DECARB CITY PIPES 2050

H/C plan of city of Bilbao

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Introduction

Bilbao, as many cities in Europe, is working to reduce the damage caused by COVID-19 pandemic on its socioeconomic situation while it is getting over the remaining consequences of the last economic and financial global crisis. Bilbao possesses some tools which contribute positively to social cohesion and, therefore, to alleviate the consequences of the crisis. All that makes Bilbao's social services system more efficient and helps to generate work opportunities for people at risk of exclusion. Bilbao now relies on a strong civil society basis which contributes building a city firmly related to people's wellbeing.

Currently, Bilbao is focused on the economic and employment challenge, and investments are being made in new businesses with better job quality conditions. Bilbao is also immersed in the social and urban rejuvenation challenge: an effort is being made to attract new young students and workers, so that they can choose Bilbao as a place to live and develop their personal and professional projects.

In the last few decades Bilbao has undergone a large restructuring and regeneration process, moving the industrial network outwards municipal limits, and with large infrastructure investments such as a subway net, treating the sea inlet or rebuilding a tram line. Building developments such as Euskalduna music house, the refurbished La Rivera market and the iconic opening of the Guggenheim Museum in 1997 have greatly changed city's physiognomy., Now, Bilbao is engaged in projects related to the reconfiguration, digitalisation and modernisation of the tourism sector, which is expected to be one of Bilbao's main income sources.

Bilbao published in 2012 an Action Plan for Sustainable Energy which laid down city's commitment to sustainability from there on. Aligned with more than 4.000 European cities, Bilbao committed to reduce by 2020 at least a 20% the CO_2 emissions with regard to 2005 levels.

Bilbao also subscribed to other local and national initiatives, such us an Action Plan against Noise, a Sustainable Urban Mobility Plan, the creation of green zones in urban area, a Climate Change Adaptation Plan, and to so many others.

More recently, Bilbao Environmental Strategy 2050 plans to achieve carbon neutrality by that date, and improve city's life quality in one-year QALY (Quality Adjusted Life Years). The Sustainable Energy and Climate Action Plan 2030, which Bilbao is now developing on the framework of Covenant of Mayors, will commit the city to reduce at least 40% GHG by that date.

Within this framework, Decarb City Pipes 2050 project is expected to play in important role on to planning the decarbonisation of the Heating and Cooling sector within the city. This document presents the work done within this project as a first "Heating & Cooling Plan" of the city of Bilbao.

Facts & figures: the context

The city of Bilbao has 347,000 inhabitants and is located on the eastern Atlantic side of the Iberian Peninsula, surrounded by mountainous areas. The capital of Bizkaia is the heart of a metropolis of more than 1 million inhabitants and considered as the main factor of economic and social development as well as modernisation of the province. Its important transport infrastructure connects the city with the main capitals of Europe, by land, air, and sea, thanks to the easy access to the sea through the port. Additionally, Bilbao is a clear example of successful case of urban reconversion, developing a great transformation from a completely industrial city to an attractive, design and service-focused city. Although it does not have a great expertise in the energy field, the background of such an important transformation shows the city's capacity to undertake forefront projects.

FIGURE 1 IMAGE OF THE CITY OF BILBAO

Focusing on data and particularly on the building stock, the vast majority are residential buildings, but the city also has a considerable number of non-residential buildings, mainly focus in the tertiary sector (shops, educational centres, offices...). The attached figure 2 shows the type of use of buildings in Bilbao. In addition, most of them are multiple ownership buildings, which in some cases hinders the refurbishment and energy efficiency actuations at building level since a consensus of the community of owners is required. There is also an important number of municipal housing buildings for residential use.

FIGURE 2 BUILDING STOCK PER USE OF BUILDING

At present, natural gas is by a wide margin the main source of heating and cooling. Gas infrastructures are deployed all over the city. Bilbao has no district heating systems yet. A low temperature district heating and cooling pilot is being developed on the city island of Zorrozaurre, as part of the area´s urban development from brownfield to a new city centre. In this Heaitng and Cooling plan, the different approaches to replace gas supply in existing urban developed districts of Bilbao is evaluated..

According to 2018 data, a total of 807 GWh amount of heating consumption was reported for the total building stock in Bilbao (543 GWh for space heating and 264 GWh for domestic hot water). About 70% of this consumption is supplied by natural gas .Cooling has a very low impact on the city, with 136 GWh stated as mainly consumed in tertiary buildings.
With regard to residential sector, a total final consumption heat demand is stated at 260 GWh for space heating and 185 GWh for domestic hot water, which results in a total final consumption of 445 GWh/a. The distribution of different equipment and types of heating in the residential sector is depicted in figure 3. It shows a very low penetration of individual heat pumps (below 1%), 15% considerable direct use of electricity (Joule) and more than 50% of individual gas boilers. Around 30% of the systems are centralised, an important data when considering centralised DH systems. The existence of old oil boilers has to be also taken into account.

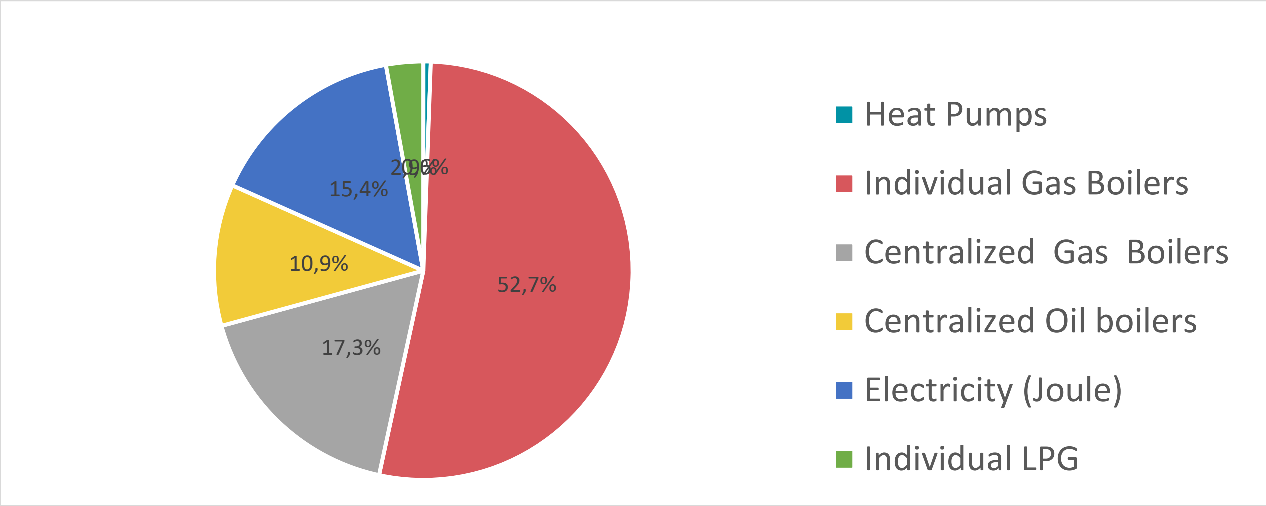

Figure 3 Type of heating systems in residential building (by % of heated area)

For the non-residential sector a similar analysis is exposed. In this case, 282 GWh of consumption was reported for space heating and 79 GWh for domestic hot water. In terms of equipment and type of system distribution, data is given in Figure 4. Natural gas boilers are still the most common systems but there is a remarkable 30% of use of heat pump, either individual or centralised. Figure 5 depicts the distribution of heating systems per use of building in the non-residential sector.

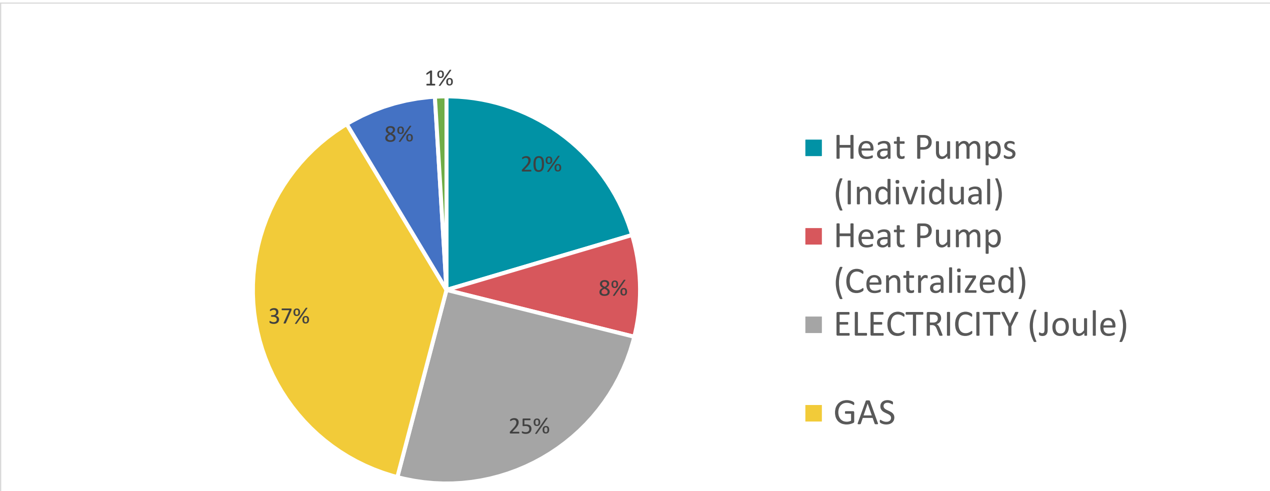

Figure 4 Type of heating systems (% of all non-residential heated area)

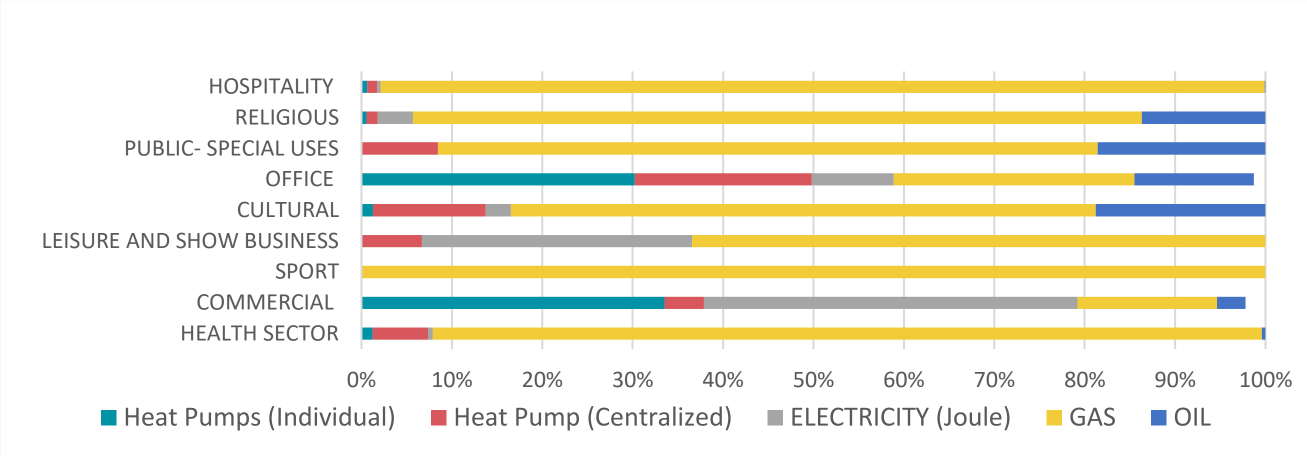

FIGURE 5 TYPE OF HEATING SYSTEMS – NON-RESIDENTIAL BUILDINGS - % OF HEATED AREA

The anticipated HC Outlook 2050 of WP2 was based on the assumption of a transition from the current systems to full electrification. In addition, some assumptions of heat savings were foreseen as well as the possibility to obtain reductions in final consumption demand by behavioural changes.

For that electrification in the residential sector individual combustion systems based on natural gas and on liquefied petroleum gas (LPG) are expected to be replaced with individual aerothermal heat pumps , water-to-water heat pumps connected to district networks or direct electric heating systems based upon the Joule effect. Centralised heat pumps are expected to substitute all current centralised gas and oil boilers, to supply both heating and hot water. For domestic hot water (DHW) systems, the 75% of current individual DHW systems are expected to be replaced with individual heat pumps. The other 25% is expected to be replaced with direct electric systems based on the Joule effect.

Process

The process of the development of HC Plan in the city of Bilbao has mainly involved the technical part of the Local Working Group. LWG entails the participation of technicians from the Sustainability Commission as well as municipal departments, regional institutions, utilities, etc.

HC Plan is a fundamental component of an existing process of generation of City Vision in which Bilbao is immersed. Energy is seen an essential driver in the next years and that leads to establish a set of strategies and objectives. The first scope was based on the definition of a 2050 City Vision which actually concerns some uncertainties to determine specific objectives in that long term. Therefore, that preliminary 2050 Vision will be useful in the examination of more applicable actions for 2030 year, that will feed into the SECAP, on which the City of Bilbao is currently working. During this process, meetings have been arranged with technicians from different areas of the City Council and also Workshops where representatives of local and regional companies and institutions have taken part.

In the first instance, a SWOT analysis of the city has been undertaken in order to develop a full awareness of the current situation of the city. This first step is really valuable to understand the starting point and addressing future potential strategies. This event also facilitates and set up a dynamic working between local agents involved in the energy transition and decarbonization of Bilbao. The diagnosis workshop was organised in six working groups: Governance and society, Energy, Mobility, Adaptation to Climate Change, Built environment and Digitization. Each group gathers local expertise in diverse sectors and promote their involvement in the diagnosis and co-development of the vision for Bilbao.

Taking into account considerations and conclusions from that first event subsequent meetings were arranged as part of the existing City Vision roadmap. These meetings intend to discuss the development of a preliminary Vision 2050 and set the strategies that will be used as an input for the upcoming SECAP of the city for 2030.

As for the HC Plan, as abovementioned, it is an important aspect within this City Vision andthe DecarbCityPipes 2050 project has enabled the preparation of a detailed analysis including geospatial evaluation of the building stock. To this end, more specific meetings have been held to analyse the city's future strategies in the HC Plan. As part of the HC Plan, Bilbao is undertaking an analysis of local energy scenarios and the possible implementation of spatial solutions at a disaggregated scale. The evaluation of all the data mapping (heating equipment, district heating demand, use of buildings...) which is described in more detail in the **Analysing Data Section** leads to identify the most suitable areas for the application of district heating and the determination of areas where individual solutions will be preferable. This mapping also includes an analysis of the potencial sources for heat exchange (with terrain or the river) for installing heat pumps and connect to district heating areas, the ownership of the building (municipal or private), the identification of special areas that are pending of rehabilitation in the next years as well as the level of protection of the buildings. This compilation of information is relevant for the identification of areas where the solutions have better conditions to be implemented in the coming years.

Framework and principles

One of the first principles for Bilbao decarbonisation strategy is to phase out direct use of fossil fuel by 2050 in all its building stock. This means that the use of natural gas for heating will need to be completely displaced by 2050 if a real decarbonisation of the building stock is aimed to be reached. Complementary measures for decarbonisation include increasing building refurbishment with high energy efficiency requirements: 50% of the building stock is expected to be nearly-zero by 2050, reducing energy supply needs.

Electrification is considered in this first heating and cooling plan as the most suitable option for both individual and centralised heating and cooling systems. The heating and cooling strategies proposed are based on installation of air, water, and geothermal based heat pumps. One of the biggest opportunities appreciated in the scope of work is the potential for using hydrothermal or geothermal heat sources for the heat pumps, achieving high coefficient of performance (COP). The foreseen scenario considers several renewable energy sources combinations to supply the heat pumps, particularly photovoltaic energy, although this will not be detailed in this document. The potential additional benefits of heat pumps on improving energy flexibility of the city's energy system are also being considered but are neither detailed in this report.

There are also some barriers that have been considered for the implementation of the electrification scenario. Heat pump technology, while very mature, it is still rather unknown for the public. While Life Cycle Costs or Total Cost of Ownership of the systems can be better than gas or oil boilers, the higher initial investment is also a main barrier. In apartment buildings, an agreement among building's owners needs to be reached when a centralized building solution is to be installed, which can also be a difficult task. Moreover, the larger space required for the equipment and storage and its potential visual and acoustic impact are some of the challenges the development team will have to cope with. On the other hand, there is a perceived uncertainty about operating costs and the variables that may intervene (actual seasonal COP, electricity prices variation and so on), as heat pump technology is a new concept for most citizens. Municipal regulations (i.e. General Urban Development Plan, Special Rehabilitation Plan, or restrictions on outdoors units) are also additional facts that will have an influence on the way the electrification scenario will be implemented.

The experiment being carried by Bilbao analysing potential leapfrogging of natural gas, by changing current oil boilers to heat pumps, has revealed some of the abovementioned barriers for implementation of heat pumps at building or apartment level. District heating systems must be studied in more detail as could overcome some of the barriers to heat pumps. This solution could fit city's energy supply requirements, particularly in some areas such as the old town or Zorrozaurre island; for example, benefiting from heat exchange with the river to efficiently run heat pumps. When a district heating solution is concerned, the heat distribution system and the required temperature at which the system will operate are questions that need to be looked in more detail. The use of H_2 or biogas for the heating and cooling of building stock is more unlikely to be set up.

Other of the principles on which Bilbao is basing on its studies is the aim of establishing a local renewable production system network in a large proportion of its building stock. A shared self-consumption, the generation of local energy communities, a flexible system and an efficient energy demand management strategy will be the pillars for Bilbao's decarbonisation by 2050.

Analyses data and aggregation

BUILDING STOCK ENERGY MODEL:

The building stock energy model of the city of Bilbao has been developed using the Enerkad® tool. The model can be used to test different scenarios for urban energy transition. For this H/C plan, the model has been used to assess the viability of district heating systems and other systems that can decarbonise the heating and cooling supply in Bilbao.

This model uses basic information from the cadastre as input data, from which building characterising and heating and cooling schedules are inferred. Enerkad tool calculates the hourly energy demand for each of the end uses of the building: heating, cooling, DHW, lighting and equipment. Using data from energy certificates regarding the installation type and fuel (see Appendix 1), fuel consumption and its associated costs and emissions can also be calculated.

The building stock model has been adjusted using real data regarding total energy consumption of the city, provided by the energy distribution companies. This is a crucial step in order to quantify energy consumption correctly and not to overestimate the reduction potential of the interventions planned.

The results are obtained in different formats, including several GIS-based formats, which allow for easy visualisation and integration of the results with other geo-referenced information.

The main GIS layers extracted from the building stock energy model are as follows:

1. Configuration of heating distribution within the buildings. Buildings with central heating systems, for example a boiler room in a residential building (from which heating and domestic hot water is distributed to individual apartments) are easier and cheaper to connect to district heating networks.

FIGURE 6 CONFIGURATION OF HEATING DISTRIBUTION

2. Energy source: Buildings with more expensive or polluting energy sources (e. g. Oil, LPG, Joule Effect electric heating) will have greater environmental and economic benefits from replacing the system

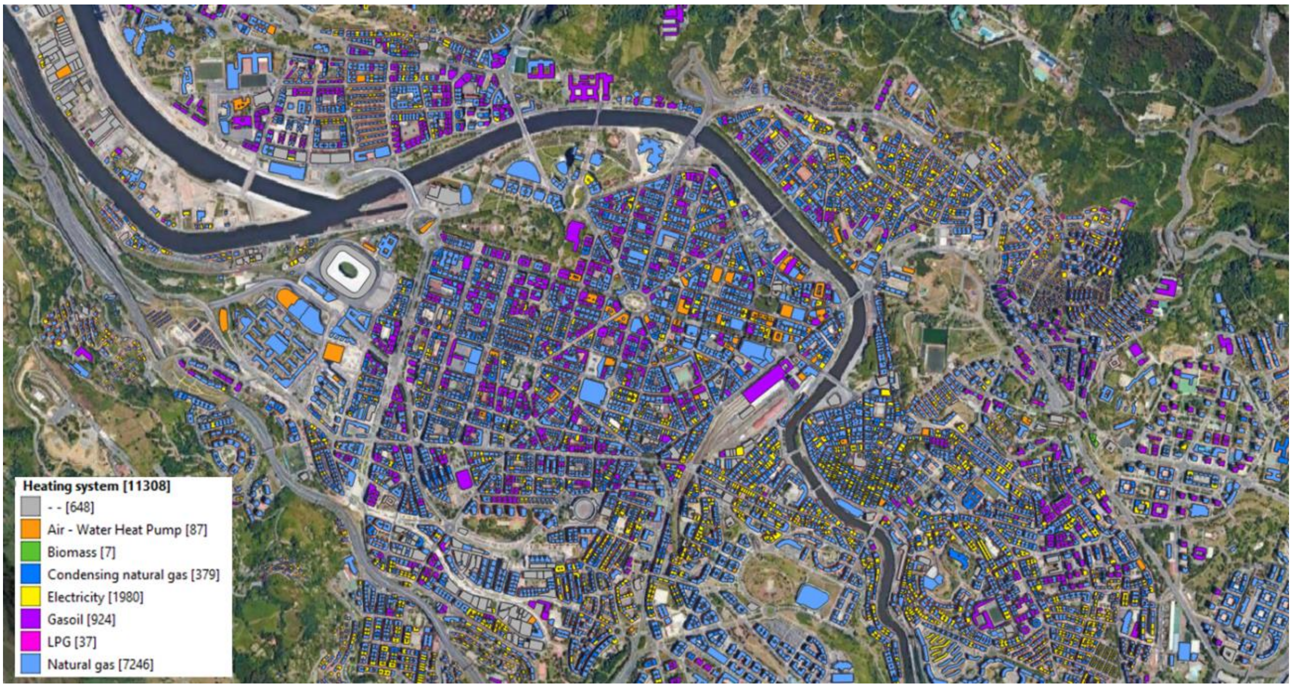

FIGURE 7 ENERGY SOURCE

3. Heating and cooling demand per square meter (usable floor area): Buildings with higher heating demand are more likely to need a refurbishment or to change to a more efficient system to lower the energy bills.

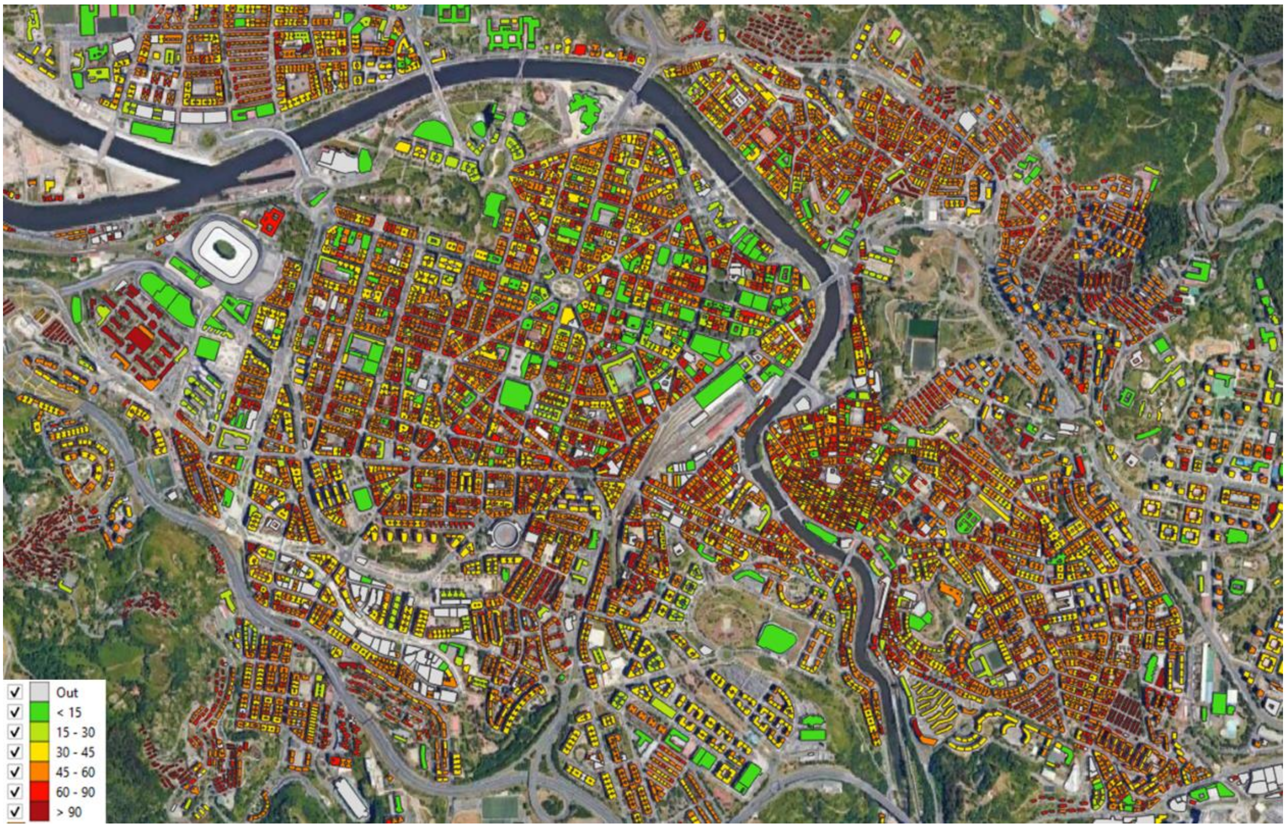

FIGURE 8 HEATING DEMAND [KWH/M²] FOR THE CITY OF BILBAO

4. Heat Density. This is the total thermal energy use of the building per m^2 of building footprint area, calculated from the energy model results. In areas with higher heating density, the economic viability of a district heating network will be favoured. This value can be converted to the MWh/hectare indicator which is commonly used for viability assessment of DH systems.

FIGURE 9 HEATING DENSITY [MJ/M2]

5. Heating/cooling density ratio: It is the ratio between heating and cooling density, which would favour a highly efficient use of heat pumps.

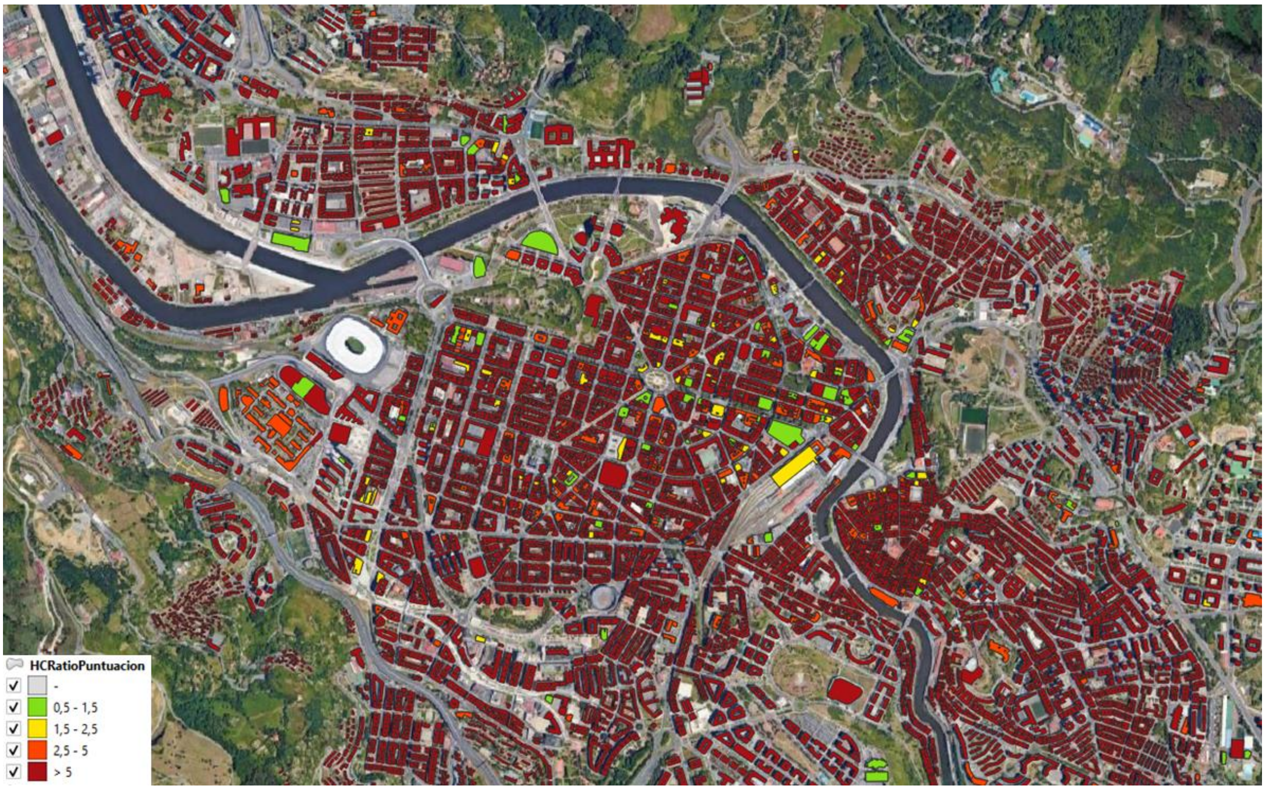

FIGURE 10 HEATING/COOLING RATIO

AGGREGATION OF ADDITIONAL INFORMATION LAYERS

The following additional geo-referenced layers have been identified as most relevant data for the analysis of the heating and cooling characteristics of the building stock.

6. Potential Heating/Cooling Energy Sources: Proximity to available heating or cooling sources, which could exchange heat with a district network. Availability of waste heat, geothermal or hydrothermal sources for heat exchange, can improve the economic viability of district heating or cooling networks.
7. Available public space: Availability of public space for the construction of necessary infrastructures.

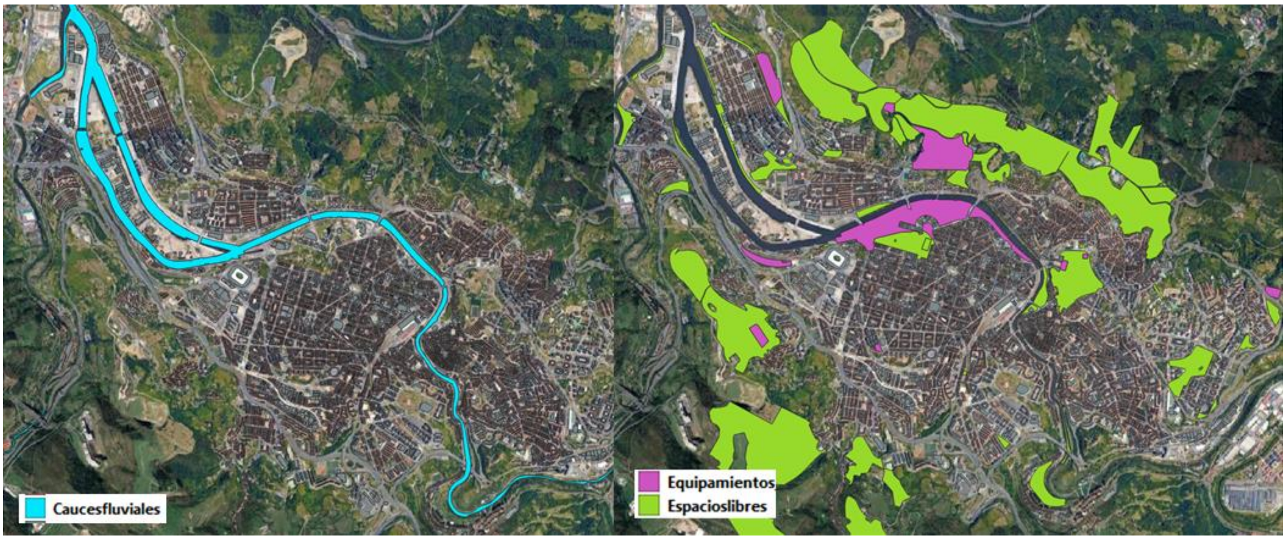

FIGURE 11 POTENTIAL ENERGY SOURCES AND AVAILABLE PUBLIC SPACE IN BILBAO

8. Protected buildings: Historic buildings or protected parts of the envelope that do not allow for retrofitting or rooftop installation of elements such as photovoltaic panels or external units for heat pumps.

FIGURE 12 PROTECTED BUILDINGS IN BILBAO

9. Public buildings: Buildings owned by public bodies such as the municipality or the Basque government. These are buildings which have a specific requirement for decarbonization under the Basque Energy Sustainability Law 4/2019, and where implementation of low carbon strategies has become a priority.

FIGURE 13 PUBLIC BUILDINGS IN BILBAO

10. City plans (future and incorporated). Plans for new developments or urban regeneration currently incorporated in urban planning or defined future plans.

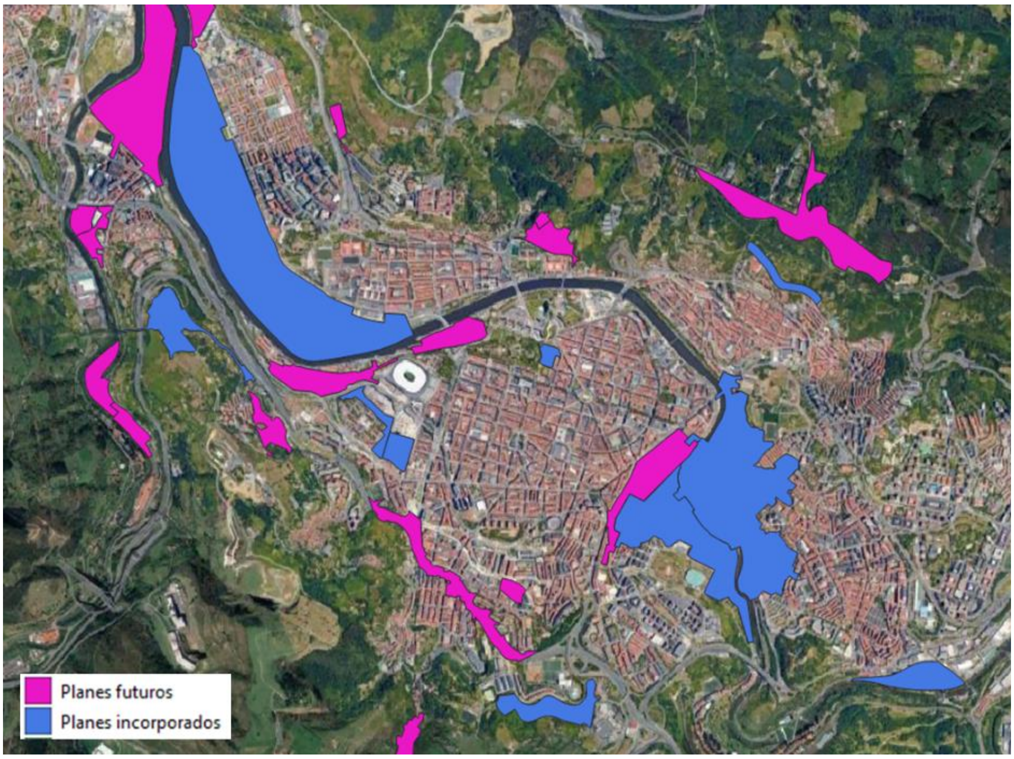

FIGURE 14 MUNICIPAL PLANS IN BILBAO

11. Degraded areas: geographical delimitation of Degraded Areas. These areas have access to subsidies for the implementation of energy efficiency and refurbishment strategies, and integral regeneration projects are more likely to be developed.

FIGURE 15 DEGRADED AREAS IN BILBAO

H/C planning

For the definition of the H/C plan, all the identified sources of information and the building stock energy model are used, to evaluate the viability of proposed strategies for decarbonisation.

The strategies for decarbonization of the building stock which will be evaluated, in line with the H/C Outlook developed by the city, consist on:

- Strategy 1 - Deep renovation of building blocks.
- Strategy 2 - Individual heat pumps
- Strategy 3 - District heating and cooling networks

To obtain an overview of which areas have the most favourable conditions for implementing decarbonisation strategies., the methodology followed consists on the weighted aggregation of the georeferenced datasets (Figure 16).

For this purpose, each of the categories of each layer is scored from 1 to 10, with 10 being the most favourable score for the implementation of a specific strategy, so that the scores may vary from one strategy to another depending on its characteristics.

A weighted overlay through a GIS tool is performed, in which different weights are applied to the layers depending on how relevant it is for the proposed strategy. As a result, a final layer is obtained with the corresponding score in each pixel, where 10 is the maximum score and 1 the minimum. This final layer is the basis for potential zoning and more detailed evaluation of the strategies in selected districts.

In addition to the raster layers, the ArcGIS Hot Spot analysis tool has also been used to facilitate the visualisation and understanding of the results. This tool identifies statistically significant spatial clusters of hot spots and cold spots.

The obtained +/-3 values reflect statistical significance at the 99 per cent confidence level; the +/-2 values reflect statistical significance at the 95 per cent confidence level; the +/-1 values reflect statistical significance at the 90 per cent confidence level; and the value 0 is not statistically significant.

These data are shown, together with the generated raster, in a layer of points with information for each of the buildings in Strategy analysis section.

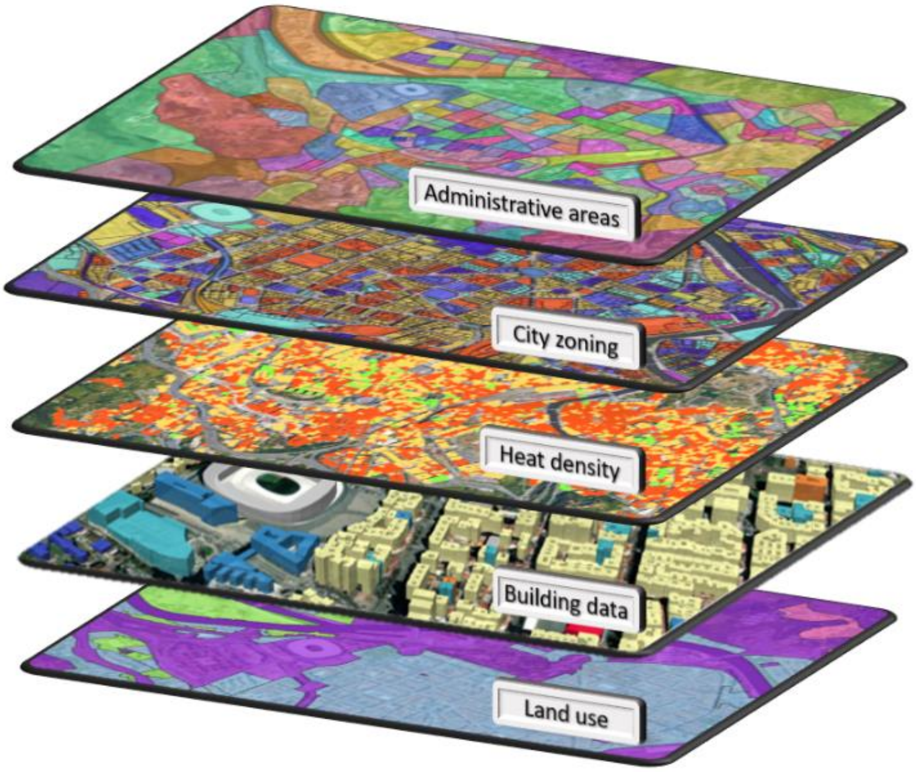

FIGURE 16 LAYER OVERLAY METHODOLOGY EXAMPLE

Layer prioritization

The AHP (analytic hierarchy process) methodology, a structured technique for dealing with complex multi-criteria decisions, has been used to assign weights to the layers in an objective way.

This methodology provides numerical values or priorities from subjective assessments by making a series of judgements based on pairwise comparisons of elements, which is especially useful for making decisions involving human perceptions and judgements, or for cases where a large number of parameters need to be compared or prioritised.
The advantage of the AHP is the incorporation of qualitative aspects that are often left out of the analysis due to the complexity to be measured but may be relevant in some cases. The result of the AHP is a ranking or prioritisation of the alternatives showing the overall preference for each of them.

Given the nature of the layers used in the analysis, they have been grouped into 4 categories or dimensions, so that the pairwise comparison is done on two scales; first comparing the categories and then the layers included in each of them.

TABLE 1 GROUPING OF LAYERS BY DIMENSIONS

DIMENSIONS	LAYERS
RESOURCES - HEAT EXCHANGE POTENTIAL AND AVAILABLE SPACE	Distance to green areas and available spaces
	Distance to water bodies
BUILDING CHARACTERISTICS	Protected buildings
	Public buildings
	Fuel for heating purposes
	Configuration of building energy systems
URBAN PLANNING	Degraded areas
	Current and future urban development plans - PGOU
ENERGY USE	Heating demand (kWh/m^2)
	Heating density
	Heating/cooling ratio

In this way, a weight is obtained for each of the dimensions and a relative importance for each layer and lastly the final weight of each of the layers on its own. This process is carried out for each strategy independently, as the relative importance of the dimensions and layers varies depending on the strategy to be applied. Once the pairwise comparison has been carried out, the relative weight of each layer in the 3 strategies is obtained.

A workshop with personnel from different departments at Bilbao City Council was carried to perform the AHP , and obtain weighing results for the different layers considered in the analysis. Results areshown in the following table

TABLE 2 FINAL WEIGHT OF THE LAYERS FOR THE 3 PROPOSED STRATEGIES

Dimensions	Layers	Sc1	Sc2	Sc3
Resources	Distance to green areas and available spaces	1,8%	1,7%	25,5%
	Distance to water bodies	1,8%	1,7%	25,5%
Building characteristics	Protected buildings	27,3%	25,2%	1,7%
	Public buildings	24,4%	23,0%	1,7%
	Fuel for heating purposes	6,8%	3,6%	0,6%
	BES configuration	3,8%	6,3%	4,6%
Urban planning	Degraded areas	12,9%	6,0%	3,1%
	Current and future urban development plans -	3,2%	18,1%	28,2%
Energy use	Heating demand (kWh/m^2)	13,0%	9,1%	1,0%
	Heating density	3,9%	3,7%	7,2%
	Heating/cooling ratio	1,1%	1,5%	0,9%

Depending on the type of decarbonization strategy considered, some of the layers do not apply or are of minor importance depending on the strategy for which they are used.

The results of strategies 1 and 2 in terms of the weights assigned to each layer and, are very similar, since in both cases the urban planning dimensions and characteristics of the building have been prioritised.Both strategies are strongly conditioned by the protection of the buildings as it is a very important constraint when making modifications to the exterior of the building, either for refurbishment or to install aerothermal systems, that affect the façade or the roof. Of the 11308 buildings included in the Bilbao model, 4426 have some type of protection, which represents almost 40% of the total building stock. These buildings are mostly located in the city centre; Casco Viejo, Abando, Indautxu or San Ignacio, although there are also others scattered in other areas of the city.

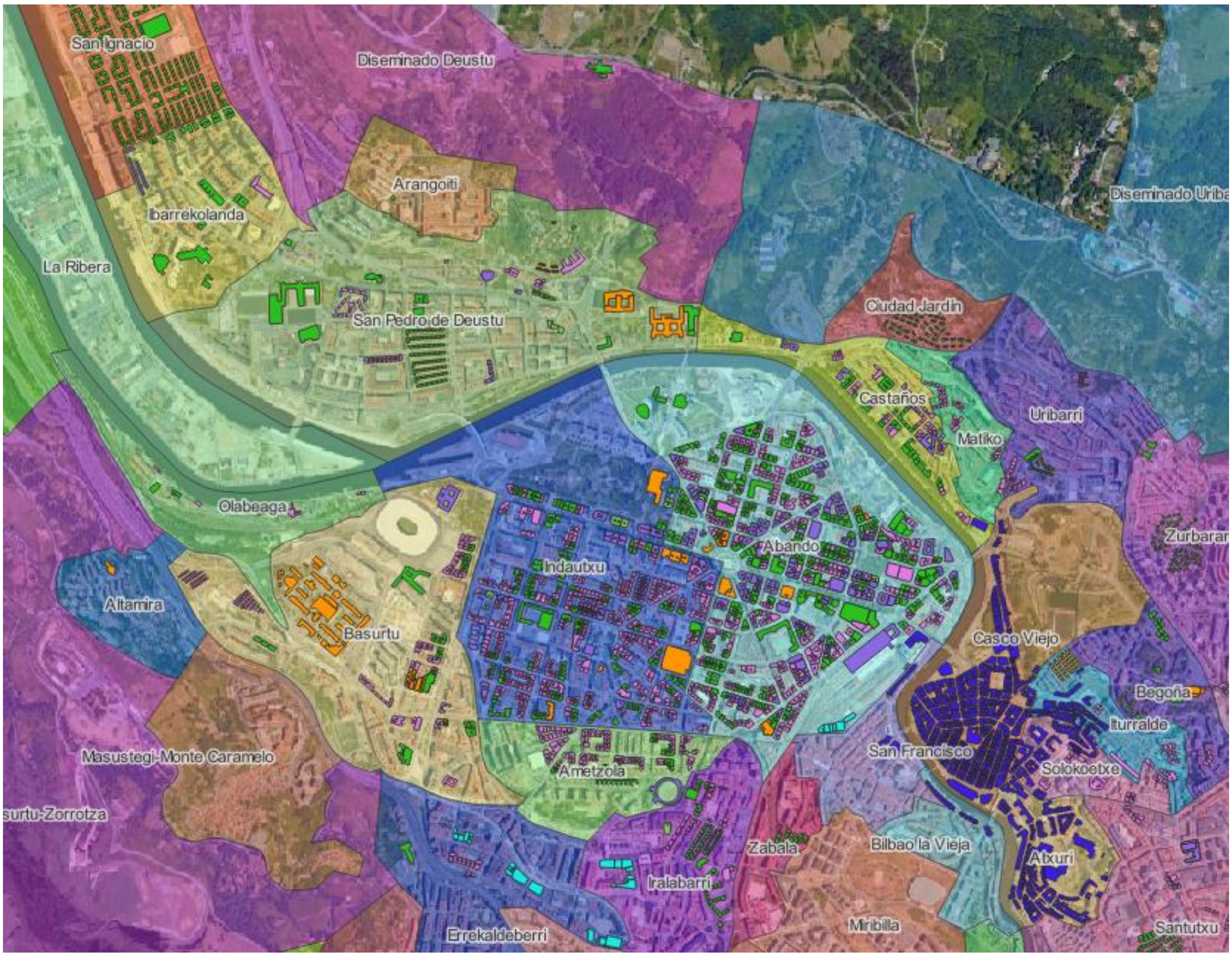

FIGURE 17 LOCATION OF PROTECTED BUILDINGS IN THE CITY'S NEIGHBOURHOODS

In the case of the strategy focused on refurbishment, more weight has been given to degraded areas within the urban context, since, as they are classified as such, they have greater access to subsidies or financial incentives for the implementation of this type of intervention. Taking into account more technical aspects, a moderate weight has been obtained in relation to thermal energy demand, as acting on buildings with low energy performance can have a major impact on whether or not the city's 2050 decarbonisation targets are met.

For the implementation of aerothermal systems on the other hand, more weight has been given to urban plans, since the implementation of these systems in new construction areas or in areas where there are planned interventions is much simpler. On the other hand, something beneficial in these new areas is that they do not form part of the historical heritage, which, as mentioned above, is one of the major limitations when it comes to interventions that modify the aesthetics of the façade and/or the roof.

For the strategy based on the implementation of district networks, a greater weight is given to the availability of resources or adequate space for the construction of the required infrastructure. The most important aspect in this case is the urban development plans, especially future ones, which would allow the incorporation of these systems from the project phase, facilitating their implementation at a lower cost.

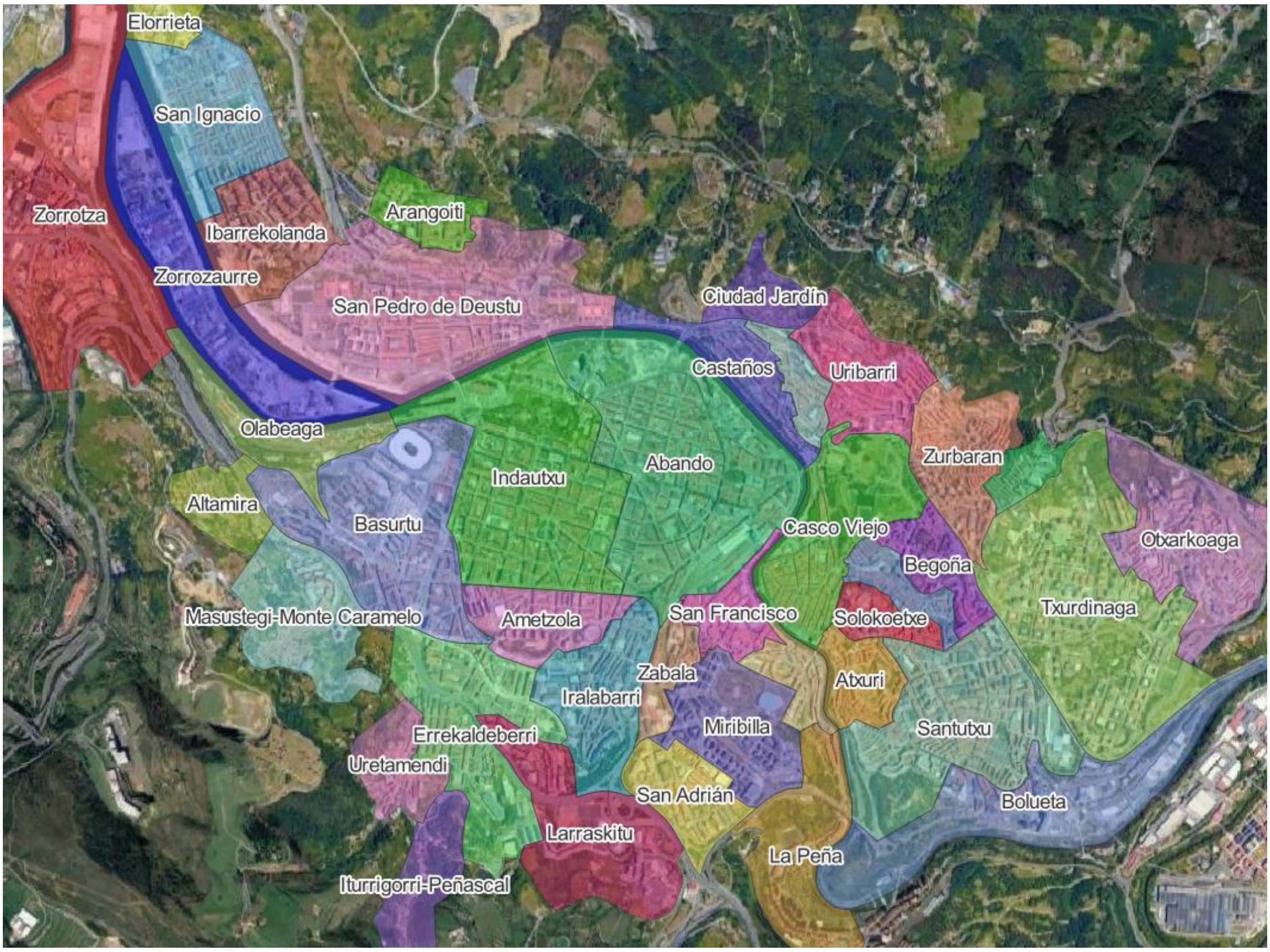

Figure 18 Zoning of Bilbao by neighbourhoods

Strategy analysis

In this section the results are shown using 2 types of maps. Firstly, for each of the strategies, a raster layer is shown with a score for each of the buildings. This score is obtained by applying the scores shown in table 2. These scores range from 1 to 10, where 1 is the minimum score and 10 is the maximum score.

A low score indicates impossibility or great difficulty of implementation and a high score indicates great potential or ease of implementation of the selected strategies in each case.

Secondly, an analysis of hotspots is presented. The ArcGIS Hot Spot analysis shows statistically significant spatial clusters of hot spots (high values) and cold spots (low values) taking into account a Distance Band or Threshold Distance.The obtained +/-3 values reflect statistical significance at the 99 per cent confidence level; the +/-2 values reflect statistical significance at the 95 per cent confidence level; the +/-1 values reflect statistical significance at the 90 per cent confidence level; and the value 0 is not statistically significant.

Strategy 1 - Deep renovation of building blocks.

For the refurbishment strategy, there is no area that stands out as having a higher potential for refurbishment, but the opposite; large areas can be observed with a very low score, due to the great weight of building characteristics, especially protection, which affect almost 40% of the city's buildings as mentioned above.

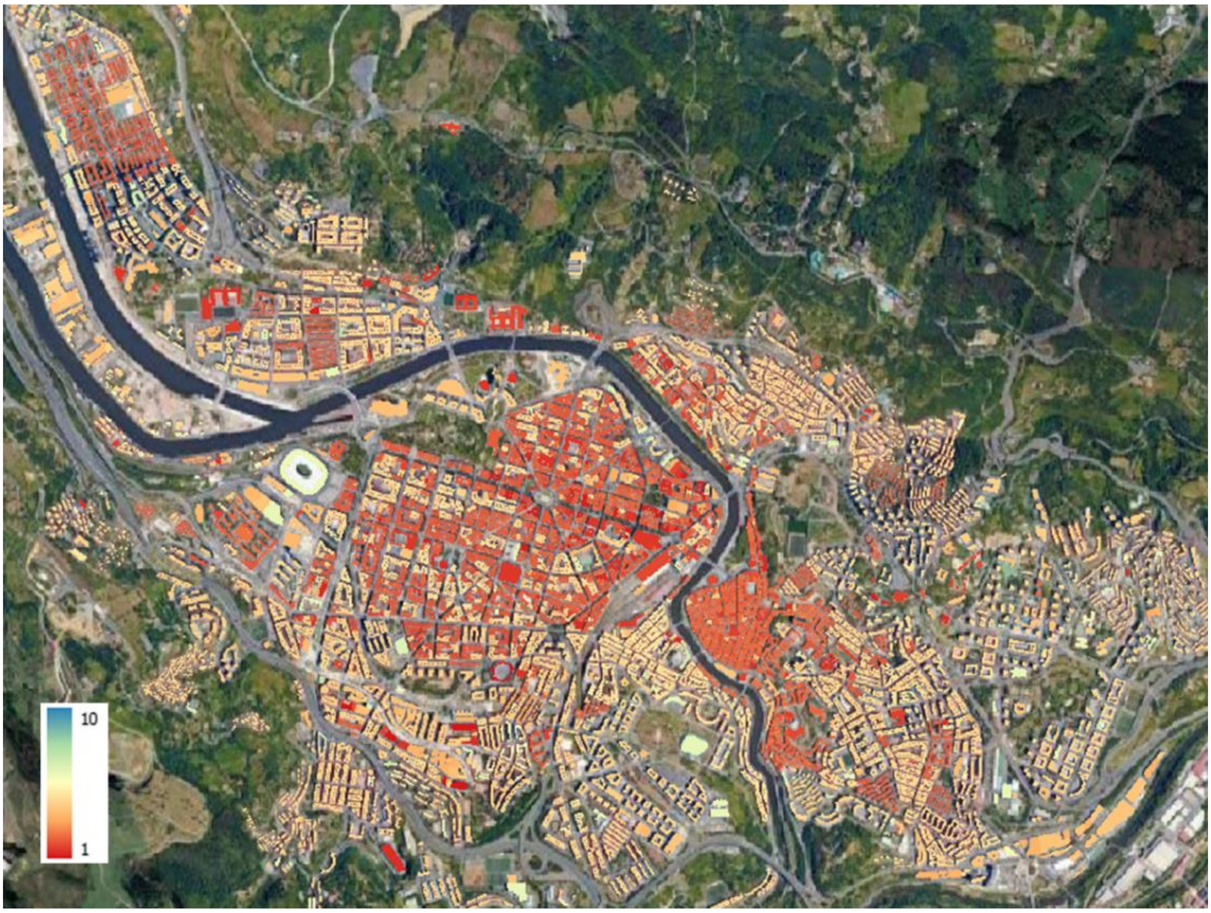

FIGURE 19 BUILDING SCORE RASTER FOR STRATEGY 1

In the image of the hotspot analysis, large areas are shown in red, as areas with the higher values grouped together, which does not mean that they are favourable for refurbishment. As can be seen in Figure 19; for this strategy, 97% of the buildings scored less than 5.

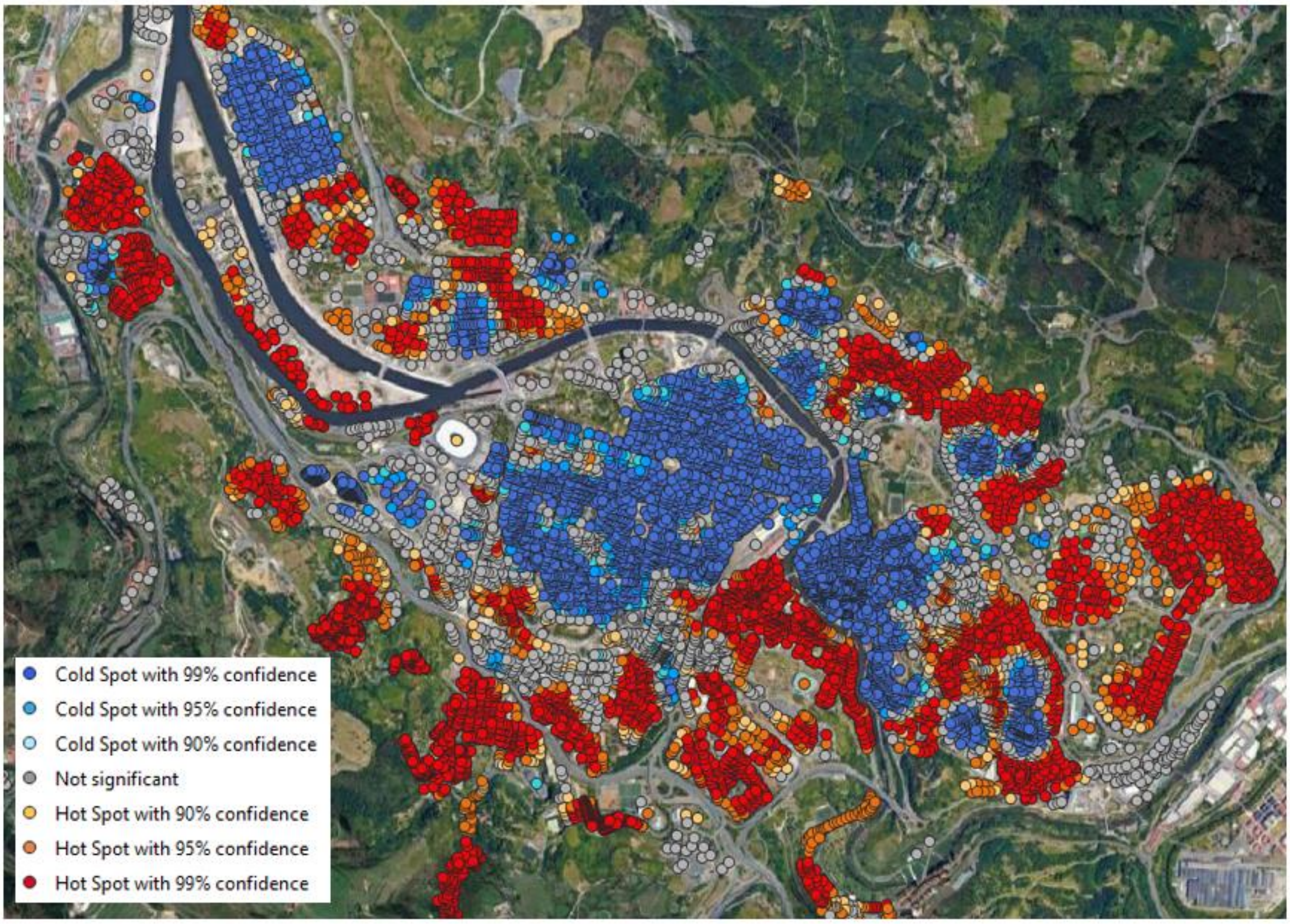

FIGURE 20 HOTSPOT ANALYSIS FOR STRATEGY 1

Strategy 2 - Individual heat pumps

For the implementation of aerothermal systems, although there are no areas with a particularly high score, there are 2 areas that stand out above the rest: Zorrozaurre, being a newly developed area, which will not form part of the protected historical heritage, and the area that includes the neighbourhoods of San Francisco and Bilbao la Vieja, as it is within an area of incorporated plans and without any type of protection.

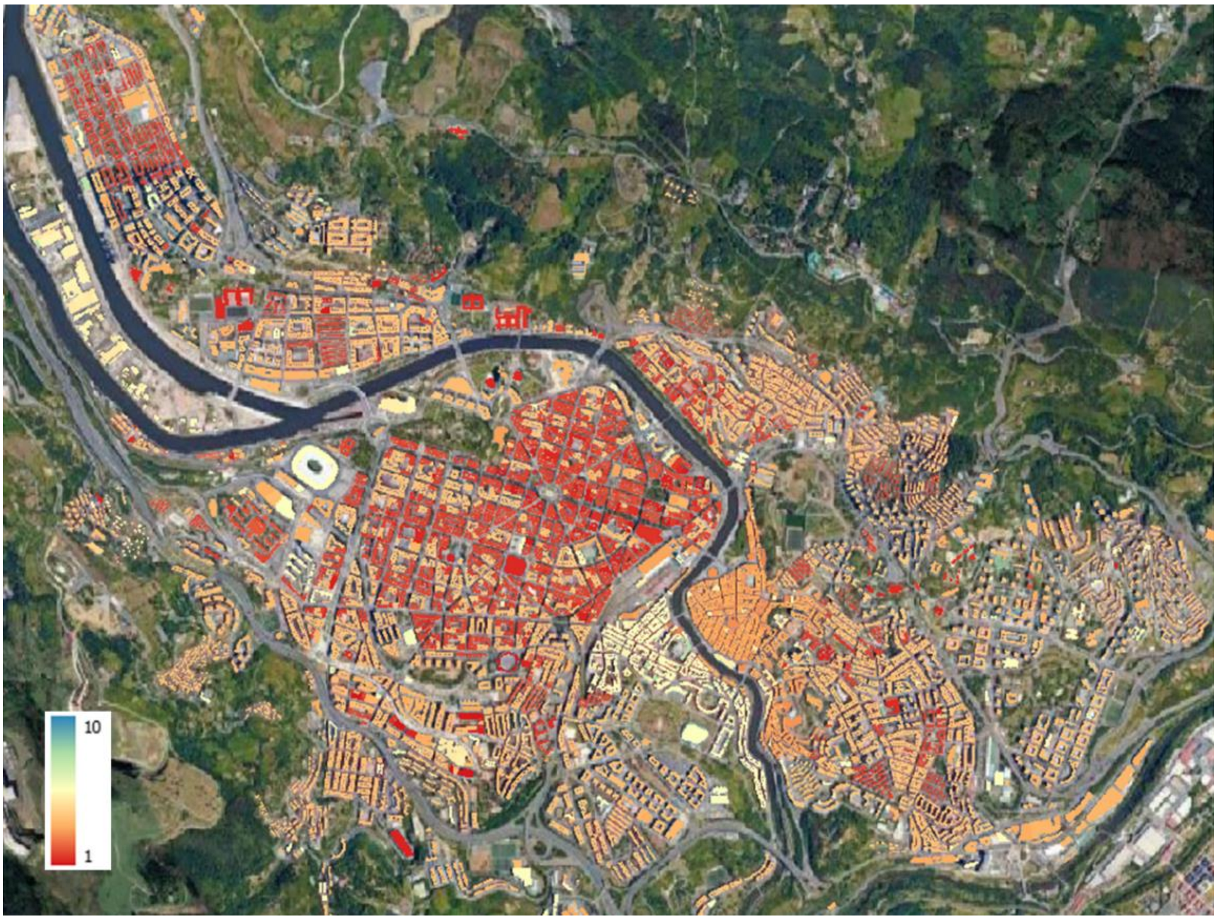

FIGURE 21 BUILDING SCORE RASTER FOR STRATEGY 2

When analysing the hotspot analysis, it can be seen that other smaller areas such as Peñascal and Altamira also have clusters of buildings with above average scores.

FIGURE 22 ZOOM IN PEÑASCAL AND ALTAMIRA NEIGHBOURHOODS

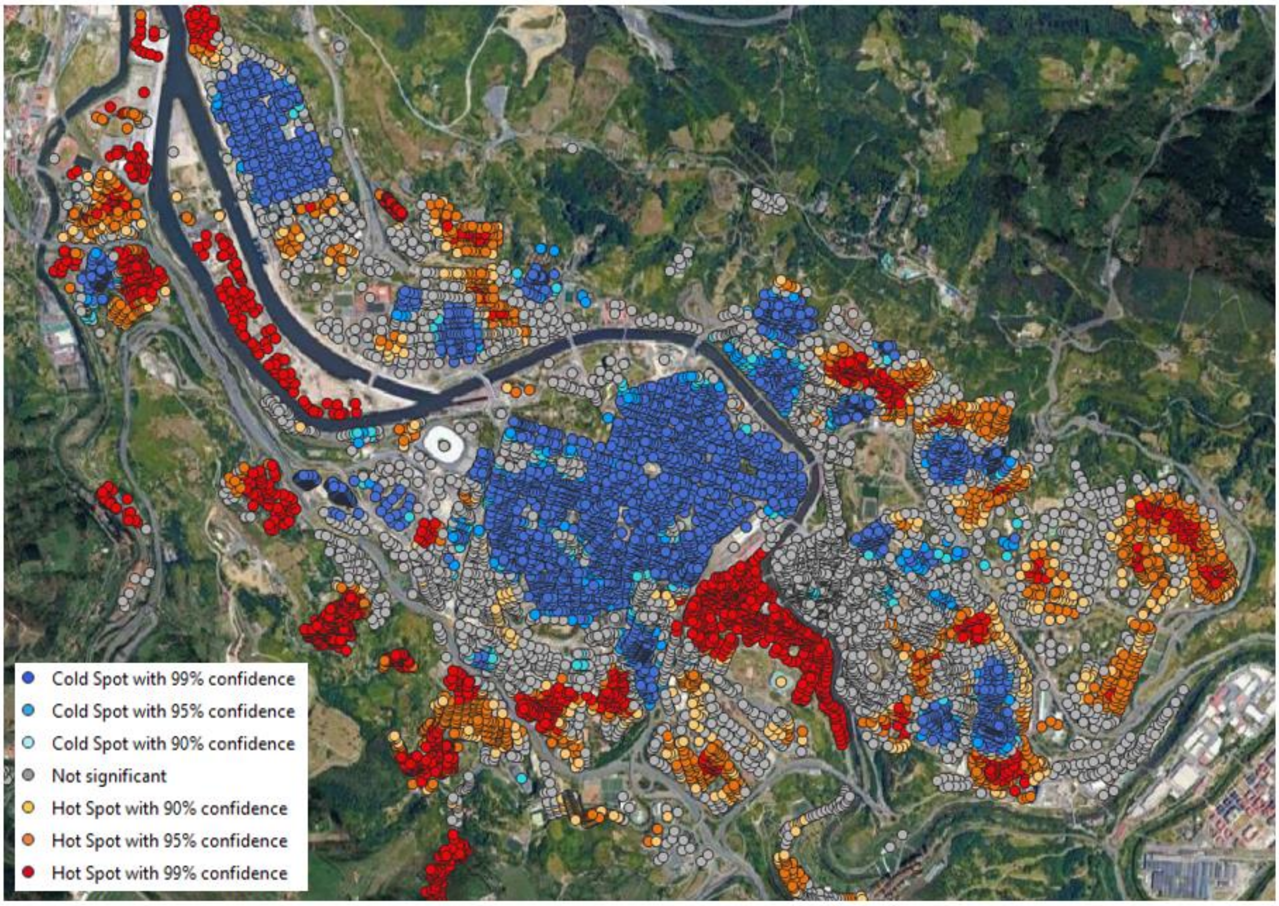

FIGURE 23 HOTSPOT ANALYSIS FOR STRATEGY 2

Strategy 3 - District heating and cooling networks

In this strategy, the protection of buildings has not been considered as a constraint , as the connection to DH networks should be in most cases feasible. Greater importance has been given to the availability of the resource and the distance to it, as well as the space available for the construction of infrastructure if necessary.

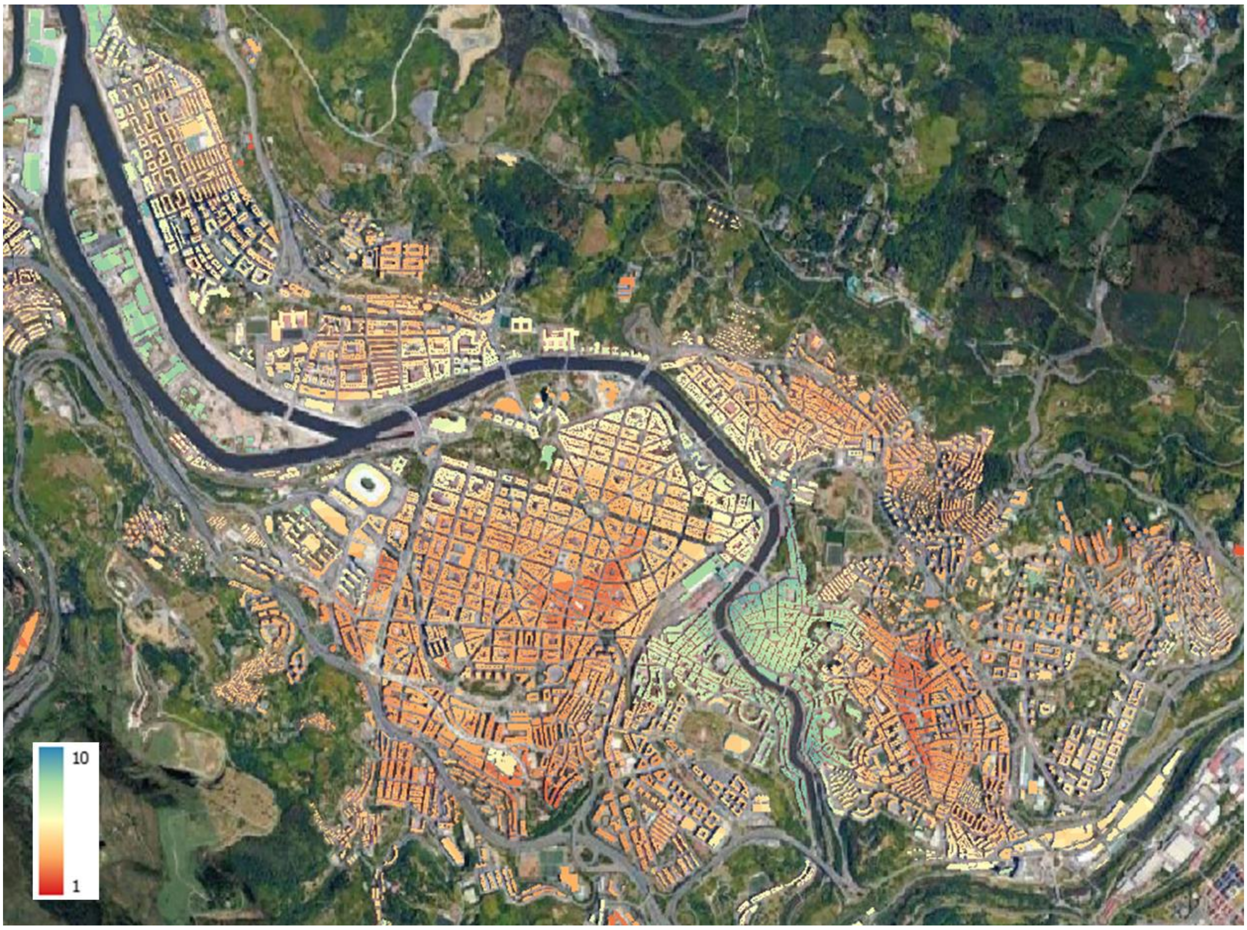

FIGURE 24 BUILDING SCORE RASTER FOR STRATEGY 3

On this third strategy, although all the areas close to the river have a relatively good score, there are several that stand out on the map: Casco Viejo, Bilbao la Vieja andSan Francisco., three neighbourhoods which are located within the area classified as Integral Rehabilitation Areas (ARIs). It is an area of considerably old buildings in which few or no improvements have been made in terms of thermal efficiency, so their consumption should be relatively high. In the case of the old town the implementation of a district heating network is an option that would need serious consideration, as the analysis presents it as a favourable area, while for the other strategies it was disfavorable due mainly to its protected status.

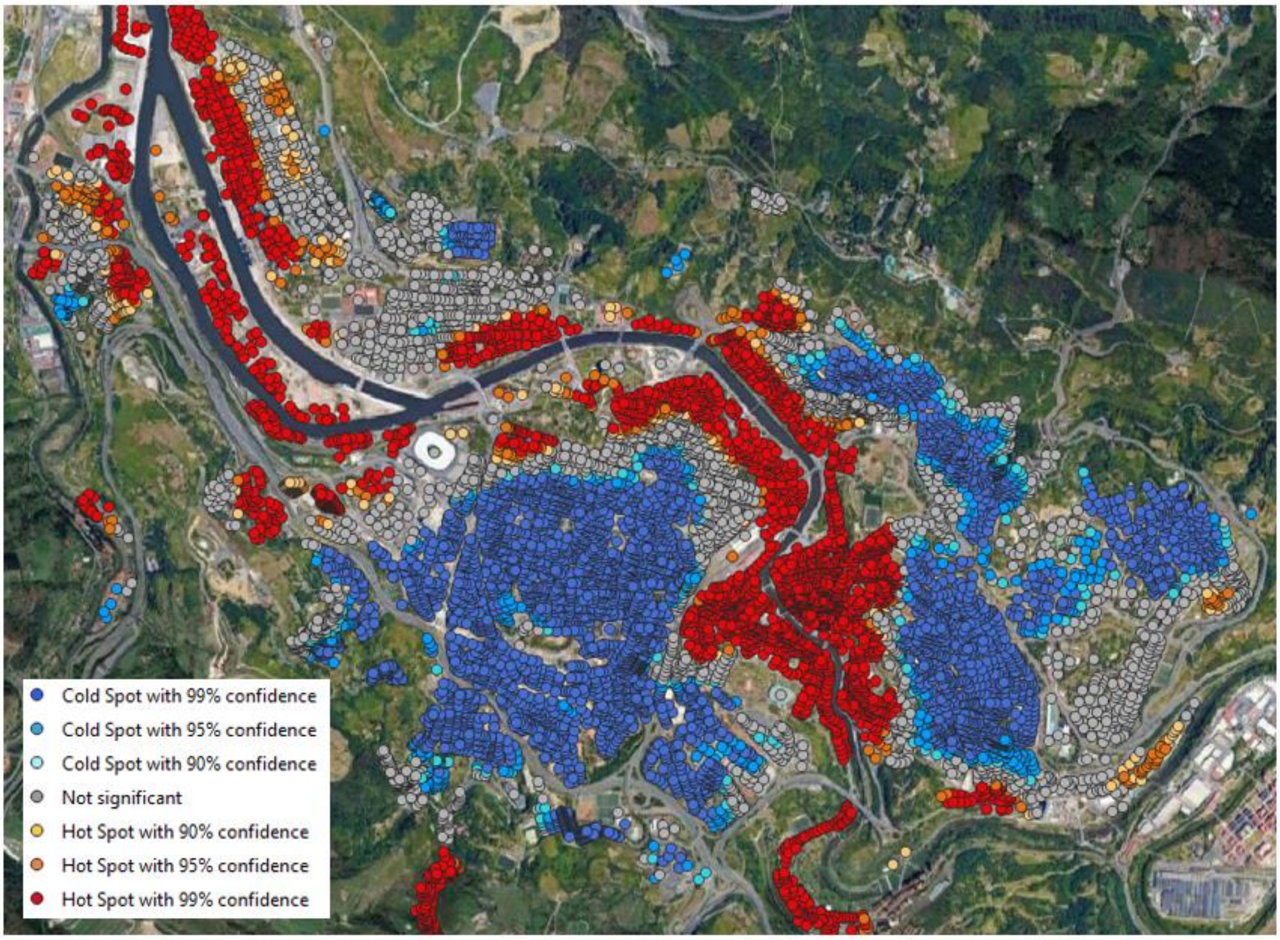

FIGURE 25 HOTSPOT ANALYSIS FOR STRATEGY 3

FIGURE 26 ZOOM ON CASCO VIEJO, BILBAO LA VIEJA AND SAN FRANCISCO

Zorrozaurre is an area currently under development in which a district network is already planned to which both residential and tertiary buildings are expected to be connected in the future.

FIGURE 27 ZOOM IN ZORROZAURRE

Bolueta: this is also an area currently under development where 3 large residential buildings have been constructed and 3 more will be built in the coming years. Although the energy demand of the new buildings is relatively low, they are high rise, so the energy density will be sufficiently high. They also have centralized gas boilers for the whole building, what would make relatively easy their connection to a decarbonised heating network. It is an area close to the river and with some open space areas which in theory could serve to install the necessary infrastructure for the district heating.
The fact that both Bolueta and Zorrozaurre are still areas under development for the coming years, makes it much easier to implement such systems as costs could be reduced by integrating it into the urbanization plans.

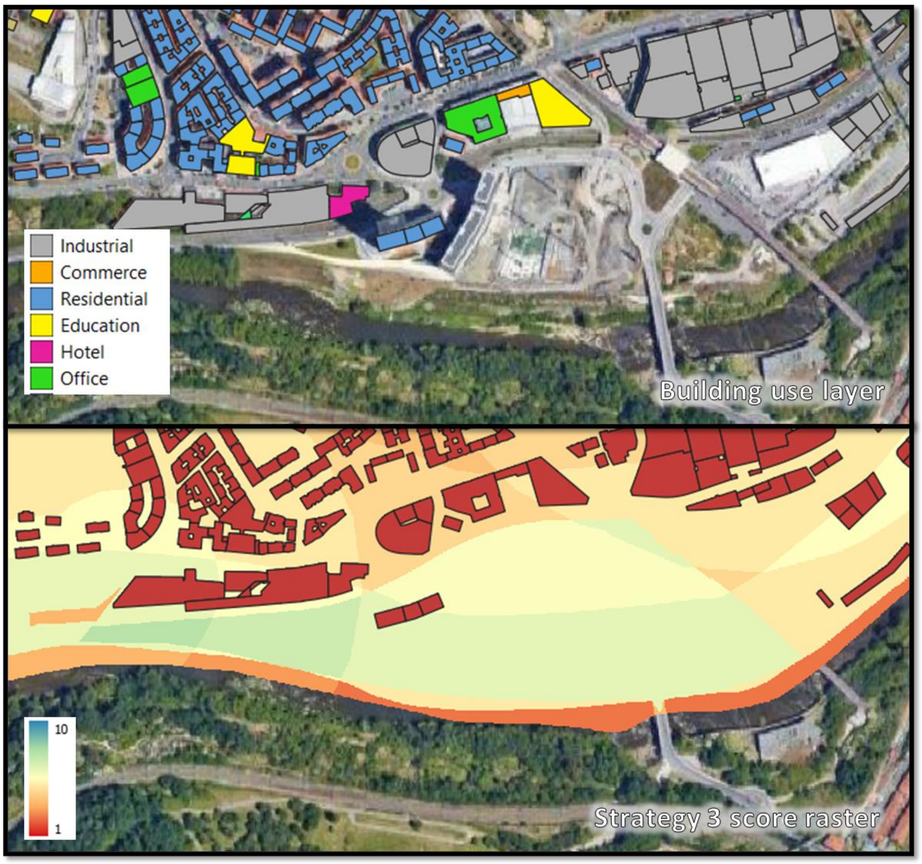

FIGURE 28 DETAIL OF THE AREA UNDER DEVELOPMENT IN BOLUETA (BUILDING LAYER AT THE TOP OF THE PICTURE AND ZOOM IN THE SCORE RASTER FOR STRATEGY 3 AT THE BOTTOM)

Summary/conclusions

When analysing energy transition scenarios in the building stock, technical criteria such as actual energy use, heat density or other technical characteristics are generarlly used as main factors influencing feasibility of the interventions. However, for planning heating and cooling strategies within a city, the technical analysis needs to be complemented with other aspects that can be crucial for implementation, such as current legislation or urban planning limitations.

In the presented analysis of three strategies for decarbonising Bilbao city’s heating and cooling, a clear conclusion is that urban planning limitations have a great weight when analysing and defining the areas in which to intervene.

The prepared GIS maps and hotspots for each strategy, gives an overview of where in the city is more favourable to deploy strategies such as deployment of district heating or instalation of heat pumps at building level. The results wukk be taken into account as a first indication of their potential within the city, and serve to plan the following steps to decide heating and cooling interventions to achieve the climate and energy objectives for 2050.

Appendix: Data use

DATA FOR THE BUILDING STOCK ENERGY MODEL

The minimum data necessary for the generation of the building model are publicly available and accessible as they are data from the cadastre. The rest of the information included in the model to make it more detailed has been provided by the municipality, obtained both from its own databases and by requesting it from other external organisms. Among these data, most important sources include the register of centralised boilers of the city and the energy certificate database provided by the regional basque government. From these sources, the availability of data on the energy systems of buildings is not 100%, but 80%, which, despite being a very high percentage, generates some uncertainty.

On the other hand, as far as the information obtained from energy certificates is concerned, in most cases a certificate is only available for a single dwelling, which is extrapolated to the rest of the building. In some cases, this assumption can lead to misassignment of individual heating and cooling systems.

OTHER DATA USED FOR THE H/C PLAN

The rest of the information used regarding the built environment such as available space, new developments or protected areas is complete and mostly publicly accessible.

Information that would have been interesting to have available would be the ownership of the buildings, beyond knowing whether they are fully public or private buildings, as knowing whether the buildings have a single owner or several owners could be a determining factor when carrying out the proposed interventions.

In general, the quality of the data is good and for the most part publicly accessible. In case it is not public, it is easily accessible upon request by the municipality.

DECARB CITY PIPES 2050

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