active movements in the city of Valencia. For this purpose, is necessary to implement 350 bicycles in Benicalap and 64 bicycles in L'Illa Perduda, being necessary to analyze the current cycle paths.

PROMOTE THE USE OF PUBLIC TRANSPORT:

There are some statistics [43] about the use of the different transport and the prediction of this use in the future, so this has been used to determine the emissions avoided respect to the initial situation determined before.

Table 5.28 Prediction of type of movements: active mobility, public transport, and private transport [43].

	INTERN MOVEMENTS		
Year	**Active mobility**	**Public transport**	**Private transport**
2020	53%	23%	24%
2025	58%	26%	15%
2030	62%	28%	10%
	EXTERN MOVEMENTS		
Year	**Active mobility**	**Public transport**	**Private transport**
2020	5%	22%	73%
2025	7%	38%	55%
2030	10%	55%	35%

In this case, as the movements are studied for Benicalap and L'Illa Perduda, inside the city of Valencia, the percentages movements considered are intern movements.

The values obtained applying the previous percentages to the previous values calculated using the penetration of electric vehicle and the changes in the movements are detailed in Table 5.29 and Table 5.30.

Table 5.29 tCO_2 emissions in Benicalap and L'Illa Perduda due the implementation of measures related with the implementation of changes in intern movements in the private transport.

Year	BENICALAP tCO_2 due to private transport	L'ILLA PERDUDA tCO_2 due to private transport
INITIAL SITUATION	33127,9	4378,1
2025	28579,3	3727,9
2030	24038,9	3158,9

Table 5.30 tCO_2 emissions in Benicalap and L'Illa Perduda due the implementation of measures related with the implementation of changes in intern movements in the private transport.

Year	BENICALAP tCO_2 due to public transport	L'ILLA PERDUDA tCO_2 due to public transport
INITIAL SITUATION	1199	169,1
2025	577,2	81,4
2030	326,6	46,1

5.4.4 PUBLIC LIGHTING

Other measure that is planned is related with public lighting, an easy measure that can be developed by the Ayuntamiento de Valencia, as a measure to reduce emissions.

The current situation of the public lighting in different spaces such as parks, streets, etc. is based on a wide range of lighting, mainly: high pressure sodium led, LED lights, metal halogen lights and others less frequent.

One of the measures that the city of Valencia is planning is the substitution of the luminaries for others more efficient, to reduce the consumption of public lighting and in consequence the CO_2 emissions. Related with that also flux reductors and astronomic clocks that will help to reduce the consumption of electricity.

The measure planned is the substitution of all types of lights mentioned by LED lights. This measure started in 2015 [43] in the city of Valencia and based on data from [20] the percentage of LEDs in 2020 was around 30%. The objective is to arrive to 2030 with all the public lighting by LEDs, these objective values are presented in Table 5.31.

Table 5.31 Objectives of installation of LEDs lighting in public system in Valencia.

Year	% LEDs in public lighting
2020	30
2025	60
2030	100

The reason of this change is reduction of the consumption related with public lighting and the CO_2 emissions. For the analysis of the electricity consumption savings, the number of lighting point and the type that will be changed for LEDs lighting is detailed and analyzed in Table 5.32 and Table 5.33.

Table 5.32 Characteristics of the public lighting in Benicalap.

Type of public lighting	Lighting points	Installed Power (kW)
High pressure sodium	1997	405
Mercury vapor lamps	0	0
LEDs lights	328	15
Metal Halogen	768	63
Others	5	0,10

Table 5.33 Characteristics of the public lighting in L'Illa Perduda.

Type of public lighting	Lighting points	Installed Power (kW)
High pressure sodium	186	36
Mercury vapor lamps	0	0
LEDs lights	61	3
Metal Halogen	105	10
Others	1	0,05

Based on this value, the savings of electricity produced by the change of each of one light from each type of light to LED has been calculated and compared with several studies [44], [45].The mean value obtained for the final situation and the initial situation was 65% of savings with all the LEDs installed in 2030 compared with 2020, considering that this year a 30% of the LEDs and the corresponding savings has been occurred.

The values of CO_2 emissions savings with the installation of LEDs in the public lighting for 2025 and 2030 are included in Table 5.34 and Table 5.35, calculated for two different scenarios, first in the case the emission factor for electricity will be the same that considered now and the second one considering the emissions factors calculated in annex G Future emission factor for the energy mix.

Table 5.34 Tons of CO_2 savings in Benicalap with the installation of LEDs lighting.

Year	Electricity savings (kWh)	tCO_2e savings current emission factor	tCO_2e savings calculated emission factor
2025	455312	78,31	59,66
2030	1018824	175,23	110,03

Table 5.35 Tons of CO_2 savings in L'Illa Perduda with the installation of LEDs lighting.

Year	Electricity savings (kWh)	tCO_2e savings current emission factor	tCO_2e savings calculated emission factor
2025	44 175	7,6	5,79
2030	98849,4	17	10,68

This is the planned strategy in this project, but also it will be a possibility in the future the analysis of the installation of solar lanterns.

5.4.5 MEASURES TO REDUCE THIRD SCOPE EMISSIONS

The previous measures presented are related with the reduction of CO_2 emissions from scope 1 and scope 2. But as show in the inventory, the scope 3 has an important role in the global emissions from the neighborhoods, and for this reason a series of measures for reduction of CO_2 from scope 3 are proposed.

The measures proposed from scope 3 are more related with awareness of people because is necessary the change of habits in the society to reduce these emissions. For this reason, is difficult to quantify the effect of these measures in the final inventory because the behavior in people is difficult to estimate. In addition to the measures related with awareness of people, other measures concerning the production process of the products responsible of CO_2 emissions in scope 3 can be implemented such as the improvement of the efficiency in the process, the implementation of renewable energy in the production of electricity to produce these goods, etc.

The list of measures proposed for third scope is presented next:

- Awareness of people about the dimension of CO_2 emissions and the necessity to reduce these emissions. Present a simple list of activities that people daily do and the emissions associated with it. This is the first step to start the change of behavior in the society.
- Reduce in general the consumption of goods, buy only things that are necessary and avoid the consumption of other goods that are not first need things.
- Plan the food consumption in order not to throw food that is bought but not consumed and buy km 0 products.
- Reduce the consumption of clothes or other manufactured products. The part of the acquisition of products that is not possible to reduce, try to buy secondhand items because, with these actions, the carbon footprint and the CO_2 associated are reduced.

- The Ayuntamiento de Valencia should create a plan to promote the evolution of the business to more sustainable business such as secondhand clothes, supermarkets free of plastic, market with local food, more shops to repair manufactured products and less to buy these items.
- Reduce the trips in plane if it is possible to take the train; or trips in car, if by train, bus, bike or even walking you can arrive to the destination.
- Increase the recycling activities and teach the citizen the correct way of recycling.
- Implementation of circular economy in the process and in the society in general.

5.5 Results and analysis

In this part of the document the different CO_2 savings associated with the measures explained are summarized and presented. These values are included in Table 5.36 and Table 5.37.

Table 5.36 Summarized results of tons of CO_2 savings with the implementation of measures in Benicalap.

YEAR	2020	2025	2030
NBS (tCO_2)	-22,37	-33,3	-59,54
PV GENERATION (tCO_2)	0	-5915,6	-9754
PUBLIC LIGHTING (tCO_2)	0	-59,66	-110,03
SUSTAINABLE TRANSPORT (tCO_2)	0	-5170,5	-9961
TOTAL (tCO_2)	-22,37	-11179	-19884,6

Table 5.37 Summarized results of tons of CO_2 savings with the implementation of measures in L'Illa Perduda.

YEAR	2020	2025	2030
NBS (tCO_2)	-7,78	-10,42	-17,39
PV GENERATION (tCO_2)	0	-1104,2	-1820,7
PUBLIC LIGHTING (tCO_2)	0	-7,6	-10,68
SUSTAINABLE TRANSPORT (tCO_2)	0	-737,9	-1342,13
TOTAL (tCO_2)	-7,78	-1860,2	-3190,9

5.6 Comparative

As mentioned during this section of the work, the results obtained for both neighborhoods are similar. In the first part of this document in 5.2 Justification of the selection of this neighborhood, the initial conclusion considering previous studies is that Benicalap has a higher decarbonization potential than L'Illa Perduda, but in this case L'Illa Perduda has a higher CO_2 savings. These values considering that only few measures have been implemented, in future works if new measures are planned it is possible that the results for the neighborhoods change.

To compare both neighborhoods in the same conditions Table 6.1 and Table 6.2 has been used because the results are presented in way of percentage.

In both cases, the global percentage of savings compare with the initial emissions from scopes 1 and 2 is around 50%, in case of Benicalap is 50,7% and for L'Illa Perduda is 56,6%.

Analyzing the four measures the one that for both neighborhoods has a higher impact in the balance of CO_2 emissions is the implementation of solar PV panels, which supposes a 24,8% of savings for Benicalap and a 32,2% of savings for L'Illa Perduda. In the second place as more contributing to CO_2 savings is the change to a sustainable transport with savings in both neighborhoods around 24%. The other two measures represent savings lower than 1%.

5.7 Roadmap

In this section a roadmap including all the measures proposed in this document is developed and presented in Figure 5.42.

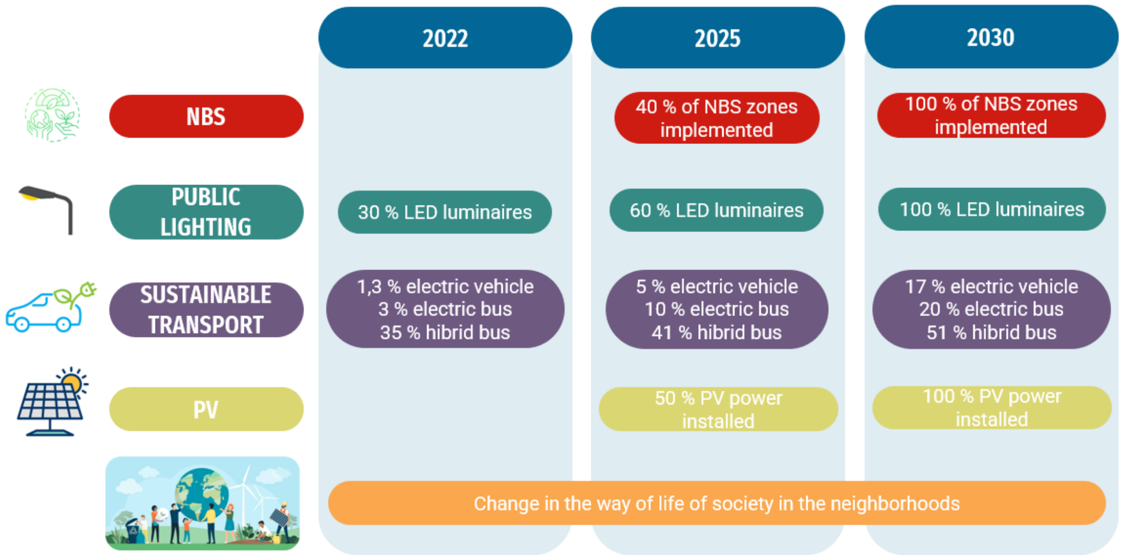

Figure 5.42 Roadmap for the neighborhoods.

6 CARBON BALANCE: INITIAL SITUATION VS FINAL SITUATION

Having developed the measures planned to approach carbon neutrality in neighborhoods a carbon balance analysis has been made. First, the initial situation during the years of the study considering that no one measures of the ones planned is implemented, so the CO_2 emissions are not reduced even they increase because the consumption of electricity will increase in the next years if no one measures are adopted [46]. In this work it has been considered an increase in the consumption of electricity of a 7% in one decade [46], in this case a 3,5% of this increase has been considered from 2020 to 2025 and the other 3,5% from 2025 to 2030.

Second, the same analysis and graphs are presented but considering the reductions applying the proposed measures. In this case, as the measures proposed are focused on scopes 1 and 2 only the emissions related with these scopes are presented. However, it is important to consider that scope 3 represent a higher impact in the final inventory, so in the future, more measures focused on this scope will be necessary. This data is presented in Figure 6.1 and Figure 6.2.

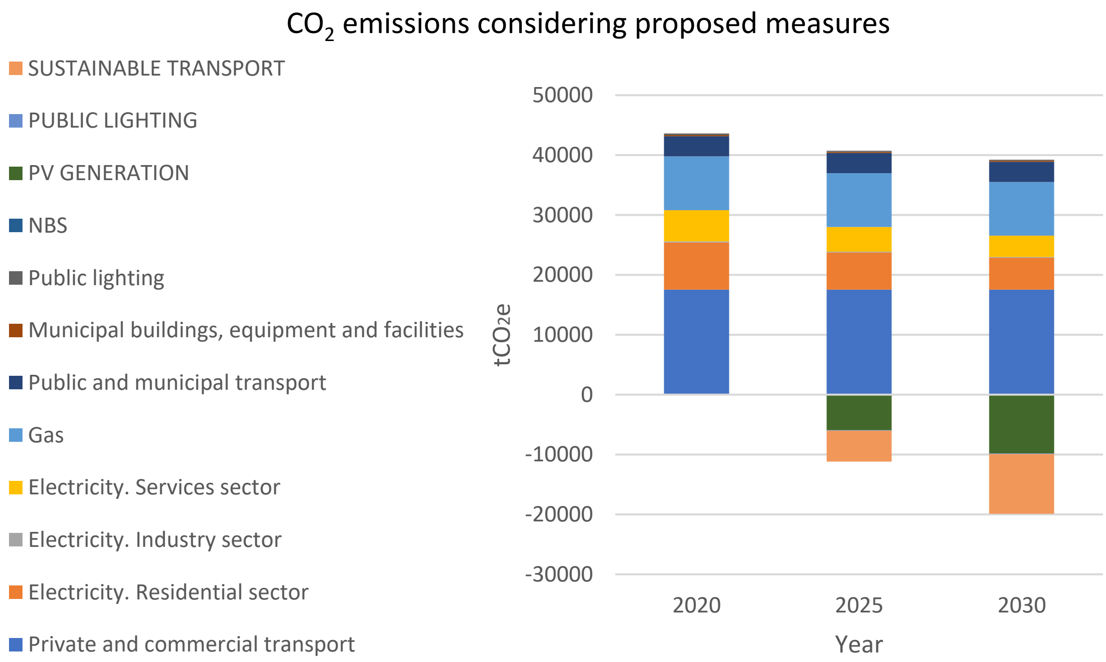

Figure 6.1 CO_2 emissions for 2020, 2025 and 2030 considering the implementation of the four measures in Benicalap.

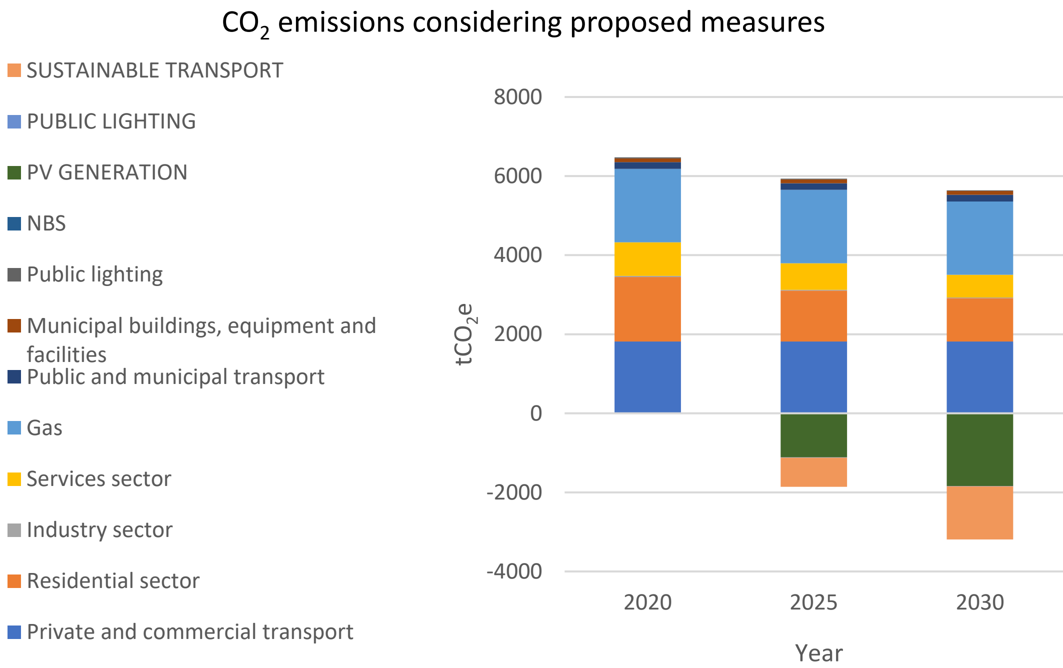

Figure 6.2 CO_2 emissions for 2020, 2025 and 2030 considering the implementation of the four measures in L'Illa Perduda.

Considering these values of the reduction by measures in the next tables are included the percentages of reduction that each measure represents to the initial total emissions. In the case of Benicalap the values are detailed in Table 6.1, and in case of L'Illa Perduda in Table 6.2.

Table 6.1 Percentages of contribution to reduction of CO_2 by the proposed measures in Benicalap.

YEAR	2020	2025	2030
NBS	0,051%	0,082%	0,152%
PV GENERATION	0,0%	14,53%	24,87%
PUBLIC LIGHTING	0,0%	0,15%	0,28%
SUSTAINABLE TRANSPORT	0,0%	12,7%	25,39%
TOTAL	0,051 %	27,46 %	50,69 %

Table 6.2 Percentages of contribution to reduction of CO_2 by the proposed measures in L'Illa Perduda.

YEAR	2020	2025	2030
NBS	0,12%	0,18%	0,31%
PV GENERATION	0,0%	18,6%	32,28%
PUBLIC LIGHTING	0,0%	0,13%	0,19%
SUSTAINABLE TRANSPORT	0,0%	12,43%	23,80%
TOTAL	0,12%	31,34%	56,58%

Comparing the values for Benicalap and L'Illa Perduda it is shown that the values are slightly different, but the four categories are aligned in the same direction.

7 ANALYSIS: ECONOMIC, SOCIAL AND RECOMMENDATIONS TO POLITICS

This type of new proposed projects, in this case the development of a carbon neutral neighborhood is not only a work that concerns the technical part to achieve it, but there are also different non-technical factors that should be analyze. It is a new concept that implies a change in a very large aspects of life that today it is planned in a direction that all these new projects will modify.

The main non-technical factors that will be evaluated and modified in order to adapt it to the new conditions are policy factors, legal factors, social factors and economic factors [17].

7.1 Social analysis

It is essential to make an analysis of the stakeholders that in one way or another are involved in the project of the development of this type of neighborhood. This analysis is based on the analysis of [47].

All the stakeholders considered and that are included in Figure 7.1 are grouped in three different big sections: private participants, public participants, and voluntary participants. In the public group are included the different governments, the private participants involved the neighborhood residents, the business in the area, the banks, etc. and voluntary participants are represented by academic participants and specialists.

Each one of these stakeholders has a different role in the project but not only that, every stakeholder has its own interest and the possibility to change the direction of the project with its actions. Because of that, in this analysis every shareholder will be group to two main criteria: the interest in the project and the influence that each one could have in the development. Relying on that information the graph presented in Figure 7.1 has been created.

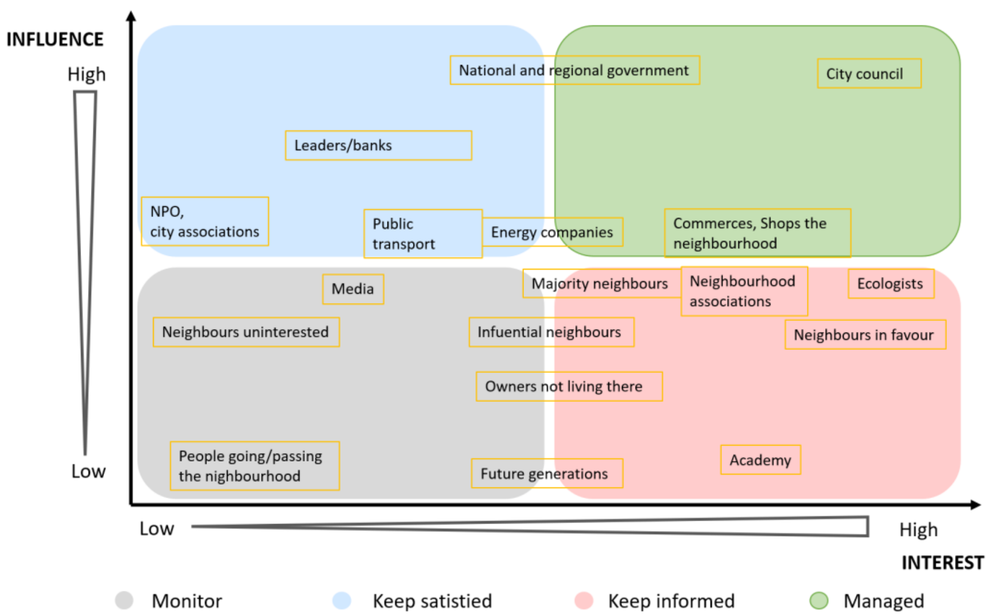

Figure 7.1 Classification of stakeholders due to its influence and interest.

All the stakeholders are divided in four categories depending on its influence and interest and for each one of them the behavior and actions should be different. Next, the attitude that the manager and developer of the project should have with the four groups has been assessed.

- Low to medium interest and low to medium influence:

In a general way this group don't have the characteristics to change the plans of the project, but it is important to monitor this group to keep it control.

- Low to medium influence and medium to high interest:

The plan with this group is to maintain them informed about all the aspects of the project trying to keep their support in the process.

- Low to medium interest and medium to high influence:

This group is more critical than the previous one because due to their influence if they are not interested, they can change the objectives or even finish the project. So, the management strategy is to maintain this group satisfied in order to keep their support.

- Medium to high influence and medium to high interest:

This is the key group because they have a big power and algo a high interest, so it is important to maintain them satisfied and to analyses all their steps related with the project. It is important to involve them in the different decisions to make good decisions.

7.2 Budget of the measures

In this part of the project the budget of the proposed measures is presented.

Table 7.1 Budget to implement the measures proposed in this project in Benicalap.

Measure	**Owners' investment (M€)**	**Private investment (M€)**	**Public investment (M€)**	**Total investment (M€)**
NBS			5,83	5,83
PV GENERATION	14,18	14,18	28,35	56,7
PUBLIC LIGHTING			0,048	0,048
SUSTAINABLE TRANSPORT	143,7		2,94	146,64
TOTAL		**209,22 M€**		

Table 7.2 Budget to implement the measures proposed in this project in L'Illa Perduda.

Measure	Owners' investment (M€)	Private investment (M€)	Public investment (M€)	Total investment (M€)
NBS			2,27	2,27
PV GENERATION	2,65	2,65	5,29	10,58
PUBLIC LIGHTING			0,0063	0,0063
SUSTAINABLE TRANSPORT	29,83		0,59	30,41
TOTAL		**43,27 M€**		

This is an estimated budget of the implementation of the measures proposed, but for a complete carbon neutral neighborhood more measures, for example a district heating and cooling, can be implemented increasing these values of investment. Also, it is necessary to depend on banks or private companies to invest in the project, and this, increase the budget with the interest that they apply to loans.

7.3 Policy and legal analysis

During all this document the key role of the change that the society should experiment in various aspects to achieve carbon neutrality has been present because without these changes the objective of carbon neutrality in cities never be achieved. For this reason, one of the aspects that should progress is the politics and the awareness campaign that politicians made. In this section some recommendations about the topics that needs a better regulation to achieve the objective of this work are presented. In this case these recommendations are focused on the measures proposed in this work.

These recommendations can include diverse types of actions such as development of rules or the application of taxes, incentives or monetary assistance and awareness campaign.

- It is necessary that citizens are awareness of the problem and know the benefits of this new neighborhoods in order they can help to this transition because as it has been mentioned in this document without the support of the diverse groups of the society is difficult to achieve the objectives.
- Build a momentum to the PV installations for auto consumption or other renewable systems as biomass systems, etc.
    - Give incentives or afford part of the cost of the PV installation to owners that install PV panels in their rooftops.

  - Create PV energy communities, to allow renewable energy to all houses.
- Promote the use of public and active transport instead of private transport:
  - Create awareness campaign of the use of these means of transport.
  - Reduce the price of public transport in order to make cheaper this type of service.
  - Establish taxes to private cars, and more specific to the most pollutant private cars to enter into the city of Valencia.
  - Give grants to people who want to change their old car to a new electric car that is less contaminant.
  - Increase the infrastructure of charge of the electric vehicle.
- Start all these actions in public buildings to give example, such as the PV installations or the improvement of the energy efficiency, etc.
- Improve the public zones such as streets, squares, etc. with the implementation of NBS.
- Search for new types of business and give the local business tools to progress to these new models of business. For example, a shop of clothes can change to a shop of secondhand shop, or a small supermarket can progress to a in bulk supermarket.
- Analyze the different companies and business and create benefits to these companies that use renewable energies:
  - Study each company and give certificates, like "Green certificate" with different degrees depending on the percentage of energy covered by renewable energies.
  - Related with the previous point reduce the taxes to these companies to promote the use of renewable energies among the companies.
- Strengthen a working group with different kind of experts focused on these topics to have current information and proposed actions plans according with the information available.
- Attract the inversion of private capital to increase the possibilities of the implementation of measures and the achievement of objectives, increasing in this way the equity to invest combining private with public money.

8 CONCLUSIONS

The world and mainly the cities should change the urban areas to mitigate the effects and adapt to climate change challenges. Sustainable plans, new policies, actions, and projects or initiatives like the one presented in this document can play a fundamental role in helping cities and governments hit different points and solve these problems, considering the results obtained in these studies.

In this project, one methodology to estimate the decarbonization potential was developed to create a roadmap with the steps to achieve the situation planned and approach to carbon neutrality.

The GHG emissions inventory was developed for both neighborhoods, Benicalap and L'Illa Perduda, and it is remarkable to say that the majority of data available is not specific to neighborhoods and is accessible at city level or even at country level. This lack of data supposes an error in the calculation that probably in the future, with more precise information, can reduce and have more realistic results.

Apart from the previous indications, the values obtained in this inventory shows that the consumption of goods is the highest responsible of emissions. The third scope (indirect emissions) is not considered in some studies, but it is important to included it. Following this sector, private transport is the second sector with biggest emissions, and the electricity consumption is the third one, with a wide difference from the rest of the sectors, with a minor representation.

Based on the initial GHG inventory four measures has been proposed for the decarbonization of the neighborhoods: NBS, PV generation, sustainable transport, and efficiency in public lighting. Having developed all these measures, PV generation is the highest contributor to reduction of CO_2 emissions, followed by the measures proposed for transport, with the electrification of vehicles. The other two measures have a low impact on the total emissions, with a contribution of less than 1% reduction.

In both cases, the global percentage of savings compare to the initial emissions from scopes 1 and 2 is around 50%, in case of Benicalap is 50,7% and for L'Illa Perduda is 56,6%, so for 2030 the reality of a carbon neutral neighborhood with the measures proposed is not viable.

Evaluating the four measures, the one that for both neighborhoods has a highest impact in the balance of CO_2 emissions is the implementation of solar PV panels, which supposes a 24,9% of savings for Benicalap and a 32,3% of savings for L'Illa Perduda. It is important to notice that total electricity produced by PV panels is similar to total electricity demand, but due to the demand curve shape it is necessary to continue consuming electricity from the grid, mainly during the night. In the second place as more contributing to CO_2 savings is the change to a sustainable transport with savings in both neighborhoods around 24%. The other two measures represent savings lower than 1%.

Finally, future works based on this methodology and information should be focused on the next improvement and extended lines:

- Include emissions related with CAPEX in the GHG inventory, to have a more detailed mix of emissions.
- Propose measures related with the reimbursement of building, starting with public buildings from the Ayuntamiento de Valencia.
- Propose energy efficiency and thermal measures because these measures are not focused on this document and are important to have a hole inventory of the contribution of a wide range of measures, such as the implementation of a district heating and cooling in the neighborhoods.
- Plan and test projects related with social initiatives to aware society in other to reduce CO_2 emissions from scope 3, as show in this work is the scope which emissions are the highest.

9 BIBLIOGRAPHY

[1] NASA, "Climate Change: How Do We Know?" https://climate.nasa.gov/evidence/ (accessed May 30, 2022).

[2] Climate Watch, "Historical GHG Emissions", Accessed: May 30, 2022. [Online]. Available: https://www.climatewatchdata.org/ghg-emissions

[3] United Nations, "Take Action for the Sustainable Development Goals." https://www.un.org/sustainabledevelopment/sustainable-development-goals/ (accessed Mar. 30, 2022).

[4] Elsevier, "Pathways to Net Zero: The Impact of Clean Energy Research," 2020.

[5] United Nations, "The Paris Agreement | UNFCCC." https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement (accessed Apr. 29, 2022).

[6] United Nations and UK Government, "Delivering the Glasgow Climate Pact: COP26 Goals." https://ukcop26.org/cop26-goals/ (accessed Apr. 20, 2022).

[7] United Nations, "Sustainable Development Goals. Goal 11: Make cities inclusive, safe, resilient and sustainable." https://www.un.org/sustainabledevelopment/cities/ (accessed May 27, 2022).

[8] European Commission, "100 Climate-Neutral Cities by 2030—By and for the Citizens, Interim Report of the Mission Board for Climate-Neutral and Smart Cities," EC Brussels, Belgium, 2020. Accessed: Mar. 05, 2022. [Online]. Available: https://op.europa.eu/en/publication-detail/-/publication/bc7e46c2-fed6-11ea-b44f-01aa75ed71a1/language-en/format-PDF/source-160480388

[9] Ayuntamiento de Valencia, "Plan de Acción para el Clima y la Energía Sostenible de la ciudad de Valencia-Diagnóstico de la situación actual de la ciudad de Valencia, 2018," 2018. Accessed: Apr. 07, 2022. [Online]. Available: https://www.valencia.es/documents/20142/424002/190415_AYTO_VALENCIA_PACES__Actualizado_.pdf/1cefe22e-7b64-1db9-7f4a-7006aa12bf75

[10] Covenant of Mayors Office and European Commission, "Covenant of Mayors for Climate & Energy EUROPE." https://www.covenantofmayors.eu/en/ (accessed Jul. 27, 2022).

[11] European Parliament, "What is carbon neutrality and how can it be achieved by 2050?," 2021. https://www.europarl.europa.eu/news/en/headlines/society/20190926STO62270/what-is-carbon-neutrality-and-how-can-it-be-achieved-by-2050 (accessed May 25, 2022).

[12] M. de Jong, S. Joss, D. Schraven, C. Zhan, and M. Weijnen, "Sustainable–smart–resilient–low carbon–eco–knowledge cities; making sense of a multitude of concepts promoting sustainable urbanization," *J Clean Prod*, vol. 109, pp. 25–38, 2015, [Online]. Available: https://doi.org/10.1016/j.jclepro.2015.02.004

[13] A. Huovila *et al.*, "Carbon-neutral cities: Critical review of theory and practice," *J Clean Prod*, vol. 341, p. 130912, 2022, [Online]. Available: https://doi.org/10.1016/j.jclepro.2022.130912

[14] World Resources Institute and World Business Council for Sustainable Development, "The Greenhouse Gas Protocol. A Corporate Accounting and Reporting Standard," 2004.

[15] World Resources Institute and World Business Council for Sustainable Development, "Corporate Value Chain (Scope 3) Accounting and Reporting Standard."

[16] JPI Urban Europe and SET Plan Action, "White Paper on PED Reference Framework for Positive Energy District and Neighbourhoods," 2020.

[17] A. Dobbelsteen, R. Roggema, N. Tillie, S. Broersma, M. Fremouw, and C. Martin, "Urban Energy Masterplanning—Approaches, Strategies, and Methods for the Energy Transition in Cities," 2018, pp. 635–660.

[18] datadis, "Consultas consumo. Energía acumulada y sumatorio de contratos." https://datadis.es/queries (accessed Apr. 28, 2022).

[19] "Códigos Postales. Valencia." https://codigopostales.com/provincia-de-valencia (accessed Jul. 04, 2022).

[20] Ajuntament de Valencia, "Oficina de Estadística | Estadísticas por temas." https://www.valencia.es/cas/estadistica/por-temas (accessed Mar. 14, 2022).

[21] Red Eléctrica de España, "Consulta los perfiles de consumo (TBD)." https://www.ree.es/es/clientes/consumidor/gestion-medidas-electricas/consulta-perfiles-de-consumo (accessed Apr. 09, 2022).

[22] I. Aparisi, "Energy study of La Marina de València. Scenario analysis towards a positive energy district.," Universidad Politécnica de Valencia, Valencia, 2021.

[23] Dirección General de Tráfico (DGT), "DGT en cifras. Inventario vehículos 2017.," 2017. https://www.dgt.es/menusecundario/dgt-en-cifras/ (accessed Jun. 27, 2022).

[24] The International Council of Clean Transpportation and DieselNet, "EU: LIGHT-DUTY: EMISSIONS." https://www.transportpolicy.net/standard/eu-light-duty-emissions/ (accessed May 08, 2022).

[25] Ayuntamiento de Valencia, "Movilidad. Mapas de Intensidad Ciudad de Valencia," Valencia, 2021. Accessed: Apr. 27, 2022. [Online]. Available: https://www.valencia.es/es/cas/movilidad/otras-descargas

[26] Valenbisi, "Valenbisi. Mapa." https://www.valenbisi.es/es/mapping (accessed Apr. 09, 2022).

[27] S. Rodríguez, "CONSUMISMO Y SOCIEDAD: UNA VISIÓN CRÍTICA DEL HOMO CONSUMENS," *Nómadas. Critical Journal of Social and Juridical Sciences*, vol. 34, no. 2, 2012.

[28] Ministerio de Agricultura Pesca y Alimentación, "Informe del Consumo de Alimentación en España 2020," Madrid, 2021. Accessed: May 11, 2022. [Online]. Available:

https://www.mapa.gob.es/eu/alimentacion/temas/consumo-tendencias/panel-de-consumo-alimentario/ultimos-datos/default.aspx

[29] F. Francés, “Carbon footprint and Overshoot Day for the city of Valencia: Current situation and trend scenarios,” Universidad Politécnica de Valencia, Valencia.

[30] E. Wieselblad, “Evaluation botton-up of the carbon emissions of a district to support the design of a carbon neutral district in Valencia,” Universidad Politécnica de Valencia, Valencia, 2021.

[31] Ajuntament de Valencia, “Oficina de Estadística | Estadísticas por Territorio | Barrios 2022,” 2022. https://www.valencia.es/es/cas/estadistica/mapa-barrios (accessed Mar. 08, 2022).

[32] Ajuntament de Válencia, “Oficina de Estadística | Cartografía de la ciudad | Barrios 2022,” 2022. https://www.valencia.es/cas/barrios-secciones (accessed Mar. 09, 2022).

[33] IIE-UPV. Cátedra de Transición Energética Urbana, “Analysis of the potential areas for the deployment of Carbon Neutral Districts,” Valencia, 2021.

[34] D. Başoğlu, E. Yöntem, S. Yöntem, B. Şenyurt, and Ö. Ylmaz, “Dynamic assessment of nature based solutions through urban level LCA,” in *Designing Sustainable Technologies, Products and Policies*, Springer, Cham, 2018, pp. 293–305.

[35] Gobierno Vasco. Departamento de Medio Ambiente Planificación Territorial y Vivienda, “KLIMATEK. Soluciones naturales para la adaptación al cambio climático en el ámbito local de la Comunidad Autónoma del País Vasco,” , 2018.

[36] European Commission, *Towards an EU Research and Innovation policy agenda for Nature-Based Solutions and Re-Naturing Cities*. Publications Office of the European Union, 2015.

[37] Ajuntament de Valencia, “Geoportal.” https://geoportal.valencia.es/apps/GeoportalHome/es/inicio/ (accessed Apr. 29, 2022).

[38] Conselleria de Política Territorial Obres Públiques i Mobilitat, “Cartografía Territorial del Stock de Carbono de la Comunitat Valenciana,” Jul. 2021.

[39] Ministerio para la Transición Ecológica, “Guía para la estimación de absorciones de Dióxido de Carbono,” May 2019.

[40] Ayuntamiento de Valencia, “Plan de movilidad urbana sostenible de la ciudad de Valencia,” Valencia, 2013. Accessed: May 06, 2022. [Online]. Available: https://www.valencia.es/es/cas/movilidad/inicio/-/content/inicio-3?uid=13E8AC560711B1ADC1257C5B0041648A

[41] IVACE, “Plan de impulso del vehículo eléctrico y despliegue de la infraestructura de recarga en la Comunitat Valenciana,” Valencia, 2017.

[42] E.M.T. Valencia, “Inventario flota EMT Valencia,” Valencia, Mar. 2020.

[43] Fundación Renovables, “Hoja de ruta para la estrategia energética de Valencia 2020-2030,” May 2020.

[44] The Climate Group, "Lighting the clean revolution. The rise of LEDs and what it means for cities," Jun. 2012.

[45] A. Djuretic and M. Kostic, "Actual energy savings when replacing high-pressure sodium with LED luminaires in street lighting," *Energy*, 2018.

[46] Ministerio para la Transición Ecológica y el Reto Demográfico, "Plan Nacional Integrado de Energía y Clima 2021-2030," 2020.

[47] C. Reynaud, "Design of a methodology, based on indicators analysis, to obtain a strategy map for carbon-neutral districts projects," Universidad Politécnica de Valencia, Valencia, 2021.

[48] IVACE Energia, "Datos energéticos de la Comunitat Valenciana 2019," Valencia, 2020.

[49] Ajuntament de Valencia, "Plan de Acción para el Clima y la Energía Sostenible de la ciudad de Valencia," 2018.

[50] ImpactE, "Consumo Eléctrico Barrios: Benicalap, L'Illa Perduda y La Carrasca," Valencia, 2022. Accessed: Jul. 08, 2022. [Online]. Available: https://www.urbanimpacte.com/

[51] ImpactE, "Demanda Térmica de Barrios: Benicalap, L'Illa Perduda y La Carrasca," Valencia, 2022. Accessed: Jul. 10, 2022. [Online]. Available: https://www.urbanimpacte.com/

[52] Ayuntamiento de Valencia, "División administrativa de los barrios municipales." https://datos.gob.es/es/catalogo/l01462508-division-administrativa-de-los-barrios-municipales (accessed Apr. 27, 2022).

[53] Red Eléctrica de España, "esios Sistema de Información del Operador del Sistema." https://www.esios.ree.es/es?locale=es (accessed Jul. 17, 2022).

[54] Instituto para la Diversificación y Ahorro de la Energía and Ministerio de Industria Turismo y Comercio, "Plan de Energías Renovables 2011-2020."

[55] G. Wernet, C. Bauer, B. Steubing, J. Reinhard, E. Moreno-Ruiz, and B. Weidema, "The ecoinvent database version 3 (part I): overview and methodology."

[56] Ayuntamiento de Valencia, "Mapas de Intensidades Ciudad de Valencia," Valencia. Accessed: Jul. 10, 2022. [Online]. Available: https://www.valencia.es/es/cas/movilidad/otras-descargas

[57] EMT Valencia, "Geoportal EMT Valencia." https://geoportal.emtvalencia.es/visor?lang=va (accessed May 24, 2022).

[58] Red Eléctrica de España, "Estructura de la generación por tecnologías." https://www.ree.es/es/datos/generacion/estructura-generacion (accessed Jul. 15, 2022).

[59] IvieLAB, "La transformación energética de la Comunitat Valenciana: lecciones de la experiencia internacional," Valencia, 2019. Accessed: Jul. 15, 2022. [Online]. Available: https://www.ivie.es/es_ES/ptproyecto/ivielab-la-transformacion-energetica-la-comunitat-valenciana-lecciones-la-experiencia-internacional/

[60] Red Eléctrica de España, "Emisiones de CO2 asociadas a la generación de electricidad en España," May 2020.

[61] N. Scarlat, M. Prussi, and M. Padella, "Quantification of the carbon intensity of electricity produced and used in Europe," *Appl Energy*, vol. 305, 2022.

[62] HYUNDAI, "kW y coches eléctricos: Todo lo que debes saber sobre su consumo y potencia eléctrica," Jun. 09, 2022. https://www.hyundai.com/es/zonaeco/eco-drive/tecnologia/cuantos-kw-necesita-coche-electrico#:~:text=L%C3%B3gicamente%20y%20como%20ocurre%20con,de%20su%20tama%C3%B1o%20y%20peso. (accessed Jul. 15, 2022).

[63] OCU, "Motos eléctricas, ¿una alternativa interesante? ," 2020. https://www.ocu.org/coches/coches/noticias/motos-electricas (accessed Jun. 27, 2022).

10 ANNEXES

A. Downscaling factors

This annex includes the different downscaling factors considered in this work and that have been necessary used to obtain a specific data from one neighborhood when the data is available at district level, city level or even country level.

These factors are based on other data available in the two scales that has been compared, for example a variable in the city of Valencia and the same variable in Benicalap. In this case, the main downscaling factors used has been obtained from the data of population and area.

These downscaling factors has been utilized depending on the aspect to be considered, and in this case an analysis is made and the more appropriate aspect, population or area, is apply.

The downscaling factors used throughout this work are detailed in the next tables. In case that the specific information is at city level the downscaling factors used are the ones detailed in Table 10.1 and Table 10.2, and in case the data is at district level the factors used are the ones included in Table 10.3 and Table 10.4.

Table 10.1 Downscaling factors for Benicalap based on city data.

	Factor	%
Population	0,052	5,25
Area	0,016	1,62

Table 10.2 Downscaling factors for L'Illa Perduda based on city data.

	Factor	%
Population	0,011	1,09
Area	0,002	0,22

Table 10.3 Downscaling factors for Benicalap based on district information.

	Factor	%
Population	0,875	87,5
Area	0,774	77,4

Table 10.4 Downscaling factors for L'Illa Perduda based on district information.

	Factor	%
Population	0,234	23,4
Area	0,079	7,86

B. Emission factors

In this annex are presented in Table 10.5 the different emission factors used in this report:

Table 10.5 Emission factors for electricity and gas.

Electricity (tCO_2/MWh)	0,172	[48]
Gas natural (tCO_2e/MWh)	0,201	[49]

C. Calculation of energy demand

In this annex it will be explained the different ways of calculation developed in this project to obtain the energy demand for both cases, electrical and thermal, and a comparison with other reports to decide the more appropriate form to do it, and in consequence the results to be used.

ELECTRICITY CONSUMPTION

The directly way to calculate these values is in base of the total consumption of the city of Valencia [20] and applying downloading factors as explained in annex A Downscaling factors. This total consumption data from the Ayuntamiento de Valencia is detailed in Table 10.6.

Table 10.6 Total consumption in MWh in the city of Valencia for 2021.

Electricity consumption	2217453	MWh
Gas consumption	850045	MWh

Applying the downscaling factors from Table 10.1 and Table 10.2 in this case considering the population factors, the data has been extrapolated to Benicalap and L'Illa Perduda and is presented in Table 10.7 and Table 10.8.

Table 10.7 Total consumption in MWh in Benicalap for 2021.

Electricity consumption	116476,5	MWh
Gas consumption	44650,4	MWh

Table 10.8 Total consumption in MWh in L'Illa Perduda for 2021.

Electricity consumption	24093,8	MWh
Gas consumption	9236,2	MWh

With the previous data the yearly electricity and gas consumption has been estimated, but for the development of some measures is necessary to have daily data consumption. For this purpose, this data has been calculated with the information from the platform Datadis [18], that provides electrical daily consumption and the number of clients that the data is collected from the area of a zip code that is selected by the user.

In this case from this platform the daily values (kWh/day) have been obtained for each main sector, residential, industrial, and public services for the year 2019. The year selected is 2019 because of the current pandemic and post-pandemic situation and the high influence of this fact in the electricity consumption and at it will be show in next chapters in the energy price.

The zip code is corresponded approximately with a district area but sometimes a neighborhood or even a district includes various zip codes, in this case Benicalap is considered that all the area of the neighborhood is located inside the 46025 and 46015 codes and L'Illa Perduda in 46022 zip code both in the city of Valencia [19].

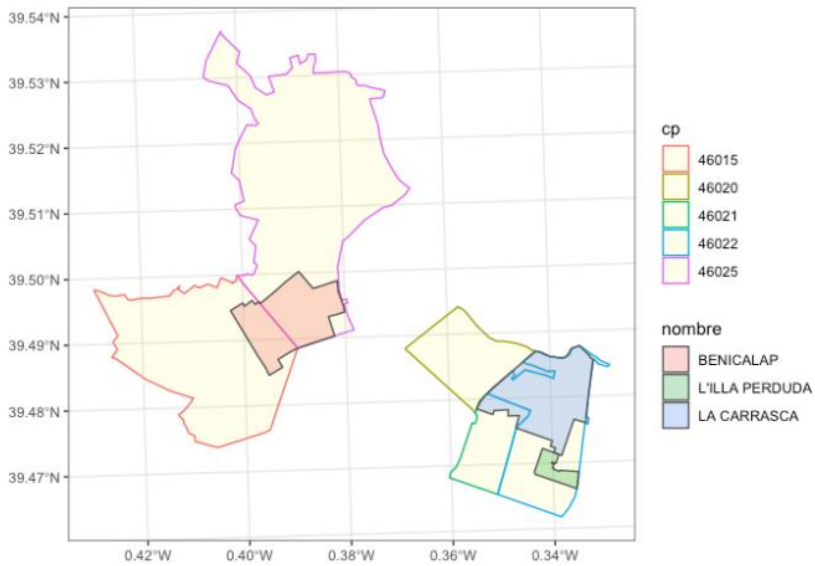

Figure 10.1 Zip Codes for the different neighborhoods [50].

These values are obtained per day, but for a more detailed analysis the values per hours should be calculated using standard curves of consumption depending on the type of consumer and for a typical day and considering these patterns. These curves of consumption are obtained from standard curves that Red Eléctrica developed and published [21].

In the case of this values obtained from Datadis, the values of the electricity consumption for the district are detailed in Table 10.9.

Table 10.9 Electricity consumption obtained from Datadis for both neighborhoods.

Electricity consumption Benicalap	77085,3	MWh
Electricity consumption L'Illa Perduda	14601,5	MWh

Comparing the values of electricity consumption from Table 10.7 and Table 10.8 with Table 10.9, the values are considerately different, even in the case of Benicalap the value obtained with downscaling factors is the double of the value from Datadis. Considering this, in this case and having more reliable data from Datadis and not applying downscaling factors, the second values has been selected. Also with this method, the values of consumption are divided in the different sectors as shown in Table 10.10 and Table 10.11.

Table 10.10 Electricity consumption by sectors for Benicalap.

Electricity consumption by sectors (MWh/year)			
Residential	Industry	Services	Total
45604,3	1136,7	30344,4	77085,3

Table 10.11 Electricity consumption by sectors for L'Illa Perduda.

Electricity consumption by sectors (MWh/year)			
Residential	Industry	Services	Total
9497,1	158,8	4945,6	14601,5

These values obtained from Datadis has been compared with other values calculated specifically for these neighborhoods with specific methods from [50] that will be summary down below, with the objective to compare and analyze the differences in the results and also to present the thermal demand of this neighborhoods.

The main steps followed to calculate the electricity consumption from this report are:

- Obtain hourly curves of consumption for uses and zip codes.
- Get the percentage of uses in each neighborhood and zip code using the Spanish Cadastral.
- Calculate the normalized consumption in each zip code for each use.
- Scale the curves for the surface constructed in each neighborhood.
- Join per neighborhoods the scaled curves.

Using these values, the final consumption by uses is obtained and detailed in Table 10.12 and Table 10.13.

Table 10.12 Electricity consumption by sectors for Benicalap based on IMPACTE report.

Electricity consumption by sectors (MWh/year)				
Residential	Industry	Services	Not specified	Total
41875,1	1314,3	29957,6	40,5	73187,6

Table 10.13 Electricity consumption by sectors for L'Illa Perduda based on IMPACTE report.

Electricity consumption by sectors (MWh/year)				
Residential	Industry	Services	Not specified	Total
9012,2	65,4	5340,4	5,24	14423,1

Comparing the values related with Benicalap from Table 10.10 and Table 10.12, the differences detected in percentage are detailed in the Table 10.14.

Table 10.14 Percentage of error comparing both methods for the case of Benicalap.

Errors comparing both methods			
Residential	Industry	Services	Total
9%	14%	1%	5%

Comparing the values related with L'Illa Perduda from Table 10.11 and Table 10.13, the differences detected in percentage are detailed in the Table 10.15.

Table 10.15 Percentage of error comparing both methods for the case of L'Illa Perduda.

Errors comparing both methods			
Residential	Industry	Services	Total
5%	143%	7%	1%

THERMAL DEMAND

The thermal demand of Benicalap and L'Illa Perduda is obtained from [51].

The process is based on the modeling of all the buildings in the neighborhoods, including different characteristics such as the year of construction or the use. With this model constructed for each point included in the model the skyline is calculated. After that the constructive characteristics are assigned to each building and finally with this model the thermal demand is obtained.

In this case the values obtained by sectors for Benicalap and L'Illa Perduda are included in Table 10.16 and Table 10.17.

Table 10.16 Results of thermal demand for Benicalap.

Thermal demand by sectors (MWh/year)					
Residential	Industry	Office	Retail	Public Services	TOTAL
131324,8	2964,2	7,16	4052,9	2105,3	140454,4

Table 10.17 Results of thermal demand for L'Illa Perduda.

Thermal demand by sectors (MWh/year)					
Residential	Industry	Office	Retail	Public Services	TOTAL
28668,5	52,08	89,72	1423,09	30233,4	28668,5

D. Calculation of rooftop surface for PV panels installation

In this annex will be presented the general procedure used to determine the roof surface usable to install solar PV panels using the software QGIS.

First, the geospatial data was obtained from the complement Spanish Inspire Cadastral Downloader where it is included the information related to the cadastral reference, number of floors above floor, the type of building related to the current use (residential, agricultural, industrial, offices, retail, and public services) and number of dwellings between others but these ones are the important ones for these calculations. The cadastral information is divided in municipalities so to develop this work the data from the city of Valencia was downloaded and a layer with these data of Valencia was created and appears as it is show in Figure 10.2.

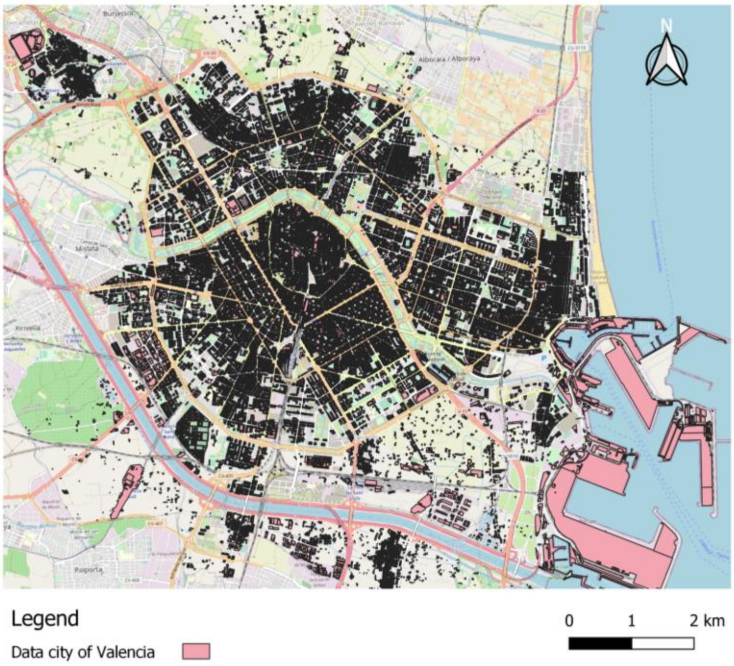

Figure 10.2 QGIS map with the information of all the city of Valencia. Elaborated from QGIS.

In base of this parameters and the data included inside it using the calculation tool and the expression area it is calculated the area of each one of the geometries included in the layer of Valencia. Using this formula the program calculates the area of all polygons, but some of them are not right to be included in available and usable roof surface. To avoid this, it is necessary to implement some conditions defined that can avoid the sum of this surfaces to the final values.

The strategies planned and that in this work has been considered as a good approximation are:

- Avoid the polygons with only one floor.
- Determine a minimum area that the polygons should have to be considered, in order to avoid small zones that can't be useful to install PV panels.

In this case, the condition selected has been the second one related with the minimum area and the value of this area considered has been 20 m^2 and filtering it in the layer properties the final surface selected, and filter was obtained.

Having this surface value connected with the different data mentioned this is exported to an Excel file in order to be able to make analysis and calculate the total surface of each type of building depending on the different characteristics. The final values reached has been presented in the results point.

But these previous steps deliver the results for the whole city of Valencia and the purpose of this master thesis is the development of a decarbonization methodology in different neighborhoods. For this, a new group of data from the "Ministerio de Asuntos Económicos y Transformación Digital" [52] is downloaded and charged in QGIS as a layer. This data contains the different administrative divisions of the neighborhood's municipalities from the city of Valencia in which it is limited the boundaries of the neighborhoods and that is shown in Figure 10.3. Starting from this layer the neighborhoods included in this work has been selected and created a new layer with the limits and area of only these neighborhoods.

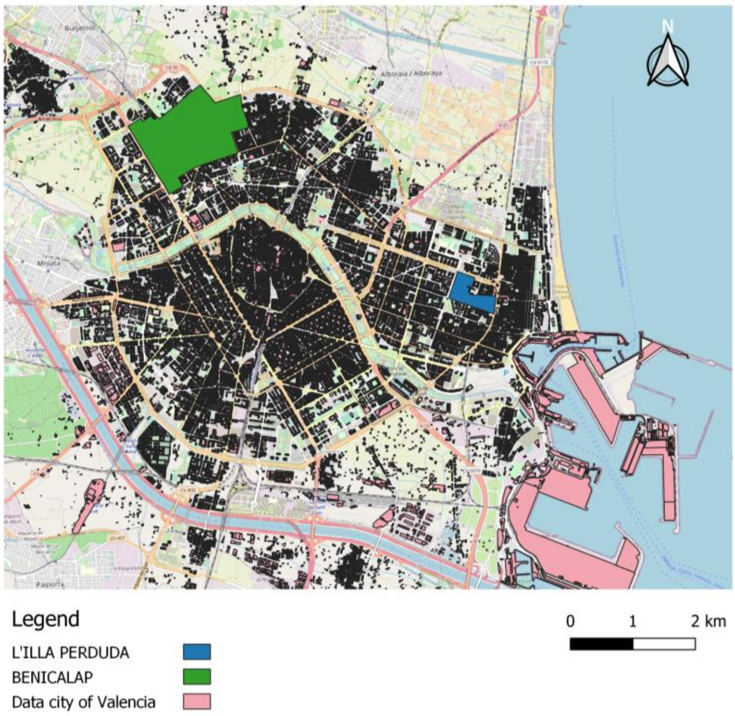

Figure 10.3 QGIS map with the data of the administrative divisions of Benicalap and L'Illa Perduda. Elaborated from QGIS.

Based on the two layers, the one related to the data of Valencia and the one with the neighborhoods borders the first one is cut overlapping the neighborhood layer and the data for each neighborhoods is obtained as show in Figure 10.4 and Figure 10.5. Using this way, the data of the available roof surface was determined.

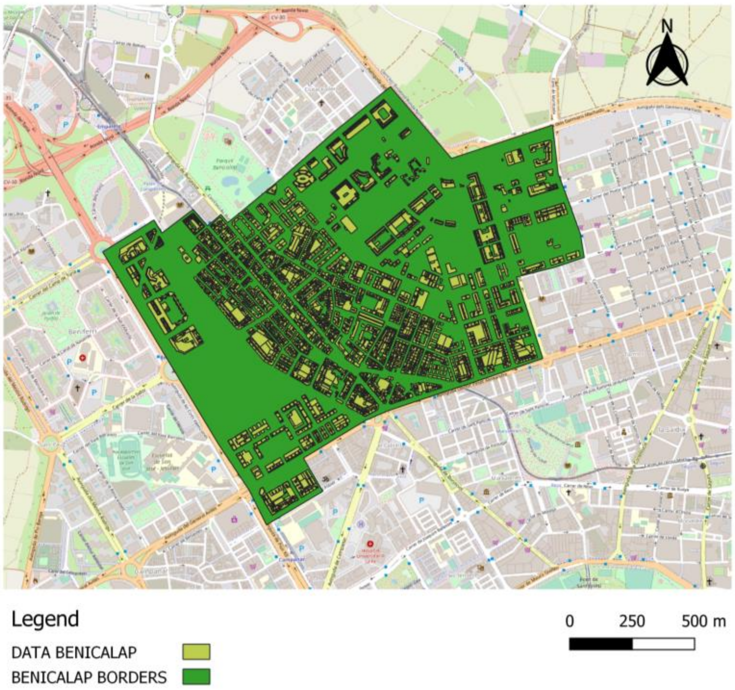

Figure 10.4 QGIS map with the data of the polygons of Benicalap. Elaborated from QGIS.

Figure 10.5 QGIS map with the data of the polygons of L'Illa Perduda. Elaborated from QGIS.

The data obtained from QGIS with the application of the previous procedure for the neighborhoods are included in Table 10.18 and Table 10.19. One column includes the total surface, and the other one, the surface with a restriction to make more accurate the suitable surface to install PV panels.

Table 10.18 Total surface of rooftops in Benicalap.

Type of building (use)	Surface (m^2)	Surface >20 m^2 (m^2)
Residential	529236	495816
Industrial	35192	34830
Office	224,9	224,9
Retail	36058	35651
Public Services	26271	26178
Others	1428	1336
TOTAL	**628413**	**594059**

Table 10.19 Total surface of rooftops in L'Illa Perduda.

Type of building (use)	Surface (m^2)	Surface >20 m^2 (m^2)
Residential	86470	82211
Industrial	1072	1072,1
Retail	2979	2979
Public Services	14352	14245
TOTAL	**104873**	**100506**

The previous data is the total surface of all the rooftops available in the neighborhoods, but it is necessary to consider that the objective of obtaining these numbers is to use these values to calculate the photovoltaic potential in the area. For this, it is necessary to evaluate the rooftops and eliminate the zones that are not available and adequate to install solar photovoltaic panels, for example, the chimney zones, the areas close to the limit of the rooftops, zones that are affected for shadows from other elements. Due to the previous reason, only areas with a surface area greater than 20 m^2 were considered as a filter to avoid some of the previous zones mentioned.

The values obtained from these two polygons inside the neighborhoods has been compared with the surface estimated with Google Earth to obtain the percentage of useful area from this sample zones of the neighborhoods.

Comparing the areas obtained from QGIS sample and the areas obtained from the useful sample zones with Google Earth, the percentage of useful area are 38% for Benicalap and 42% for L'Illa Perduda, as detailed in Table 10.20.

Table 10.20 Percentage of useful area in the sample of Benicalap and L'Illa Perduda.

BENICALAP	
Sample TOTAL surface QGIS (m^2)	5952
Sample USEFUL surface Google Earth (m^2)	2266
%	**38**
L'ILLA PERDUDA	
Sample TOTAL surface QGIS (m^2)	14330
Sample USEFUL surface Google Earth (m^2)	6074
%	**42**

Due to the previous percentages obtained before and considering that these values present an error percentage when this data was used during this work, a sensitivity analysis will be made considering three values for each neighborhood, shown in Table 10.21. The value of Second % is the previously obtained value, and the others are calculated considering a decrease (First %) and an increase (Third %) respect to the value of Second % from 2-3%, to been able to develop a sensitivity analysis with these values of surfaces useful for the calculation of PV power installed.

Table 10.21 Useful surface percentages to be considered.

Neighborhood	First %	Second %	Third %
Benicalap	35	38	40
L'Illa Perduda	40	42	45

E. Calculation of PV installation

In this annex the values and data used to simulate the solar PV installation in Homer are presented and detailed.

First, it is important to consider that in the simulation of the system planned in this project the elements that are consider are: PV installation, the electricity grid, and the electricity demand, as detailed in the scheme in Figure 10.6.

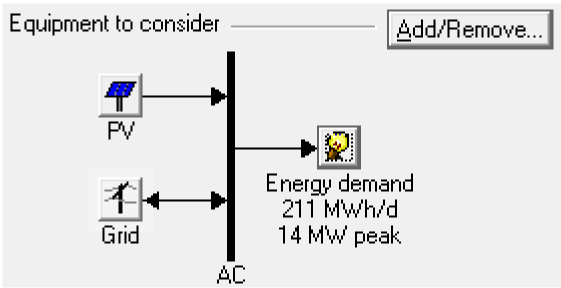

Figure 10.6 Scheme from Homer for the simulation of the PV installation.

- Solar resource: this data about the solar irradiation has been obtained from PVGIS and detailed in Figure 10.7.

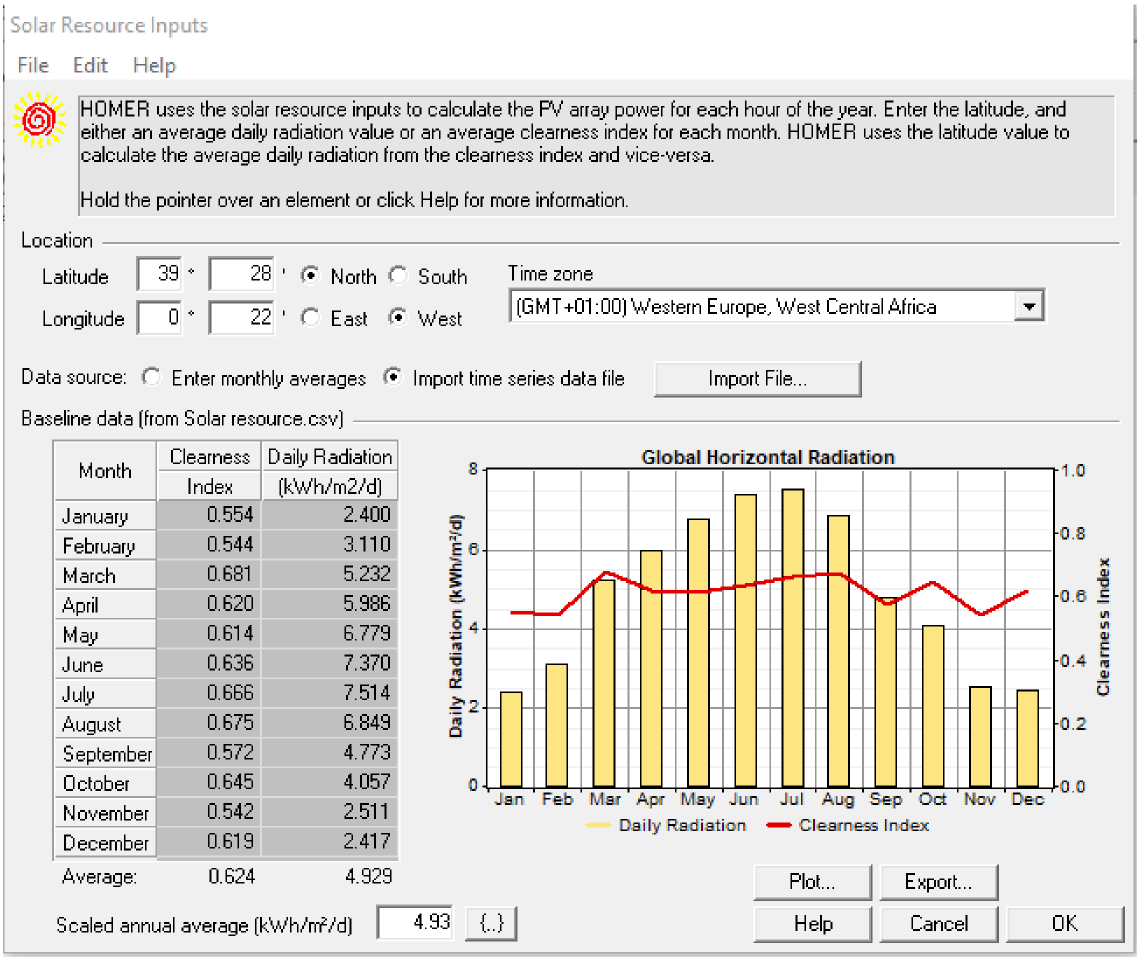

Figure 10.7 Solar Resource Inputs from Homer used in the simulations.

- Hourly energy demand of the neighborhood: this data is obtained from the process explained from the data of Datadis. In total an excel with 8760 values is introduced in the system. The values and graphs such as daily profile or the seasonal profile that appear in the software are presented in Figure 10.8.

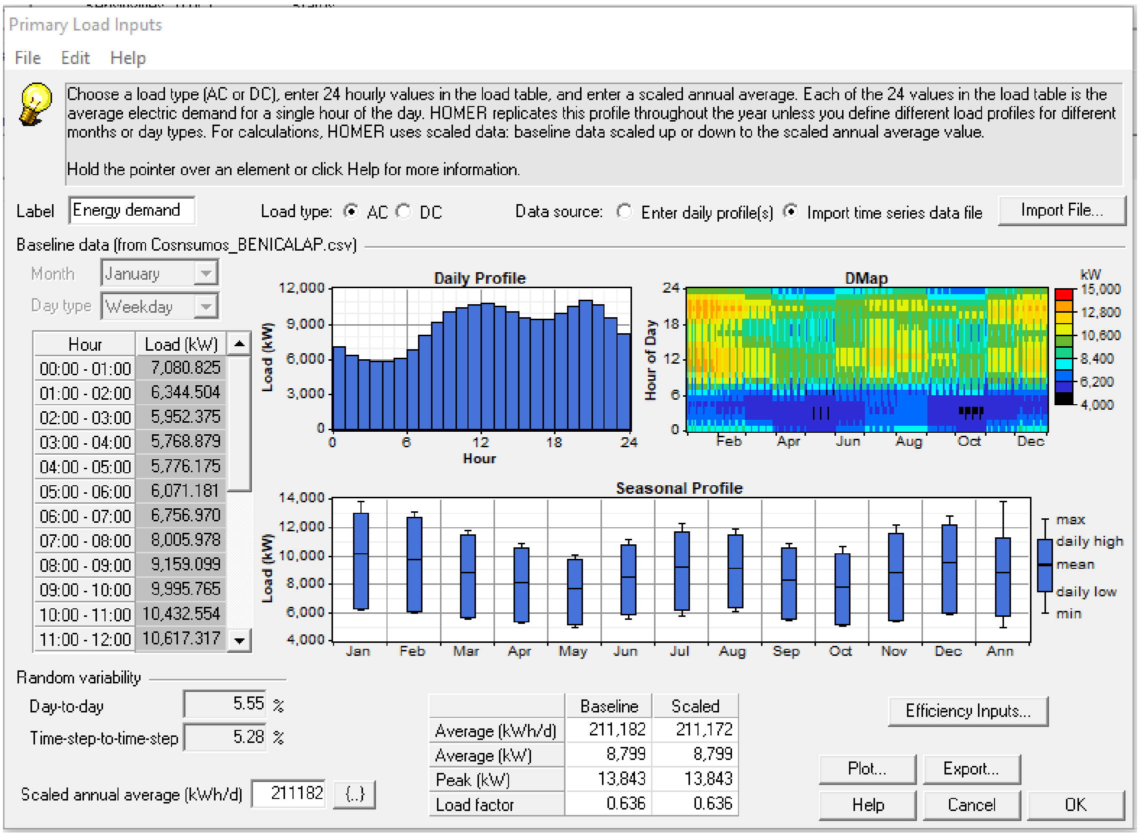

Figure 10.8 Data presented in Homer with the introduction of electricity demand.

- Division of hours in the different electricity tariff periods: period 1 (peak), period 2 (standard) and period 3 (valley), as presented in the graph of Figure 10.9.

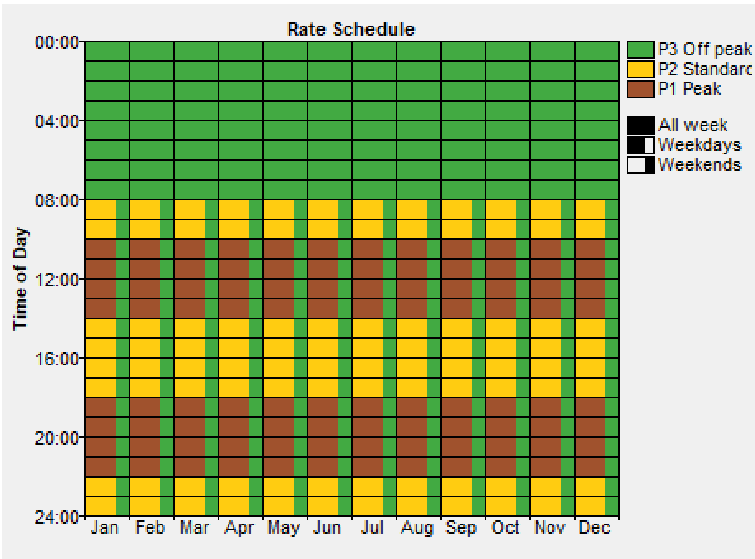

Figure 10.9 Rate schedule with the identification of the three period tariffs.

- Energy price: data obtained from REE [53], and calculated a mean value for the three tariff periods, with the results included in Table 10.22.

Table 10.22 Annual electricity price for 2021 and 2022.

Energy Price Annual Average (€/kWh)		
Price Period	2021	2022
Mean value	0,218	0,297
P1 Punta	0,285	0,369
P2 Llano	0,227	0,300
P3 Valle	0,185	0,263

- Power and energy taxes and fees: this data was obtained from the "Comisión Nacional de los Mercados y la Competencia" and included in Table 10.23.

Table 10.23 Power and energy term fees for the different periods.

Regulated prices	Period 1	Period 2	Period 3
Power term fees (€/kW year)	30,67		1,42
Energy term fees (€/kW)	0,1331	0,0418	0,006

- The taxes considered to apply to the prices are:
    - IVA ("Impuesto de Valor Añadido"): 21%.
    - Impuesto eléctrico: 5,113%

  The previous values from Table 10.23 are modified in order to obtain the values with the taxes, which are the values that should be introduced in Homer and are presented in Table 10.24.

Table 10.24 Power and energy term fees for the different periods including taxes.

Regulated prices	Period 1	Period 2	Period 3
Power term fees (€/kW year)	39,01		1,81
Power term fees (€/kW month)	3,25		0,1510
Energy term fees (€/kW)	0,1693	0,0531	0,0076

- Data from the PV installation. As previously mentioned, a sensitivity analysis has been developed for the installed power in the neighborhoods. Based on the total surface of the neighborhoods and with the previous analysis detailed, three scenarios have been simulated for each neighborhood, with one peak power for each one, as presented in the section of sizes in Figure 10.11.

This PV installed power has been calculated for two different panels inclination installation: 15º and 35º, and the powers obtained for the introduction in the simulation are included in Table 10.25 and Table 10.26. This percentages of areas are different for the neighborhoods because of the results obtained from Google Earth. These angles have been selected because 35º is near the optimum angle for the city of Valencia and the 15º because a simulation with a lower angle wants to be included in order to calculate if the production is higher and compare the results and select the better one.

Table 10.25 Installed PV powers introduces in Homer for the simulations for Benicalap.

% Useful area	Installed power with 15º of inclination (MW)	Installed power with 35º of inclination (MW)
30	42	30
35	49,5	34,5
38	52,5	37,5
40	55,5	40,5
50	69	49,5

Table 10.26 Installed PV powers introduces in Homer for the simulations for L'Illa Perduda.

% Useful area	Installed power with 15º of inclination (MW)	Installed power with 35º of inclination (MW)
30	7	4,9
40	9,45	6,65
42	9,8	7
45	10,5	7,7
50	11,55	8,4

PROCESS TO CALCULATE POWER (W/m^2)

To calculate the previous installed power, it is necessary to calculate the value of power (W/m^2) for this specific location, the panel selected, that in this case is the model TSM-DE09.08 from Trina Solar and the different inclinations selected. In the case of the panel with an inclination of 15º this value is 142 W/m^2 and in the case of 35º is 102 W/m^2.

For the calculation of this previous values, it is necessary to make some calculations about the distance between panels, and for this, the next figure (Figure 10.10) represents the distance to include, also considering the next equations.

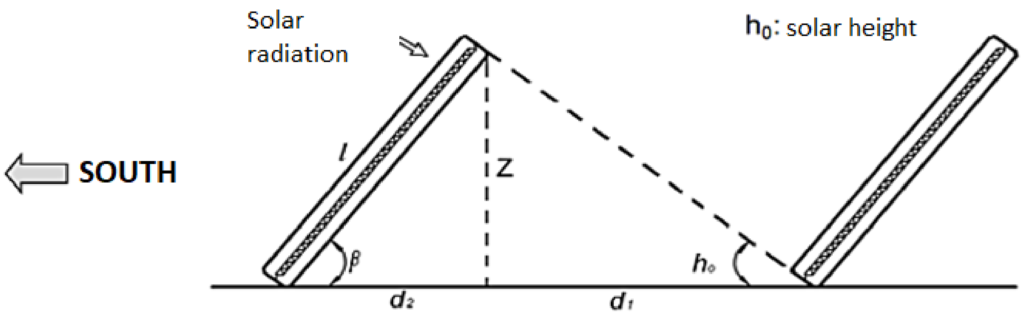

Figure 10.10 Scheme of PV panels distance between rows.

The equations used are the next:

$$d = d_1 + d_2 = \frac{Z}{tanh_0} + \frac{Z}{\tan\beta} = l\,\frac{sen\,\beta}{tanh_0} + l\,\frac{sen\,\beta}{\tan\beta}$$

In this case the installations will be working during all the year, so the calculations are developed considering the more unfavorable day, in this case for this type of installations is the 21st of December, day in which:

$$h_0 = 90 - latitude + \delta$$

Table 10.27 table collects the partial results obtained from the application of this formulas to obtain the final W/m^2.

Table 10.27 Results of PV calculations to obtain power in kW/m^2 for the calculation of PV installed power.

Latitude	40	40
Declination (δ)	-23,45	-23,45
h_0	26,55	26,55
Panel inclination in º (β)	15	35
Panel longitude, L (m)	1,754	1,754
Panel width, L (m)	1,096	1,096
D	1,63	2,23
d1	0,57	1,30
d2	1,06	0,93
Unitary rooftop area	2,85	3,92
Power (kW)	0,408	0,408
Power (kW/m^2)	0,142	0,102

Considering the previous values of power (kW/m^2), with the total surface and the percentage of useful surface the powers can be calculated, and the values obtained with this process are the ones included in Table 10.25 and Table 10.26.

Also, a series of costs has been considered:

- Capital cost: this cost has been calculated from the data about the evolution of prices of PV installation in rooftops [54], but changing the cost of PV modules for current prices and obtaining a value of 1080 €/kW.
- Replacement cost: 500 €/kW.
- O&M cost: this value was obtained from [54].

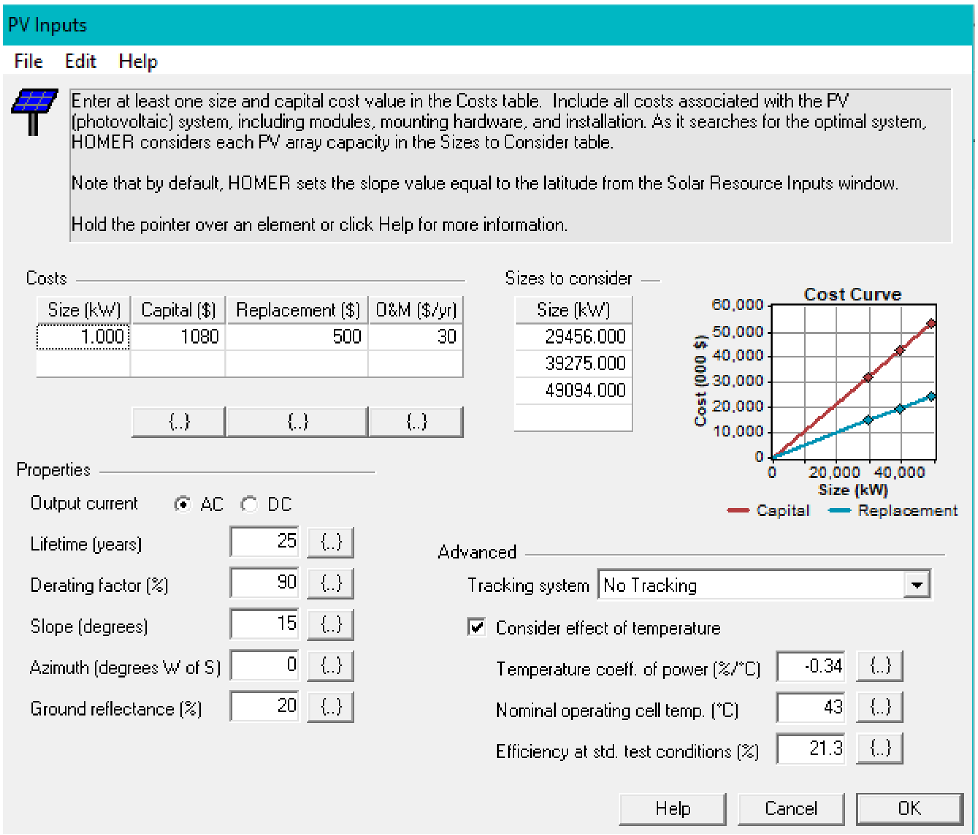

Figure 10.11 PV inputs consideration in Homer simulations.

The results obtained from the simulation of the PV installation with the characteristics previously mentioned are included in Table 10.28 and Table 10.29 for Benicalap and for L'Illa Perduda, respectively.

Table 10.28 Results from simulations in Homer for the PV installation in Benicalap.

Percentage useful area (%)	Inclination (º)	Total capital cost (M€)	Operating cost (M€/year)	COE (€/kWh)	PV Production (MWh/year)	Grid Purchases (MWh/year)	Grid Sales (MWh/year)	Total electricity production (MWh/year)	Primary load (MWh/year)	Renewable fraction	Renewable fraction self-consumption
30	15	45,36	8,91	0,146	72252	43275	38446	115527	77085	0,63	0,44
35	15	53,46	7,5	0,130	85154	42450	50522	127604	77085	0,67	0,45
38	15	56,7	7,07	0,124	90315	42179	55350	132495	77085	0,68	0,45
40	15	59,94	6,7	0,119	95476	41932	59930	137408	77085	0,69	0,46
50	15	74,52	5,55	0,104	118700	41059	75441	159759	77085	0,74	0,56
30	35	32,4	11,03	0,166	54361	45470	22751	99832	77085	0,54	0,41
35	35	37,26	9,9	0,159	62516	44611	30046	107127	77085	0,58	0,42
38	35	40,5	9,15	0,157	67952	44131	35002	112083	77085	0,61	0,43
40	35	43,74	8,41	0,156	73388	43703	40010	117091	77085	0,63	0,43
50	35	53,46	6,58	0,155	89697	42696	55301	132394	77085	0,68	0,45

Table 10.29 Results from simulations in Homer for the PV installation in L'Illa Perduda.

Percentage useful area (%)	Inclination (º)	Total capital cost (M€)	Operating cost (M€/year)	COE (€/kWh)	PV Production (MWh/year)	Grid Purchases (MWh/year)	Grid Sales (MWh/year)	Total electricity production (MWh/year)	Primary load (MWh/year)	Renewable fraction	Renewable fraction self-consumption
30	15	7,56	1,87	0,154	12042	8366	5811	20408	14601	0,59	0,43
40	15	10,21	1,3	0,125	16256	8069	9729	24326	14601	0,67	0,45
42	15	10,58	1,22	0,121	16858	8038	10299	24896	14601	0,68	0,45
45	15	11,34	1,06	0,112	18063	7979	11445	26042	14601	0,69	0,45
50	15	12,47	0,83	0,100	19869	7904	13176	27773	14601	0,72	0,46
30	35	5,29	2,31	0,177	8879	8829	3111	17708	14601	0,50	0,40
40	35	7,18	1,9	0,153	12050	8461	5915	20512	14601	0,59	0,42
42	35	7,56	1,77	0,148	12684	8406	6493	21090	14601	0,60	0,42
45	35	8,32	1,6	0,139	13952	8306	7662	22259	14601	0,63	0,43
50	35	9,07	1,43	0,130	15221	8221	8845	23442	14601	0,65	0,44

F. Transport calculations for GHG inventory

In this annex, the calculations of the distance travelled by each mean of transport will be explained and the CO_2 emissions emitted presented.

Private system

The type of European regulation is detailed in Table 4.3 and the distance travelled by each mean of private transport is included in Table 10.30.

Table 10.30 Kilometers travelled per type of car and year.

Age	Years	Cars	Motorcycles	Small Trucks (<3500 kg)
0-4	2017-2021	19689	4656	26278
5 to 9	2012-2016	15301	3243	19017
10 to 14	2007-2011	12399	2867	15623
15 to 19	2002-2006	10532	2462	12898
> 20	<2001	8472	1692	11153

Car fleet

First of all, the car fleet is included in Table 10.31, the kilometers travelled by a car depending on the year of matriculation is detailed in Table 10.30.

Table 10.31 Fleet of two wheels in the city of Valencia per European regulation and type of fuel.

Regulation	Type of fuel					Total
	Petrol	Diesel oil	Electricity	LPG	CNG	
PREEURO	41022	3556	1	0	0	44579
EURO 1	5726	1920	0	0	0	7646
EURO 2	13065	11469	0	0	0	24534
EURO 3	33374	44439	0	0	0	77813
EURO 4	35348	63312	0	0	0	98660
EURO 5	20232	36129	13	26	1	56401
EURO 6	24647	23086	109	67	18	47927
Total	**173414**	**183911**	**123**	**93**	**19**	**357560**

Two wheels fleet

Also, the two wheels fleet is included in Table 10.32 and the total kilometers travelled by a two wheel vehicle depending on the year of matriculation is included in Table 10.30.

Table 10.32 Fleet of two wheels in the city of Valencia per European regulation and type of fuel.

Regulation	Type of fuel				Total	%
	Petrol	Diesel oil	Electricity	Others		
PREEURO	41022	3556	1	0	44579	11,73%
EURO 1	5726	1920	0	0	7646	2,01%
EURO 2	14848	11478	0	0	26326	6,93%
EURO 3	47130	44546	0	0	91676	24,12%
EURO 4	40101	63477	18	0	103596	27,25%
EURO 5	21386	36158	52	26	57622	15,16%
EURO 6	25352	23121	130	67	48670	12,80%
Total	195565	184256	201	93	380115	

Small trucks (< 3500 kg)

For the case of small trucks, the information previously presented for the case of cars and two-wheels is included in Table 10.33 and the kilometers travelled in Table 10.30.

Table 10.33 Fleet of small trucks (< 3500 kg) in the city of Valencia per European regulation and type of fuel.

Regulation	Type of fuel				Total	%
	Petrol	Diesel oil	Electricity	Others		
PREEURO	182	2550	0	0	2732	11,56%
EURO 1	104	964	0	0	1068	4,52%
EURO 2	118	2819	0	0	2937	12,43%
EURO 3	184	5970	0	0	6154	26,05%
EURO 4	189	7618	1	4	7812	33,06%
EURO 5	30	1745	4	1	1780	7,53%
EURO 6	36	1094	14	0	1144	4,84%
Total	843	22760	19	5	23627	

Considering the inventory about the private vehicle fleet in Valencia the next data presented is the emissions related with each type of vehicle and regulation [55].

Table 10.34 Emissions factor (tCO_2e/km) for car fleet.

Regulation	Type of fuel				
	Petrol	Diesel oil	Electricity	LPG	CNG
PREEURO	0,000419	0,000368	0,000225	0,000313	0,00035
EURO 1	0,000403	0,000356	0,000225	0,000313	0,000366
EURO 2	0,000387	0,000344	0,000225	0,000313	0,000322
EURO 3	0,000371	0,000332	0,000225	0,000313	0,000308
EURO 4	0,000355	0,00032	0,000225	0,000313	0,000294
EURO 5	0,000342	0,000313	0,000225	0,000313	0,000285
EURO 6	0,000329	0,000306	0,000225	0,000313	0,000276

Table 10.35 Emissions factor (tCO_2e/km) for two wheels fleet.

Regulation	Type of fuel				
	Petrol	Diesel oil	Electricity	LPG	CNG
PREEURO	0,000124	0,000124	0,000124	0,000124	0,000124
EURO 1	0,000124	0,000124	0,000124	0,000124	0,000124
EURO 2	0,000124	0,000124	0,000124	0,000124	0,000124
EURO 3	0,000124	0,000124	0,000124	0,000124	0,000124
EURO 4	0,000124	0,000124	0,000124	0,000124	0,000124
EURO 5	0,000124	0,000124	0,000124	0,000124	0,000124
EURO 6	0,000124	0,000124	0,000124	0,000124	0,000124

Based on all the data presented the private vehicle emissions from vehicles of the neighborhood has been calculated and presented in Table 10.36 and Table 10.37. For this estimation it has been considered that only a 20% of the total kilometers that the vehicles travelled in a year are made in the neighborhood of Benicalap and only a 10% of the total kilometers in the neighborhood of L'Illa Perduda, considering these differences due to the contrast in the size of the neighborhoods.

Table 10.36 Tons of CO_2e emitted by private vehicles from Benicalap.

	Petrol	Diesel oil	Electricity	LPG	CNG
Tourisms	7979,2	8078,8	5,56	5,65	1,07
Two wheels	680,8	710,3	1,08		
Small Trucks	44,78	1134	0,33		
SUBTOTAL	8704,7	9923,1	6,97	5,65	1,07
	TOTAL		**18641**		

Table 10.37 Tons of CO_2e emitted by private vehicles from L'Illa Perduda.

	Petrol	Diesel oil	Electricity	LPG	CNG
Tourisms	1650,5	1671,1	1,15	1,17	0,22
Two wheels	140,8	146,9	0,22		
Small Trucks	9,26	234,6	0,07		
SUBTOTAL	1800,6	2052,6	1,44	1,17	0,22
	TOTAL		**3856,1**		

To estimate more precisely the emissions, produce by the private transport it is important to consider the emissions from private vehicles that cross the district. For this reason, the traffic of main streets and the kilometers of each of them what has been studied and presented in Table 10.38 and Table 10.39.

Table 10.38 Main streets data about Benicalap [56].

		IMD	km	Diary km total
A35	Av. Burjasot	5556,3	0,6	3306
A95	Av. Dr. Peset	51102,4	0,65	33216,6
A367	Juan XXIII	22293,8	0,86	19172,6
A407	Av. U.D. Levante	13050,8	0,5	6460,2
A220	La Safor	3412,8	0,158	539,2
A169	N. Benlloch	11402,3	0,6	6841,4
A219	La Safor	10091,5	0,13	1261,4
A81	Corts Valencianes	60543,1	0,56	33904,1
A82	Corts Valencianes	73348,4	0,58	42542,1
A111	Gral. Avilés	45920,3	0,6	27322,6
A168	N. Benlloch	10179,6	0,5	5089,8
				179656

Table 10.39 Main streets data about L'Illa Perduda [56].

		IMD	km	Diary km total
A231	Justo y Pastor	8864,1	0,44	3855,9
A415	Justo y Pastor II	6317,3	0,35	2211
A359	J.M. Haro	5092,8	0,2	993,1
A50	Blasco Ibañez	29259,9	0,29	8339,1
B74	M.Ginez	6391,4	0,38	2396,8
A235	Serrería	42763,8	0,28	11760,1
				29555

Considering this data, and without having the data of the type of vehicle, the emissions considered has been the ones related with car fleet. Based on the previous values from Table 10.34 a general value for emissions for these vehicles from out of the area has been calculated and established in 0,00035 tCO_2e/km, because the diary IMD is known but the type of vehicles counted in this statistics is not detailed, so a general value based on the percentages of each type of vehicle and the emissions of each one of this type has been calculated.

The emissions related with these vehicles are included in Table 10.40.

Table 10.40 Emissions of CO_2 related with vehicles not considered inside the area.

Benicalap	15580,17	tCO_2e
L'Illa Perduda	2563,16	tCO_2e

Public system

Bus system

In base of the information about the EMT (Empresa Municipal de Transportes) of Valencia [20] the bus system of Valencia has a total of 61 lines that considering the 485 vehicles travel 17852496 kilometers per year.

To calculate the total kilometers that these lines travelled in the neighborhood first the bus lines that pass through the area are selected and calculated the total distance that in one trip is travelled. In Figure 10.12 the purple lines represent the circuit of the different lines that are in Benicalap and in Figure 10.13 the purple lines are the correspondent to the bus lines in L'Illa Perduda. Table 10.41 and Table 10.42 include the lines that travel in the two neighborhoods, the total distance of the line and the distance that drive in the neighborhood.

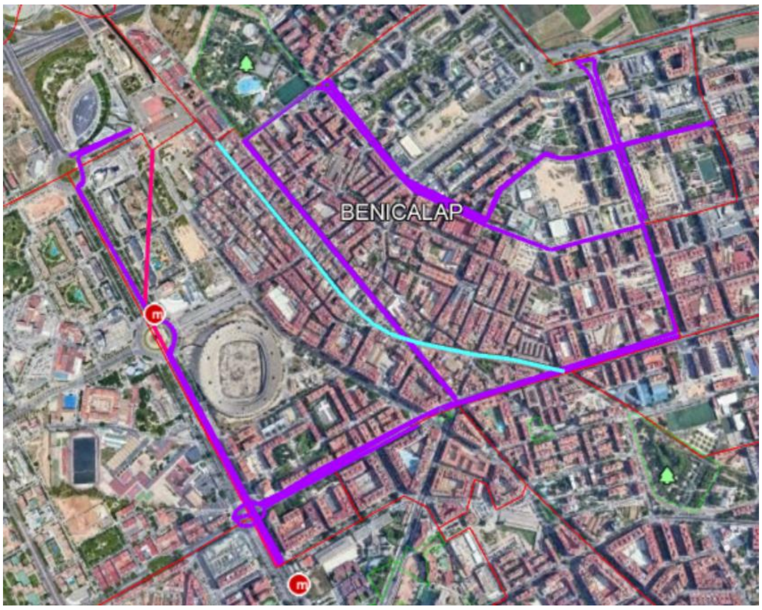

Figure 10.12 Transport system in Benicalap. Elaborated from Google Earth.

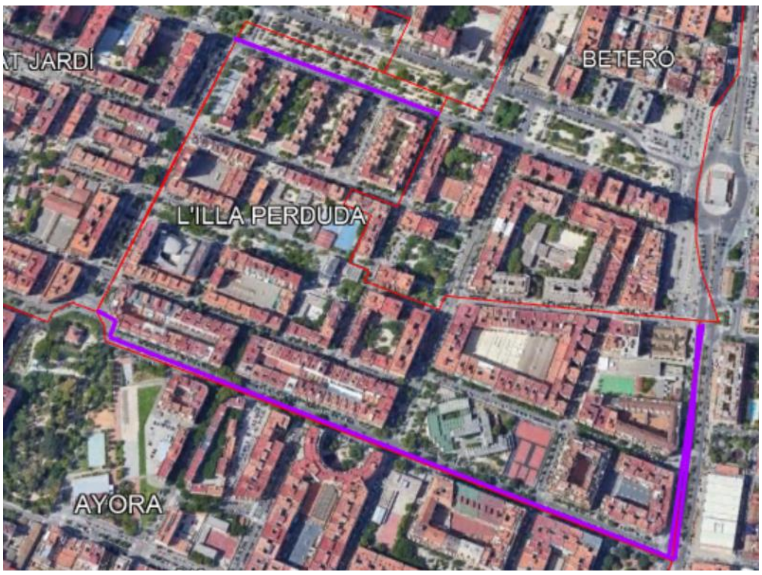

Figure 10.13 Transport system in L'Illa Perduda. Elaborated from Google Earth.

Table 10.41 Bus system in Benicalap.

Lines	Total kilometers	Kilometers in the neighborhood	% Kilometers in the neighborhood
12	15,24	2,57	16,86%
28	10,7	1,33	12,43%
60	10,74	0,74	6,89%
62	17,89	1,32	7,38%
63	14,45	1,32	9,13%
64	17,28	2,98	17,25%
94	14,59	1,29	8,84%
99	30,26	1,72	5,68%
N3	15,28	1,32	8,64%
N10	13,47	2,71	20,12%

Table 10.42 Bus system in L'Illa Perduda.

Lines	Total kilometers	Kilometers in the neighborhood	% Kilometers in the neighborhood
31	15,23	0,3	1,97%
32	15,17	1,1	7,25%
81	9,29	0,3	3,23%
99	30,26	0,28	0,93%
N1	14,64	0,5	3,42%

Considering the distance of each of the lines and the total travels in the line, in base of the first and last departure and the frequency [57] of each of the lines for the different periods considered, weekdays, weekends and holidays the total kilometers travelled in the district can be calculated and show in Table 10.43 and Table 10.44.

Table 10.43 Kilometers travelled per year in Benicalap by the buses system.

Lines	Total kilometers
12	56283
28	42525,4
60	23466,9
62	33726
63	28908
64	93831,3
94	31536,6
99	45714,2
N3	56283
N10	42525,4
TOTAL	**363346,1**

Table 10.44 Kilometers travelled per year in L'Illa Perduda by the buses system.

Lines	Total kilometers
31	6063,9
32	27946
81	9784,5
99	7441,8
TOTAL	**51235,7**

Metro system

In case of the metro system, it is only applied in Benicalap because the neighborhood of L'Illa Perduda do not count with stops in the area for this system. The process is the same applied for the bus system. Firstly, the lines that cross the neighborhood are identified in the Figure 10.12 with pink color, in base of the total distance travelled in the neighborhood which is detailed in Table 10.45 and the frequency [20], the total kilometers are calculated and indicated in Table 10.46.

Table 10.45 Metro system in Benicalap.

Lines	Total kilometers	Kilometers in Benicalap	% Kilometers in Benicalap	Total Stops	Stops in Benicalap	% Stops in Benicalap
Line 1	72,15	1,28	1,77%	40	1	2,50%
Line 2	39,45	1,28	3,25%	33	1	3,03%

Table 10.46 Kilometers travelled per year in Benicalap by the metro system.

Lines	Total kilometers
Line 1	61039,4
Line 2	65460,5
TOTAL	**126499,8**

Tram system

As in the case of the metro system, the tram service is only available in the district of Benicalap with the route that it is detailed in Figure 10.12 with blue color. Using the same process that for the metro and bus system the total kilometers travelled by the tram in Benicalap are calculated and included in Table 10.48.

Table 10.47 Tram system in Benicalap.

Lines	Total kilometers	Kilometers in Benicalap	% Kilometers in Benicalap	Total Stops	Stops in Benicalap	% Stops in Benicalap
Line 4	17	1,26	7,41%	33	3	9,09%

Table 10.48 Kilometers travelled per year in Benicalap by the tram system**.**

Lines	Total kilometers
Line 4	68789,7

Considering the previous values and the emission factors for this means of transport, the emissions related with public transport in Benicalap and L'Illa Perduda are detailed in Table 10.49.

Table 10.49 Emissions of CO_2 from public transport.

Benicalap	3367,65	tCO_2e
L'Illa Perduda	169,08	tCO_2e

Valenbisi

In point Transport it is included the characteristics of the public bicycle system for the city of Valencia. In this part of the document the location and locking point of the different stations in the two neighborhoods will be exposed. In Figure 10.14 is detailed the location of the Valenbisi stations in Benicalap and the data about each of them is detailed in Table 10.50. For the case of L'Illa Perduda the location appears in Figure 10.15 and the data in Table 10.51.

Figure 10.14 Location of Valenbisi stations in Benicalap.

Table 10.50 Data of Valenbisi stations in Benicalap.

Station	Nª Station	Locking Points
Nicasio Benlloch - Amics dels Corpus	205	24
Monduber - Peset Aleixandre	174	19
Juan XXIII - Domingo Gómez	175	15
Rio Segre - Rafael Company	236	15
Poeta Serrano Clavero - General Llorens	230	15
Periodista Gil Sumbiela - Poeta Serrano Clavero	206	15
Levante U.D. - Ecuador	237	15
Salvador Cerveró - Carlos Cortina	271	15
		133

Figure 10.15 Location of Valenbisi stations in L'Illa Perduda.

Table 10.51 Location of Valenbisi stations in L'Illa Perduda.

Station	Nª Station	Locking Points
Serrería, 67	84	15
José María de Haro - Justo y Pastor	160	20
Blasco Ibañez - Pintor José Mongrell	99	20
		55

G. Future emission factor for the energy mix

In this annex the calculations developed to estimate the emission factors for the next years for the electricity generation mix will be explained.

First of all, it is important to consider that the emission factor for the electricity mix in the Spain as a country has a certain value and the Valencian Community as part of Spain another one because of the difference in the power installed of the different energy sources, and in consequence the energy generated. But also, it is considered that the Valencian Community has a percentage of import of energy from the rest of Spain and due to that reason, it is necessary to estimate the emission factor both for the Valencian Community and Spain.

For the calculation of this emission factors two main data are considered: the energy generation in the years from 2020 to 2030 and the emission factor of each of the sources that generate this electricity. The electricity generation by sources for the Valencian Community and Spain for a certain number of the next years are presented in Table 10.52 and Table 10.53. These values are obtained from different reports that have considered the changes in the sources, mainly considering the increase of the integration of renewable sources in the generation mix and the predicable increase of the energy demand.

Table 10.52 Spanish electricity generation (GWh) by source for 2020, 2025 and 2030 [58], [46].

Year	2020	2025	2030
Wind	60670	92926	119520
Solar Photovoltaic	16304	39055	70491
Solar Thermal	5608	14322	23170
Hydraulic	28288	28323	28351
Storage	4594	5888	11960
Biogas	813	1009	1204
Geothermal	0	94	188
Marine Energy	0	57	113
Coal	33160	7777	0
Combine cycle	29291	23284	32725
Cogeneration coal	78	0	0
Cogeneration gas	22382	17408	14197
Cogeneration petrol	2463	1767	982
Others	2463	1872	1769
Gas	10141	7606	5071
Renewable cogeneration	988	1058	1126
Biomass	4757	6165	10031
Residual cogeneration	160	122	84
USW	918	799	355
Nuclear	58039	58039	24952
Total	281117	307571	346289

Table 10.53 Valencian Community electricity generation (GWh) by source for 2020 and 2030 [59], [58].

Year	2020	2030
Mere pumping	1337	946
Hydraulic	433	430
Combine Cycle	4081	4209
Wind	2198	9192
Photovoltaic	527	3660
Solar Thermal	87	88
Other renewables	37	235
Cogeneration	1469	2710

The emission factors used and applied to the future measures proposed in 5.4 are the ones obtained from the report of REE [60].

Table 10.54 Emissions factors associated with electricity generation in Spain.

Technology	Emissions (tCO_{2e}/MWh)
Coal Thermal Plant	0,95
Combined Cycle Thermal Plant	0,37
Fuel-Oil Thermal Plant	0,77
Cogeneration	0,38
Wastes	0,24

Considering that the percentage of electricity imported from the rest of Spain in the Valencian Community is constant during all the years of the study and has a value of 35% [48].

It is also important to consider that in addition to the emissions produced by the electricity generation there are a quantity of upstream and downstream process related with this production of electricity, for example the losses in the electricity transport system [61].

The values obtained for the emission factor from 2020 to 2030 are detailed in Table 10.55.

Table 10.55 Emission factors for the Valencian Community electricity mix.

	tCO_2/MWh
2020	0,172
2021	0,156
2022	0,149
2023	0,143
2024	0,137
2025	0,131
2026	0,126
2027	0,121
2028	0,116
2029	0,112
2030	0,108

H. Calculations for electric vehicle measure

In this annex the calculations developed to estimate the CO_2 savings related with the substitution of current vehicle fleet for a new fleet with electric vehicles that are less contaminants are presented.

For calculating the CO_2 emissions by the new electric vehicles, the consumption of kWh/km, the daily kilometers travelled, and the electricity emission factor should be considered. In this case the value for electric cars is 0,15 kWh/km [62] and in the case of two wheels vehicles is 0,04 kWh/km [63], the mean daily kilometers travelled in the neighborhoods has been calculated considering the size of the neighborhoods and the maximum length of its, being 7 kilometers in Benicalap and 3,5 kilometers in L'Illa Perduda for cars and 1,5 kilometers in Benicalap and 1 kilometer in L'Illa Perduda for the case of two wheels vehicles. The emission factor used to calculate the CO_2 emissions are the ones detailed in annex G Future emission factor for the energy mix.

The values calculated for cars are detailed in Table 10.56 and Table 10.57.

Table 10.56 CO_2 emissions from the penetration of the electric cars in the transport system in Benicalap.

Year	Number of electric cars in Benicalap	kWh/year	tCO_2e/year
2020	267	102327,75	6,55
2025	1026	393214,50	22,14
2030	3413	1308032,25	67,31

Table 10.57 CO_2 emissions from the penetration of the electric cars in the transport system in L'Illa Perduda.

Year	Number of electric cars in L'Illa Perduda	kWh/year	tCO_2e/year
2020	56	10731,00	0,69
2025	213	40816,13	2,30
2030	707	135478,88	6,97

To calculate the emissions related with two wheels electric vehicles and small trucks the same percentages of penetration of electric cars in Benicalap and L'Illa Perduda has been used to determine the penetration of two wheels electric vehicles, 1% in 2020, 5% in 2025 and 17% in 2030 and are expressed in Table 10.58 and Table 10.59 for Benicalap and Table 10.60 and Table 10.61 for L'Illa Perduda.

Table 10.58 CO_2 emissions from the penetration of the electric two wheels vehicles in the transport system in Benicalap.

Year	Number of electric two wheels vehicles in Benicalap	kWh/year	tCO_2e/year
2020	39	854,1	0,11
2025	225	4927	0,28
2030	747	16359	0,84

Table 10.59 CO_2 emissions from the penetration of the electric small trucks vehicles in the transport system in Benicalap.

Year	Number of small trucks in Benicalap	kWh/year	tCO_2e/year
2020	17	43435	5,52
2025	63	160965	18,65
2030	209	533995	58,37

Table 10.60 CO_2 emissions from the penetration of the electric two wheels vehicles in the transport system in L'Illa Perduda.

Year	Number of electric two wheels vehicles in L'Illa Perduda	kWh/year	tCO_2e/year
2020	8	116,8	0,01
2025	47	686,2	0,06
2030	155	2263	0,20

Table 10.61 CO_2 emissions from the penetration of the electric small trucks vehicles in the transport system in L'Illa Perduda.

Year	Number of small trucks in L'Illa Perduda	kWh/year	tCO_2e/year
2020	4	10220	1,30
2025	13	33215	3,85
2030	44	112420	12,29

Other emissions due to electric cars should be considered, as previously taking into account, the emissions related with electric cars that are not from people living in the neighborhood but pass through it. For this calculation the penetration of electric vehicle considered is the same as for Benicalap and L'Illa Perduda, assuming an equal distribution of this mean of transport in Valencia. Considering the value of the total kilometers developed by these external vehicles from Table 10.40 and the data previously indicated for electric cars the next values are obtained and exposed in Table 10.62 and Table 10.63.

Table 10.62 CO_2 emissions from external electric vehicles in Benicalap.

YEAR	Daily kilometers travelled by electric vehicles in Benicalap	kWh/year	tCO_2e/year
2020	1796	98361	6,30
2025	8982	491808	27,69
2030	30541	1672147	86,04

Table 10.63 CO_2 emissions from external electric vehicles in L'Illa Perduda.

YEAR	Daily kilometers travelled by electric vehicles in L'Illa Perduda	kWh/year	tCO_2e/year
2020	295,6	2,78	1,04
2025	1477	13,92	4,56
2030	5024	47,32	14,15

I. Budget

In this part of the works is presented the estimation budget necessary to develop this study in the current industry situation. This budget includes a description of the phases of the project, dividing this total budget in three different factors: human resources costs, equipment costs and other general costs.

This project has been developed during seven months and a total of 800 hours were dedicated by the student to this work. In the case of supervisors, every two weeks a tracking meeting took place and at the final phase, the revision of the report was carried out.

Human resources costs

Three individuals developed the activities of this project: one student and two supervisors. The cost per hour for student and supervisor are included in Table 10.64.

Table 10.64 Cost of human resources.

Student (€/h)	25
Supervisor (€/h)	60

To determine the total human cost, the next activities has been developed and included in this budget: literature review, methodology, data acquisition, modelling, writing and revision and guidance. Table 10.65 includes the cost related with human resources in this project.

Table 10.65 Estimated budget for human resources.

TASK	NUMBER OF PERSON	CATEGORY	NUMBER OF HOURS (h)	TOTAL COST (€)
Literature review	1	Junior Engineer	150	3750
Methodology	1	Junior Engineer	50	1250
Data acquisition	1	Junior Engineer	200	5000
Case study calculations and simulation	1	Junior Engineer	240	6000
Writing	1	Junior Engineer	120	3000
Review and guidance	3	Junior Engineer (1)	40	1000
		Supervisor (2)	80	4800
TOTAL COST			880	24800

Equipment

For this project, no specialized technical equipment has been used, only the computers from all the persons who has been involved in this work. The laptop from the student has been used during all the period of the project, which is 800 hours and the supervisors 40 hours each one. To calculate the estimated cost the hours of use during the project has been divided by the total hours of life estimated for the divide. Table 10.66 includes the total cost concerning equipment used in the project.

Table 10.66 Estimated budget for equipment.

EQUIPMENT	PRICE (€)	AMORTISATION PERIOD (y)	PROJECT USE PERIOD (months)	TOTAL COST (€)
Laptop Junior Engineer	900	5	7	105
Laptop Professor	1400	5	1	23,33
Laptop Professor	1400	5	1	23,33
HOMER license	125 €/month	-	3	375
		TOTAL COST		526,66

General costs

Apart from the cost previously mentioned there are other cost that identified in this project: electricity and internet, so the electricity bill and internet bill has been considered. The cost related with this budget is included in Table 10.67.

Table 10.67 Estimated budget for general costs.

	QUANTITY (units)	UNIT COST (€/unit)	TOTAL COST (€)
Electricity bill	7	70	490
Internet bill	7	20	140
	TOTAL COST		630

Budget summary

In this point the final budget is summarized and presented. To all the previous cost calculated, various taxes must be applied: industrial profit (10%) and regular IVA tax (21%). The final budget of the project is 36789,98 € and is detailed in Table 10.68.

Table 10.68 Total budget of the project.

	COST (€)
Human resources budget	24800
Equipment budget	526,66
General cost budget	630,00
GROSS BUDGET	25956,66
Industrial profit	2595,66
IVA	5450,89
TOTAL BUDGET	**34003,21 €**