Territorial Metabolism and Sustainability:

The Case Study of the French Bask country

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Abstract

This work aims to determine how it is possible to achieve a territory's sustainability using the concept of territorial metabolism. To illustrate, I study the case of the French Bask country, starting with the description of this territory's context and the social, economic, and environmental issues it is facing. Then I define what is heard behind territorial metabolism and explain why it is an efficient manner to understand the territory's functioning and to act to get closer to sustainability. Going back to the French Bask country, I develop ways to optimize the metabolism and use it to rebalance the territory, solve many inhabitants' daily issues and reduce the environmental footprint. The analysis of the territory shows indeed that the territory is suffering from a significant polarization, the coast concentrating demographic, economic and touristic development. This generates many flows, of people, goods, and information from the interior country to the coast, that the population is regretting. The territorial metabolism approach enables to deal with those flows and change their paths.

Key words

Territorial metabolism, sustainability, material flow analysis, greenhouse gas emissions, mobility, agriculture, energy planning, circularity, renewable energy

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Introduction: Act to limit climate change at the scale of the French Bask Country

The IPCC (Intergovernmental Panel on Climate Change) published in July 2021 a first edition of its 6th report. Its conclusions are clear:

- The global warming must reach +1.5°C in 2030, that is to say ten years earlier than what the last report announced, unless the greenhouse gas emissions drop very fast.
- The sea level rise has already reached +20cm since 1900, and another rise of +20cm may happen before 2050.
- Human activities are responsible for the climate change.

Faced with these statements, goals have been set at different scales, that establish the limits not to exceed in order to hold back climate change and its consequences on biodiversity and human societies. Greenhouse gas emissions have especially been blamed for the global average temperature increase. That is why numerous documents nowadays require a reduction of GHG emissions at different scales.

Since 1995, COPs (Conferences Of the Parties) gather each year countries of the world to speed up the fight against climate change. Among them, some have led to the ratification of international agreements for the reduction of greenhouse gas emissions. The COP3 in Japan in 1997 is particularly famous, as it led to the adoption of the Kyoto Protocol. The Kyoto Protocol was the first agreement legally constraining in the climate fight. The 55 industrialized countries that signed it had to reduce the GHG emissions between 2008 and 2012 of at least 5.5% comparing to the 1990 level. Among the countries that ratified the protocol, a reduction of 25% of the emissions was registered between 1990 and 2012. In that sense, the protocol seems to be a success. However, many countries did not ratify it, in particular the United States of America, China and Canada: countries that emit a lot. At the global scale, during this period, the reduction of emissions would only be of 4%.

The COP21 in 2015 came to the adoption of the Paris agreements, signed by 195 parties (194 countries and the European Union) and ratified by 192 of them. They aim at limiting the global warming below 2°C comparing to the preindustrial era, and even better below 1.5°C if possible.

In this work, I will focus on the national case of France, and more precisely the territory of the French Bask country, located at the South-West corner of the country. In France, the objective of the Paris agreements has been adapted at the national scale with the *Stratégie Nationale Bas Carbone* (Low-Carbon National Strategy), with the purpose of reaching carbon neutrality by 2050. A first step in 2030 has been set, before which a reduction of 40% in comparison to the 1990 level should be reached. Territories must now act to achieve these objectives at their scale.

The French Bask country is a territory of 3,000 km² and hosting 312.000 inhabitants. It has a very strong cultural identity, with its own language, sports, and festivities. It is included in the French department of the Atlantic-Pyrenees and the region New-Aquitaine. Since 2017, the territory exists also politically with the creation of the conurbation authority of the

Bask Country, gathering the 158 cities into a political entity. This vast and rich territory is today subject to many issues. The polarization of the territory between the coast and the remote land is the reason for many daily work-home journeys by car throughout the territory. An increasing tourism is putting pressure on real estate prices and making the territory unaffordable for its inhabitants. Finally, the territory must also take its responsibility in the fight against climate change.

My work aims at finding proposals in terms of territorial and urban planning to limit the impact of the territory on climate change, while addressing other social, economic, and political issues the territory is currently facing. As GHG emissions play a relevant role in global warming, we will estimate them on the territory - their amount, and their origins - in order to find adapted solutions to reduce them.

Since the beginning of the 2000s, studies about territorial metabolism arise. In France, the work of the researcher Sabine Barles, focusing particularly on Paris and its urban area, has shown the impact of cities on the environment through all that they reject (air, water and soil pollution, waste). She was also involved in the studies of metabolism of several urban areas in France, by quantifying in and outflows. She defined territorial metabolism as the analysis of material and energy flows, going in, out and inside the territory. Those flows that are generating by the multiple activities of the territory, and then the society living it. This analysis is thus in close relationship with the issues of circular economy, but also greenhouse gas emissions and other pollutions. It appeared as a new manner to consider the territory, that allows to take into account its environmental footprint. Studies of metabolism are for this reason more and more tackled as a way to address sustainable development’s requirements.

Also, in the French Bask country, territorial metabolism can be a precious tool to understand and fix social, environmental, and economic issues the territory is experiencing. We will try and analyze its metabolism nowadays, and find ways to optimize it, promoting circular paths.

Chapter I - The French Bask Country, a complex territory with a strong identity

1. Presentation of the territory

1.1. Geography of the territory

1.1.1. Location of the studied area

The territory that I am going to study is the French Bask country, a territory of 3 000 km2 in the South-West corner of France. It is located in the region of New-Aquitaine, and in the department of the Atlantic-Pyrenees.

The territory is bordered by the Atlantic Ocean on the West and the Pyrenees chain on the South (also being the administrative border with Spain). On the North, the Adour River is making the border on one part. Otherwise, they are minor mountainous chains, part of the Pyrenees that are bordering the territory.

In 2018, the territory counted 312 280 inhabitants. The main city of the Bask country is Bayonne with 50 000 inhabitants. Other towns along the Atlantic coast or more remote in the mountains are well-known for their heritage and attract each year thousands of tourists.

Figure 1. Location of the Bask country in France
Source: own production

1.1.2. A territory linked to Spain

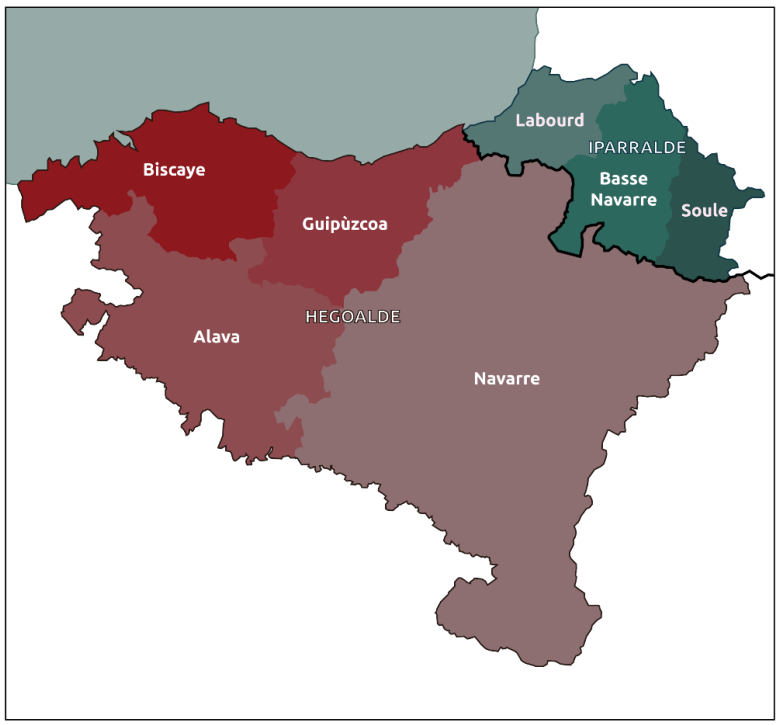


Figure 2. The seven provinces of the Bask country

The Bask country is actually spread on both the Spanish and French sides of the border. It is composed of seven provinces, among them, four are in Spain (Biscaye, Guipùzcoa, Alava, and Navarre), while the three remainings are in France: the Labourd or the coastal part, the Basse-Navarre, and the Soule, which is the most remote one, in the mountains. The whole Bask country exists thanks to a unique culture shared by its population: in particular, the bask language is a very old language that was born and evaluated on this territory. Other values, habits, and architecture are part of the bask identity, as in Spain as in France.

Today the territory is not only linked to Spain for cultural reasons. International trade has made the area the perfect place for goods travels from the Iberic peninsula to the rest of Europe. Therefore, thousands of merchandize trucks are crossing the territory every day on the main road axis.

1.1.3. Magnificent but fragile natural areas

Variety of landscapes

The geographical situation of the Basque Country, at the confluence of the Ocean and the Pyrenees, gives this territory a unique composition of landscapes.

From the Adour to the Bidassoa, beaches, creeks, and cliffs follow one another. From Guéthary to Orhy, the majestic sites of the coast, the rich agricultural plains, the grassy

slopes of the hills, the gorges and valleys, all unique, at the foot of the first peaks of the Pyrenees.

Figure 3. Les Deux Jumeaux, Hendaye, picture taken by me

Figure 4. Atlantic coast between Hendaye and Ciboure, picture taken by me

Figure 5. Biarritz beach, picture taken by me

Figure 6. Hills around Saint-Jean-Pied-de-Port, picture taken by me

A nature threatened by climate change and sea level rise

These landscapes are already subject to the hazards of climate change. Near-shore areas will experience pressure from rising ocean levels. Cliffs are seriously threatened by erosion. Inland landscapes will be subject to erosion from extreme rainfall events and periods of drought. In December 2021, the city of Bayonne knew a flood event, following weeks of important rain episodes.

Moreover, the attractivity of the territory is putting pressure on land values, and many natural spaces are being artificialized in order to build new houses and services to meet the needs of the growing population. We are therefore inducing a loss of biodiversity.

1.2. A territory defined by its own strong identity

1.2.1. The French Bask country since Prehistoric times

The Bas country is a territory with a long history. The first population settled there during Prehistoric times. At that time, the territory was seen as a strategic place to settle thanks to the richness of its biodiversity and its food opportunities. From this moment, it has developed its own language and culture, linked to the territory. Step by step, the territory has structured itself depending on this unique culture.

During the Antiquity and the Middle-Age, its location at the carrefour of the Iberic peninsula and the rest of Europe has fostered the development of trade exchanges in the Bask Country.

In addition, Bayonne situated at the confluence of two rivers and close to its mouth in the ocean has rapidly been seen as a strategic place for port activities. Shipyards were built as soon as the 13th century. During the 16th century, the natural displacement of the Adour mouth has threatened those activities and has pushed to open a new artificial mouth 6km from Bayonne to preserve the port activities of the city.

Today, new dynamics and issues are modifying the interactions between spaces. Despite invasions during its History, the Bask country has succeeded in preserving its identity.

1.2.2. The Bask culture

The Bask Country is a territory marked by human activity since prehistoric times, which gives it a particularly strong cultural and linguistic identity. Combined with its geographical location and weather conditions, the Bask Country benefits from numerous richness which are as many assets for its development.

The language

The Bask language is a very old language, that even appeared before the Roman invasion, and has survived until now. In 2016, 24.2% of the inhabitants of Spanish and French Bask countries speak Bask. Another 14% understand it. In the French Bask country, the more going to remote areas, the more important the proportion of people speaking Bask. It is 49.5% in the provinces of Basse-Navarre and Soule, 23% in the Labourd, and of 8.4% in the cities of Bayonne-Anglet-Biarritz.

This feature shows that the most attractive places are the ones becoming the least “Bask”. There are the ones where the Bask identity is going backward.

To face this issue, important cultural activities have tried to put the Bask language back on the stage since the 1960s. Moreover, the creation of schools in Bask language (*ikastola*) has been developed to make the language live again. Today, the language is spoken by people of all ages. The proportion of young people speaking bask fluently increased a lot since the 1990s. The language is really part of the Bask culture and is used today as a tool to reinforce the Bask identity.

In 1968, the Reform of the language created a unified language, named *Euskal Batua*.

Sports

- ### Dance and Pastorales

The traditional Bask dance is practiced a lot during religious or secular festivities. This is danced by everybody in the central places of towns.

The Pastorales are a spectacle carried out entirely by all the village. This Middle-Age tradition from the Soule allies theatre and dance. It follows many rules, and the told stories are often the same.

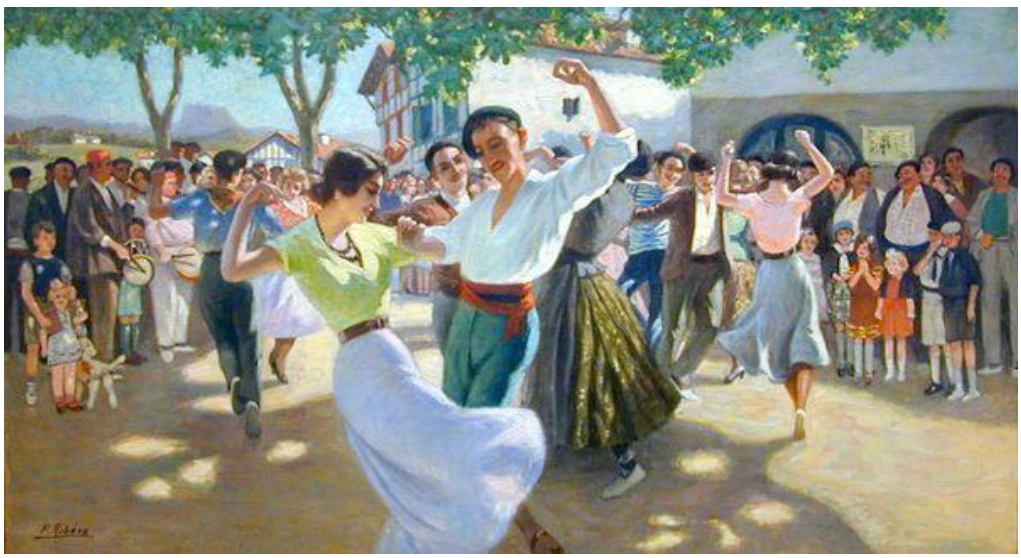


Figure 7. Painting by Pierre Ribera (1930) showing people dancing Fandango, one type of the Bask dances

❖ Pelota

This very old sport, which appeared probably during the XVIth century, is without a doubt part of the Bask culture. In the Bask Country, there is no village that does not have its pelota court. There are different ways to play pelota, from the bare hand game and the *pala* game to the one played with a *chistera* (*remonte* and *cesta punta*). Two teams are confronting and must throw the ball against the recognizable tall wall, then retrieve it.

Today, the Bask country has 5 829 persons enrolled in one of the 67 pelota clubs of the territory (Sports Ministery, 2011).

Figure 8. Pelote game, source: infobasque.com

Figure 9. Pelote instruments, source: infobasque.com

❖ Rugby

As soon as rugby was introduced in France, it has found a favorable audience in the South-West part of the country, and particularly in the Bask country. Today, many of the best

teams in France are from there. In the Bask country, the Aviron Bayonnais and the Biarritz Olympic have won many trophies since the beginning of the 20th century. Around them, it is the whole territory that is supporting one or the other team, and on game days the population moves largely to the stadiums to scream and sing their support.

In 2011, the territory has 7 290 people enrolled in one of the 28 rugby clubs, according to the Sports Ministery.

- Surf

In 1956, two Californian come to Biarritz and bring with them their surfboard. It is the first time that such an object is seen in Europe. Immediately, the sport develops on the Bask coast, with in 1959 the opening of the first surf club. Soon the first competitions, at national, European, and international levels are also organized there.

Today, surf is a real reason to come to the Bask country. With the variety of waves you can find there, many tourists come to do a surf camp and get initiated to this sport. The Bask coast has remained one of the hottest spots in Europe and in the world to practice surf. Consequently, it has also become one of the pillars of the Bask economy: many international companies (Quicksilver for instance) are settled there and have created many jobs.

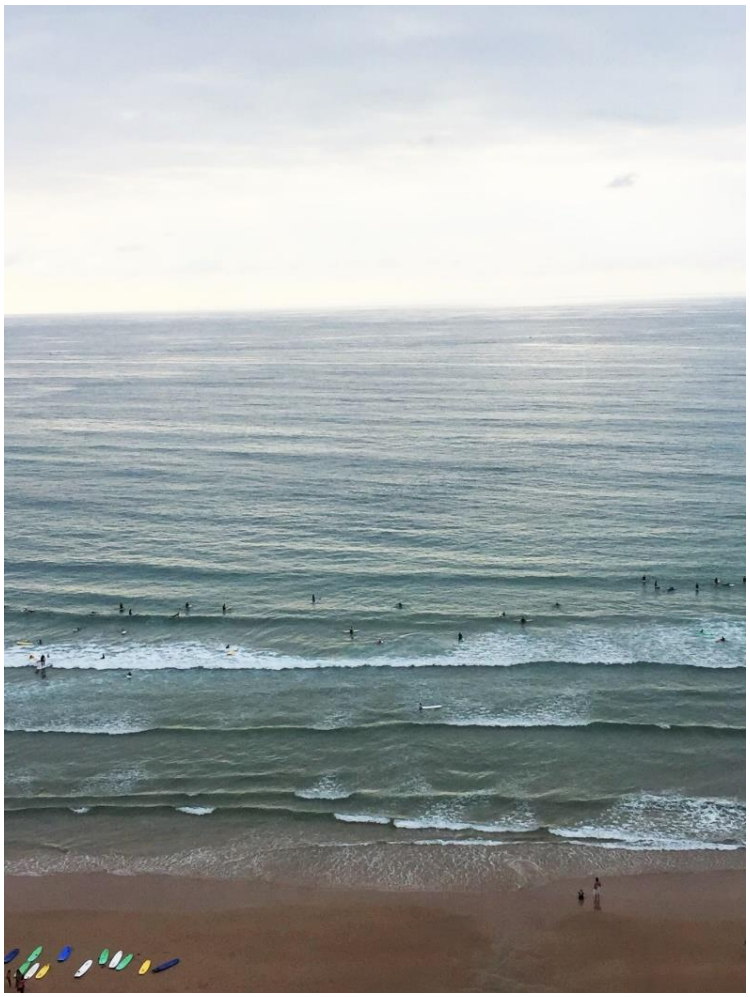


Figure 10. The coast of the Basks in Biarritz, picture taken by me

Architectural heritage

Figure 11. Bayonne city center, picture taken by me

Figure 12. Biarritz waterfront, picture taken by me

Many cities also attract people for their architectural beauty. The typical Bask houses are recognizable, white with their red or green beams, and create a unique atmosphere while walking in town. The built, as well as the natural heritage is then part of the attractions of the territory.

Festivities

But it is also famous for its festivities. The village festivals are indeed part of the local culture. During summer, each city is organizing its own, with more or less attractivity. The most famous ones are by far the Bayonne ones, hosting more than a million visitors for one weekend at the end of July. They are the fifth biggest popular gathering in the world.

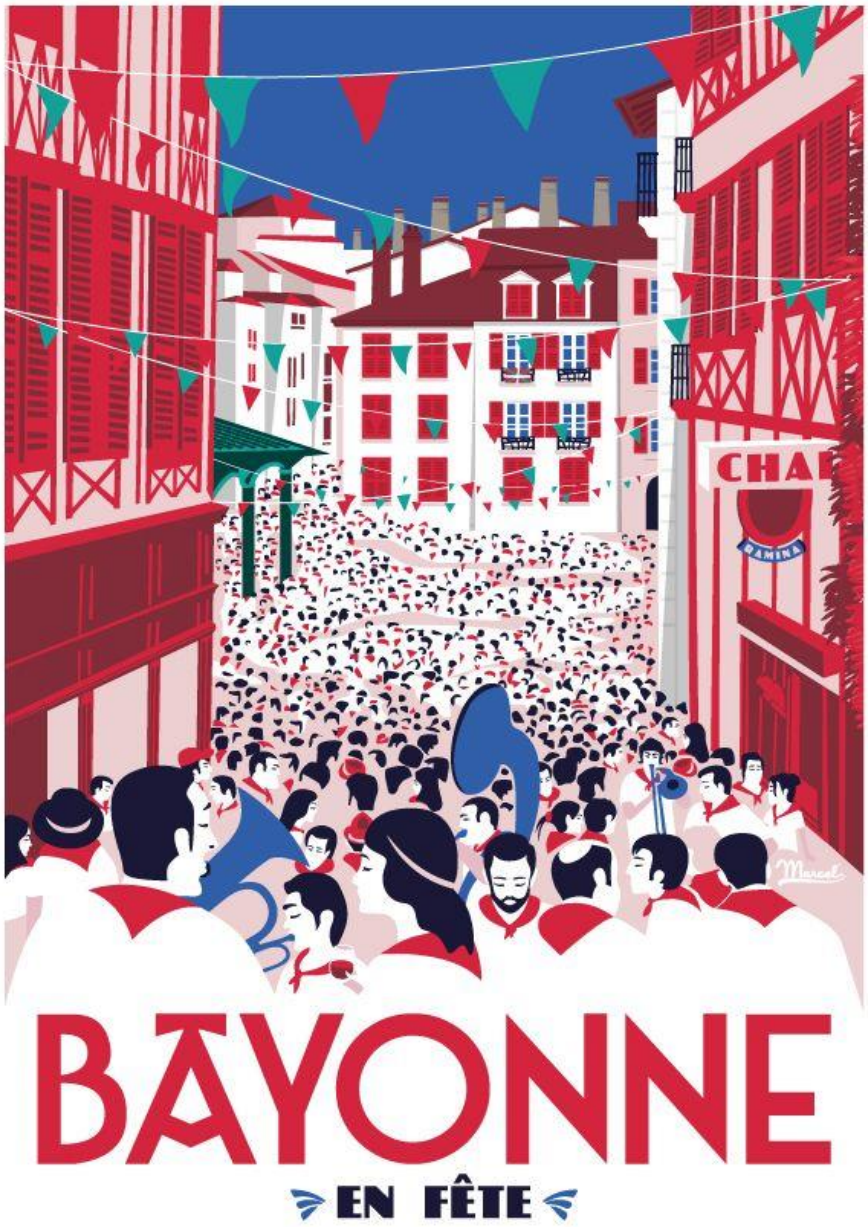


Figure 13. postcard Bayonne en fête

1.3. An unbalanced territory: the coastal area concentrating all activities

1.3.1. Urban structure of the territory

The Bask Country is then a territory apart for centuries, with its own interactions and functioning. But today, new dynamics are modifying how the territory runs. To understand this new functioning, three complementary approaches have been chosen. The first consists of picturing the influence area of cities and their relations. The second shows the living areas that structure the territory. The last approach identifies, through the living-workplace moves, the daily practices of the territory's inhabitants.

Cities influence in the French Bask Country

The INSEE (French institute of statistics) defines an **urban area** by the influence zone of a city on its *neighboring cities*. It estimates the job attraction of a city: if 40% of the working population of a city works in an urban area, then this city belongs to this urban area. The more jobs in the area, the bigger the urban area is.

Four main urban hubs are structuring the territory.

Among them, Bayonne has experienced an increasing influence since the 1960s. Today, sixty cities, among them twelve are outside the territory, are part of its influence zone. It represents 234 000 inhabitants (INSEE, 2018), which is 76% of the territory's population. It shows a high level of interaction among cities on the coastline.

St-Jean-Pied-de-Port, St-Palais, and Mauléon-Licharre are considered minor hubs because they polarize smaller areas: between six and nine cities in their urban areas. They gather each between 4 200 and 7 000 inhabitants.

Standing apart from any city's influence, thirty-eight isolated cities are located in mountainous areas.

Moreover, the Bask country is integrated into a bigger network of cities, that extends along the coastline and its direct hinterland with cities like Capbreton, St-Vincent -de-Tyrosse, Dax, and Peyrehorade. All of these cities are linked thanks to an efficient road and highway network.

Living areas

A **living area** is defined as the smallest territory within which inhabitants have access to the most needed infrastructures and services. They are determined by the presence of infrastructures and services in each city, and by the travel time of neighboring cities to the centrality. **Centralities** can be of three types: **proximity hubs**, addressing inhabitants' daily needs, **intermediary** and **superior hubs**, addressing more and more specific needs.

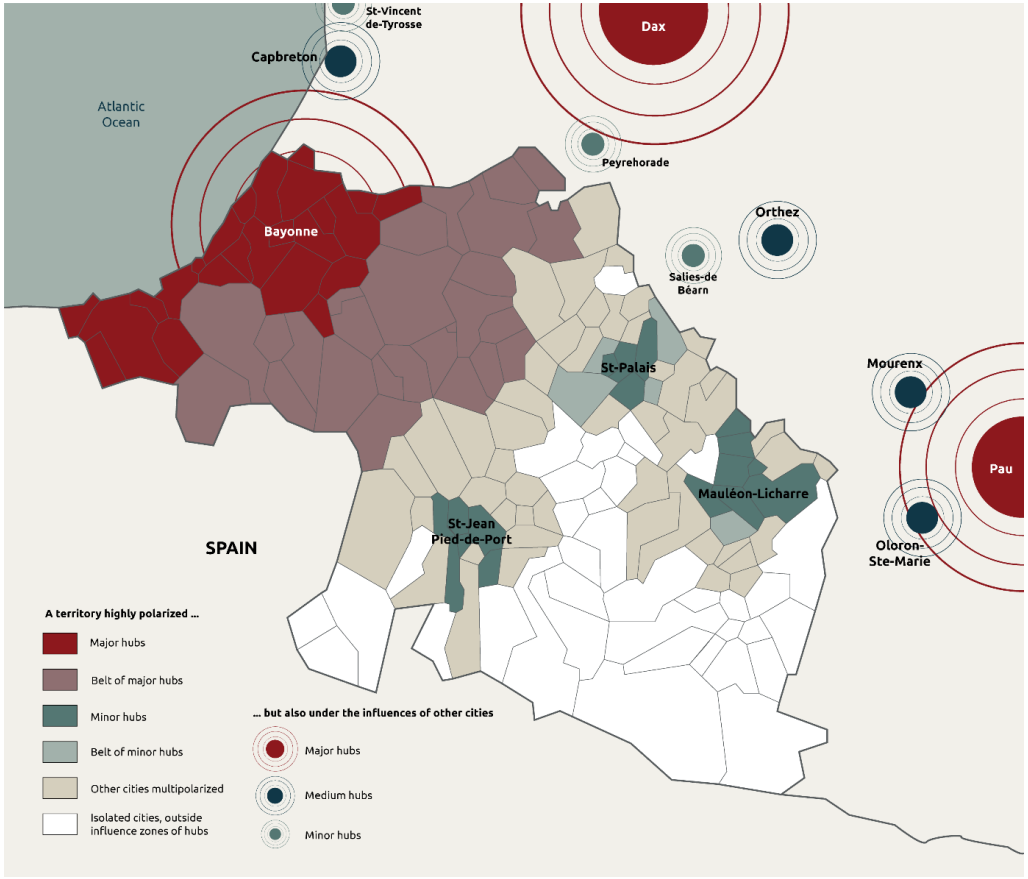


Figure 14. The Influence cities in and around the French Bask country
Source: AUDAP, Little Atlas of the Bask country, 2015

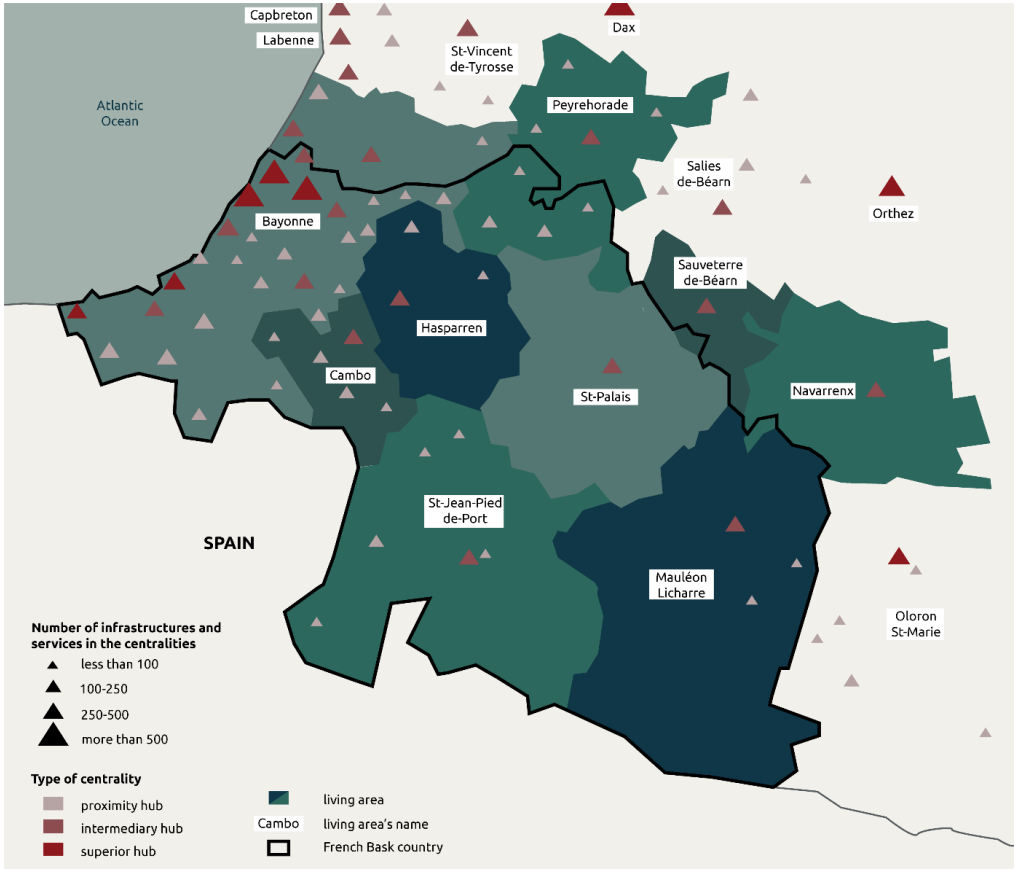


Figure 15. Living areas in the Bask country
Source: AUDAP, Little Atlas of the Bask country, 2015

In the French Bask country, nine living areas are structuring the inhabitants' daily lives. Among them, only six have their center city within the territory. The main one is again Bayonne with 37 cities (28 within the territory) and 237 000 inhabitants living in those 28 cities. It stands for 76% of the Bask country population. Other living areas are Cambo-les-Bains, Hasparren, Mauléon-Licharre, Saint-Jean-Pied-de-Port, Saint-Palais. The living areas of Peyrehorade, Navarrenx, Sauveterre-en-Béarn are also entering the Bask country. It shows the dynamics drawing people outside the territory.

We can observe geographic heterogeneity in the articulation of the living areas, as superior hubs are all located on the coast. It means that inhabitants from the whole territory, as well as from the South of Landes come there to find some specific services and infrastructures.

Another efficient indicator to approach the way people behave on the territory is the travel time to Bayonne. The longer the travel time, the less often inhabitants would make the travel.

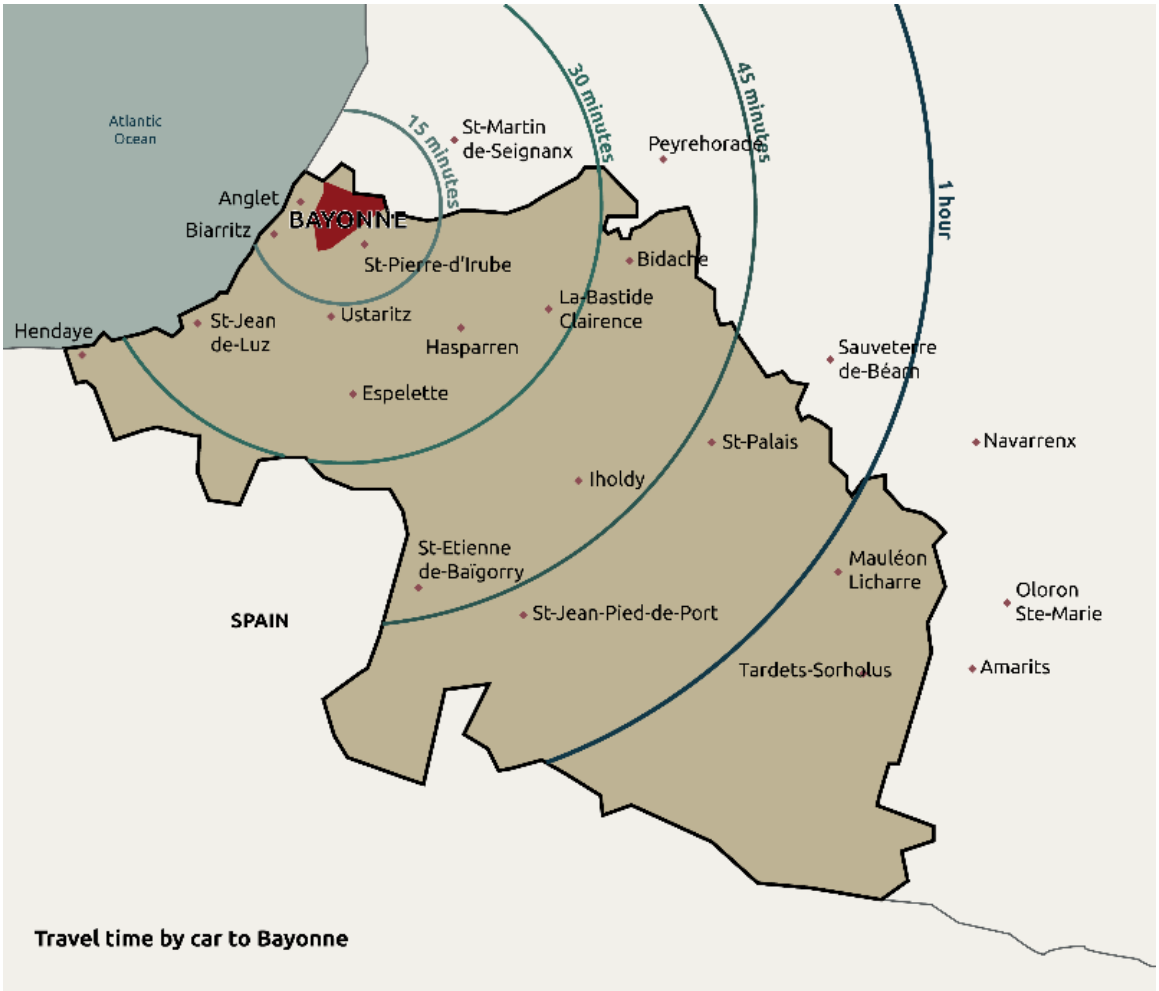


Figure 16. Travel time by car to Bayonne
Source: Google maps

1.3.2. Demography: a growing population

For all these assets, the territory has experienced for several decencies a growing population. In 2018, the Bask country had 312,278 inhabitants, which is an increase of 13,876 inhabitants compared to the population of 2013 (+4.7%). Between 2006 and 2012, the territory already experienced an increase in population of 2 734 inhabitants (+0.9%). Therefore, the Bask country is an appealing place to live, attracting each year even more people.

The most populated cities are located along the coast. This is also where the population growth rates are the highest. This area is then expected to become denser and denser, while small towns of the remote area are losing population. However, many coastal cities have already reached a saturation level: Biarritz, Anglet for instance do not have a growth rate so relevant. People who want to settle there, are more and more obliged to choose cities a bit further from the ocean. That is why we can observe a growing demographic attractivity of cities in the interior, which enjoy good accessibility to the coast, and lower real estate prices.

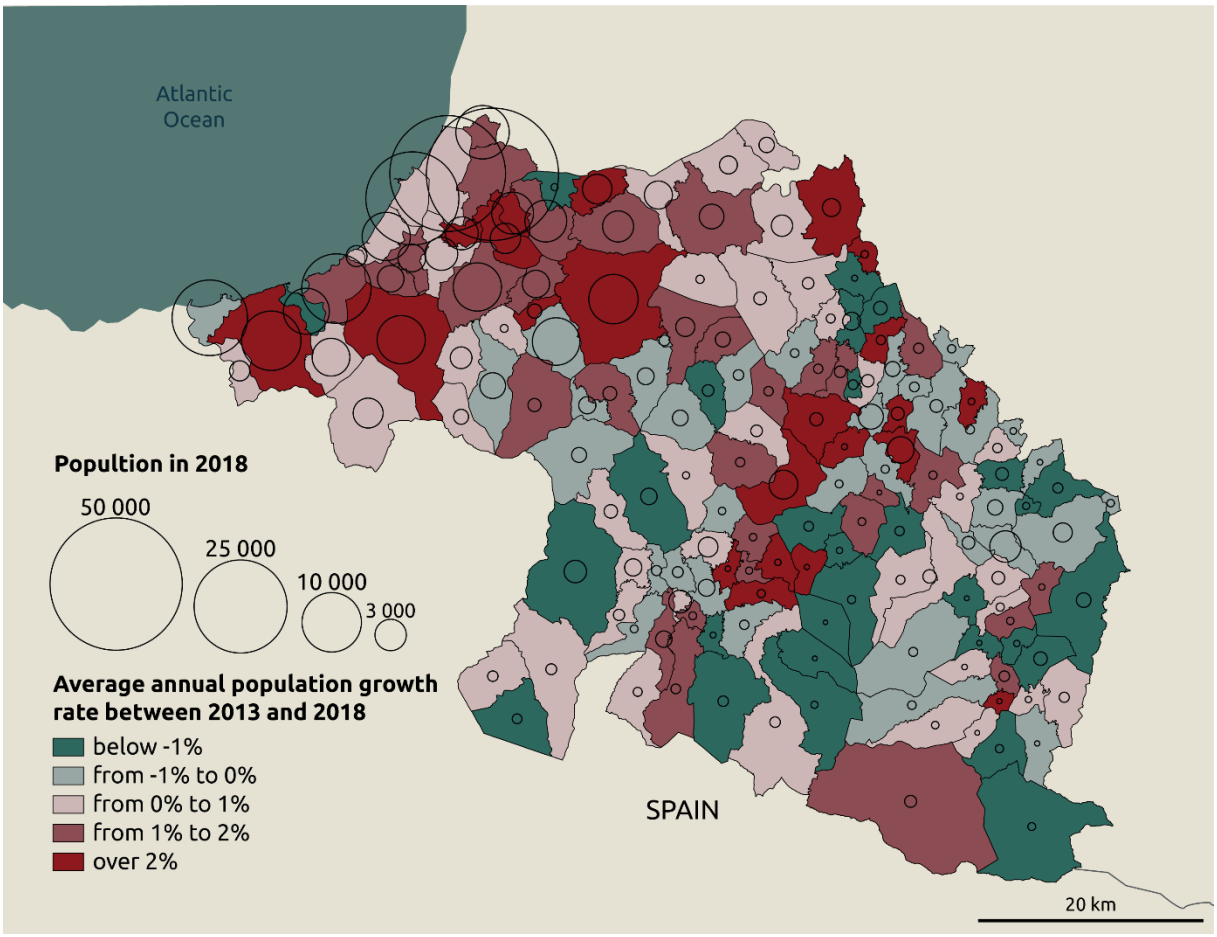


Figure 17. Demography of the Bask country
Source: INSEE, population census 2013 and 2018

1.3.3. Employment structure

In 2018, the territory has 128 075 jobs, which represents an increase of 5,1% (+6 241 jobs) since 2013. Between 2008 and 2013, the territory has already experienced an increase of +6,6% (+7 558 jobs), while at the national scale, the evolution of jobs was only +1,2% due to the economic crisis. The Bask country has therefore avoided the economic crisis and has continued to grow economically during this period.

Job creations are mainly located in the coastal area, where the increase was +6,1%, whereas the Basse-Navarre knew a loss of 2,4%, and the Soule enjoyed an increase of only +3,1%. More broadly, the coast concentrates more jobs, more activities, and many inhabitants of the territory work there while living in a more remote place. We speak about **job centrality**, which is a city gathering at least 800 job positions. In the Bask country, 22 cities are job centralities. There are the cities on the coast: 19 on 22 job centralities are there. The three remaining ones are the biggest cities in the remote territory: St-Palais, St-Jean-Pied-de-Port, and Mauléon-Licharre.

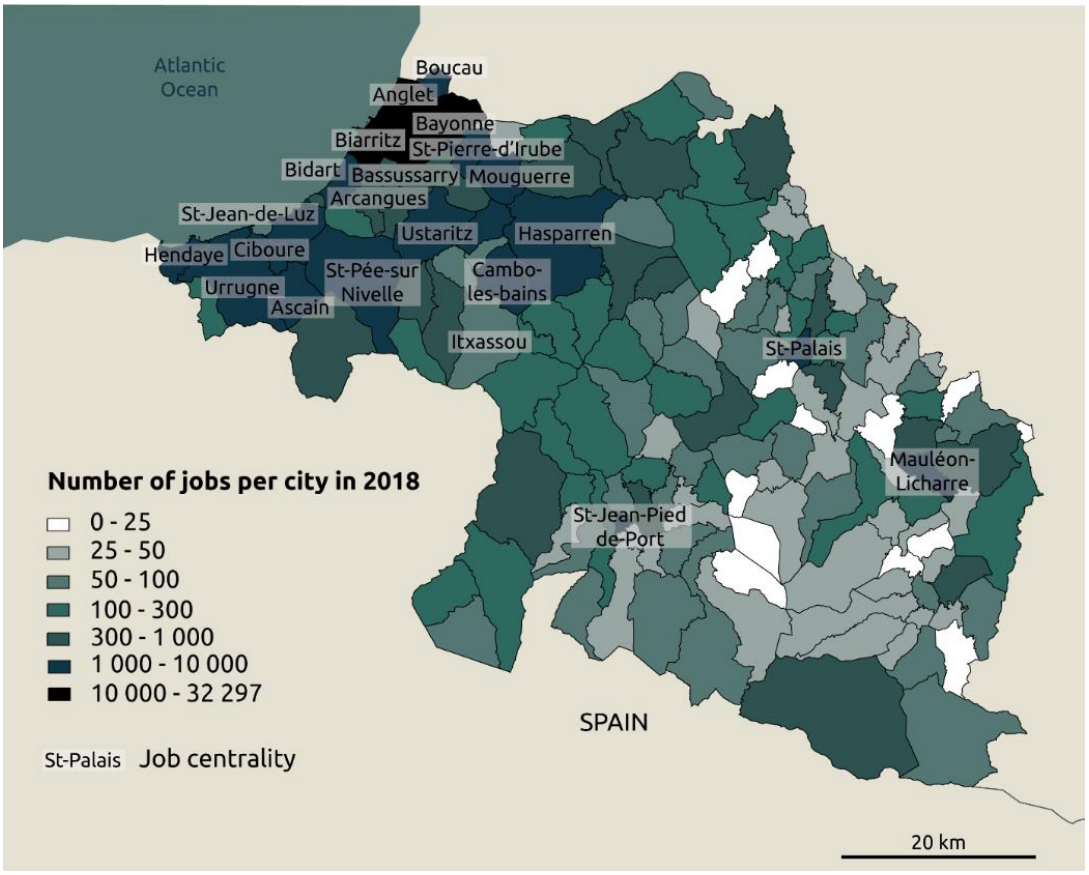


Figure 18. Employment structure in the Bask country: number of jobs per city
Source: INSEE, population census, 2018

Among those jobs, 70% are dedicated to **presential activities**. The INSEE defines presential activities as activities whose production of goods and services is aimed at satisfying the needs of people present in the area, whether they are residents or tourists. On the contrary, **productive activities** are activities that produce goods that are mainly

consumed outside the area and service activities that are mainly oriented towards companies in this sphere. The territory is therefore strongly marked by an economy designed to meet local needs. But only half of the cities have a more important presential structure than a productive one. This is because cities with the strongest presential activities are mainly located on the coast, where the number of jobs is higher. Cities of the interior are more designated toward a productive economy, with some small industries and intensive farming dedicated to national or even global trade.

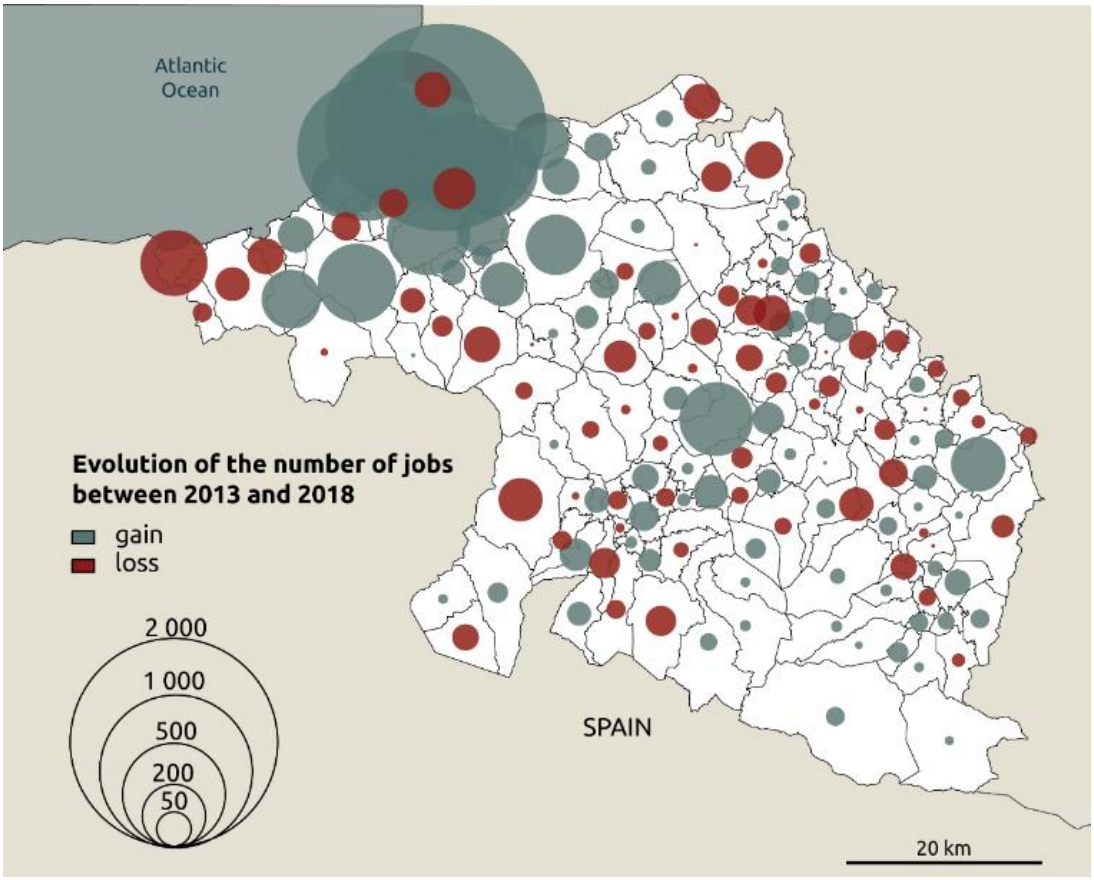


Figure 19. Employment structure in the Bask country: evolution of jobs number between 2013 and 2018
Source: INSEE, population census, 2013 and 2018

Another division of employment can be done depending on sectors: primary or agricultural; secondary or industrial; and tertiary. Most of the time, industrial and agricultural production are destinated, at least partially to be exported outside the territory. They then correspond to productive activities. The tertiary sector represents mainly presential activities: shops, restaurants are services destinated for people in the territory. But some tertiary employments can be productive when it provides services for people outside the territory, or for other productive activities.

Repartition of employment depending on those three sectors is shown on the maps below. It can be noticed that tertiary employments are less present in some cities of the Soule, where agricultural jobs represent a more important share.

Moreover, the Bask country job offer is also attracting workers living outside the territory, mainly living in the South of the Landes department. 1 job on 10 in the Bask country is occupied by a worker not living in Bask country.

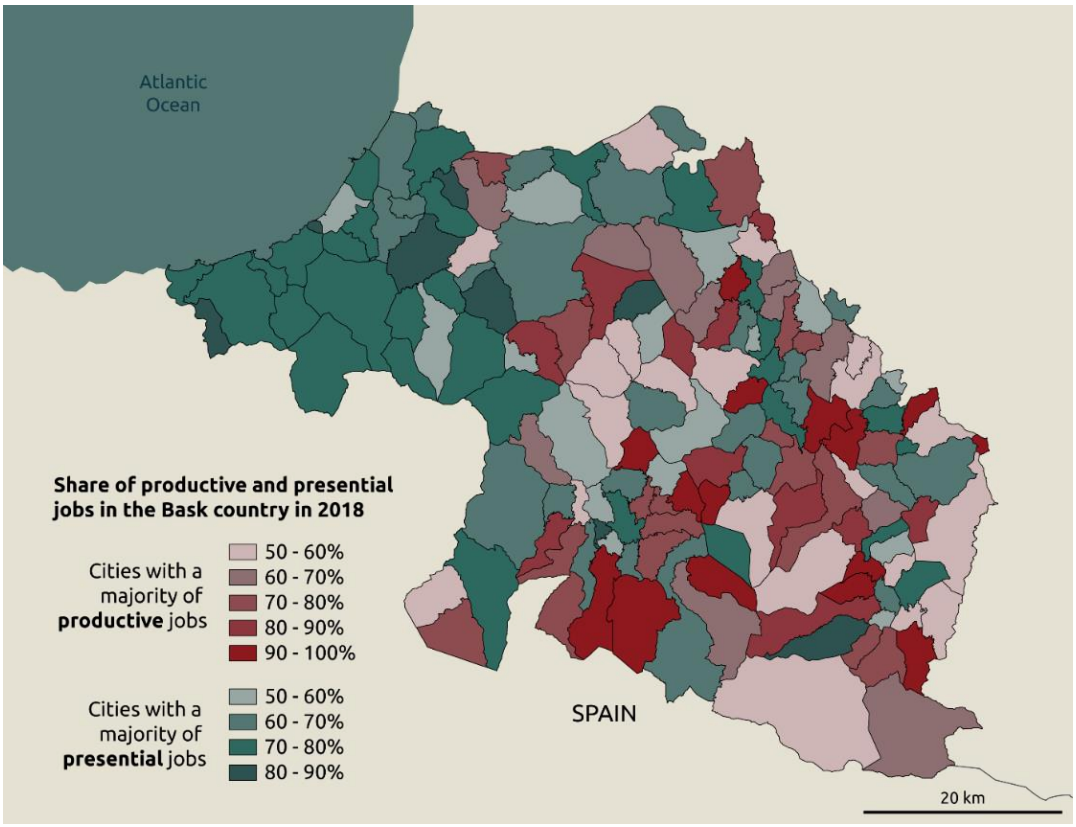


Figure 20. Employment structure in the Bask country: share of productive and presential jobs
Source: INSEE, population census, 2018

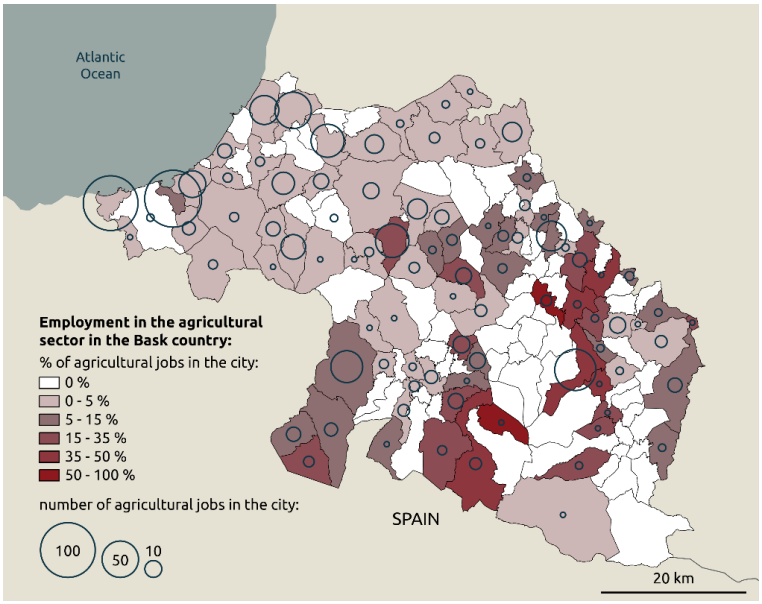


Figure 21. Employment structure in the Bask country: Primary sector

Source: INSEE, CLAP files, 2015

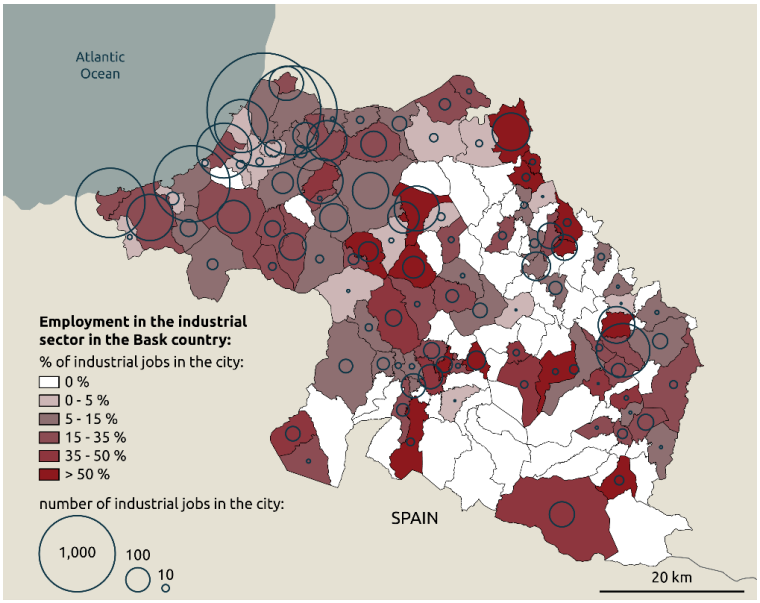


Figure 22. Employment structure in the Bask country: Secondary sector

Source: INSEE, CLAP files, 2015

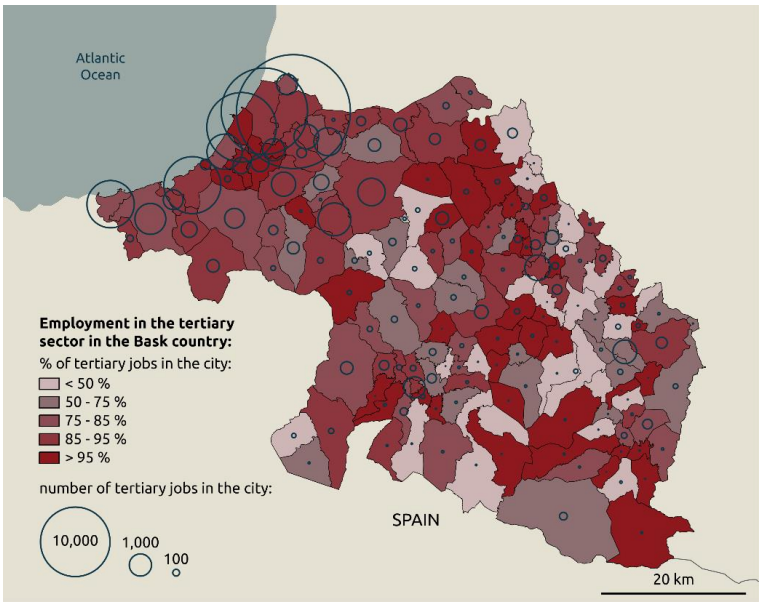


Figure 23. Employment structure in the Bask country: Tertiary sector

Source: INSEE, CLAP files, 2015

2. Domains that affect sustainable development

2.1. Mobility on the Bask country: car dependance and uncomplete public transportation network

2.1.1. Work-home journeys

This polarization of jobs' localization between the coast and the interior causes many daily work-home journeys within the territory.

- 82% of workers use their car to go to their workplace because they live in a more remote area.
- 1,7 million kilometers are traveled each day by workers who do not work in the same city they live in.

This is creating many traffic jam issues, as well as important GHG emissions due to the mobility of inhabitants.

Living area	Number of workers	Workers not working within the living area	Workplace outside the living area		
			1st	2nd	3rd
Côte Basque Adour	49 588	23%	Landes (5-10%)	Sud Pays Basque (<5%)	Nive-Adour (<5%)
Sud Pays Basque	27 106	35%	Côte Basque Adour (10-20%)	Espagne (10-20%)	Errobi (<5%)
Errobi	12 807	61%	Côte Basque Adour (20-50%)	Sud Pays Basque (5-10%)	Nive-Adour (<5%)
Nive-Adour	8 683	76%	Côte Basque Adour (>50%)	Landes (5-10%)	Errobi (<5%)
Pays de Hasparren	6 974	58%	Côte Basque Adour (20-50%)	Errobi (5-10%)	Nive-Adour (<5%)
Garazi-Baigorri	5 290	30%	Côte Basque Adour (5-10%)	Errobi (5-10%)	Iholdi-Ostibarre (<5%)
Soule-Xiberoa	5 056	26%	Béarn (10-20%)	Amikuze (5-10%)	Côte Basque Adour (<5%)
Amikuze	3 897	35%	Béarn (5-10%)	Côte Basque Adour (5-10%)	Soule-Xiberoa (<5%)
Pays de Bidache	2 590	61%	Côte Basque Adour (20-50%)	Landes (10-20%)	Béarn (5-10%)
Iholdi-Ostibarre	1 581	50%	Garazi-Baigorri (10-20%)	Amikuze (5-10%)	Pays de Hasparren (<5%)

Table 1. Flow of people for home-work travels in the Bask country
Source : Observation économique du Pays Basque 2019 – CCI Bayonne Pays Basque

We observe a general tendency of journeys from the interior of the territory to the coast. A few journeys parallel to the coast, between Garazi-Baigorri, Iholdi-Otzibarre, and Amikuze, are also to be noticed.

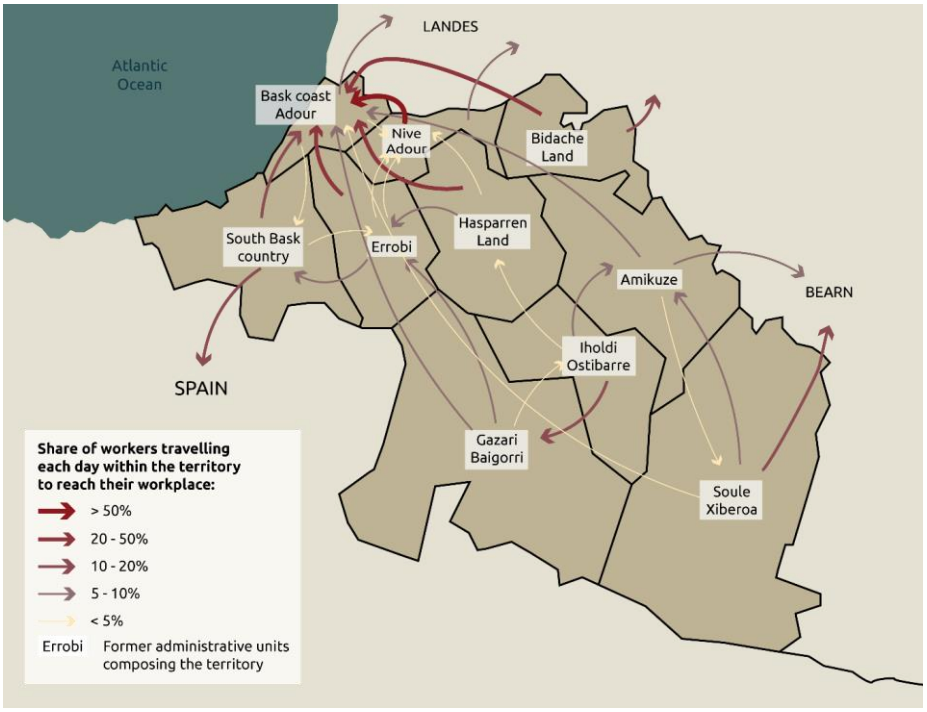


Figure 24. Work-home journeys through the territory

Source: Economic Observatory of the Bask country, CCI Bayonne

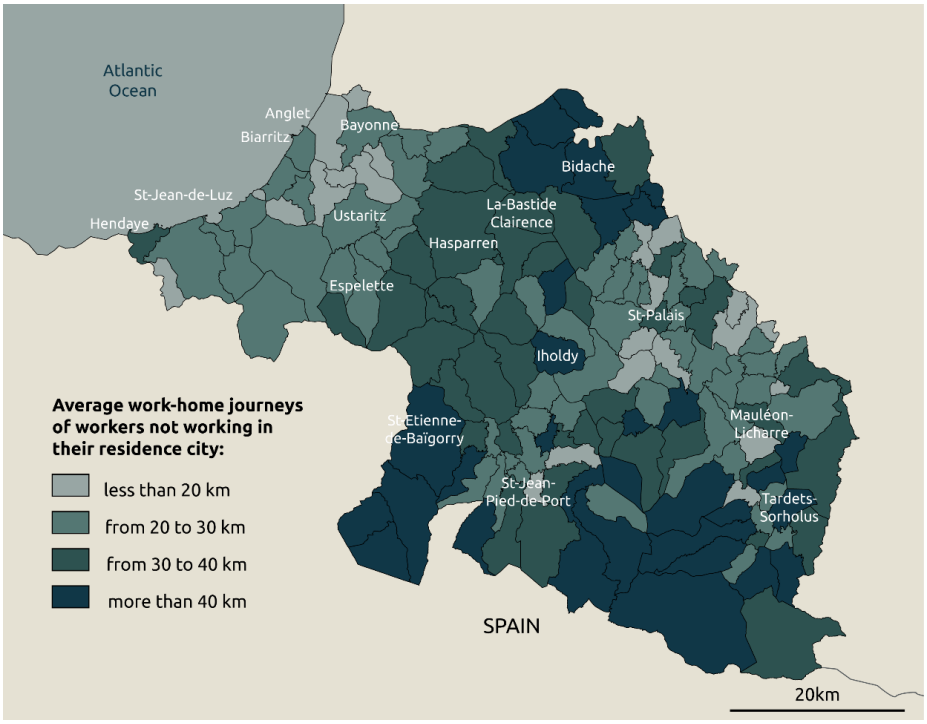


Figure 25. Length of work-home journey

Source: AUDAP, Little Atlas of the Bask country, 2015

The map below shows that cities where the fewest inhabitants are also working, are mostly located around Bayonne. This is due to the fact that Bayonne and cities along the coast are high job centralities. But as all workers can not live there, some go live in places a bit more remote and commute every day. We experience a phenomenon of suburbanization.

In the interior country, the share of workers working in their residence cities is generally high, except in the main cities – St-Palais, Mauléon-Licharre, Tardets-Srholus – where commuters are more present. Because those cities are more important, and therefore more attractive, some people are more ready to settle there and have longer journeys to go to work.

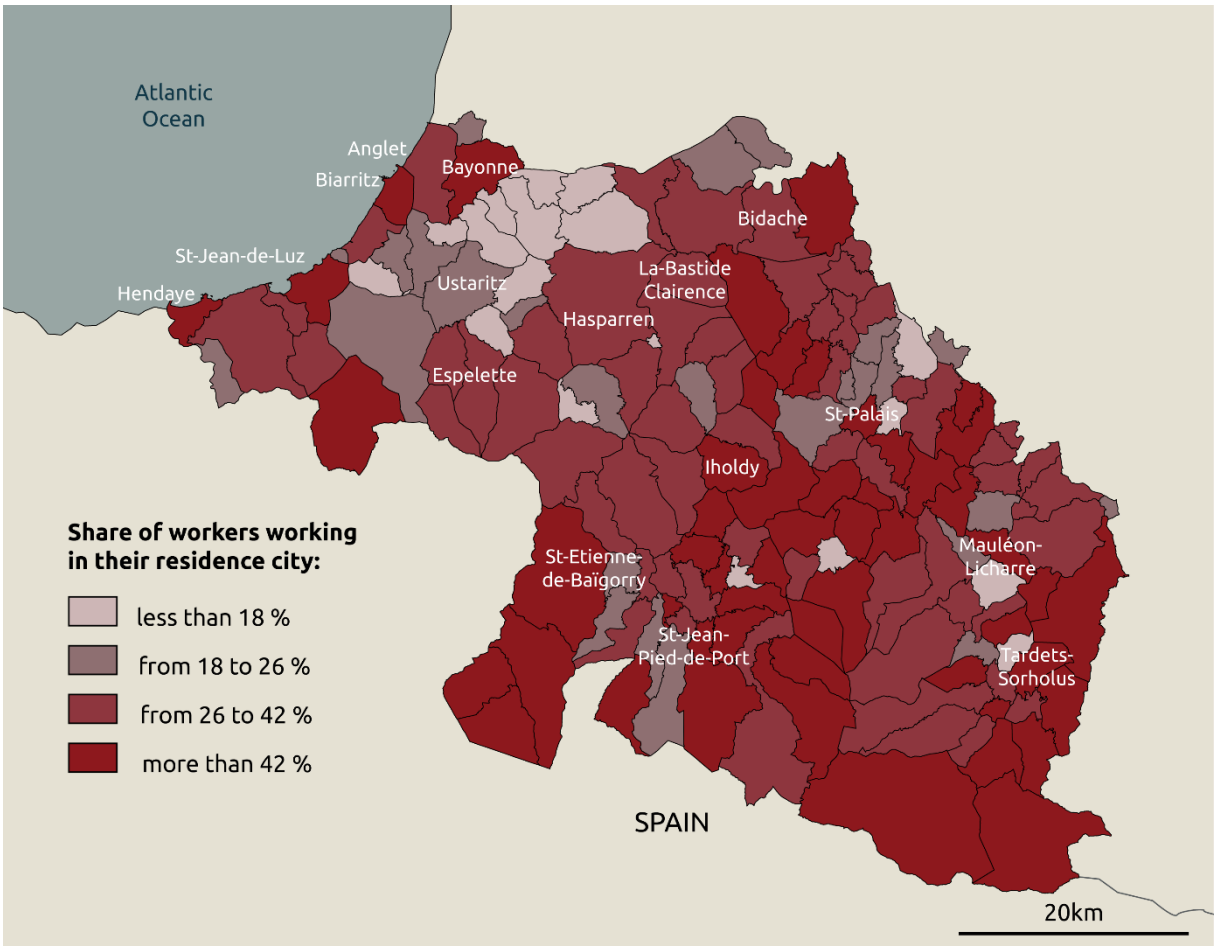


Figure 26. Workers working in their residence city
Source: AUDAP, Little Atlas of the Bask country, 015

2.1.2. The inefficiency of public transportation

Workers, but also other users of the territory, use mainly their cars to move within it. It raises the question of why other means of transportation are that much neglected.

Railway network

The SNCF network covers a part of the territory. In particular the TGV between Paris and Hendaye stops in many cities on the coast. Several TER lines also run several times a day between Bayonne and Saint-Jean-Pied-de-Port, and from Bayonne to Pau.

The TERs run approximately every hour between 6 am and 9 pm. The line along the coast is even a bit more frequent. But we can clearly see that this network is not covering the whole territory. And for every people not living in a city served by the railway lines, it can be tough to realize daily the journey using this mean of transportation.

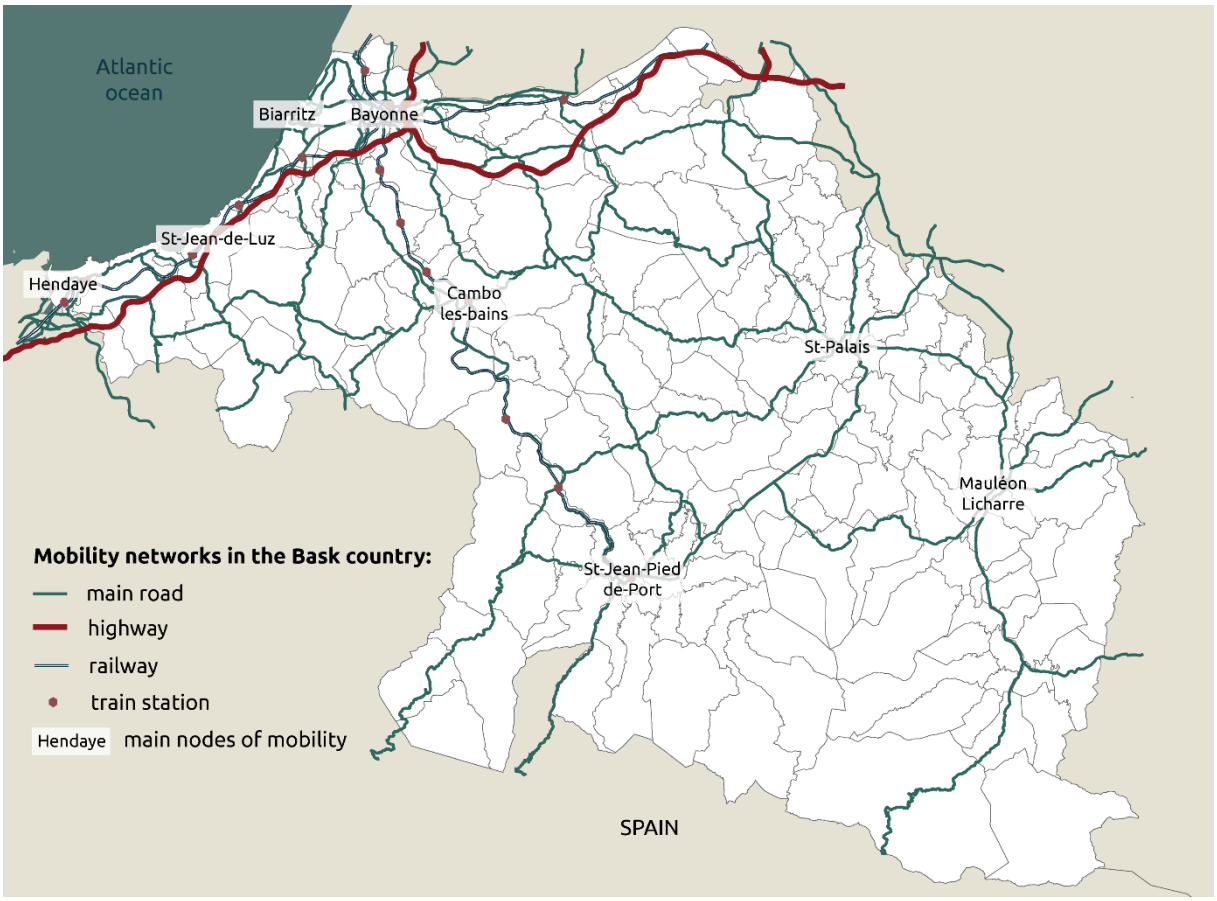


Figure 27. Mobility network in the Bask country
Source: SNCF

Bus network

Several bus lines are also crossing the territory. The cities of Bayonne, Anglet, and Biarritz are particularly well served by the Txik txak network. Many lines are travelling several times per hour between the three cities. But while leaving this urban area, the lines are fewer and less frequent.

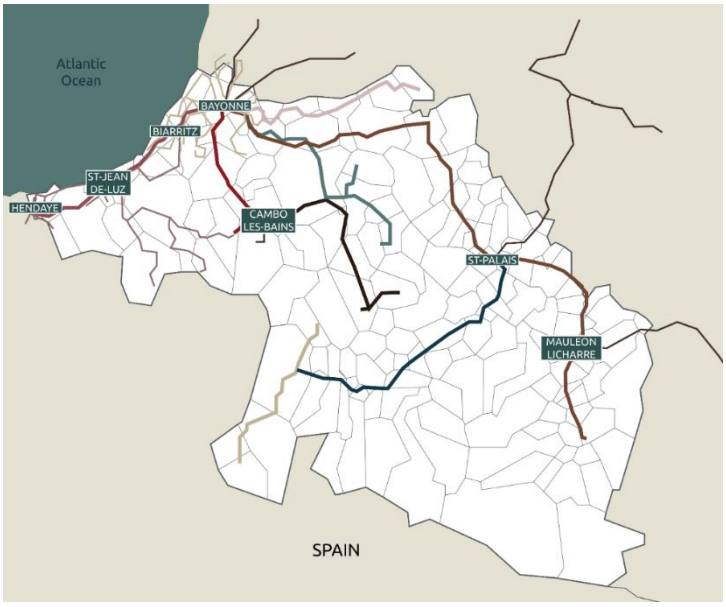


Figure 28. Bus network in the Bask country

Source: Chronoplus

Again, many cities are located far from any public transportation line. And even if you do live in a city served by the train or the bus, the inflexibility of the schedules can make it difficult to use it daily for the work-home journeys.

A solution to really limit the use of the car could be to use it only to reach a train station or a bus stop. But this could appear inconvenient for many people, who rather use their car for the whole travel. Traffic jams, especially during rush hours, are a real issue the territory is experiencing, making the journeys 2-3 times longer. During summer in particular, when tourists are representing additional pressure on the road traffic. Nonetheless, the car is often faster than combining train and bus to do the same journey. That shows really the inefficiency of the public transportation network in the Bask country.

2.1.3. Transportation of goods: the Bask country, a major interface for international trade

The Bask Country is a major logistical interface between the Iberian Peninsula and the rest of Europe. The port of Bayonne (the ninth largest in France), the industrial port of Tarnos, and the European Freight Center are evidence of the role played by the Bask Country in international trade. Thus, the A63 freeway sees 8500 heavy goods vehicles pass by every day, which represents 20% of the traffic outside the summer period.[1]

This function implies not only additional road traffic but also railway and sea transportation are concerned. Many goods come and leave our territory every day by any transportation means.

2.2. A rich agriculture and farming making the renown of the territory

2.2.1. Local specificities contributing to the renown of the territory

Agricultural lands stand for 170 000 ha, on a total surface area of 300 000 ha. In this regard, agriculture constitutes a marking element of the territory. The Bask Country is indeed strongly characterized by its production of meat and dairy products, which participate and reinforce the Bask identity. Many products benefit from an official sign of identification of quality and origin. Two signs exist: AOC (appellation d'origine contrôlée – controlled origin appellation) and IGP (indication géographique protégée – protected geographic indication).

In the Bask country, products benefitting from one or the other are:

- the Irouléguy wine (AOC)
- the Espelette pepper (AOC)
- the Ossau-Iraty cheese (AOC)
- the Bayonne Ham (IGP)
- the Adour Kiwi (IGP)

[1] PCAET of the Bask country, 2021

Others do not have an official sign but still contribute to Bask country renown, such as the cherries from Itxassou and the Bask apple trees.

The territory has 4,597 farms and on the 170,000 ha of agricultural lands, 70% is useful agricultural surface, and 30% is collective pasture in mountain areas. Livestock is present in 85.5% of the farms, mostly with dairy sheep or beef cattle.[2]

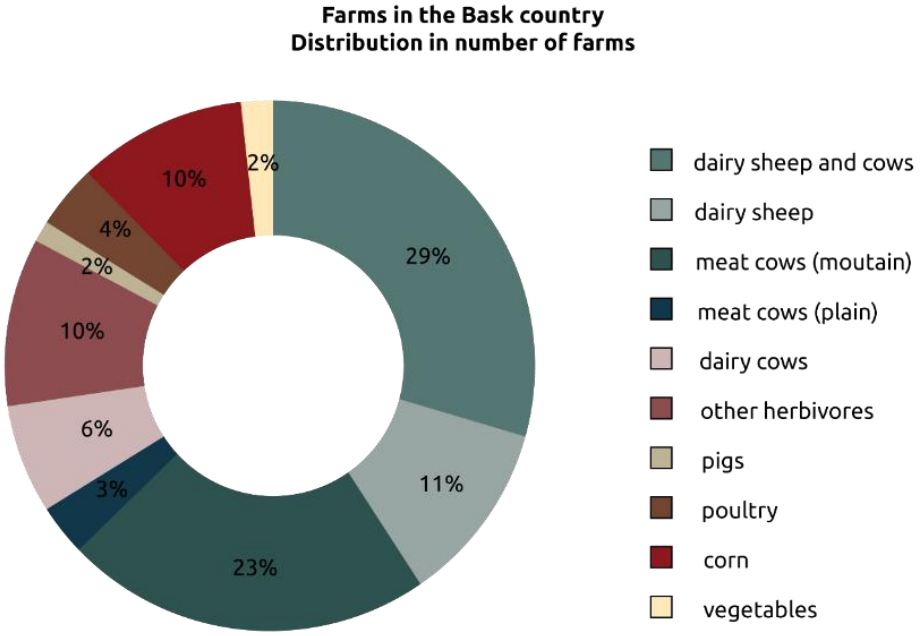


Figure 29. Farms types in the Bask country
Source: ClimAgri Pays Basque – Study for a climate energy strategy of agricultural and forest sectors in the Bask country, 2015

Moreover, the Bask country also has specificities in the way they breed their sheep and cows: transhumance is the traditional way to breed Bask sheep and is still applied today. It consists in moving the flocks to higher pastures in the mountains during summer. This practice also contributed to shaping the territory, with a system of houses located on high places in the mountain to host the shepherds.

Figure 30. Sheep herd in the hills near Espelette, picture taken by me

[2] Climagri Pays Basque, 2015

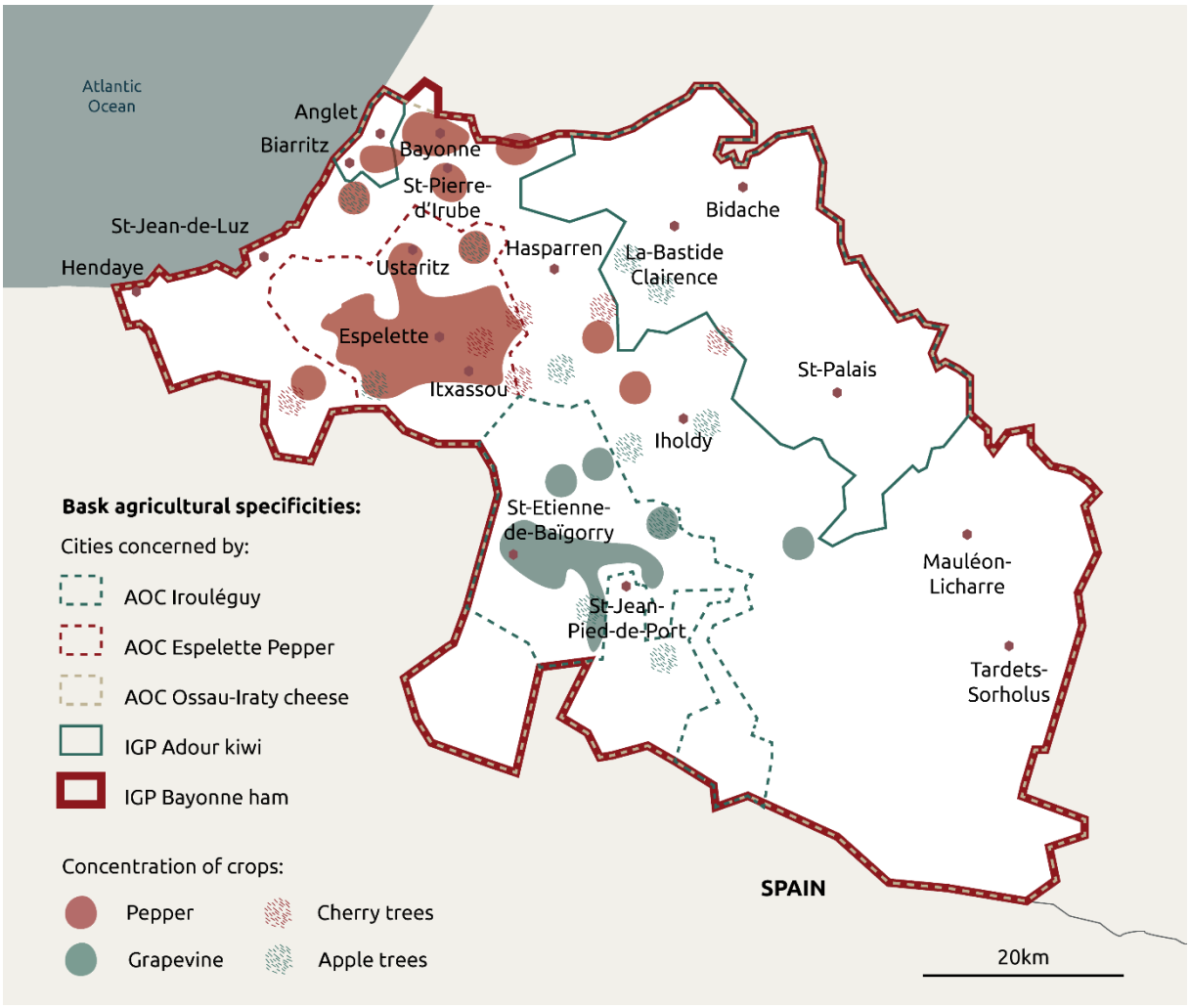
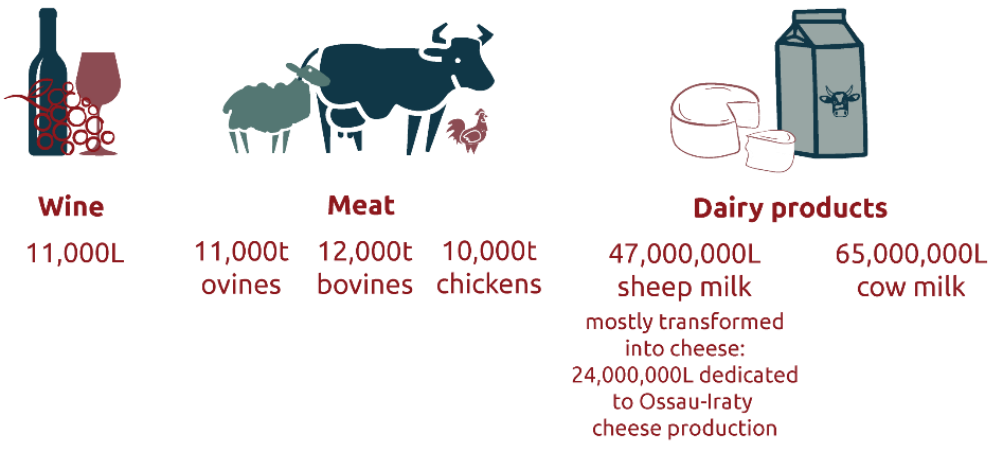


Figure 31. The Bask agriculture
Source: AUDAP, Little Atlas of the Bask country, 2015 – DRAAF, agricultural data, 2021

2.2.2. An important food production

In 2015, the Climagri report estimated the local food production as below:



Eggs 2,200t | **Fruits** 2,500t | **Vegetables** | **Corn**

On those, an important part is dedicated to importation: Bask products are commercialized everywhere in France, and also all around the world.

2.3. The attractivity of the territory

2.3.1. Tourism: A targeted destination for French people and foreigners

Tourists come for many reasons: enjoying the beaches, hiking in the mountain, surfing. The Way of Saint James also passes through the territory, and it brings many pilgrims to spend a few days there.

In total, in a year, the number of tourists spending at least one night on the territory is 13 million. They come from the whole country, but also from other countries. Spanish, German, and Dutch are particularly represented among the tourists. The tourist activity knows a peak during summer.

Tourism, therefore, has become a relevant economic activity for the territory, that is responsible for the development of presential jobs and the wealth of the territory. Many hotels, campsites, as well as restaurants and other structures to address tourists' needs have appeared in the most attractive areas.

The capacity of beds on the territory is 81,100 beds. 44% of this capacity is provided by campsites, 16% by hotels, 16% by furnished rent appartements (AirBnB for instance), and 13% by tourist residences. The remaining 11% corresponds to vacation villages (6%), collective accommodations (3%), bed and breakfasts (2%), and youth hostels (<1%). The map below is showing the location of those accommodations, only for hotels, campsites, vacation villages, tourist residences, and youth hostels (INSEE, 2021). For the others, we could not collect localized data.

69% of the bed capacity and 80% of accommodation establishments are located in the littoral area. Here again, the territory's touristic attractivity is not well spread and activities are concentrated on the coast.

However, people sometimes are not attracted only to spend a few days in the Bask country. The number of secondary houses shows a real tendency to settle there. In 2012, the Bask country counted 38 502 secondary houses. In 2018, this number has reached 42 555 (+4 053 secondary houses in 6 years). Secondary houses represent 21% of houses on the territory and up to 42% in Biarritz. The issue it is raising is a rise of real estate prices, which makes more and more the territory unaffordable for its own inhabitants. Again,

secondary residences are mainly located in the most attractive places, that is to say along the coast.

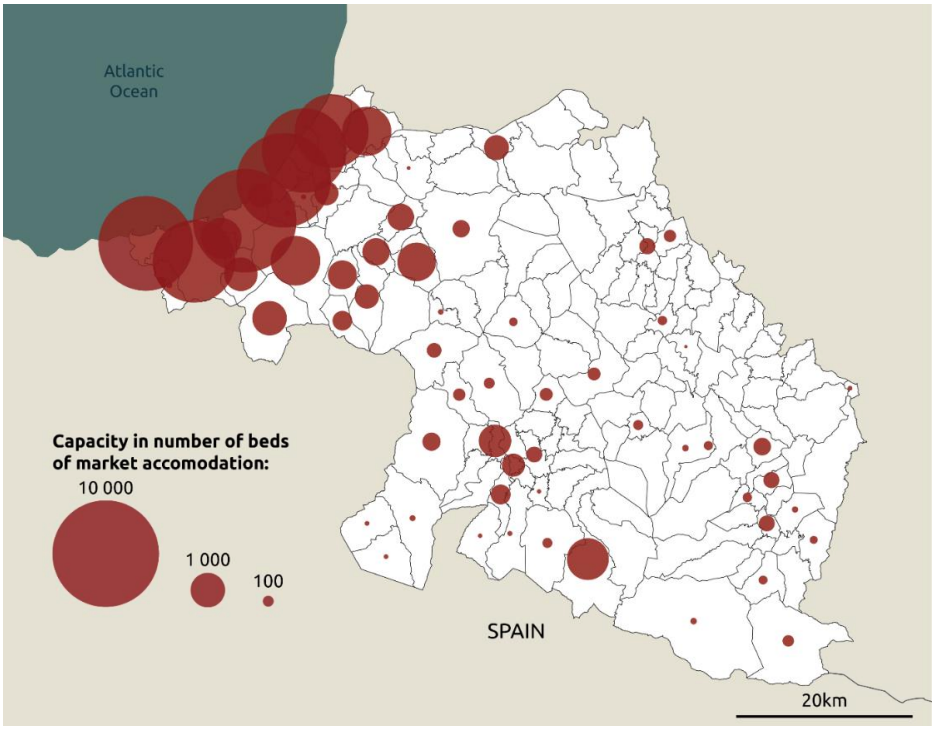


Figure 32. Attractivity of the Bask country: number of beds in the market accomodation
Source: INSEE, tourism census, 2021

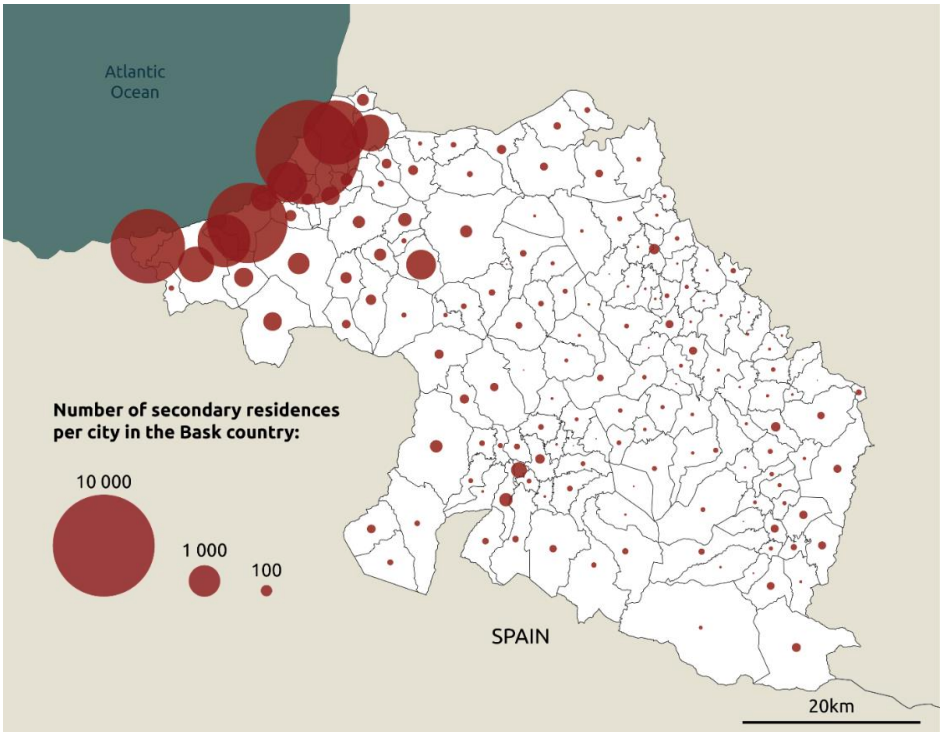


Figure 33. Attractivity of the Bask country: number of secondary residences
Source: INSEE, tourism census, 2021

2.3.2. Fight for land

This price rise is a real issue the territory is experiencing. For a house in Biarritz, the price today is 8,190€ per m2. And in all coastal cities, the average m2 price for a house is 6,400€.

Moreover, this phenomenon is starting to happen not only along the coast but also in a bit more remote cities, as the coast is already saturated. To find a house today in the main cities of the Bask country is very difficult, and prices are higher than in most French metropolises.

As a matter of comparison, prices in Saint-Palais are equivalent to the ones in Pau, the department capital that benefits from high service offers. Toulouse and Bordeaux, among the biggest French cities, remain cheaper than the Bask coast.

City or group of cities	Selling price per m2 for a house
Biarritz	8,190 €
Bayonne	4,930 €
Saint-Palais	2,310 €
Mauléon-Licharre	1,700 €
Saint-Jean-Pied-de-Port	750 €
Labourd	4,090 €
Basse-Navarre	1,660 €
Soule	1,090 €
Pau	2,330 €
Dax	2,320 €
Bordeaux	5,310 €
Toulouse	4,060 €

Table 2. M² price in various cities
Source: Efficity, March 2022

More and more voices are raised among the population that denounces this tendency. People are reclaiming the right to own their country and want real measures to stop the territory to be bought by “foreigners”. Solutions such as obtaining the right to become a homeowner only if one’s has lived a certain amount of time on the territory are being discussed within political spheres. This could stop the increase of secondary houses and keep the Bask country affordable for Bask people.

A recent case of an agricultural land being sold for 2 million euros in the remote country to a rich old woman who wanted to build there a secondary house has raised many protests within the territory. The attractivity of the Bask country is not only stealing lands from the inhabitants, but also from agricultural activities. Many Bask people see it as a real threat to their integrity and identity. They want to preserve their land and keep it affordable for their children.

Indeed, the strong identity of the Bask country has pushed it to claim independency many times in History. On the other side of the border, the Spanish Bask country has succeeded to obtain its own government. This is giving ideas to independentist parties in the French part. And the price rise is a good reason for them to fight for their right.

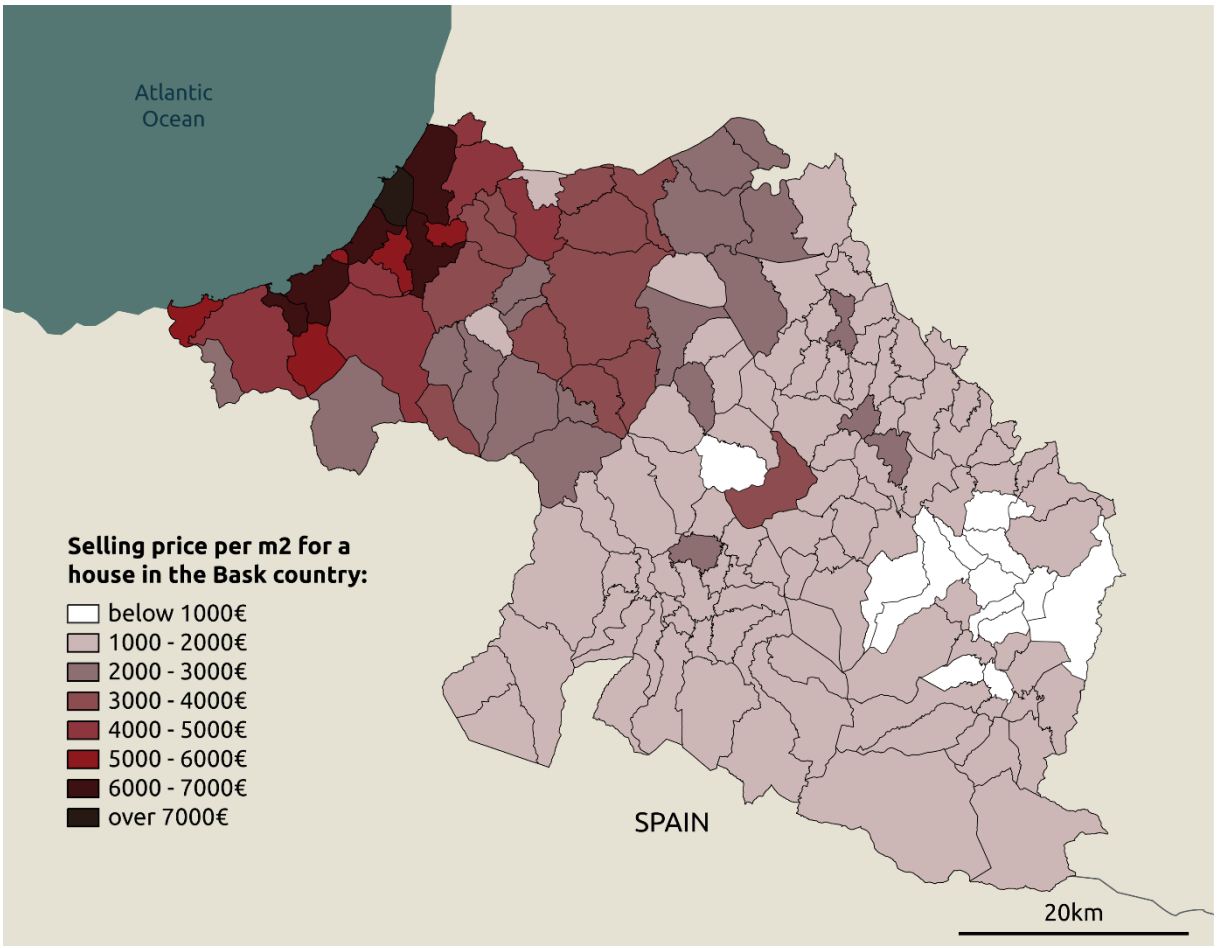


Figure 34. M² price in the Bask country
Source: Efficity, March 2022

Chapter II – Territorial metabolism: a key to make the territory more sustainable

1. Defining the problems

1.1. SWOT Analysis

Considering the local context that we exposed just before, we can now identify the strengths, weaknesses, opportunities, and threats of the territory.

Strengths

- Rich Agriculture
- Variety of landscapes
- Unique and rich local culture
- Strong identity
- Large natural spaces
- Economic dynamism

Weaknesses

- Attracting more people that it can host
- Car dependance and frequent traffic jams
- Geographic polarization between the coast and the interior

Opportunities

- Food autonomy

Threats

- Soil artificialization and loss of natural spaces
- Decrease of agricultural lands in aid of tertiary activities
- Price rise and territory becoming unaffordable
- Loss of identity and authenticity

1.2. Draw the future of the Bask country

1.2.1. The Bask identity turned to its population, and no more a reason for attractivity

The Bask identity is a strong asset of the territory. Thanks to language, sports, and festivities, as well as agricultural practices, bask people succeeded until now to preserve

their authenticity. But today, this identity is making the territory so attractive that some are scared of its loss or impoverishment. With millions of tourists visiting every year, and an increase of secondary residences, from people living in other French regions, the territory is becoming unaffordable for the Bask people. The bask identity is making the renown and the attractivity of the territory, that are killing it in return.

However, this strong identity can be used in the other way, to improve inhabitants' daily life, rather than to appeal to foreigners to the territory. Its identity is a rich resource for the territory: agricultural production for instance can be destinated to assure the territory's integrity, rather than to spread its identity's results throughout the country and the world.

Currently, this immoderate attractivity is responsible for the polarization of the territory. As the coast is much more attractive, eyes are all riveted solely on this part of the territory, and all the interior country is suffering from a lack of attention, in terms of economic development. While focusing on the Bask identity and enhancing it in all the aspects it can evoke, it will rebalance the territory. Then, talking about the Bask country will no more refer only to the coast, but all the territory will be considered.

1.2.2. Take part in the global fight for environment protection

Nowadays, human activities have been recognized as responsible for much damage to our environment. The Bask country, such as the whole globe, is experiencing climate change and loss of biodiversity and must adapt itself.

On the other hand, the fight against climate change is a global fight, and every territory must be aware of its responsibility in this phenomenon, and act to reduce its impact.

a. Greenhouse effect: a vital phenomenon that has become dangerous

The so-called "greenhouse effect" is a phenomenon that has always taken place in the Earth's atmosphere: on the one hand, the gases present there filter the sun's radiation. This allows part of the sun's rays to never reach the Earth's surface. They are reflected and do not enter the atmosphere at all.

On the other hand, the rays which could penetrate in the atmosphere heat the Earth by the energy which they bring to it. The Earth emits infrared rays to cool itself. These infrared rays are absorbed by the greenhouse gases, which prevents the Earth from cooling down too much.

The scientific community has shown that without this mechanism, life might not have developed on Earth. Indeed, this phenomenon blocks some of the Sun's dangerous rays from leaving the atmosphere, including most of the ultraviolet rays. In addition, without the greenhouse effect, temperatures would be much lower on our planet. The average temperature at the Earth's surface would be -18°C instead of the current +14°C.

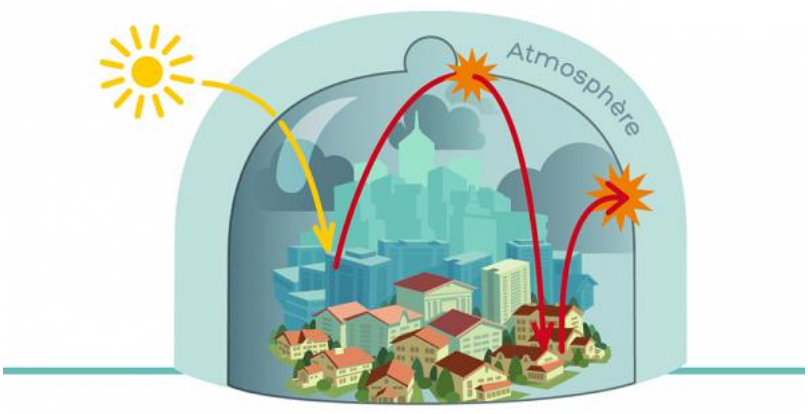


Figure 35.The greenhouse effect
Source: Ecologic Transition Ministery, 2018

However, since the industrial revolution of the 19th century, anthropogenic activities have led to an increase in emissions of gases responsible for the greenhouse effect[3]. Global emissions of greenhouse gases have increased by more than 80% since 1970 and 45% since 1990, reaching 49 GtCO2e in 2010 and 55.3 Gt CO2e in 2018[4]. The infrared emitted by the Earth is therefore increasingly absorbed, and the Earth is cooling less and less. Temperatures are rising, and we are witnessing climate change. This climate change has already had consequences on the planet: melting ice, rising sea levels, erosion of biodiversity, frequent natural disasters, etc.

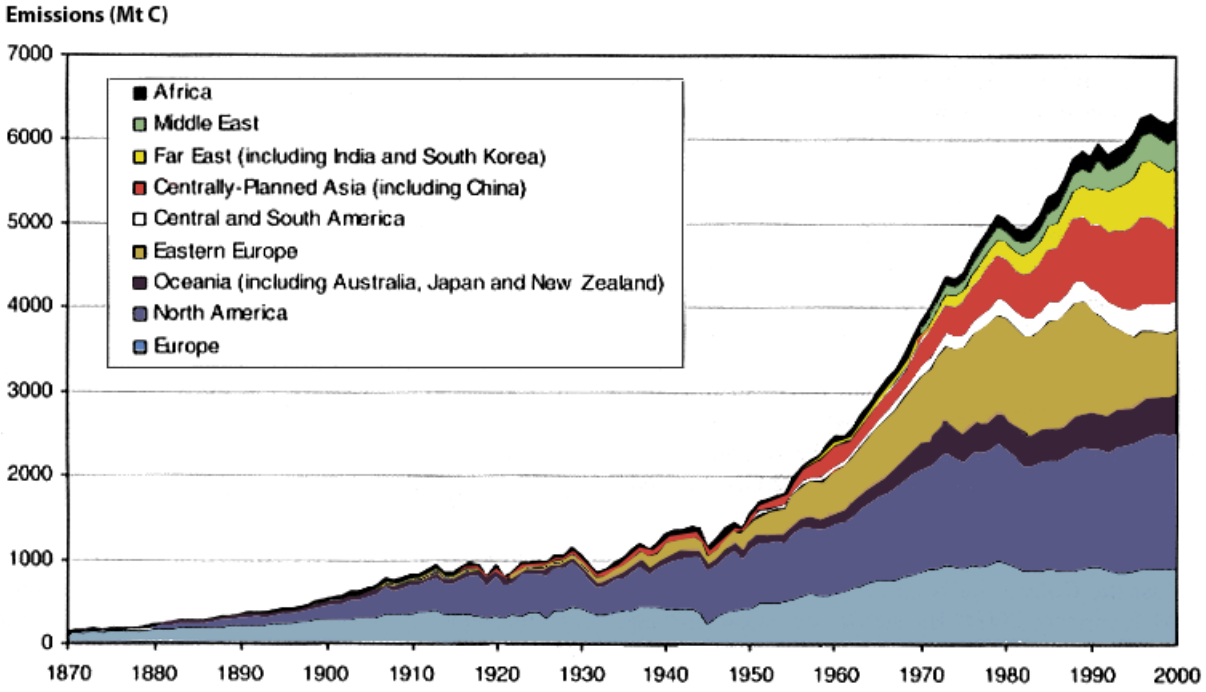


Figure 36. Global evolution of emissions coming from combustibles from 1870 to 2000
Source: Jean-Marc Jancovici, 2006

[3] IPCC, 1st report, 2013
[4] UN Environnement – Emissions Gap Report 201

The greenhouse effect is therefore a necessary phenomenon for the development and preservation of life on Earth, but too many emissions are proving to be harmful to the planet, as the climate change already have consequences on human societies.

b. The greenhouse gasses

The Kyoto Protocol of 2005 establishes a list of seven greenhouse gases that are called "direct greenhouse gases". They will be detailed below.

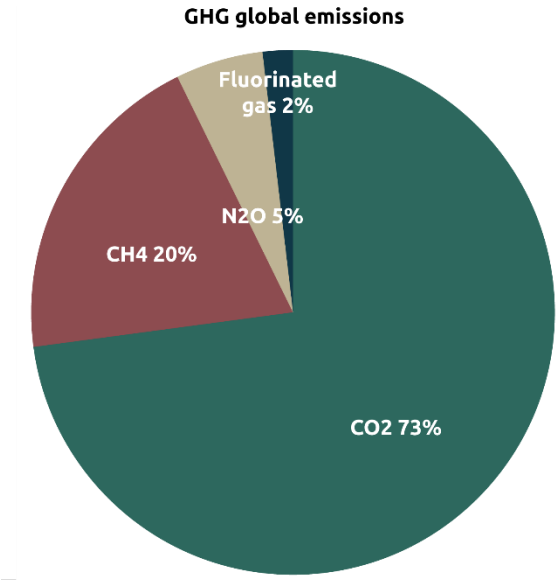


Figure 37. GHG global emissions

Source: IPCC, 3rd report, 2014

Among the fluorinated gases are HFC, PFC, SF6 and NF3.

Carbon dioxyd CO_2

CO2 emissions are the most important and therefore the ones that must be reduced the most. They are responsible for nearly 75% of global GHG emissions[5].

Road transport is responsible for 40% of these emissions. The progressive increase in traffic since the 19th century has produced more and more air pollution. However, the increasing use of biofuels, as well as the renewal of the car fleet by less energy consuming vehicles, is gradually reducing these emissions.[6]

However, this must be put into perspective: studies[7] have shown that polluting vehicles that Europe no longer wants are exported to developing countries to be sold second-hand. This is a relocation of emissions, not a removal of them. At the same time, the longer life span of vehicles makes it possible to soften the emissions linked to their manufacture (representing around 10% of the emissions from use).

Moreover, the residential and tertiary sectors are also responsible for 21% of CO2 emissions, caused by heating systems using fossil fuels (natural gas, fuel oil).

[5] IPCC, 3rd report, 2014
[6] CITEPA, SECTEN report, 2021
[7] Carbone 4, « Renouvellement du parc automobile : où vont les voitures dont l'Europe ne veut plus ? », 2021

In general, CO2 emissions are linked to two processes:

- The use of fuels, to run vehicles or to heat (natural gas, fuel oil, etc). By burning these fuels to obtain heat or energy, a chemical reaction takes place during which CO2 is released.
- Decarbonation processes, that is to say the transformation of carbon contained in carbonates into CO2 under the effect of heat. This process can be found in many industrial sectors: cement and glass production, iron and steel industry, lime production, tiles, and bricks.

Methane CH_4

Methane emissions are mainly due to the agricultural sector (enteric fermentation of ruminants) and to waste.[8]

Waste, produced by households, companies or communities, is collected, incinerated, eliminated using biological processes (composting, methanization) or sorted for recovery. Wastewater treatment processes also cause GHG emissions. 72% of GHG emissions from waste treatment are due to storage alone.

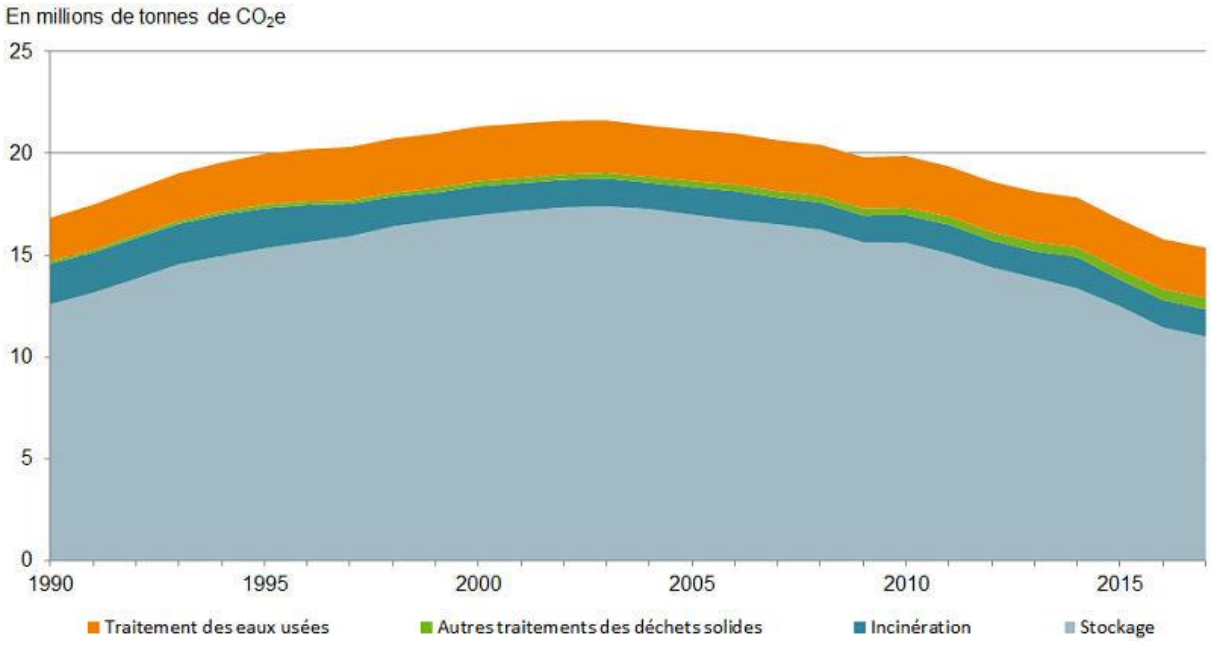


Figure 38. Evolution of GHG emissions linked to waste from 1990 in France
Source: CITEPA, SECTEN Report, 2018

On a global scale, methane accounts for about 13% of emissions, but this can vary greatly from one territory to another. Territories with a greater presence of livestock may see their methane emissions occupy a larger share. This is the case in the French Bask country, where cattle and sheep breeding is very important. The territory's agricultural sector is the largest emitter of GHGs, with consequently high methane emissions.

[8] CITEPA, SECTEN report, 2021

Nitrogen oxide N_2O

These emissions are also very much linked to the agricultural sector: N2O emissions are mainly due to mineral and organic nitrogen fertilizers, spread on agricultural soils. Animal manure management is also a source of N2O5 emissions.[9]

Hydrofluorocarbure HFC

HFC emissions have been increasing since 1995, when other gases of the same family (CFCs and HCFCs) were banned. They were implicated in the phenomenon of the hole in the ozone layer. HFCs were then used as a replacement for these two gases, as a refrigerant in cooling systems (air conditioning), but also in insulation foams, aerosols, and fire extinguishing equipment.

Perfluorocarbure PFC

Until the 1990s, the only contributor to PFC emissions was the manufacturing industry, with aluminum production accounting for two-thirds of these emissions. The rest of the emissions were related to the production of trifluoroacetic acid (TFA) and fluorinated gases, the manufacture of semiconductors and photovoltaic panels, and the use of PFCs as solvents. Today, PFCs are also used in the residential and tertiary sectors for medical and cosmetic applications, but they remain marginal (3% of total emissions) compared to industrial emissions.

Sulfur hexafluorure SF_6

These emissions are found on the one hand in the manufacturing industry sector, and in particular during the production of magnesium. Thus, it is the manufacture and use of high voltage electrical equipment, and the manufacture of cables and particle gas pedals that are sources of emissions. On the other hand, the residential and tertiary sectors are also responsible for 7% of the emissions, in particular energy distribution.

Nitrous trifluorure NF_3

NF3 emissions are entirely due to the manufacturing industry and in particular to the manufacture of semiconductors.

Indirect GHG

In addition to direct greenhouse gases, some gases are listed as indirect greenhouse gases. These are gases that have an impact on the greenhouse effect, but either have a low GWP (see section 1.3. for the meaning of GWP) and therefore a limited impact on climate change; or they react with other gases in the atmosphere to form a direct GHG. These include:

- HFO, which is a form of unsaturated HFC and has a low GWP

- Carbon monoxide CO and NMVOCs (non-methane volatile organic compounds) which oxidize to CO2 in the atmosphere

[9] CITEPA, SECTEN report, 2021

- Nitrogen oxides NOx which oxidize to N2O in the atmosphere

- Sulfur oxides SOx (SO2 and SO3) which play a role in climate cooling

In addition, ozone O3 is also often considered as a greenhouse gas. Ozone is naturally present in the stratosphere (the highest part of the atmosphere) and creates the ozone layer that filters the Sun's rays and protects the Earth from ultraviolet radiation. However, ozone is also emitted in an anthropogenic way when it comes from the exhaust of vehicles, or from certain solvents. It then remains stored in the lower atmosphere (the troposphere) and is considered as an atmospheric pollutant. Indeed, it has harmful consequences on the respiratory systems of living beings and can even be fatal above an air concentration of 50 ppm[10]. In addition to being an atmospheric pollutant, ozone also has an impact on the greenhouse effect, but not enough to be listed by the IPCC as a major GHG.

c. Impact of greenhouse gas on the climate: the Global Warming Potential

The seven GHGs are differentiated from each other by their **global warming powers** (GWP). This GWP is calculated with reference to CO2 and thus allows us to compare the impact on the climate of the different greenhouse gases. It also makes it possible to express each of these emissions in tCO2e (ton of CO2 equivalent) using the formula below:

Quantity of emission [t] x GWP = quantity of CO2 equivalent emission [tCO_2e]

Each GHG also has an atmospheric **residence time** that represents the time it takes for the gas to disappear into the atmosphere.

Greenhouse gas		**GWP in 100 y**	**Residence (in years)**
Carbon dioxide	CO_2	1	200
Methane	CH_4	25	12
Nitrogen oxide	N_2O	298	120
Hydrofluorocarbure	HFC	124 à 14 800	10 000
Perfluorocarbure	PFC	7 390 à 12 200	
Sulfur hexaflorure	SF_6	22 800	3 200
Nitrogen triflorure	NF_3	17 200	500

Table 3. GHG characteristics
Source : IPCC, 5th report, 2007

d. Carbon neutrality: a set goal at several scales

In order to mitigate the rise in temperature caused by the greenhouse effect, the Kyoto Protocol established **carbon budgets**.[11] These represent the quantity of GHGs that can still

[10] CITEPA, SECTEN report, 2021
[11] Institut Paris Région, Note rapide n°878, « Zéro émissions nettes : De quoi parle-t-on ? », december 2020

be emitted on a global scale to contain global warming below a certain threshold. Two thresholds have so far been defined with their own carbon budgets: one for a warming of the global average temperature of +2°C, and one for a warming of +1.5°C. The carbon budgets not to be exceeded are estimated via modelling. Therefore the IPCC has established two carbon budgets for each of the two thresholds: the one for which the threshold will not be reached with a probability of 0.5, and the one for which it will not be reached with a probability of 0.66.

Threshold	Probability of 0.5	Probability of 0.66
Global warming below +2°C		985 GtCO2e
Global warming below +1.5°C	395 GtCO2e	235 GtCO2e

Table 4. Remaining carbon budgets in 2020
Source: IPCC, 5th report, 2013

However, in 2019, global CO2 emissions have reached 44 GtCO2. Thus, at this rate, the 1.5°C budget will be exceeded in 6 years, and the 2°C budget in 23 years, with a probability of 0.66. We can therefore see the urgency to act to reduce GHG emissions. Especially since these budgets have been calculated only for CO2 emissions, but other greenhouse gases must of course be taken into consideration.

With this in mind, the European Union and France have transcribed the objectives of the Kyoto Protocol into their legislation. In France, the National Low Carbon Strategy (SNBC) aims at carbon neutrality by 2050, compeling the territories to work towards this goal.

The Bask country is therefore also committed to this objective. And it is even possible to go further, by increasing carbon sequestration and becoming a territory with negative GHG emissions. The large natural areas and the rich agriculture of the territory represent indeed two levers of action for carbon sequestration.

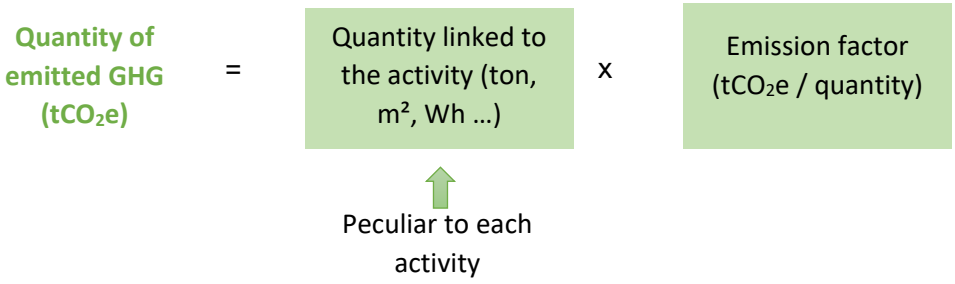
2. Assessment of greenhouse gas emissions in the French Bask Country

2.1. How to estimate greenhouse gas emissions: the emissions factors

To calculate the emissions, we use the Carbon base established by ADEME which puts online and regularly updates a list of emission factors. The emission factors provide the quantity of greenhouse gases emitted by a particular activity[12].

The factors are very numerous and imply to go and find the corresponding activity data with the same precision.

[12] ADEME and Ministery of Ecology, Sustainable Development, Transportation and Housing, « Typologie des facteurs d'émission – Fiche Ressource n°3 », June 2011



2.2. Energy and non-energy emissions

2.2.1. Energy consumption

First of all, energy consumption is a source of GHG emissions: the energy consumed in buildings to meet the needs of heating, electricity, etc., but also the fuels consumed by means of transport.

For fossil fuels, these emission factors are reliable because the calculations are based on a physical reaction and provided by the Intergovernmental Panel on Climate Change (IPCC)[13]. In some cases, they also include so-called upstream emissions, corresponding to the CO2 emitted during the production and transport phases, and possibly the refining of the fuel. This result is obviously much more approximate: it should consider the precise conditions of extraction and transport. For natural gas, for example, these conditions are not identical depending on whether it was imported from Russia, Norway or Algeria.

For electricity, the emission factors depend on the country's electricity generation fleet, in particular on the electricity mix used and the performance of the power plants. In France, the strong presence of nuclear power allows for a relatively low CO2 content for 1kWh of electricity compared to other European countries. Finally, for electrical energy, the emission factors will also depend on the use made of it, as some uses can be considered as mobilizing thermal power plants to a greater or lesser extent, and therefore requiring more or less carbon-based energy.

Finally, the consumption of fossil energies is much more emitting of GHG, compared to electric and renewable energies. In the Bask Country, fossil fuels account for 61% of the energy mix with 42% of petroleum products and 19% of natural gas[14]. It is on this share of fossil energy that we must act in priority to reduce emissions. The other energy sources are electricity (26%), renewable energy (13%) and thermal energy (less than 1%).

It is therefore necessary to collect energy consumption data by energy and by use (for electricity), and to cross-reference them with the appropriate emission factor.

[13] ADEME and Ministery of Ecology, Sustainable Development, Transportation and Housing, Typologie des facteurs d'émission, 2010
[14] Data from AREC New-Aquitaine – Terristory 2018

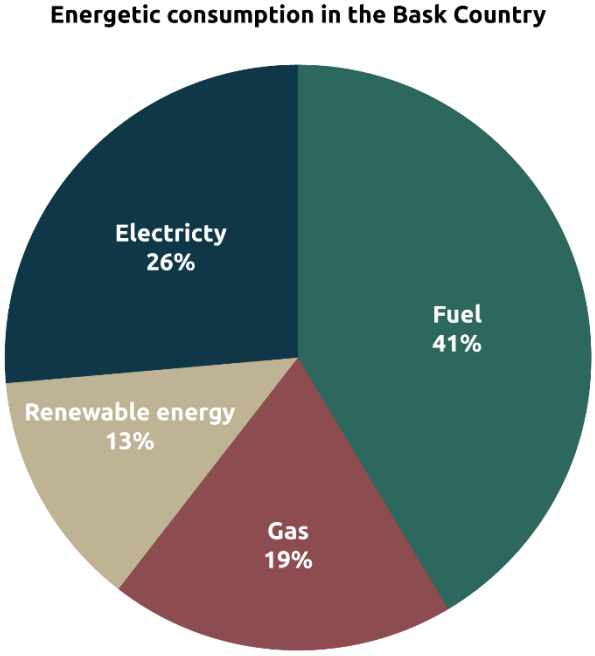


Figure 39. Energetic consumption in the Bask country
Source: AREC Terristory, 2018

However, GHG emissions are not only due to energy consumption. Several other sources must be considered as well.

Energy	Use	Emission factor in $kgCO_2e/kWh$
Electricity	Heating	0.149
	Warming water	0.0543
	Cuisson	0.0535
	Specific electricity	0.0906
	Industry	0.0405
Gas network	Natural gas	0.244
	Biomehtane	0.044
Bottled gas (propane or butane)		0.273
Fuel	For household	0.324
	For industires	0.324
Wood	Logs – 20% humidity	0.0295

Table 5. Emission factors of energetic emissions depending on energy sources ad use
Source: ADEME, 2019

2.2.2. Agriculture

The agricultural sector is responsible for many emissions, and not only those related to energy consumption. Livestock breeding, with animal manure and the use of fertilizers for agricultural surfaces, is also an emitter of methane and nitrous oxide. Methane represents

45% of the emissions from the agricultural sector in France, while N2O represents 42% of these.

It is particularly interesting to estimate these emissions, because agriculture is the most emitting sector in the Bask Country. In total, the non-energy emissions in the Bask Country represent 39% of the emissions[15]. These emissions are mainly due to agriculture, which distinguishes the Bask Country from other territories at the national level. Indeed, non-energy emissions represent only 30% of the emissions of the whole France[16], of which 17% comes from agriculture.

- **Breeding**

Animal excrement, during enteric fermentation, releases greenhouse gases. These emissions vary from one animal to another. Ruminants, cattle and sheep, are particularly emitters, because of their digestive process releasing methane through oral eructation, dejections and flatulence. The table below gives the emission factors based on the national average per animal.

However, the manure management system must also be taken into account, since the emissions for the same species will not be the same. A distinction is made between liquid manure, manure and grazing. The table below shows the national distribution of manure management systems per animal. It is essential to collect this information on the scale of our territory, in order to have an estimate of GHG emissions more appropriate to local specificities.

Animal	**CH4 emissions** In kg/capita/year	**CH4 emissions** in kgCO2e/capita/year
Milk cow	121	3025
Other cattle	51	1275
Sheep	9,3	232,5
Goat	11,7	292,5
Sow	2,5	62,5
Other porcines	0,65	16,25
Horses	21,8	545
Mule and donkey	12,1	302,5
Poultry	-	-

Table 6. Methane emissions due to enteric fermentation in farming
Source: CITEPA, OMINEA guide, 2013

	Milk cow	Other cattle	Sheep	Goat	Sow	Other porcine	Horse	Poultry
SG(slurry)	18%	3,9%	0,3%	3,2%	90,4%	94,2%	0%	3,5%
SG(manure)	39,5%	42%	25,4%	86%	8%	5,3%	41,7%	89,5%
SG(grazing)	39,5%	42,9%	74 ,4%	10,8%	1,6%	0,5%	58,3%	7%

Table 7. Manure management system depending on the animal
Source: OMINEA report, 2021

[15] PCAET of the Bask country (2021))
[16] notre-environnement.gouv.fr, « Les émissions de gaz à effet de serre et l'empreinte carbone », 2021

The IPCC has developed the following formula to more accurately estimate per capita methane emissions.

$$FE_{CH4} = SV \times 365_{days/year} \times Bo \times 0{,}67_{kg/m3} \times \sum_{k} FCM_k \times SG_k$$

Where SV is the quantity of est la quantité of excreted volatile solids in kg/day

Bo is the capacity of CH4 maximal production in m^3/kg of SV

FCM_k is the conversion factor in CH4

And k is the management system (manure, liquid manure or grazing)

These factors are given for each animal in the table below:

		Milk cow	Other cattle	Sheep	Goat	Porcine	Horse	Donkey	Poultry
Bo		0,24	0,18	0,19	0,18	0,45	0,30	0,33	0,38
SV		3,46 – 4,22	1,81 – 2,86	0,4-1,04	0,42 – 1,15	0,4	2,13	0,94	0,2
FCM	**Slurry**	39%	39%	-	-	39%	-	-	1,5%
	Manure	1%	1%	1%	1%	1%	1%	1%	1,5%
	Grazing	1%	1%	1%	1%	1%	1%	1%	1%

Table 8. Characteristics of CH4 emissions for breeding
Source: OMINEA report, 2021

However, animal dejectations are also responsible for nitrous oxide N2O emissions. For each animal, the following formula gives the emissions of this GHG:

$$FE_{N2O} = F_{ex} \times \frac{44}{28} \times \sum_{k} (FD_k \times SG_k)$$

Where F_{ex} is the nitrogen excretion factor of the animal in kg/capita/year

FD_k is the N2O direct emission factor of the management system

k is the management system (manure, slurry or grazing)

The pieces of information to be collected are therefore:

- the number of livestock per animal and per municipality in our territory,
- the distribution of manure management systems used on our territory: either an average for the entire territory, or data by municipality if available.

For these different factors, the IPCC gives these figures:

Animal	F_{ex} in kg/capita/year
Milk cow	115.6
Other cattle	59.1
Sheep	16.7
Goat	14.1
Sow	21.2
Other porcine	5.8
Horse	60.2
Mule and donkey	17.1
Hen	0.61
Chicken	0.34
Other poultry	0.71

Table 9. Nitrogen excretion factor per animal
Source: CITEPA, OMINEA report, 2021

Dejection management system	FD
Slurry	0.1%
Manure	2%
Grazing	2%

Table 10. N2O direct emissions factor per dejection management system
Source: CITEPA – rapport OMINEA, 2021

- **Nitrogenous fertilizers**

The use of nitrogen fertilizers to fertilize agricultural soils is also a source of greenhouse gas emissions, mainly nitrous oxide N2O. These fertilizers can be of different types: mineral, organic (animal manure or sludge from water treatment plants) or vegetable (crop residues or nitrophilic plants). Depending on their type, the emission factors will vary.

According to IPCC[17] and ADEME[18] calculations, we obtain emission factors as followed.

It is therefore necessary to know the quantities of fertilizers applied by commune according to their type, and their nitrogen container.

[17] IPCC (2006b), level 1
[18] ADEME, Carbone Base, section « Agriculture – sols agricoles »

Fertilizer type	Emission factor in kgN_2O / kg of spread nitrogen	Emission factor in kgCO_2e / kg of spread nitrogen
Spread of mineral fertilizer	0,021	6,258
Spread of organic fertilizer (animals dejections, plants, compost, sewage plant sludge…)	0,022	6,556
Crop residues	0,019	5,662
Animal dejections from cattle, poultry	0,038	11,324
Animal dejections from sheep and other pasture animals	0,022	6,556

Table 11. Emission factors for fertilizers spreading
Source: ADEME, 2021

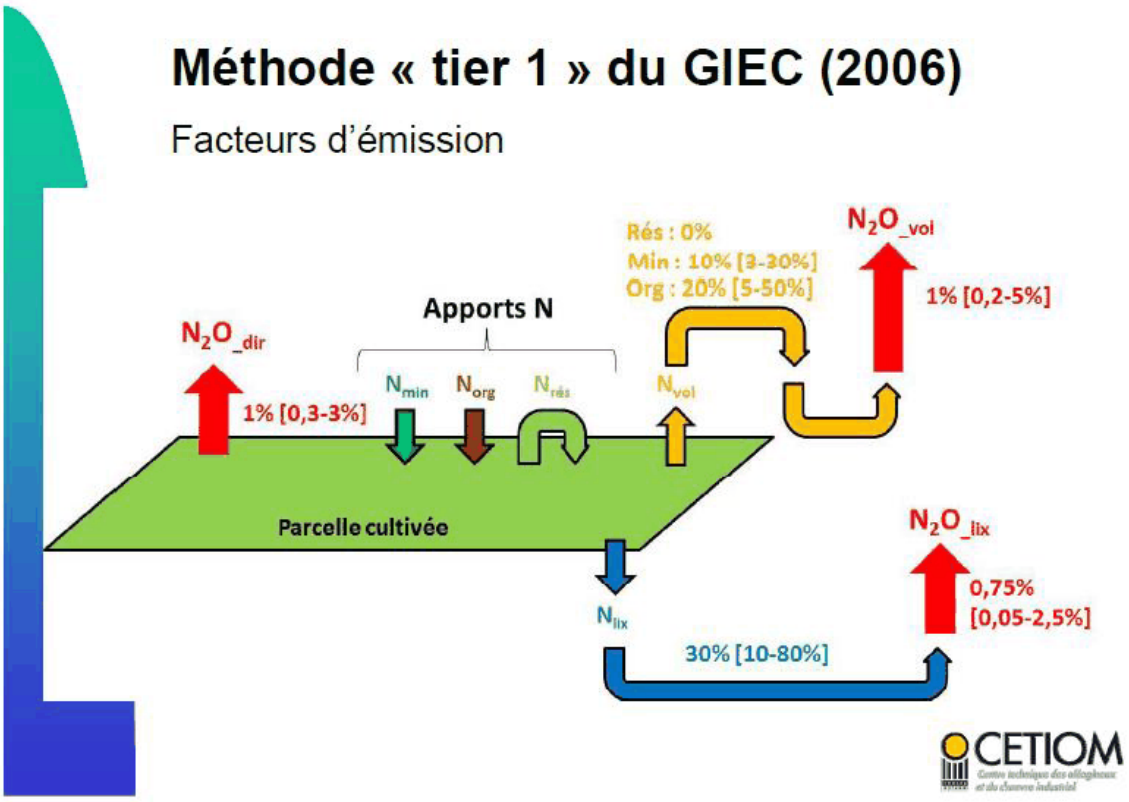


Figure 40. N2O emission according to the IPCC (2006b) level 1
Source: ADEME, methodologic report AGRIBALYSE, 2016

2.2.3. Industry

Many specific industrial processes emit GHGs: these are called direct emissions. All greenhouse gases are concerned:

- CO2 is emitted during the decarbonation of limestone in the non-metallic mineral products industries (cement, lime, plaster, terracotta, ceramics, glass)
- Fluorinated gases result from the use of solvents, foams and aerosols, fugitive emissions from air-conditioning and refrigeration systems, or from specific

industrial processes (semiconductor industry, food industry and implementation of cold chains)
- Waste treatment and recovery are the source of CH4 emissions during the degradation of this waste (storage, landfill, treatment of sewage sludge), and of CO2 during incineration.

These emissions will be very specific to the studied territory, depending on the industrial establishments located there. It is necessary to collect this information, establishment by establishment. The IREP file published by GeoRisks twice a year lists the pollutant emissions of some industrial infrastructures on the whole French territory. This data will be used in the GHG emissions assessment, but it will have to be supplemented by other, more complete data sources.

2.2.4. LULUCF (Land Use, Land Use Change and Forestry)

Forests and hedgerows naturally absorb carbon through photosynthesis and store it in the vegetation and soil: they are said to be **carbon sinks**. These emissions, although negative, must also be taken into account in the greenhouse gas diagnosis. Indeed, it is thanks to these negative emissions that we will be able to compensate for those positively emitted. This is an important lever for achieving carbon neutrality. We speak of **carbon sequestration**, which is the action of absorbing CO2 via photosynthesis. This allows the **storage of carbon** in the soil or vegetation.

Conversely, a change in land use can also be a source of positive emissions. When a soil is uncovered, all the carbon it stored is released into the atmosphere. Deforestation, urbanization, and certain agricultural practices therefore release buried carbon stocks.

LULUCF (Land Use, Land Use Change and Forestry) refers to all positive or negative emissions from the land. The emission factors associated with this category are given below.

	**Cultivation**	**Meadow**	**Forest**	**Pervious lands**	**Impervious lands**
Cultivation in arable land		-1,8 (+-0,95)	-1,61 (+-0,88)	0	190 (+-80)
Permanent meadow	3,48 (+-1,1)		-0,37 (+-0,73)	0	290 (+-120)
Forest	2,75	0,37 (+-0,37)		0	290 (+-120)

Table 12. Land use changes emission factors
Source: ADEME Carbon Base,2021

2.3. France carbon footprint

In 2019, France's carbon footprint was estimated at 605 MtCO2e. When compared to the total population, the carbon footprint is estimated at 9.0 tCO2e per person. Emissions associated with imports represent almost half (49%) of the footprint. The carbon footprint

is composed of 78% CO2, 14% CH4 and 7% N2O. Estimates for the year 2020 show a strong decrease in emissions, but this should be put in context, as the COVID crisis has significantly slowed the economy and limited travel.

Compared to 1995, France's carbon footprint has decreased by 15%: domestic emissions have decreased by 31% while emissions associated with imports have increased by 12%. Given the increase in population, the evolution of the carbon footprint relative to the number of inhabitants decreases more strongly (-25%) between 1995 (11.0 tCO2e/person) and 2020. [19]

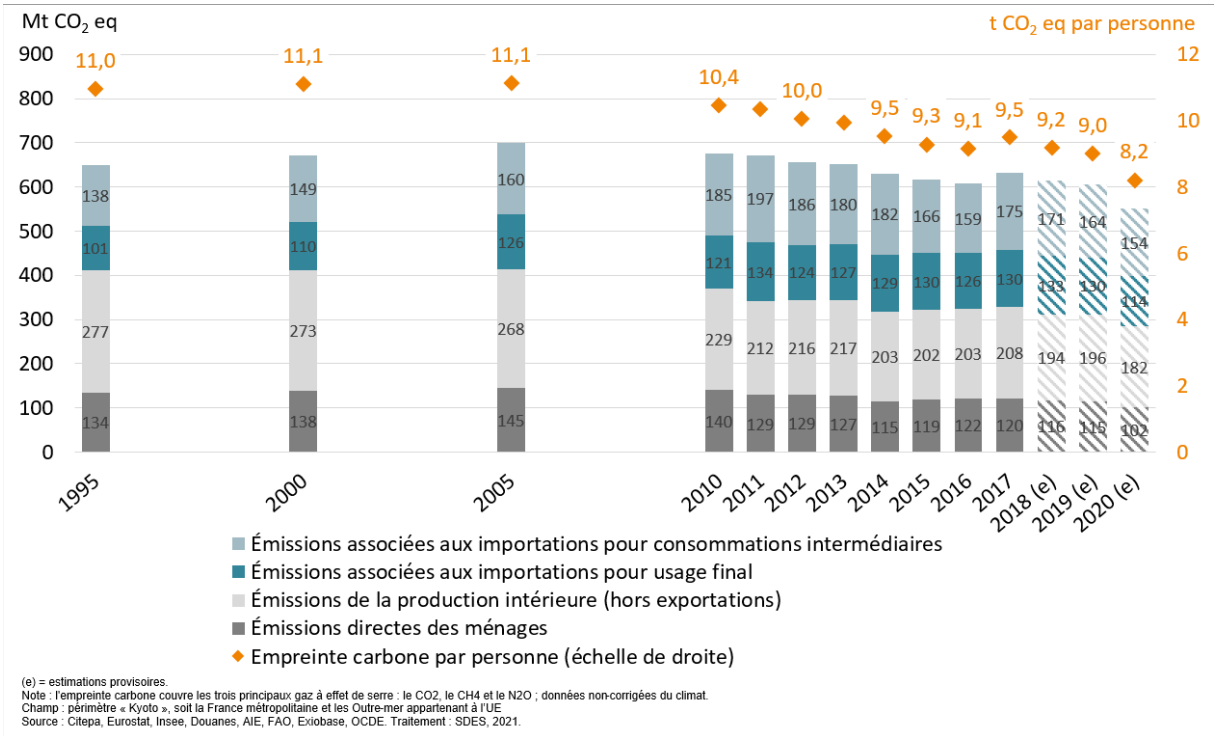


Figure 41. Estimates of France carbon footprint from 1995 to 2020
Source: CITEPA, Eurostat, INSEE, Douanes, AIE, FAO, Exiobase, OCDE. Traitement : SDES 2021

2.4. The emissions of the French Bask Country by business sectors

The choice was made to diagnose the GHG emissions of the year 2019. Indeed, all the data for 2020 are not yet available, and 2019 is the closest year with all the available data.

Also, the diagnosis will be carried out by business sector:

- Residential
- Tertiary
- Industry
- Agriculture

[19] notre-environnement.gouv.fr, « Les émissions de gaz à effet de serre et l'empreinte carbone », 2021

- Transportation

2.4.1. Residential sector

Energetic emissions

In the residential sector, the emissions come mainly from the energy consumption in the houses. Therefore, we are looking for consumption data of the different energies. For some energies, electricity in particular, the emission factors also depend on the use made of it. Four categories of energy use can be distinguished:

- Heating needs: themselves separated into two sub-categories, main heating, and supplementary heating

- Domestic hot water (DHW)

- Cooking

- Specific electricity for the operation of all other appliances

In the Bask Country, the distribution of consumption for the residential sector is as follows:

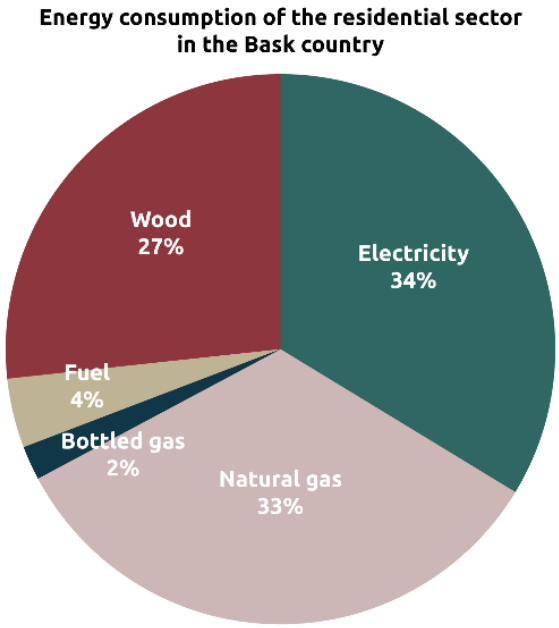


Figure 42. Energy consumption of the residention sector in the Bask country

Source: French Ministery of ecological transition (2019), AREC (2018)

One of the particularities of our territory is the strong presence of wood as the main heating energy: it reaches 27% of the total consumption of the sector.

Natural gas represents 33% of consumption, although the network only supplies a few municipalities in our territory. All the others will therefore not be concerned by the consumption of gas in the network for their heating needs. The list of municipalities served by natural gas can be found at https://www.grdf.fr/collectivites/commune-desservie-gaz.

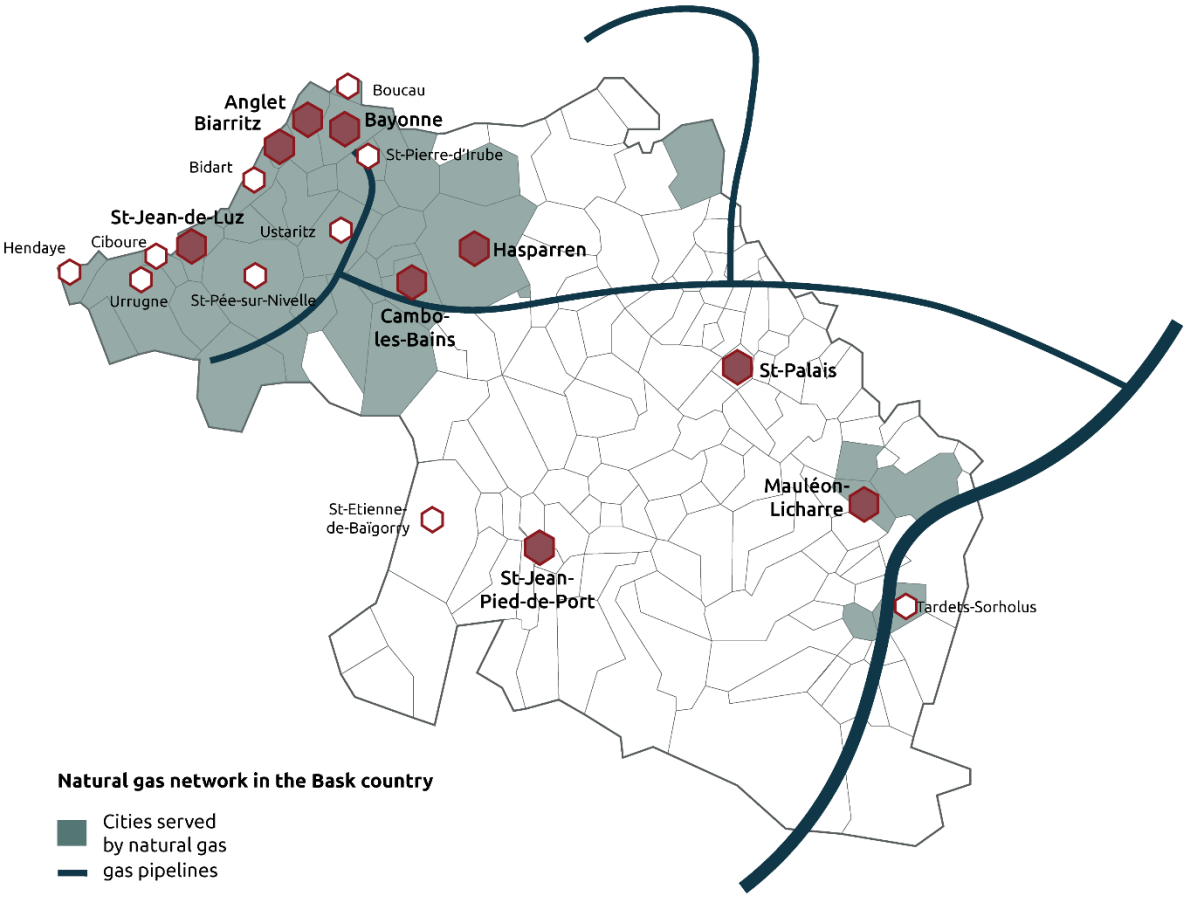


Figure 43. Natural gas network in the Bak country
Source: GRDF, 2021

The rest of the consumption is provided by electricity (34%) and domestic fuel oil (4%).

These consumptions can then be cross-referenced with the appropriate emission factors to obtain an estimation of the GHG emissions of the residential sector. The residential sector of the Bask Country emits 333,9 ktCO2e of greenhouse gases through its energy consumption.

We see that not all energy consumption has the same environmental impact. Some should be favored, others reduced.

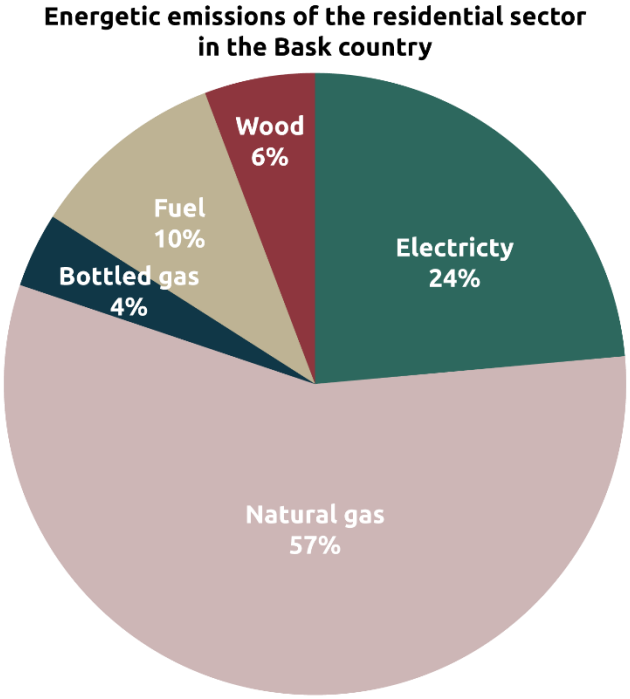


Figure 44. Energetic emissions of the residential sector in the Bask country

Source: own results, 2021

Wood, for example, represents more than a quarter of consumption, but only 6% of emissions. This is due to a low emission factor. It should be noted that it was considered that all the wood consumption came from a wood log heating - 20% humidity. The ADEME gives several other emission factors for:

- Wood pellets - 8% humidity
- Forestry chips - 25% humidity
- Sawdust and sawmill offcuts - 50% moisture content
- Crushed crates and pallets - 20% moisture content.

But it would be very difficult to obtain a consumption model of the different woods in our territory. In any case, the use of wood energy to meet heating needs appears to emit significantly less GHG than other energy sources.

On the contrary, gas consumption represents only one third of the total energy consumption of the residential sector, but 56% of the emissions. Gas is therefore a high emitter, and it would be beneficial to reduce its consumption. The same is true for fuel oil. This analysis therefore already allows us to identify levers for reducing GHG emissions.

All these data have made it possible to obtain results at the municipal level. The results of the emissions per inhabitant and per dwelling are presented below and are more meaningful at the municipal level than the total emissions. Emissions per municipality depend on its population: a municipality with 30,000 inhabitants will necessarily emit more than one with 1,000 inhabitants.

For per capita emissions, the national average is 878 kgCO2e/inhabitant. We can see that about half of the municipalities in the territory are above this average, the other half below. Moreover, the coastal municipalities and the structuring poles have the highest per capita emissions, which are also the municipalities with the most inhabitants.

As for the emissions per dwelling, the national average is 3150 kgCO2e while that of our territory is 1631 kgCO2e per dwelling, that is to say a little more than half of the national

one. Moreover, the municipality with the highest emissions per dwelling is at 2718 kgCO2e, well still below the national average. These low figures can be explained by several factors:

- First of all, wood represents an important part of the energy consumption for heating needs (27%). As wood has a low emission factor, the emissions per dwelling are much lower. The municipalities with the lowest emissions are located far from the coast, in areas that do not have access to the gas network and with a high share of wood energy in their consumption.

- However, per capita emissions are not particularly low compared to the national average. This is due to the large number of second homes in the territory, which lowers the housing/inhabitant ratio. 42% of the housing in Biarritz are second homes. On the scale of the whole territory, 21% of housing is concerned. However, second homes consume less than other homes, being occupied a few days a year. It is estimated that the consumption of secondary residences is about:

- 10% of the heating consumption compared to a main residence
- 15% of the consumption of domestic hot water compared to a primary residence
- 10% of the specific electricity consumption compared to a main residence
- 10% of cooking consumption compared to a primary residence.

It can be seen that the coastal municipalities are not the ones with the highest emissions per dwelling.

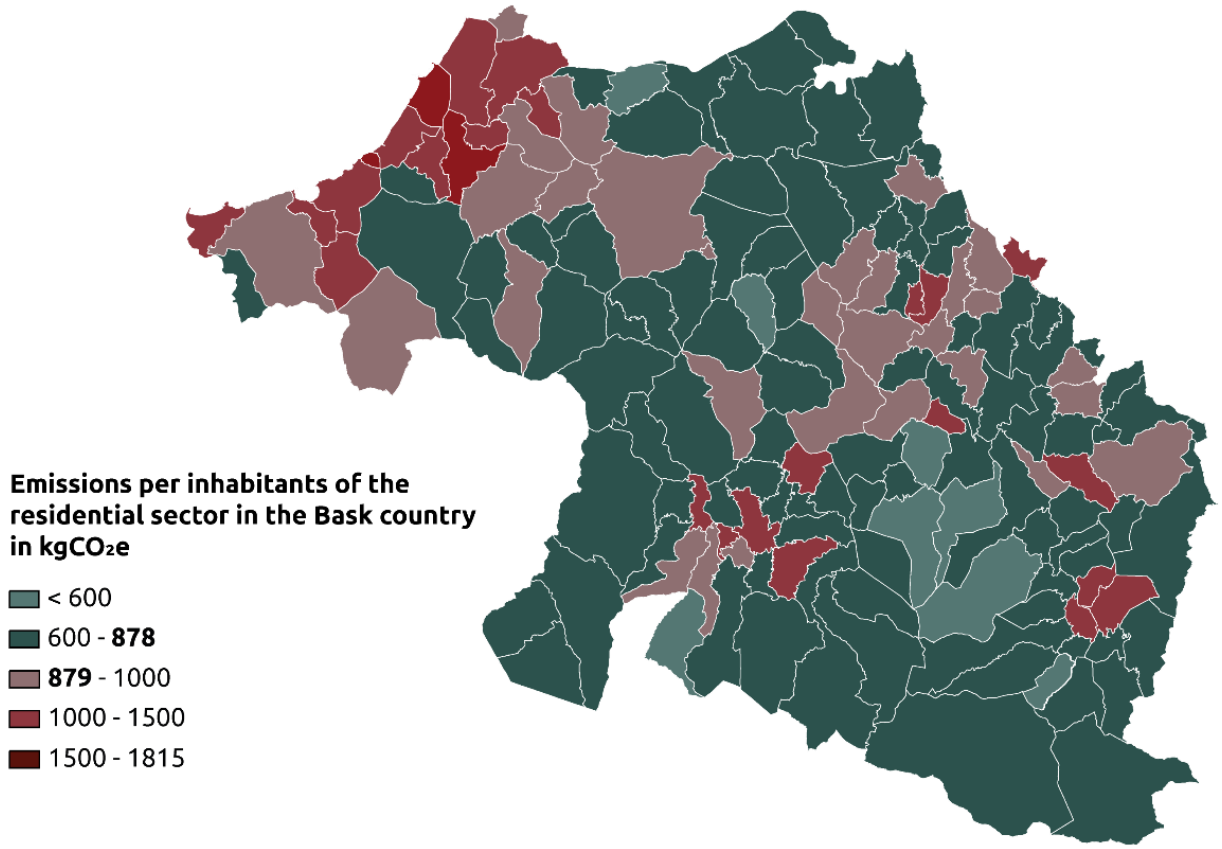


Figure 45. Emissions per inhabitants of the residential sector in the Bask country
Source: own production, 2021

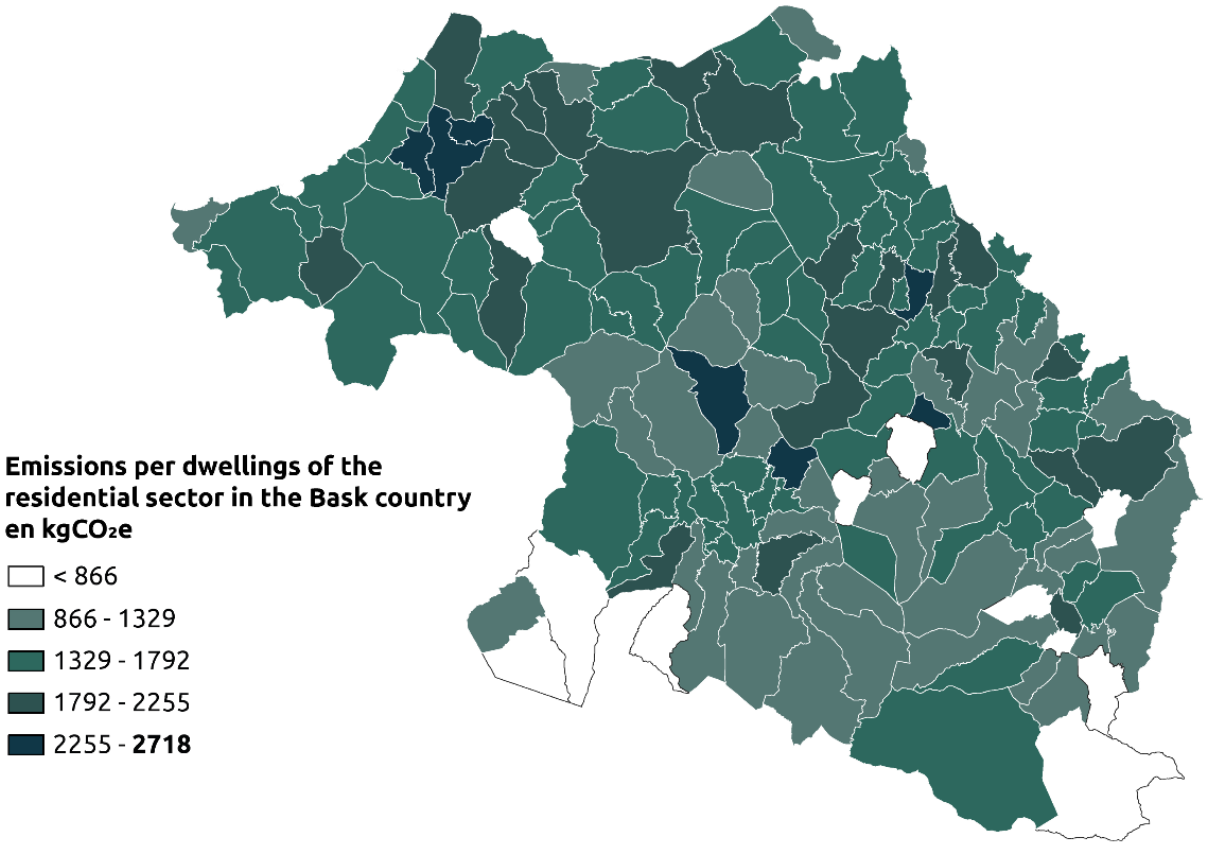


Figure 46. Emissions per dwellings of the residential sector in the Bask country
Source: own production, 2021

Non-energetic emissions

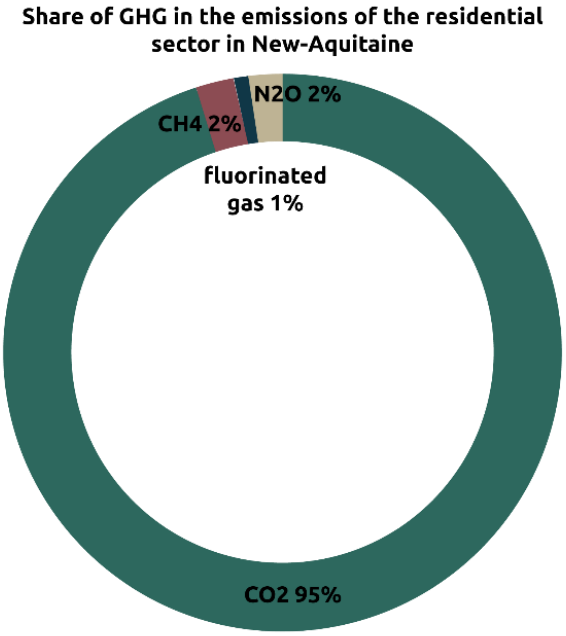


Figure 47. GHG emissions of the residential sector in New-Aquitaine

Source: AREC 2015

Energy-related GHG emissions from the residential sector are largely CO2, but also some CH4 and N2O, which are emitted during the production and transportation of energy.

However, fluorinated gases (HFCs, PFCs, SF6, NF3) are also emitted in the residential sector: these are non-energy emissions that occur through the use of certain sprays or leaks in air conditioning units. The AREC[20] has estimated these emissions at 0.05 tCO2e per inhabitant on the territory of the Bask country. This gives us a total of 15,3 ktCO2e of non-energy emissions in the territory.

Total

Finally, the emissions of the residential sector of the Bask Country represent 349,3 ktCO2e.

2.4.2. Tertiary sector

Energetic emissions

Emissions from the tertiary sector are mainly energy-related. Therefore, energy consumption data were collected and cross-referenced with the appropriate emission factors. The methodology used is similar to the one used for the residential sector.

Consumption is more dominated by electricity. Wood represents a much smaller share.

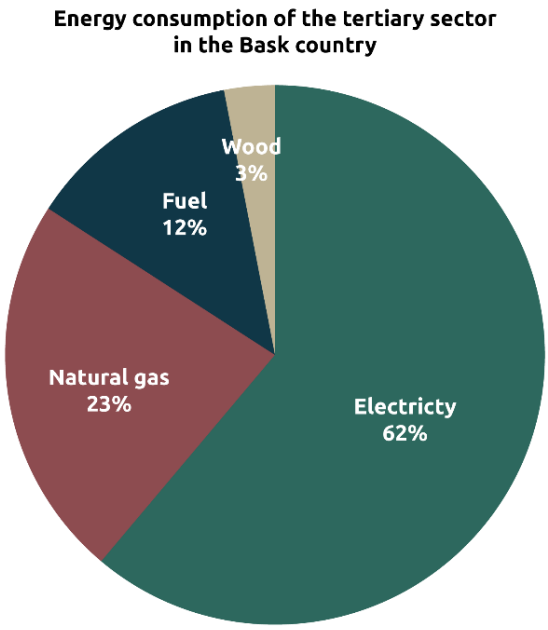


Figure 48. Energy consumption of the tertiary sector in the Bask country
Source: Ministry of the Ecologic Transition (2019), AREC (2018)

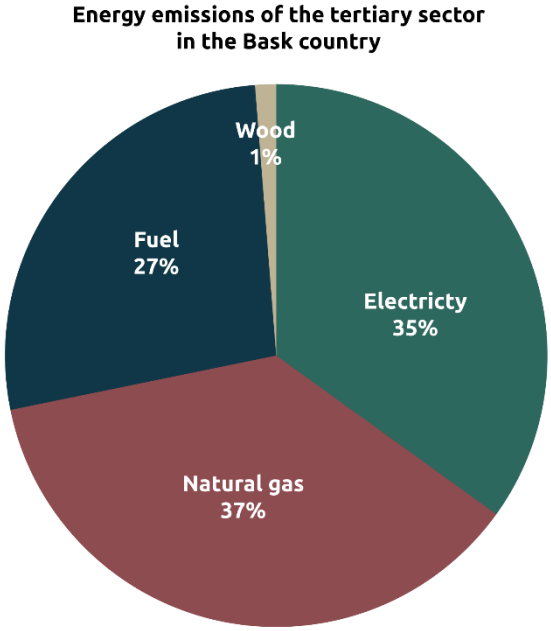


Figure 49. Energy emissions of the tertiary sector in the Bask country
Source: own poduction, 2021

The emissions obtained are the following. We obtain a total of 153,0 ktCO2e of energy emissions in the Bask Country. The consumption of electricity, natural gas and fuel oil have about the same weight in the total emissions, with respectively 35%, 37% and 27% of the GHG emitted.

[20] AREC, Terristory, 2018

The INSEE CLAP file (Connaissance Locale de l'Appareil Productif) provides the number of establishments in the tertiary sector per municipality, as well as the number of jobs. This makes it possible to display the results by establishment and by employment in the commune.

Emissions are more important on the coast than in the interior. Some communes even have zero emissions from the tertiary sector. This is not necessarily due to a total absence of the tertiary sector in these communes, but rather to the fact that some small professionals are listed in the residential sector in the data provided on energy consumption.

The structuring centers of the interior (Saint-Palais, Saint-Jean-Pied-de-Port, Mauléon-Licharre, Tardets) also appear to be more emitting than their neighbors.

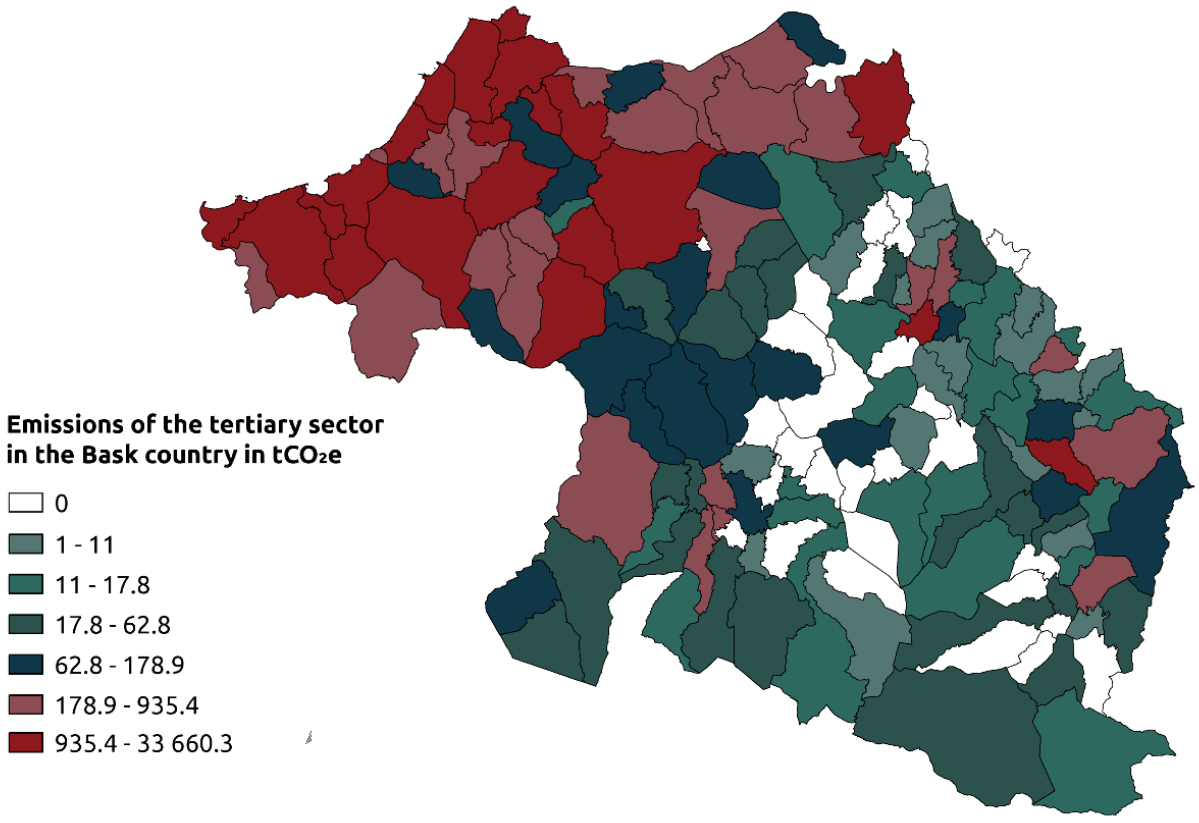


Figure 50. Emissions of the tertiairy sector in the Bask country
Source: own production, 2021

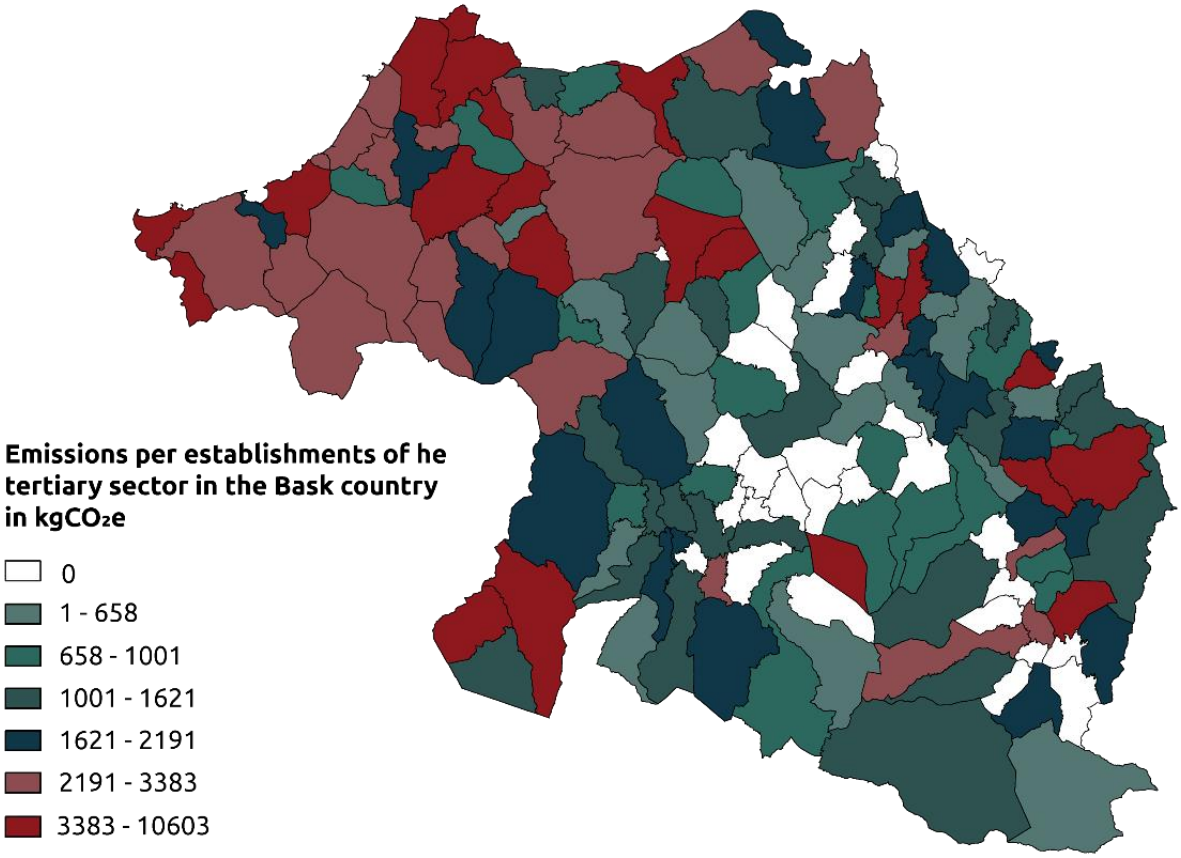


Figure 51. Emissions per establishments of the tertiary sector in the Bask country
Source: own production, 2021

Non-energetic emissions

In the same way as for the residential sector, the tertiary sector also emits fluorinated gases. The AREC[21] gives 0.57 tCO2e per employee in the Bask country. This gives a total of 55.3 ktCO2e of non-energy emissions.

Total

Finally, we obtain a total of 208,3 ktCO2e emitted by the tertiary sector on the territory of the Bask country.

2.4.3. Industrial sector

There were 2187 industrial establishments in the territory mainly in the following sectors in 2015[22]:

- Aeronautics, mechanics, and robotics, located mainly in the Bask Country technology park and the two specialized platforms, Compositadour and Addimadour (10,000 jobs - 120 companies)
- The food industry (3,084 jobs[23] - 585 companies[24])

[21] AREC, Terristory, 2018
[22] INSEE, CLAP file, 2015

- The gliding industry in Hendaye, Saint-Jean-de-Luz and Ciboure, where the Ocean Start technology site is being structured (3,200 jobs - 400 companies[25])
- The industrial-port zone of the Adour estuary.

There is also a concentration of industrial activities around the port of Bayonne, and therefore the municipalities of Boucau, Bayonne and Anglet. There are many industrial establishments, and of greater importance. They therefore emit more than the average for the industrial sector in our territory, which is 603,6 tCO2e per municipality for the industrial sector.

Smaller industrial centers around Tardets and Mauléon-Licharre in Soule are also responsible for GHG emissions.

Energetic consumptions

Industry in the Bask country consumes 385 GWh, mainly from electricity (58%) and gas (38%)[26]. However, fuel oil still represents 4% of consumption and 11% of energy emissions.

The total energy emissions of the industrial sector amount to 49,8 ktCO2e for the Bask country.

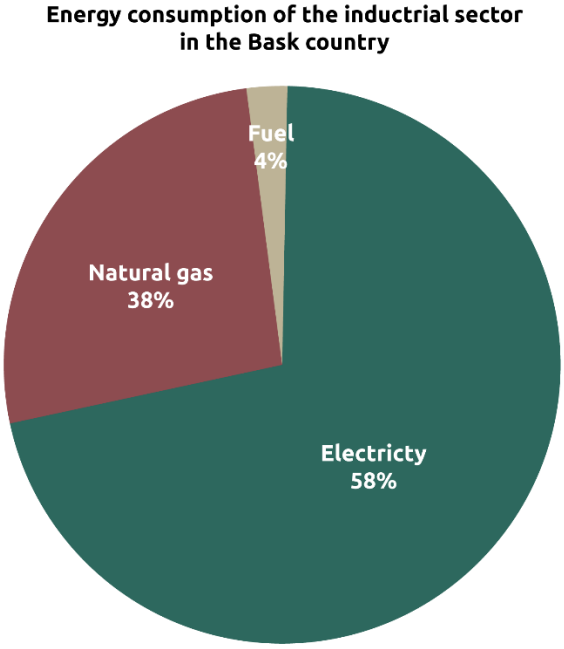


Figure 52. Energy consumption of the industrial sector in the Bask country
Source: Ministry of the Ecologic Transition (2019), AREC (2018)

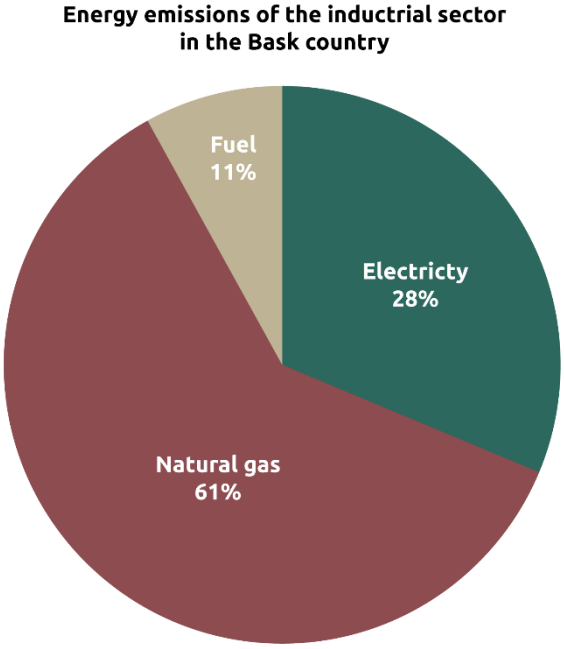


Figure 53. Energy emissions of the industrial sector in the Bask country
Source: own production, 2021

[23] CAPB, Schéma Directeur de Développement Economique, 2018
[24] SIRENE, 2019
[25] CCI, "Le Pays Basque en Chiffre », 2010
[26] SDES files, 2019

Direct emissions linked to industrial processes

The IREP register is updated twice a year and publishes the polluting emissions of industrial facilities in France. It lists the main discharges and transfers of pollutants into the water, air and waste declared by certain establishments (main industrial installations, urban wastewater treatment plants of more than 100,000 population equivalent, certain livestock farms).[27]

On the territory of the Bask country, only three industrial establishments declare in this register GHG emissions, which represent 45.5 ktCO2e.

Total emissions of the industrial sector

The total emissions for the industrial sector of the Bask country is then 95,3 ktCO2e. Thanks to the file CLAP (Local Knowledge of the Productive System) of the INSEE, is drawn from this result of the averages by establishments and by commune. This file gives the number of establishments per commune.

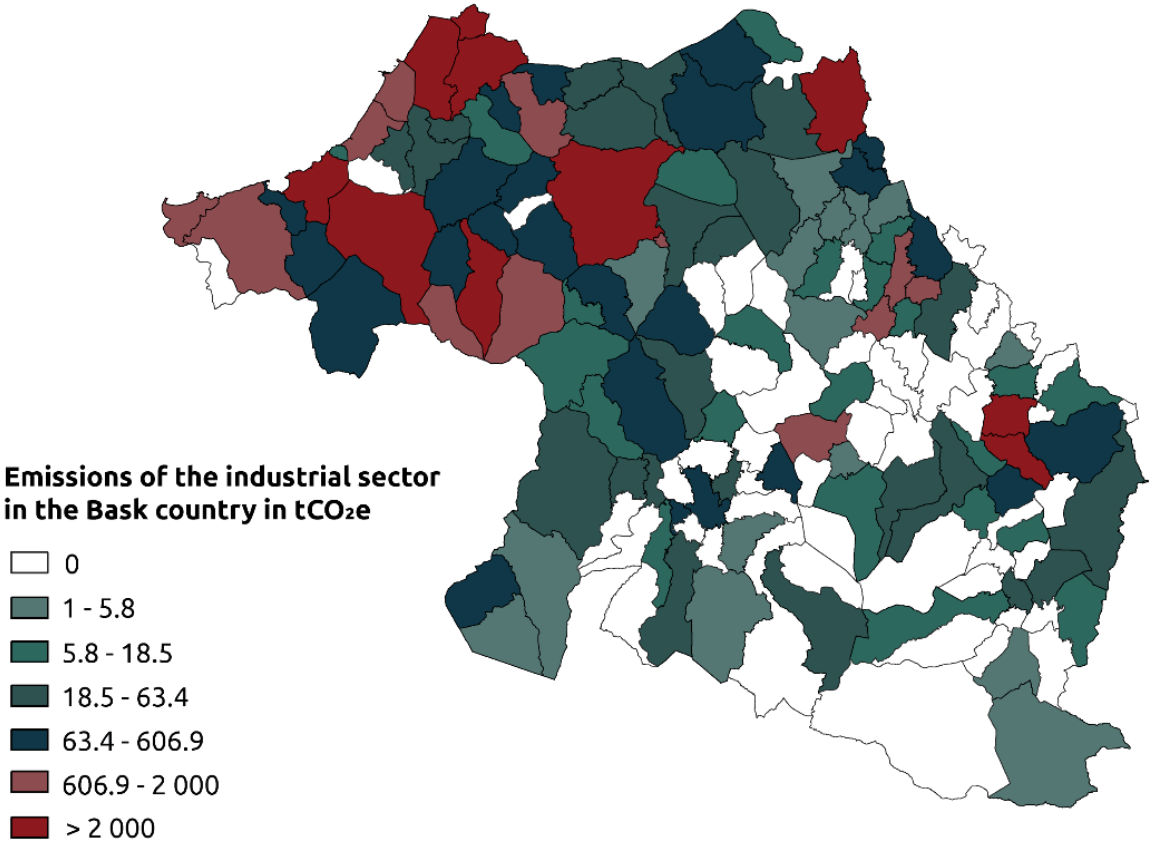


Figure 54. Emissions of the industrial sector in the Bask country
Source: own production, 2021

[27] Géorisques

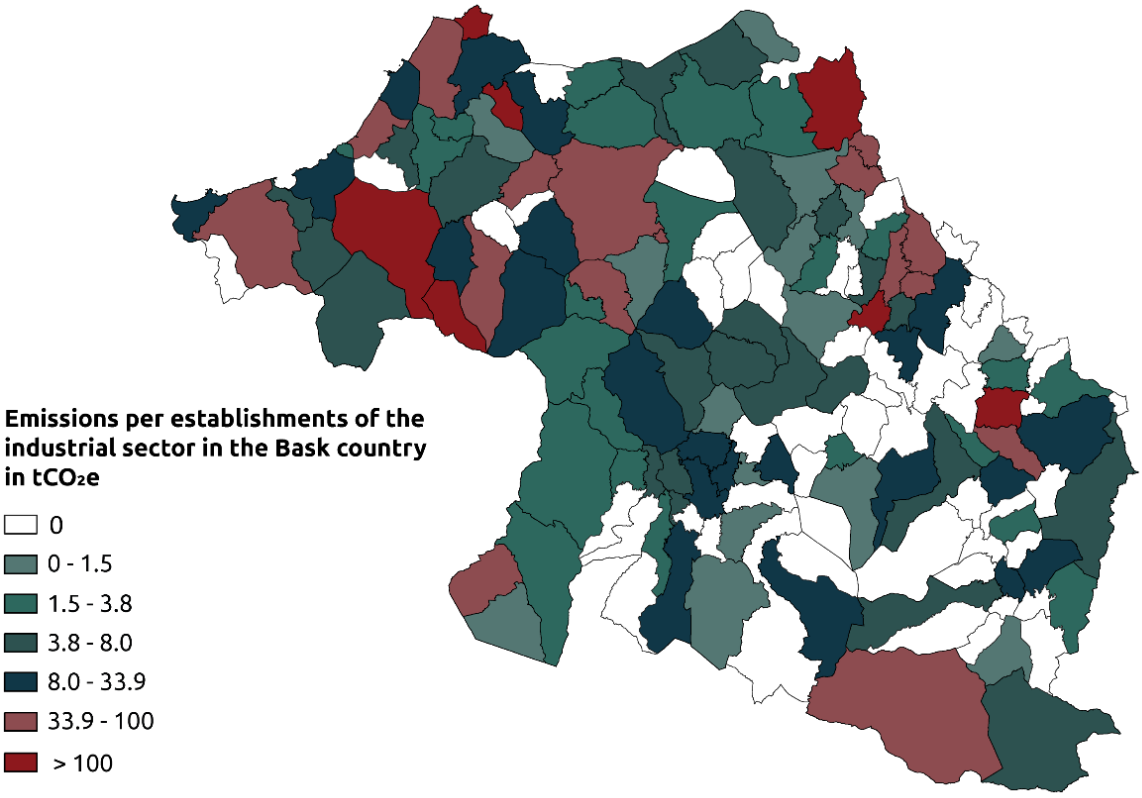


Figure 55. Emissions per establishments of the industrial sector in the Bask country
Source: own production, 2021

2.4.4. Agricultural sector

The agricultural sector is in the Bask Country the leading emitter of greenhouse gases, with 38% of total emissions in the territory. The peculiarity of this is that it is mainly non-energy emissions, and emissions not of CO2 but of methane CH4 and nitrous oxide N2O.

Energetic consumptions

Agriculture is nevertheless an energy consumer, to heat buildings and operate agricultural machinery. This sector is highly dependent on fossil fuels. Of the 171,5 GWh consumed for agriculture, 76% comes from oil products, 22% from electricity and 2% from natural gas.

Emissions amount to 45.1 ktCO2e, of which more than three quarters comes from the consumption of oil products.

However, energetic emissions only represent 5% of the emissions of the agricultural sector in the Bask country. We are about to see where the non-energetic emissions are coming from.

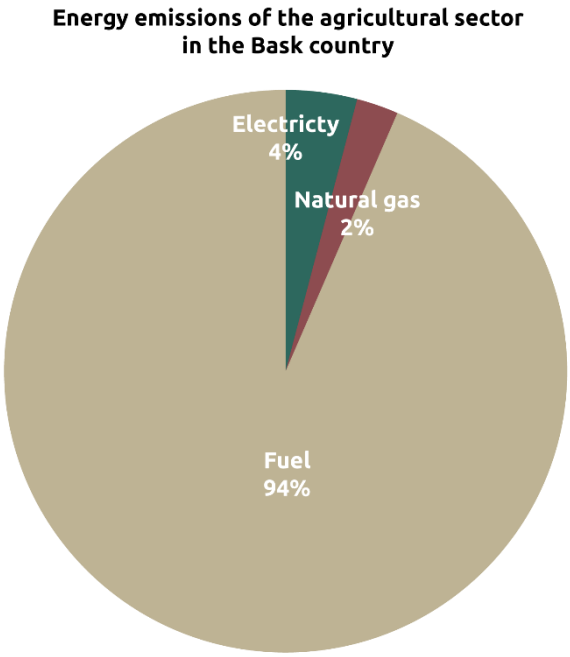


Figure 56. Energy emissions of the agricultural sector in the Bask country

Source: Ministry of the Ecologic Transition (2019), AREC (2018)

Breeding and livestock manure

In order to calculate emissions related to livestock manure, precise data on the number of livestock per municipality is required, as well as the distribution of manure management methods (slurry, manure or grazing) at a municipal level. A study was carried out in 2018 by the territory which estimated those emissions to reach 580,3 ktCO2e.

Fertilizer use for agricultural lands

In order to calculate the emissions related to fertilizer use, precise data on the quantity of fertilizers applied to agricultural soils by municipality are required, as well as the share of each type of fertilizer at a municipal level. A study was carried out in 2018 by the territory which estimated those emissions to reach 210,2 ktCO2e.

Total emissions

In total, the emissions of the agricultural sector are of 835,6 ktCO2e.

2.4.5. Transport sector

The transportation sector is the second largest emitter of GHGs in our territory.

Road transportation

First of all, road transport itself has several aspects:

- The home-work trips made by the territory's inhabitants. Indeed, there is a strong dependence on the private car in the territory: 82% of the working population uses the car daily for their work-home journey (PCAET Bask country, 2021).

- The surplus of traffic in the summer due to tourism is also to be evaluated, but this requires data on road traffic evolution during the year, which could not be obtained for the moment.

- Finally, the transport of goods by land cannot be neglected in our territory.

A study carried out by the territory estimated in 2018 the emissions of road traffic to reach 714 ktCO2e, representing then 98% of the transportation emissions.

Railway

The SNCF network covers a part of the territory with in particular the TGV between Paris and Hendaye which stops in many cities on the coast. Several TER lines also run several times a day between Bayonne and Saint-Jean-Pied-de-Port, and from Bayonne to Pau.

ADEME provides the emission factors calculated by SNCF. These factors depend on the type of train (TER, TGV or intercity), the number of kilometers traveled, and the type of traction. In France, more and more lines are electrically driven, but some, such as the Bayonne - Saint-Jean-Pied-de-Port line, still use diesel traction.

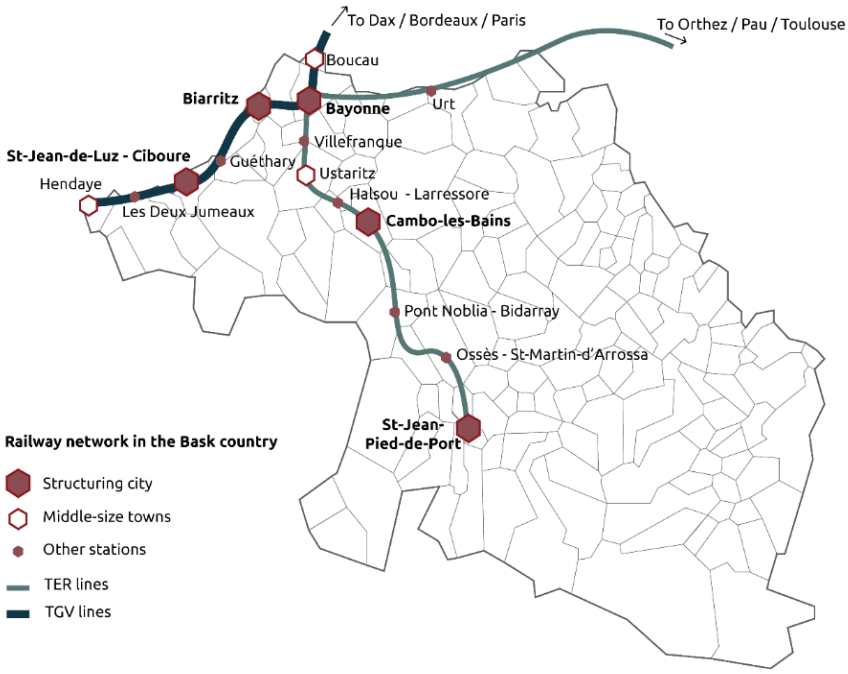


Figure 57. Railway network in the Bask country

Source: SNCF

	Diesel traction (l/km)	Electricity traction (kWh/km)
TER	1.04	11.00
Intercités	1.44	17.00
TGV	/	17.90
Fret SNCF	3.44	19.40

Table 13. Train energy cnsumptions
Source: SNCF Mobilités – données 2012

	Bordeaux – Hendaye line		Bayonne - Saint-Jean-Pied-de-Port line		Bayonne-Pau line
	Bordeaux - Bayonne	Bayonne - Hendaye	Bayonne - Cambo	Cambo – Saint-Jean-Pied-de-Port	
Number of TGV per week	136	136	/	/	/
Number of TER per week	115	90	127	82	65
Number of Intercités per week	/	/	/	/	55
Line length (km)	11	38.8	20.6	34.8	16.3
Traction	électrique		Thermique gasoil		électrique
Energy consumption	173.56 MWh		5688.6 litres de gasoil		26.90 MWh
Emission factor	0.0402 kgCO_2e/kWh		3.16 kgCO_2e/litre		0.0402 kgCO_2e/kWh
Emissions in tCO_2e per week	6.977		17.976		1.081

Table 14. SNCF network in the bask country
Source: SNCF, Base Carbone ADEME, 2021

On a year, we then obtain:

Total emissions = (6.977 + 17.976 + 1.081) * 42 = 1093.442 tCO_2e

We thus obtain a total of 1,1 ktCO2e of greenhouse gases emitted by the rail transport of people.

Emissions linked to rail transport remain marginal compared to other means of transport, but they should be taken into account in order to have a precise vision of the emissions of our territory.

Sea transportation

The relevance of the Port of Bayonne implies a high level of maritime traffic. According to the Kyoto Protocol, the perimeter to be taken into account when carrying out carbon balances does not include sea and air traffic. However, in view of the specificities of our territory, it seemed more appropriate to include them.

The table below gives details of the ships that entered the port during 2019 according to the site they visited. In order to calculate the emissions of maritime transport linked to the port, information on the engines of the ships is still missing.

The territory carried out a study in 2018 that estimated sea transportation emissions reaching 3ktCO2e.

Air transportation

Finally, air traffic should also be taken into account with Biarritz airport, which receives medium-haul flights every day. The flight schedule for the summer of 2021[28] available on

[28] Biarritz Anglet Bayonne Airport, Summer 2021 flight program

the official website of the airport shows approximately 112 takeoffs per week for business aviation, so 2,240 aircraft movements over the entire summer period. For the year 2019[29], 6,509 aircraft movements for business aviation, 13,956 for the flying club and 1,412 for military aircraft are recorded.

Given the location of the Bask Country, it would seem more appropriate to take into account only the emissions emitted during take-off and landing, that is to say the phase of flight called LTO (Landing and Take-Off).

The 2006 IPCC Guidelines publish emission factors by gas, according to the type of aircraft for a take-off or landing.

The study carried out by the territory claimed the air transportation emissions to be of 10 ktCO2e.

Total

The sum of all means of transportation's emissions give a total of 729 ktCO2e emitted by the transportation sector.

2.4.6. General results for the Bask country

Finally, here are the results per business sectors:

This gives a total of 2 217,6 ktCO2e of GHG emitted over a year in the Bask Country. The distribution by sector shows that transportation and agriculture dominate the total emissions.

Sectors	**GHG emissions ($ktCO_2e$)**	**%**	**Emissions per inhabitant (tCO_2e)**
Residential	349,3	16%	1.14
Tertiary	208,3	9%	0.68
Industry	95,4	4%	0.31
Agriculture	835,6	38%	2.73
Transportation	729	33%	2.38
TOTAL	**2 217,6**	100%	**7.24**

Table 15. GHG emissions results per business sectors
Source: own production

[29] Biarritz Anglet Bayonne Airport, Activity report, 2019

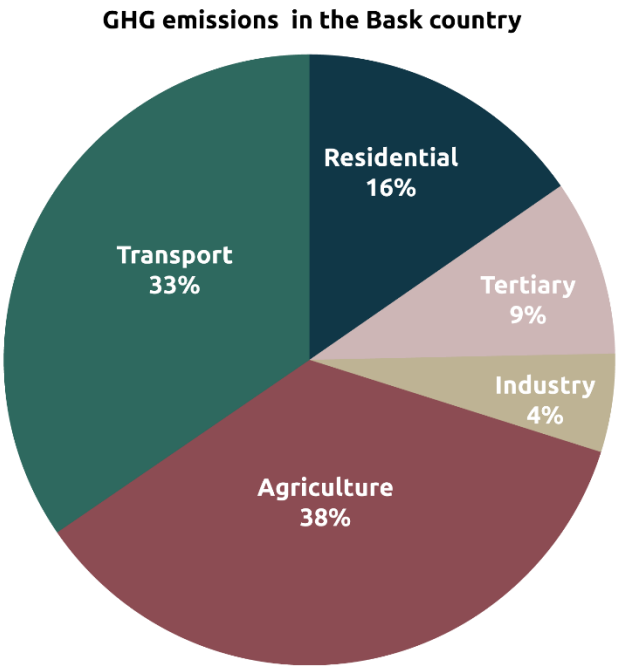


Figure 58. GHG emissions in the Bask country
Source: own production, 2021

3. Concept: Optimize the territorial metabolism to rebalance the territory

3.1. Territorial metabolism

3.1.1. Definitions of territorial metabolism

The term metabolism has been directly taken from biology. Here is then compared a territory's operation and the one of a body or a cell. The territory needs to draw certain resources (energy, raw materials, etc) in order to work correctly, and then it rejects in nature what it has ingested, but with a new aspect.

The notion of "territorial metabolism" was first used by the American engineer Abel Wolman in the 1960s. Specialized in urban sanitarian systems, he got interested in the quantification of water, food, and fuel flows needed for an imaginary city of 1 billion inhabitants. He defined the metabolism of a city as:

> *« All the materials and commodities needed to sustain the city's inhabitants at home, at work, and at play. Over a period of time, these requirements include even the construction materials needed to build and rebuild the city itself. The metabolic cycle is not completed until the wastes and residues of daily life have been removed and disposed of with a minimum of nuisance and hazard. »*[30]

[30] Abel Wolman, "The Metabolism of Cities" 1965

In 2018, Sabine Barles defines territorial metabolism as:

> *« The whole energy and material flows put at stake by a territory's operation. […] The territorial metabolism reflects then the socio-ecological regime of the territory, that is to say, the way the society and biosphere interact locally during a certain period of time. »*[31]

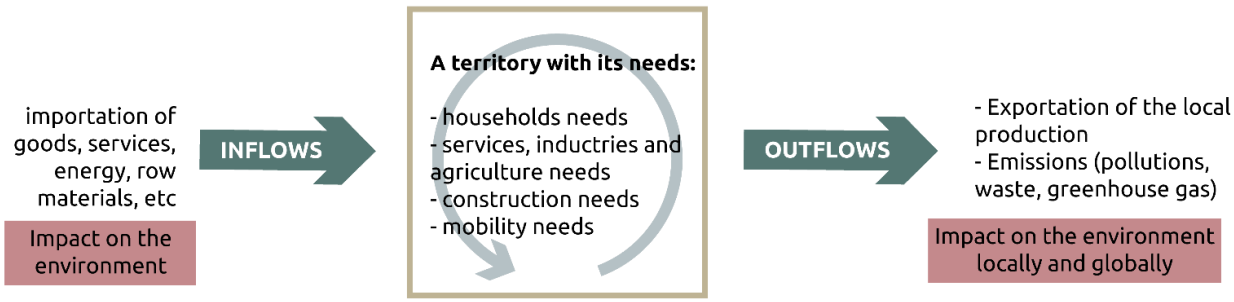
So, territorial metabolism consists in studying all flows generated by a society inscribed into a territory. We consider:

- Material, goods, merchandise flows
- Energy flows
- Service and data flows
- Waste and pollution flows

Then can be inflows, outflows, or flows within the territory.

That is an approach centered on the territory's needs and what is put at stake to address them. Needs of households, services, industrial and agricultural activities mean getting various goods and services that come from inside or outside the territory. We are speaking about **final domestic demand**. It includes the domestic production dedicated to consumption on the territory and the importations for final or intermediary use. While identifying those flows, while quantifying them, we can determine to what extent the territory has the ability to address its own needs, and to what extent it can be dependent on other territories.

With the aim of making the economy more circular, it appears important to realize a diagnosis of those flows. It is in that way that we can identify inconsistencies and lacks in the metabolism. We can then correct them to favor a local production.



[31] Sabine Barles, « Métabolisme urbain, transitions socio-écologiques et relations ville-campagne », 2018

Moreover, emissions (GHG, waste, pollutants) are also considered as an outflow, being the result of the activities of the territory. This flow, as it has a negative impact on the environment, does not have consequences only on the territory, but also globally. So it is important to quantify it, in order to picture the impact of the territory on a larger scale.

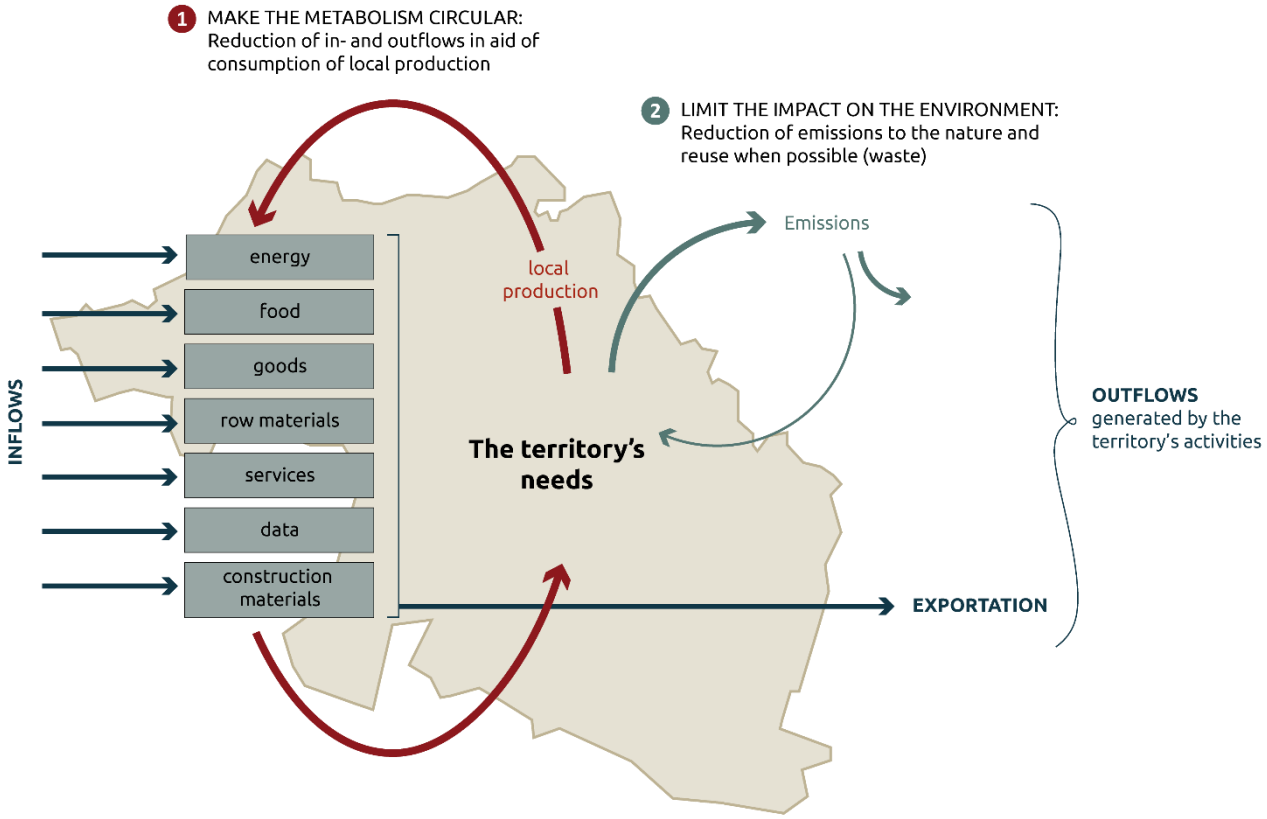


Figure 59. Why study the territorial metabolism in the Bask country
Source: own production, 2021

3.1.2. Material Flow Analysis

Material Flow Analysis (MFA) is the main tool for describing and understanding territorial metabolism[32]. It can be carried out at different scales. At the regional and departmental levels, it has been gradually generalized since the year 2000. The diagram above shows the result of the analysis of material flows carried out in 2010 for the Burgundy region. Several arrows appear, each designating a type of flow in the region. We will detail them below.

[32] Sabine Barles, MOOC UVED ECI, « L'analyse des flux de matières à l'échelle des territoires », 2015

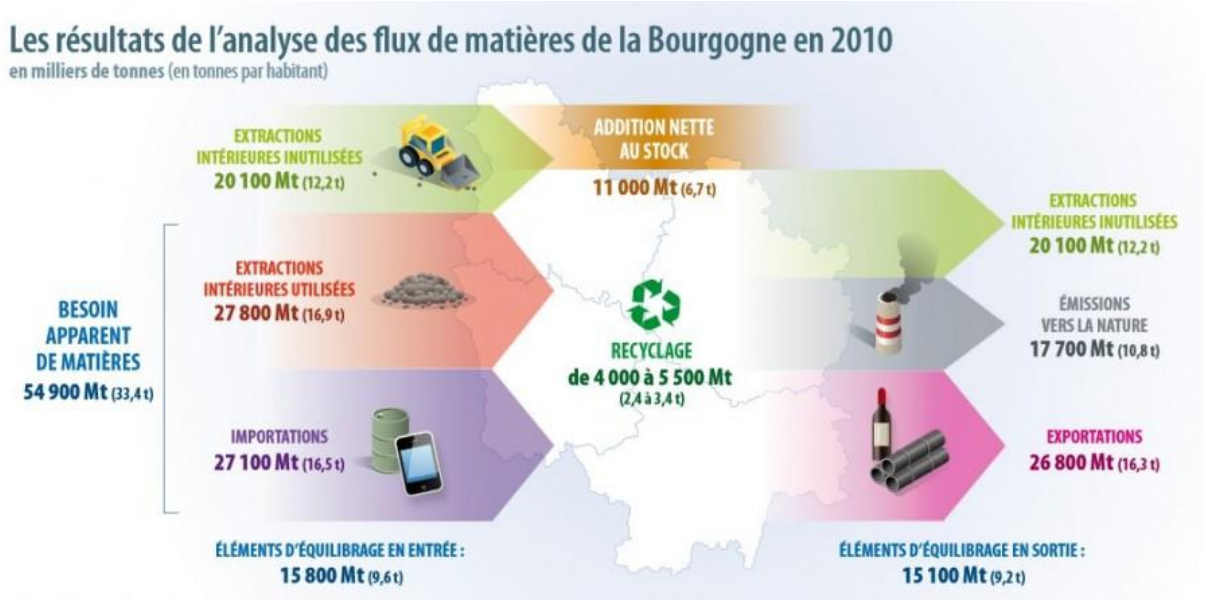


Figure 60. Results of a Material Flows Analysis carried out by the Bourgogne region
Source: Bourgogne region, 2010

INFLOWS:

- **Unused domestic extraction**
- **Used domestic extraction**

The categories used and unused domestic extractions symbolize everything that is taken from the territory for productive or non-productive purposes. They are therefore closely linked to the figures for local agricultural production, mining, and raw material extraction. In short, everything that the soil of the territory can give to society.

- **Imports**

Imports serve to ensure the needs of the territory that cannot be met by domestic extractions. Identifying these flows can make it possible to become aware of certain dependencies on other territories.

- **Input balancing elements**

This representation also aims at respecting Lavoisier's principle: "nothing is created, nothing is lost, everything is transformed". Thus, the total quantity of material entering must be equal to the total quantity leaving. The balancing elements at the input and output are water and air flows that affect the mass balance, and that must be considered for the Lavoisier principle to be respected.

For example, in the case of the combustion of a hydrocarbon, the chemical reaction that is involved can be written in a simplified way as follows:

hydrocarbon + oxygen = carbon dioxide + water

Now, the MFA counts the mass of the hydrocarbon as input and the carbon dioxide produced as output. In order to take into account the principle of conservation of mass and to balance the incoming and outgoing masses, it is thus necessary to also count in input the quantity of oxygen which was necessary for the reaction of combustion, and in output the quantity of water vapor which results from this reaction. The so-called "balancing elements" thus make it possible to take into account the masses of air consumed and those of water produced in order to balance the balance.

NET ADDITION TO THE STOCK:

The net addition to the stock represents the materials that accumulate on the territory, in the form of durable goods (e.g. a car) but also buildings, infrastructure, urbanization, and the artificialization of the environment.

OUTFLOWS:

- **Unused domestic extraction**
- **Emissions to nature**

The category of emissions to nature takes into account air, water and soil pollution, but also greenhouse gas emissions and untreated waste. It represents the territory's discharges that are not valorized and that can even have a negative impact on the environment: climate change, erosion of biodiversity. Quantifying this outgoing flow thus shows the responsibility that the territory has for the biosphere through its operation.

- **Exports**

Exports are the result of local industrial or agricultural production marketed outside the territory. They represent a source of income for the territory.

In the French Bask Country, agricultural production is a major exporter to the rest of France, Spain and the rest of the world. Certain industries (notably those present in the Bayonne industrial-port zone) also produce specific products that are not intended for local consumption, but for international marketing.

Thus, quantifying all these flows and putting them in parallel allows us to make the link between certain exported goods that could be used in the territory in the first place and avoid these imports. Knowing what is imported, what is exported and what is produced locally, is a first step to identify the levers towards circularization of the economy.

3.1.3. Many territories are tackling the metabolism studies

Territorial metabolism made a few appearances in the literature in the 1970s, only to disappear and return in the 1990s. But it is only with the 2000s and the researcher Sabine Barles in France, that urban planning has seized this subject. More and more territories

have understood that territorial metabolism could provide them with keys to understanding the new concerns in terms of sustainable development.

Spatial scale	Number of territorial metabolism studies
City	6
Department	6
EPCI	11
Region	18
SCoT	2
Associations	1

Table 16. Number of publications about territorial metabolism
Source: Institut Paris Région, from Oliveira & Vaz 2020

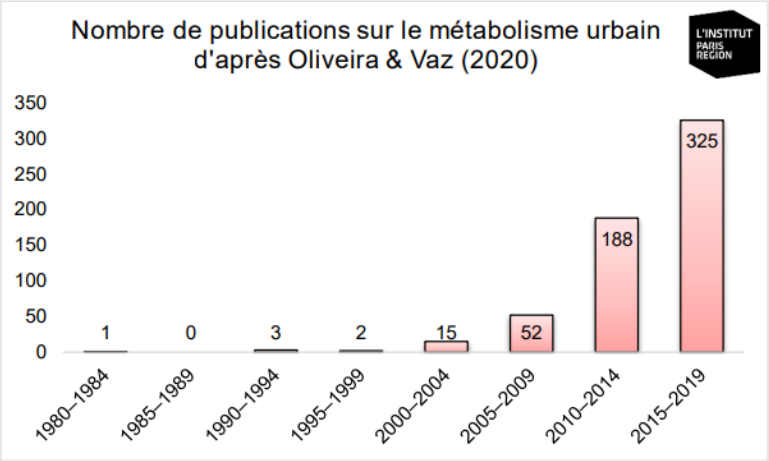


Figure 61.Spatial scale concerned by territorial metabolism studies in France

Source: Institut Paris Région, « Les études de métabolisme territorial : état des lieux et perspectives », 2021

Metabolism studies are becoming more widespread at the municipal or inter-municipal level. Some large French metropolises (Lille European Metropolis, Nantes Metropolis) have taken up this study in order to have a better understanding of their functioning. However, at the municipal level, the studies carried out are not complete and only take into account energy imports, not those of goods and services. The city of Paris has been particularly innovative on this subject, with the help of researcher Sabine Barles, a specialist in the field. Some groups of municipalities are also working on metabolism by focusing on a particular type of flow. For example, Plaine Commune, which brings together nine municipalities in Seine-Saint-Denis, is working on the circularization of construction materials, which began in 2015 with an urban metabolism approach at the scale of these nine municipalities[33].

[33] Justine Emringer interview, Impulser le métabolisme urbain (dixit.net), 2021

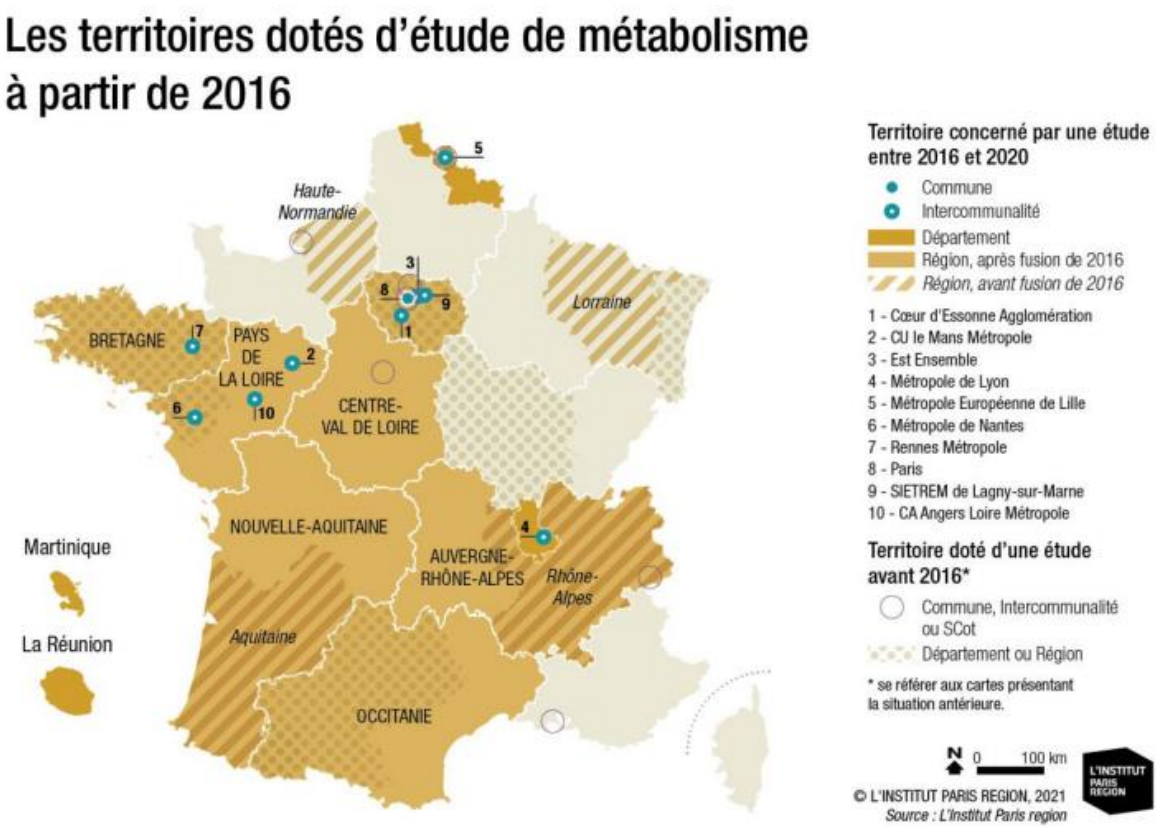


Figure 62. Territories that carried out a metabolism study in France since 2016
Source: Institut Paris Région, 2021

3.1.4. Link between metabolism and greenhouse gas emissions

The first studies on the danger that human activities represented to the environment date back to the 1970s. In 1971, thirty scientists from the Massachusetts Institute of Technology published a "Report on the impact of man on the climate". In 1997, the Kyoto Protocol was signed by 184 countries. For the so-called "Annex B" countries, which correspond to the industrialized countries of the time, quantified GHG emission reduction targets were set.

Since then, the Annex B countries have worked to reduce their emissions. We are witnessing a small decrease in emissions in all these countries. However, on a global scale, the amount of GHGs emitted has been increasing steadily, reaching very critical levels. A decline in GHG emissions in Western countries has not prevented an increase in emissions on a global scale.[34]

[34] Commissariat Général au Développement Durable, Méthodologie de calcul de l'empreinte carbone de la demande finale intérieure française, avril 2016

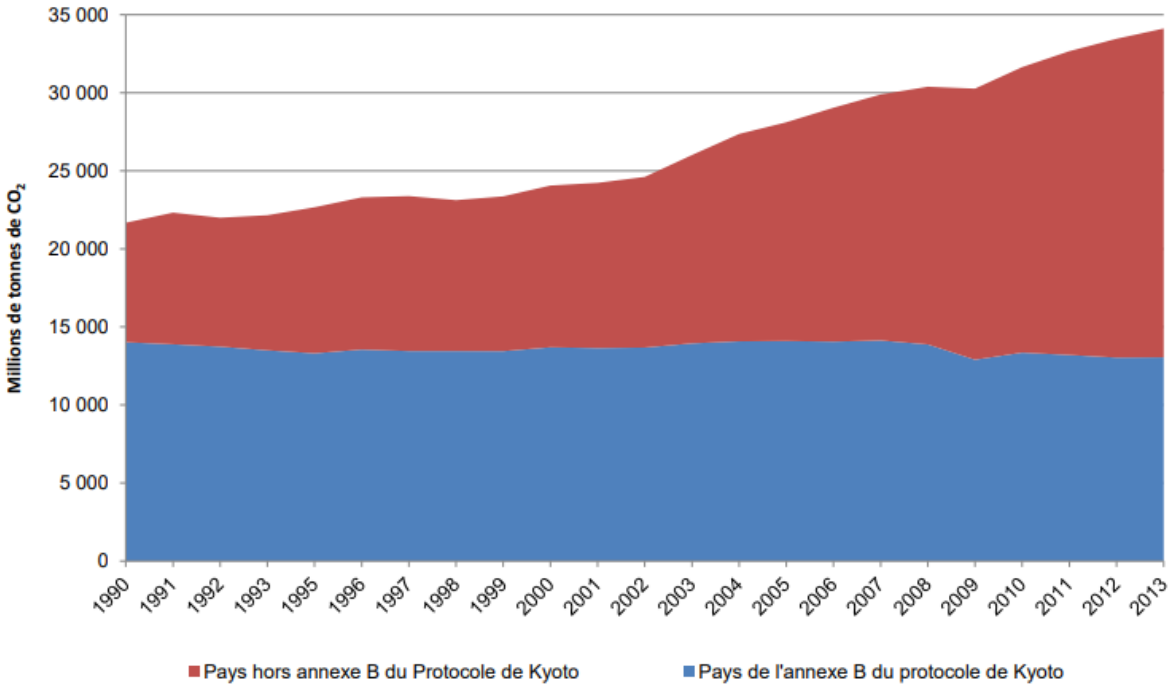


Figure 63. Evolution of GHG emissions by countries having signed commitments to reduce their emissions under the Kyoto Protocol (Annex B) and by all other countries
Source: Carbon Dioxyde Information Analysis Center (CDIAC) – Global carbon Budget, 2014

The relocation of industries has resulted in a decrease in emissions in Western countries. But these industries have not disappeared and continue to emit in other territories, where environmental protection regulations are often less strict.

As the consumption of manufactured goods worldwide does not decrease, industrial production and the emissions it generates cannot be drastically reduced. We speak of the **transfer of emissions to third countries via international trade**[35]. Thus, since 1990, the countries having signed commitments to reduce GHG emissions under the Kyoto Protocol have managed to stabilize them. But at the same time, CO2 emissions linked to imports from countries outside the protocol have more than doubled. In addition, many Asian countries have experienced strong economic growth in recent years, allowing their populations to achieve higher standards of living and consume more. These countries are therefore emitting more and more GHGs.

Acting to reduce emissions in a closed area can therefore only be effective if it does not generate emissions elsewhere. Eliminating a polluting industrial establishment is not necessarily a solution. Helping it to adapt its processes to emit less, encouraging it to make greater use of local resources rather than importing raw materials from the other side of the planet, and to produce primarily for the needs of the territory in which it is located, are all much more significant in the fight for the climate.

We are touching directly on the field of analysis of territorial metabolism: import/export, recycling, circularity, domestic extraction, domestic needs. The study of territorial metabolism is interested, among other things, in inflows. By quantifying these flows, we can obtain an estimate of the GHGs emitted elsewhere to meet the needs of the territory.

[35] Aichele et al 2012 ; Boitier 2012 ; Peters et al 2011

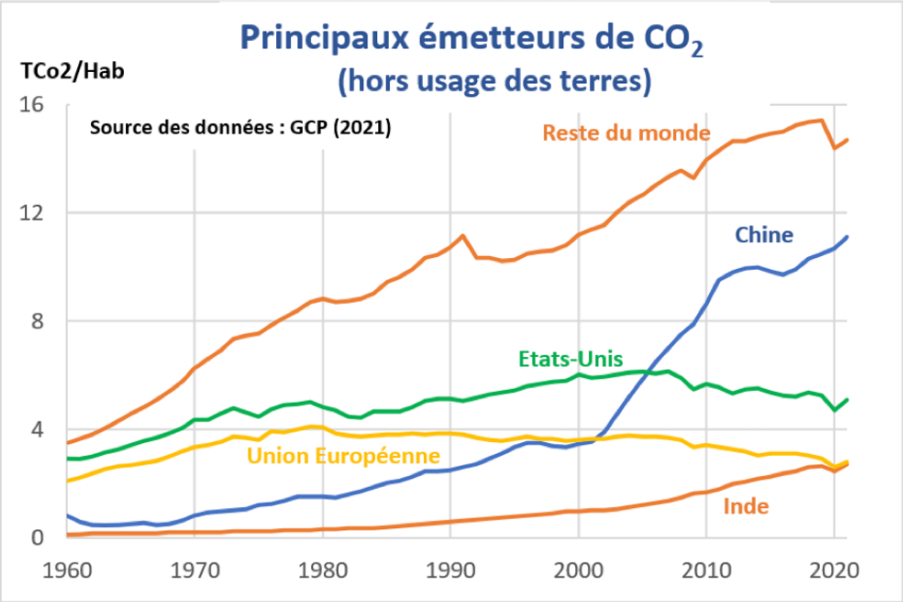


Figure 64.Main CO2 emitters
Source: Christian Pertuis, « Empreinte carbone : les trois thermomètres de l'action climatique », 2021

The three carbon footprints

There are three ways to calculate the carbon footprint of a territory[36]:

- The **territorial footprint** estimates greenhouse gas emissions within the territory's borders.

- However, it is often questioned, as it does not really demonstrate the impact of the society anchored in a territory on the environment. Indeed, with the globalization of economies, it is now possible to consume goods and services produced anywhere in the world, and not without a carbon footprint. The **consumption footprint** is a second way of estimating the GHG emissions of a territory, considering the final uses of goods and services. This is referred to as the **domestic final demand** of a territory. The consumption footprint takes into account the goods and services produced in the territory or outside to meet this demand (household consumption, needs of economic activities, etc.). In relation to the territorial footprint, we, therefore, add the emissions generated by the production of goods and services consumed in the territory; and we subtract those of goods and services produced in the territory but consumed elsewhere.

  This footprint is divided into four components:
  - Direct emissions from households
  - Emissions from domestic production (excluding exports)
  - Emissions associated with imports for final use
  - Emissions associated with imports for intermediate consumption.

  We can see that the European Union is the first net importer of CO2 emissions with a consumption footprint that exceeds its own emissions by 18%.

[36] Christian de Perthuis, « Empreinte carbone : les trois thermomètres de l'action climatique », The Conversation, 24/11/2021

- Finally, the **extraction footprint** accounts for the emissions resulting from the extraction of fossil energy in the territory (coal, oil, gas of fossil origin). It should be noted that our territory is not at all concerned by this component.

The territorial footprint is the easiest to estimate, as it is only local data to be used. The data on imports and exports, necessary to calculate the consumption footprint, are more complicated to collect on the scale of a territory like the French Bask country. Thus, the territorial footprint represents a good entry point.

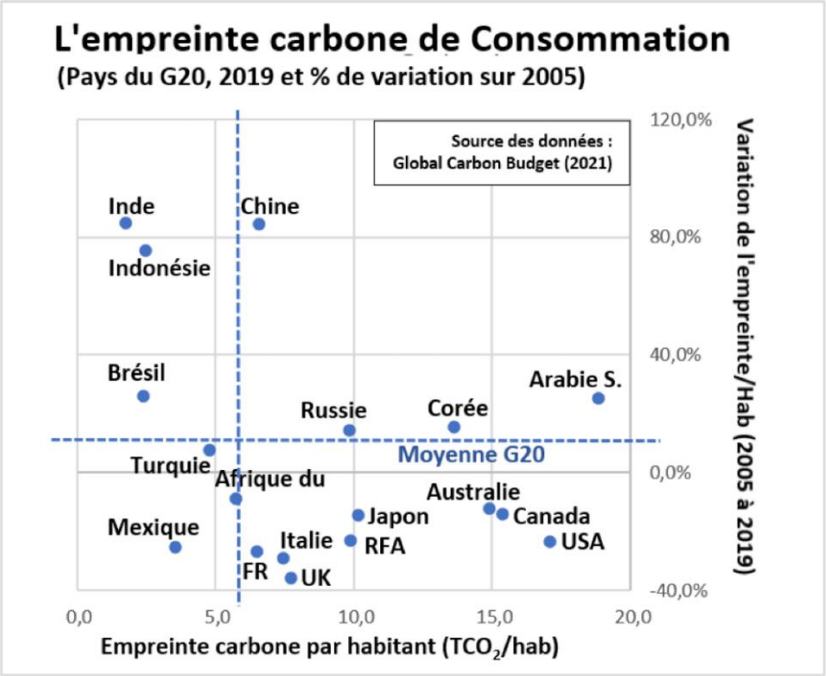


Figure 65. Consumption carbon footprint
Source: Christian Pertuis, « Empreinte carbone : les trois thermomètres de l'action climatique », 2021

3.2. How territorial metabolism can address the issues the French Bask country is facing

In territorial planning, we used to consider territories as a rigid entity, defined by borders, and composed only by what they contain. Territorial metabolism is breaking this way to see territories and bring a new vision that is changing how we consider territories, bus also how we act on them. Territories are not seen as changing elements that live thanks to movement and exchanges of materials, energy, knowledge, people. It is a way of seeing the territory centered on its needs and what is set in motion to address these needs.

Nowadays, the Bask country is facing many issues. The whole mobility system is to be renewed to address better the flow of people occurring on the territory and reduce the environmental impact it has currently. Bask people are also more and more regretting a loss of their identity, that is linked to flows of goods, knowledge, heritage going too much toward the outside. Finally, the fight against climate change can be translated through the

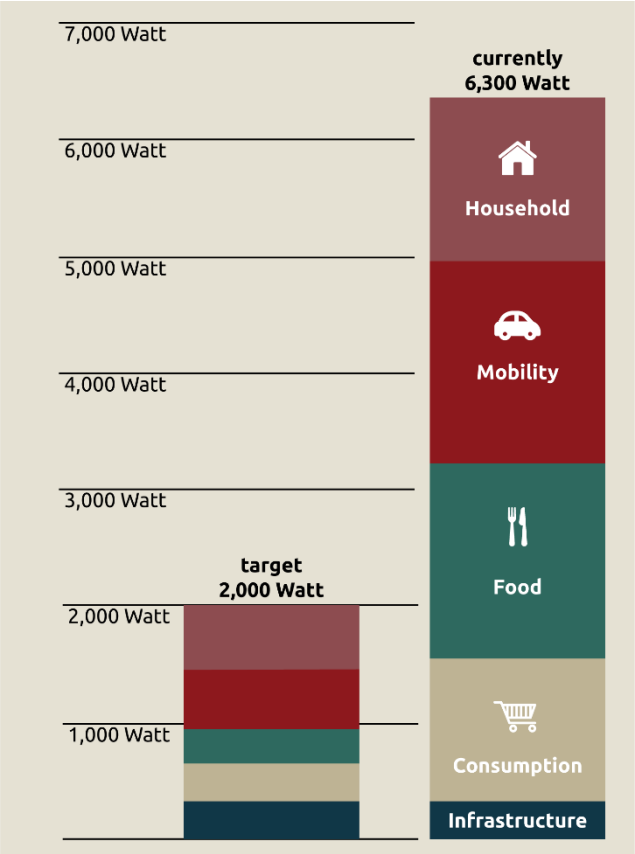
quantity of greenhouse gas emissions the territory is responsible for, emissions being considered as an outflow resulting from the territory's functioning. Thus, all these issues are dealing with flows taking place on the territory. A way to answer these issues is then to act on those flows, to change their direction, that is to say, to remodel the metabolism of the Bask country.

I will therefore take the concept of territorial metabolism as key to resolving the territory's issues. To rebalance its structure, flows will have to be more destinated to the inside and will take place no more from or to the coast. Highlights will have to be set also on smaller towns and rural areas of the interior territory. All flows – of people, goods, services – responsible for the escape of Bask richness will be reduced.

Chapter III – Designing a better metabolism for the French Bask Country to become more sustainable

Introduction: Consume less and better

As seen in the previous chapter, most GHG emissions currently are of energetic origin. To reduce emissions and limit climate change, it, therefore, urges to reduce energy consumption. All the more so as the global storage of fossil resources is to be emptied soon. These consumptions must be the first to be reduced, while an emphasis must be given to renewable energy.



The 2000-watt society is a model that aims to lower yearly global source energy demand to 2000 watts per person with an amount of 75% from renewable origin. At this level and type of energy use, greenhouse gas emissions will be limited to one ton of CO2 per person per year. Limiting non-renewable energy consumption at this level also maintains global warming at the levels agreed to in the 2016 Paris Climate Accord. As a matter of comparison, Americans today use on average 12,000 watts per person and 20 tons of CO2 per person each year. This energy-consumption reduction must concern every aspect of our daily life.

Figure 66. Reduction of energy consumption according to the 2000-watt society principles
Source: 2,000 Watt society goals for Swiss

1. Increase the local production of renewable energy

1.1. Origin of energy consumptions today in the French Bask country

Following the data collected from different energy suppliers, as well as from the AREC Nouvelle-Aquitaine. It is possible to draw up the energy metabolism of the Bask Country (see tables 2 and 3).

19,5% of the energy consumed on the territory is produced there. This local production concerns primarily wood energy to meet heating needs in the residential sector. Photovoltaic and hydraulic electricity production also play a role.

Currently, it is estimated that 20% of the primary energy consumed in the Bask Country is of renewable origin. For this estimate, the exact data of renewable energy production in the territory are taken into account. For electricity, we consider that what is not produced locally comes from the French electricity mix, composed of 19.1% of renewable energy[37]. This figure of 20% is higher than the national average, which is only 13.1%[38].

Energy consumption in GWh	**electricity**	**gas**	**fuel**	**wood**	**biofuel**	**Total per sector**
Residential	807	830	99	634	/	2,370
Tertiary	626	235	125	29	/	1,015
Industry	223	145	16	0	/	385
Agriculture	37	3	131	/	/	171
Transportation	10	5	2 227	/	175	2,417
Total per energy	1,703	1,218	2,598	664	175	**6,358**
% of the total production	27%	19%	41%	10%	3%	**100%**
Of whom renewable	402	6	0	664	175	**1,247**
%	24%	6%	0%	100%	100%	**20%**
Of whom locally produced	95	6	0	664	0	**765**
%	4%	0.5%	0%	100%	0%	**12%**

Table 17. Energy consumption in GWh in the Bask country
Source: AREC Terristory 2018, Ecology Ministery 2019, diagnostic Algoé for the PCAET of the CAPB 2019

Electricity production	**Production in GWh**
Solar panels	28
Hydraulic	48
Bioenergy / biomasse électrique	19
Total	**95**

Table 18. Electricity production in the Bask country
Source: GRDF 2019, AREC Terristory 2018, SDEPA

[37] « La production d'électricité », Ministère de la transition écologique, 2017, La production d'électricité | Ministère de la Transition écologique (ecologie.gouv.fr)
[38] « Les chiffres clés des énergies renouvelables », Datalab – Ecologic Transition Ministery, 2021

1.2. Potentials of increasing renewable energy production on the soil of the Bask country

First of all, it is important to be aware of the gap that exists between what appears as renewable energy potential, and what can actually be produced. To estimate this gap, we define several types of potential.

The **theoretical potential** is based on the physical possibility of using a renewable resource. The **technical potential** defines which part of the theoretical potential can actually be used. The **ecological potential** indicates the resources that can be used sustainably with regard to the technologies currently available. Finally, the **economic potential** is what can be settled for real, depending on financial resources.

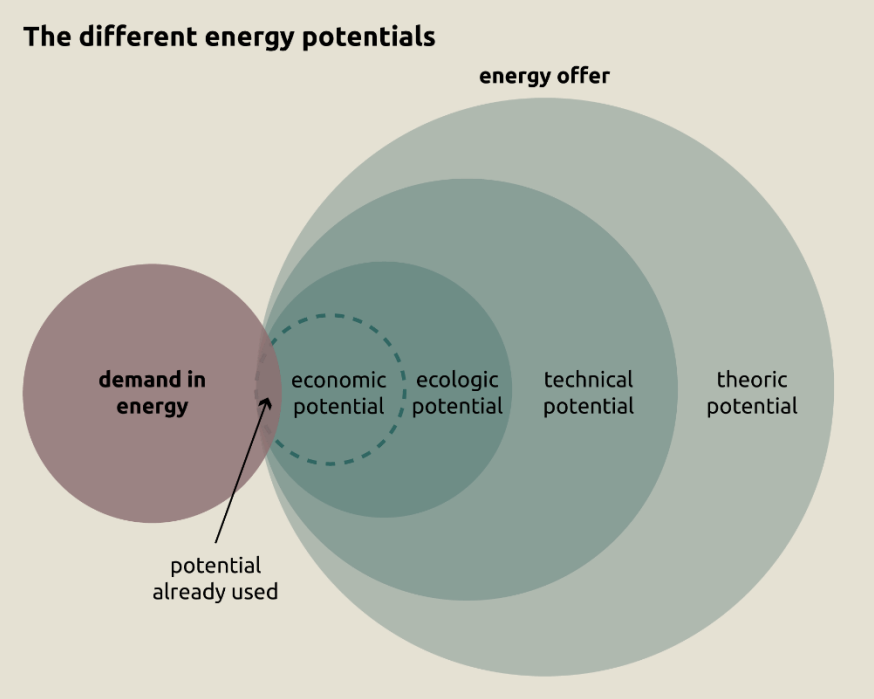


Figure 67. Potentials of energy production
Source: own production, inspired by Pianificazione energetica del territorio, Svizzera energia and Città dell'energia

Taking the example of solar panels, the theoretical potential will be calculated depending on the intensity of solar radiation, and all the energy it is conveyed. The technical potential will take into account the efficiency of the solar collectors, which is never 100%, a share of the energy is always lost. The ecological potential will consider the location where it is possible to install solar collectors, then the radiations that will be actually caught by the panels. Finally, the economic potential will represent the panels that can for real be installed.

The French Bask country benefits from many renewable resources that could be more triggered. Increasing the local production of renewable energy and dedicating it to the consumption of the territory will improve a circular metabolism of energy and reduce its environmental footprint.

1.2.1. Solar energy

Roof surfaces with a good slope and exposure can be used for heat or electricity (photovoltaic) production. The only limit for electricity production is the available surface. Taking into consideration the amount of sunshine in the Bask country, and solar panels' efficiency, the potential of solar energy has been estimated at 274 GWh for heating and at 1,226 GWh for photovoltaic.

Solar panels should be installed where the energy demand is. Two strategic places appear. Firstly, dense urban areas can host solar panels on their roof for direct use of the energy in the buildings around. Secondly, agricultural buildings are often very large and offer large roof surfaces that can be turned into solar panels. This can help agriculture consume local and green energy and reduce energy imports for this sector. The large surfaces the agricultural buildings offer may even enable then to produce more energy than they consume. Then, the energy will be integrated into the electricity network to be consumed elsewhere.

In any case, the panels would rather be installed on the south slopes of the roofs for better efficiency.

- **Add solar panels on roofs of dense urban environment**

- **Turn roofs of agricultural buildings into solar panels producing energy directly used for the farm's needs**

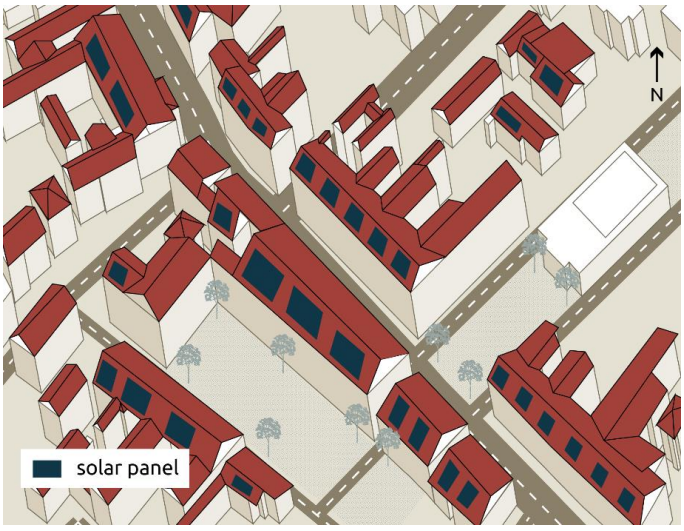


Figure 68. Solar panels in cities
Source: own production

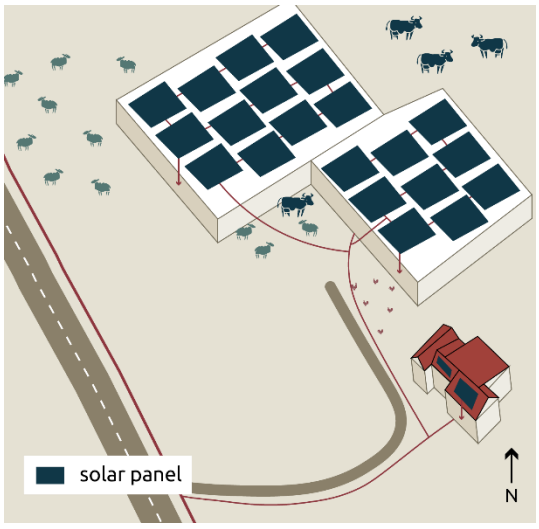


Figure 69. Solar panels on agricultural buildings
Source: own production

1.2.2. Wind energy

The potential of wind energy is very variable from one case to another and depends on many criteria: wind force, distance from settlement areas, noise pollution, landscape

protection. In the Bask country, a study has been led in 2012, estimating that 85% of the cities of the territory own a favorable place for wind energy production. The production would reach between 52.5 and 77.7 GWh.

1.2.3. Hydropower

It is an energy source already used in the Bask country, with 16 hydroelectric factories producing 48 GWh a year. The many waterways of the territory offer an opportunity to develop this resource still more and double the production.

1.1.1. Wave energy

It is a new manner to produce renewable energy, which is still under development. It refers to the production of electricity from the energy of the waves. There is a vast inventory of wave energy solutions, some of them submerged, others installed on the surface, on the shore, or offshore. The energy capture systems vary from one prototype to another: mechanical energy capture on the surface (undulations) or underwater (translations or orbital movements), capture of pressure variations during the passage of waves (water height variations) or physical capture of a water mass (via a reservoir).

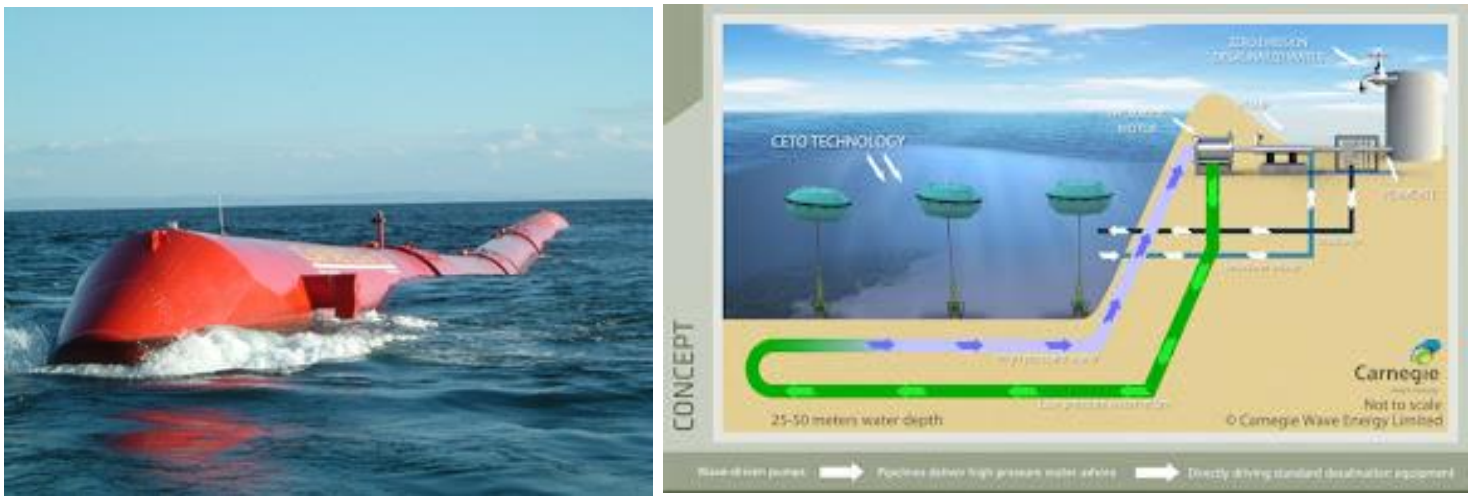


Figure 70. Examples of wave energy production infrastructures
Source: tpe-hydroelectricité-loquidy.com (right), Carnegie (left)

The location of the Bask country, with the Atlantic Ocean and many ocean currents, represents a relevant opportunity for the production of this energy. A potential of 110 GWh has been calculated. Carnegie Wave energy has also calculated a wave energy potential for the Atlantic coast of France of 63 kW per meter.

1.1.2. Wood energy

Wood energy, as seen in chapter II, is very low-emitting energy. Moreover, it is a local resource, so perfect to foster a circular metabolism of energy. It is already largely used in the Bask country (664 GWh), and especially in rural areas. It must be also encouraged in more urban ones. We can thus hope to reach a consumption of 800 GWh from this energy.

- **Organize a network bringing woods to towns**

This network will connect cities and bring wood from where the resource is to the urban areas that need it. It will be transported on roads, but also by railway as much as possible to limit greenhouse gas emissions due to the transportation.

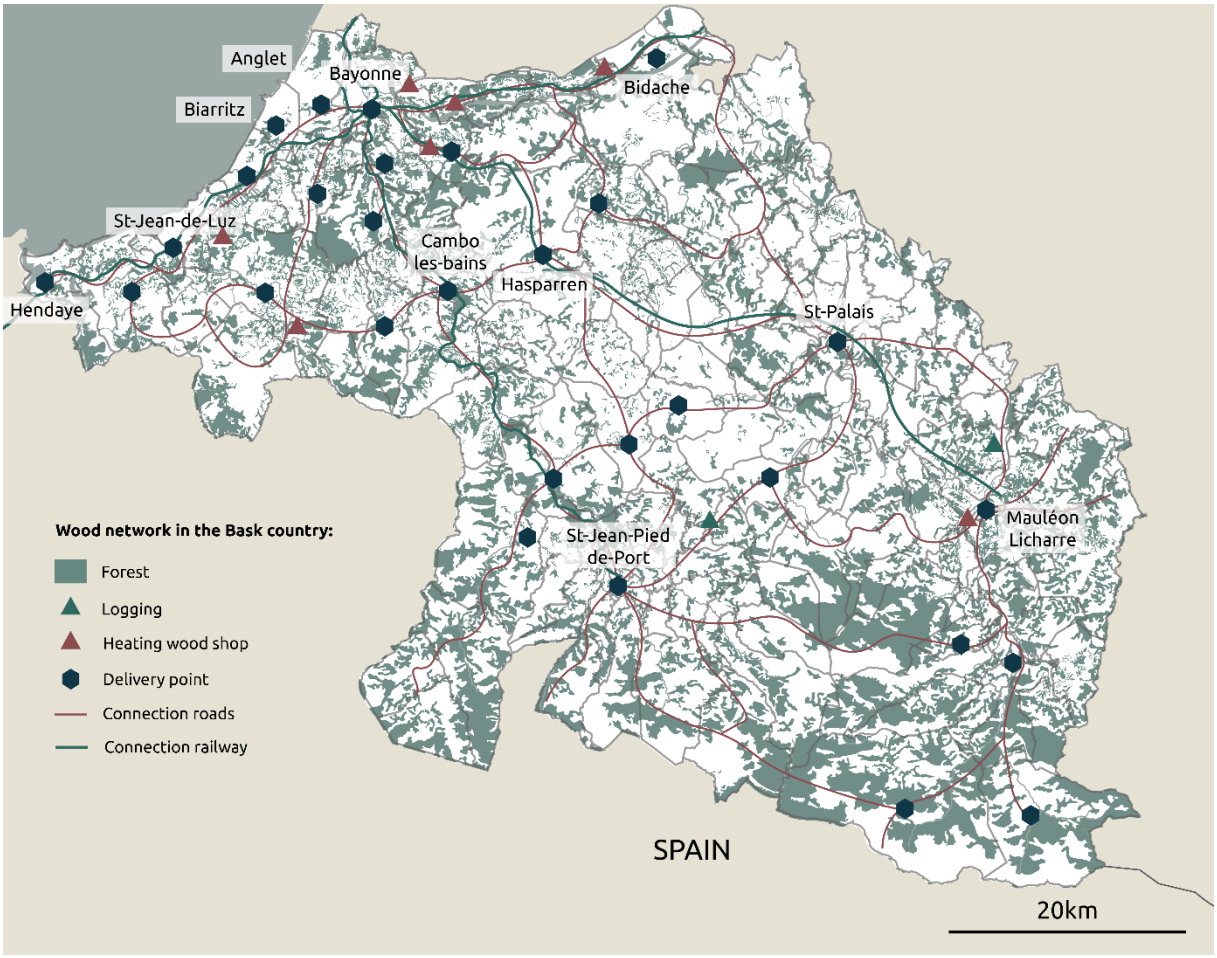


Figure 71. Wood network in the Bask country
Source: own production using Google maps data

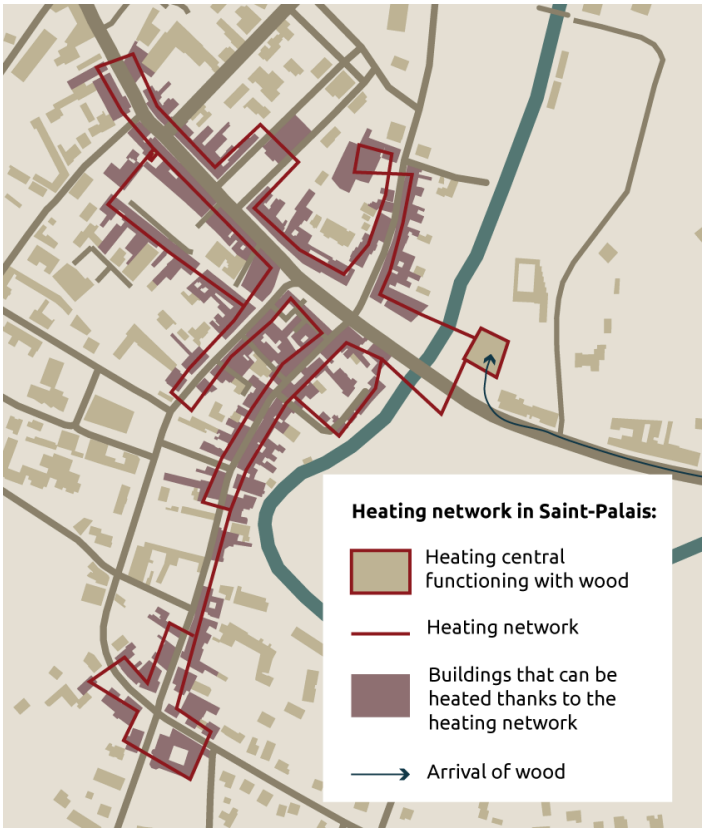
1.1.3. Heating networks

Bayonne, Saint-Jean-Pied-de-Port et Alos-Sibas-Abense are already provided with such heating networks. They allow living units, schools, swimming pools, community centers to

be heated with boilers using wood energy. In Bayonne, the network provides a whole neighborhood of 3,200 living units.

Many projects are currently being developed in cities like Hasparren, Ustaritz, Cambo-les-Bains. Currently, the energy consumption of those cities for heating needs is 6,475 MWh, 5,628 MWh, and 5,227 MWh. Considering that the heating network will cover only the densest part of the city center, we can estimate that it will concern 20% of the living units of the city. That is to say, heating networks will represent for those three cities a total of approximately 3,500 MWh.

Other cities could be concerned with such equipment. Any cities with a dense center represent an interesting opportunity to develop heating networks. Moreover, heating power plants could use wood energy, in order to increase the share of this energy in the mix of the Bask country, as said in the previous part.



The city of Saint-Palais can be used as an example. A network going through its dense and small city center will enable to heat many living units, as well as shops and other facilities. The power plant located outside the city center will be easily accessible for the trucks which deliver the wood. The network as described opposite will enable 216 buildings up to three floors to be heated.

Figure 72. Heating network in Saint-Palais

Source : own production

1.1.4. Methanization

Waste from the food-processing industry, bio waste, agricultural effluents, crop residues, intermediate crops for energy purposes, and sewage plant sludge could be valorized through the production of green gas. All of these emit methane, a GHG gas that can also constitute a resource for renewable energy. It is an opportunity to turn a GHG emitter into a local and green source of energy. It has been estimated that on the Bask country territory an amount of 250 GWh could be produced in that way. It represents one-fifth of the gas consumption in the Bask country.

The settlement of such infrastructures must be encouraged on the Bask country territory, with strategic location, close to agricultural lands, which provide many of the raw materials for this energy production (animal dejections mainly).

- **Open methanizers and connect them to the gas network of the territory**

- **Organize a network for animals dejections' collection in the farms that bring them to methanizers without overloading the farmers**

1.1.5. Conclusions

Renewable energy	Production potential on the Bask country
Solar panels	1,500 GWh
Wind energy	60 GWh
Hydroelectricity	100 GWh
Heating network	
Methanization	250 GWh
Wood energy	800 GWh
Wave energy	110 GWh
TOTAL	**2,760 GWh**

Table 19. Potential of renewable energy production in the Bask country

The current energy consumption in the Bask country being 6,358 GWh, renewable and local energy could reach a share of 43% of this consumption.

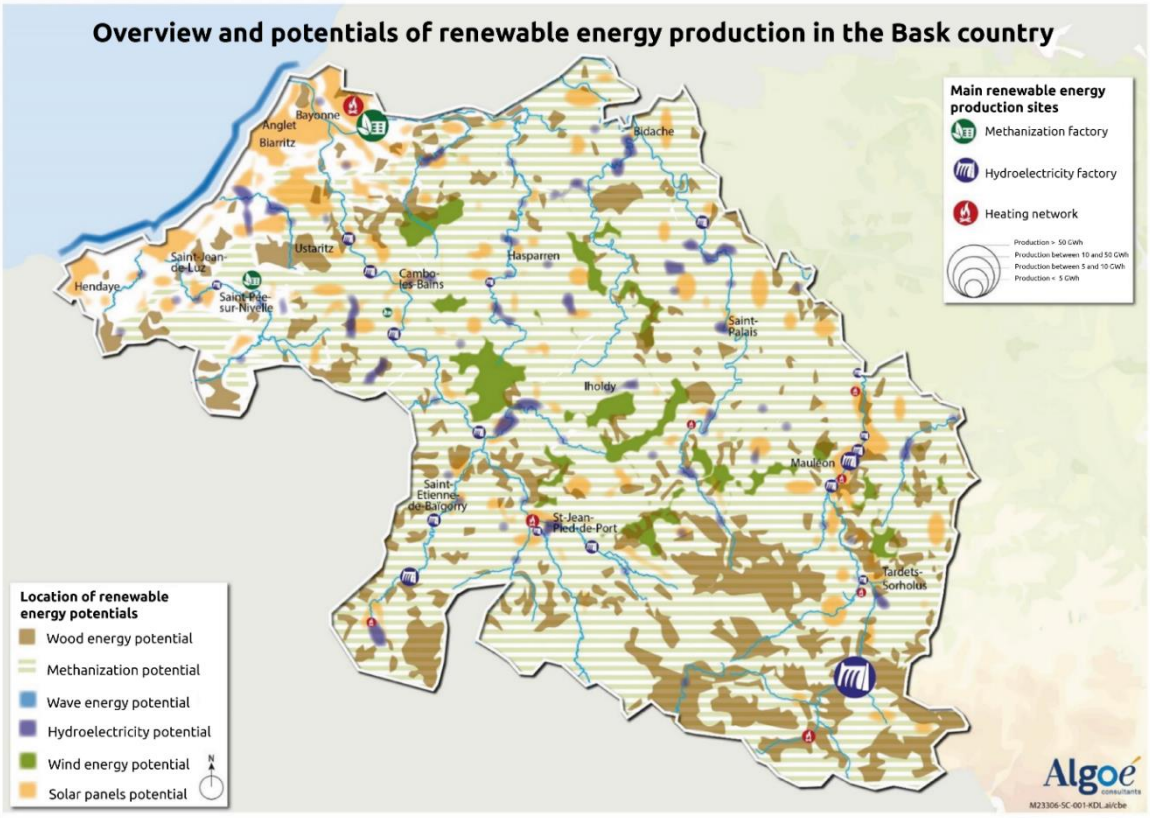


Figure 73. Map of renewable energy potentials
Source: Algoé and PCAET of the Bask country, 2017

2. Urban environment

2.1. Densification of city centers

The denser an urban environment, the less it consumes. Indeed, households next to each other can benefit from the heating of their neighbors and would need smaller energy consumption to reach a comfortable temperature. A dense urban tissue would also be a perfect place to set a heating network, enabling households to be heated with the underground heat.

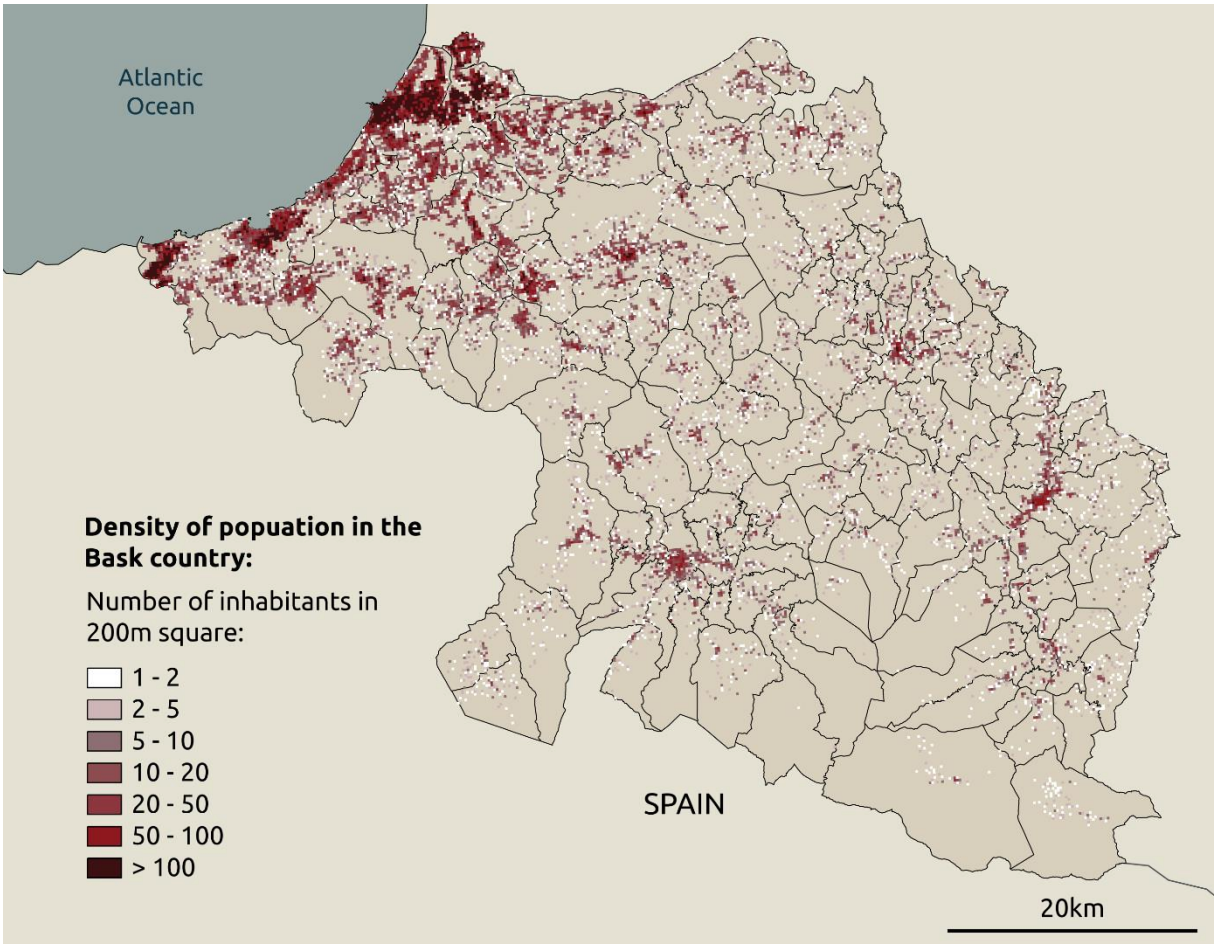


Figure 74. Density of population in the Bask country
Source: Geoportail, INSEE FiLoSoFi 2015

Therefore, collective buildings must be privileged for new construction rather than individual houses.

- **Forbid construction of new individual houses**

Making city centers denser must become a priority. Currently, city centers of many towns in the Bask country are losing dynamism, many living units have been empty for years,

while their surroundings are targeted by foreigners who want to build their secondary houses. City centers must be filled, before building new living units. But then, those must be made more attractive. Cities will in this way benefit from a general regeneration, and gain attractivity.

- **Renovate existing buildings in city centers**

To increase density even more in city centers, the number of living units must also be increased.

- **Add floors above city center apartments**

Saint-Palais study case

To illustrate how to apply all the actions I am proposing, I chose to take the example of the city of Saint-Palais. Saint-Palais is one of the major cities in the interior territory of the Bask country but remains a human-scale city with 1,840 inhabitants in 2018 (INSEE, population census 2018). It is a good example to show how to set up those actions in the Bask environment.

Figure 75. Services' offer in Saint-Palais
Source: own production from Google Maps data

In Saint-Palais, houses are 2 or 3-floors. Adding one floor to some streets of the city center will represent an opportunity for new living units and facilities. It will therefore make the

city denser and enable to provide it with some lacking services. Floors will be added to areas we want to densify first. The central street, where 2 or 3-floors buildings are standing next to each other, concentrates the main facilities of the city: shops, coffees, pharmacy, restaurants, banks, hostels, hairdresser. It is then the perfect place to start the densification while adding one floor on each side of the street. The added floors will preserve the typical Bask architecture that is part of the cultural identity of the territory.

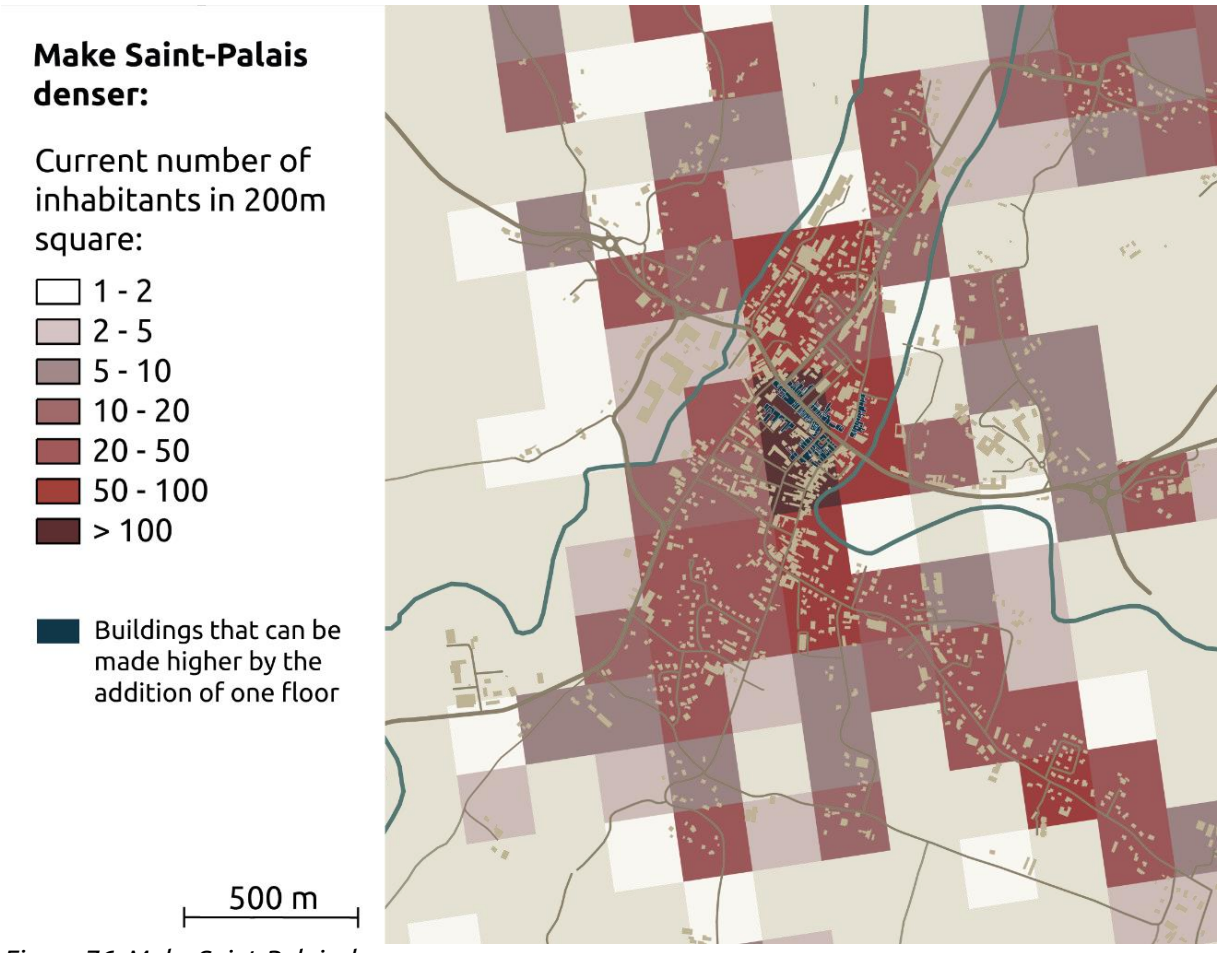


Figure 76. Make Saint-Palais denser
Source: own production usiqng data from Geoportail, INSEE FiLoSoFi 2015

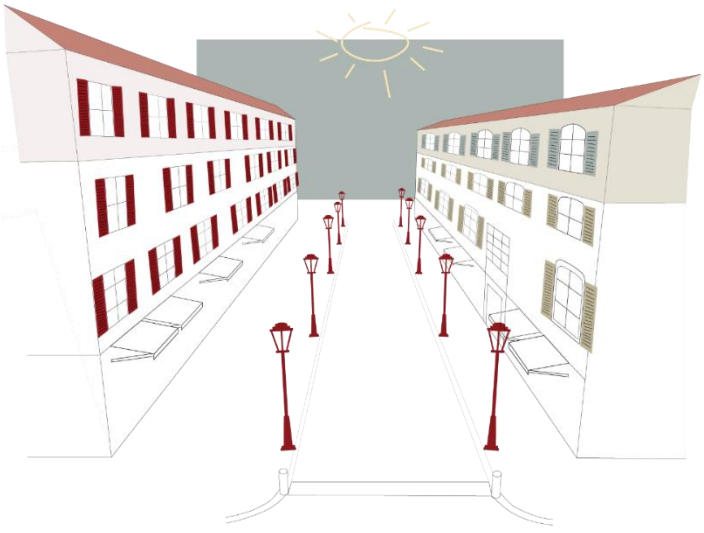


Figure 77. Add one floor to densify in Saint-Palais

Source: own production

It is important to prevent urban sprawl to happen while structuring the city as dense centralities that concentrate living units and services, surrounded by less dense areas which link the dense ones with each other. The scheme opposite shows this targeted urban structure.

Figure 78. Density structure of Saint-Palais

Source: own production

2.2. Make living units greener

For new constructions and renovated buildings, the goal of low energy consumption must be emphasized, in order to reduce the consumption of non-renewable energy by households. Many actions can be carried out to achieve this goal.

- **Have efficient insulation**

According to the Ademe (Agency for the Environment and Energy Management), 30% of the heat escapes from a poorly insulated house through the attic and roof (this is the priority in terms of insulation), 25% through the walls, 10 or 15% through the windows and 7 or 10% through the floors. The thermal insulation project, therefore, takes into account the different elements of the building: walls, doors and windows, roof, floors, and intermediate floors. Insulating the roof and attic is a priority because warm air rises and naturally settles there. For windows insulation, changing them for double-glazing is a good solution. For wall insulation, two options exist: from the inside or from the outside. Thermal insulation from the outside is more efficient, as it limits thermal bridges, and would be chosen rather than from the inside if possible.

The quality of the thermal insulation will strongly depend on the insulation material used. Insulators are classified into 5 groups:

- mineral insulation (cellular glass, glass or rock wool, perlite, vermiculite...),
- synthetic insulators (polystyrene, polyurethane...),
- natural insulating materials of vegetable origin (wood, hemp, flax, cellulose wadding...) and animal origin (sheep's wool, duck feathers...),
- thermo-reflectors or thin insulators
- the so-called "new generation" insulators (monomur brick, vacuum insulation panels, or PIV...).

Depending on the part of the house to be insulated, some materials are more suitable than others:

- walls: cellular glass, rock wool, glass wool, polystyrene, thin insulation, wood fiber, hemp, flax fiber, cellulose wadding, PIV, "monomur" brick, sheep wool
- ceilings: perlite, glass wool, duck feathers, sheep wool, polyurethane, polystyrene
- roofs, attics: perlite, rock wool, glass wool, vermiculite, polystyrene, thin insulation, wood fiber, hemp, flax fiber, duck feathers, cellulose wadding, sheep wool
- floors: polystyrene, thin insulation, wood fiber, hemp, flax fiber, duck feathers, cellulose wadding
- roof terraces: cellular glass, rock or glass wool, polyurethane, polystyrene, perlite, green roofing

- **Have a heating system using electricity or renewable energy (heating network for instance) for heating system, rather than fuel or gas**

- **Encourage inhabitants to make insulation or heating system renovation in their house thanks to a financial compensation**

2.3. Circular metabolism of buildings materials

In material flow analyses, building and urbanization are considered a net addition to the territory's stock. Indeed, this implies the use of construction materials that are often imported and that are destined to remain on the territory. Imports of these materials are often unavoidable because new constructions use a variety of materials that cannot all be extracted locally.

- **Choose building materials that are locally produced if possible and have a small ecological footprint**

However, more and more research is emerging on the recycling, reuse, and repurposing of construction materials. These three terms refer to three ways of giving a second life to a construction material:

Recycle: the material has been crushed to reconstitute raw material.

Reuse: the degraded material has passed through the status of waste and then finds a new use, different from its initial use.

Repurpose: the material finds a use identical to the one it used to have, it is taken back as it. [39]

This is also called "urban mining". It is a way of conceiving the city as already full of material that can be used, and of building only with what is already in the city.

Since 2015, Plaine Commune, a territorial public establishment that includes nine municipalities in Seine-Saint-Denis (near Paris) and nearly 400,000 inhabitants, has embarked on a process of recovery and reuse of construction materials. This approach aims to circularize urban metabolism, to limit imports as much as possible. This is a particularly important issue, as major changes are already planned in the area, particularly with the construction of infrastructure for the Paris 2024 Olympic Games. This undertaking also aims to develop a methodology to facilitate the reproduction of this approach in other territories. This begins with a diagnosis of the urban mine, of what the territory already has, and how it can be reused. Then, it is necessary to trace the in- and outflows of materials, match them, and establish links between the sites.[40]

In the Bask Country, some municipalities are under pressure to build new housing and services. This is strongly questioned on the territory. To this extent, the territory could draw inspiration from the work of the Plaine Commune, and build such a circular metabolism of building materials, that would limit waste and importation of brand-new materials.

3. Mobility

Today transportation is the second most important GHG emitter in the Bask country, due to the efficiency of public transportation that is not able to meet the population's needs. The polarization of the territory, concentrating activities around the city of Bayonne is also responsible for too many and too long work-home journeys every day.

3.1. Make working and living places closer

A first strategy is then to reinforce the role of medium cities throughout the territory and develop their more tertiary and industrial activities. By creating jobs in remote cities, the polarization of the territory will be reduced.

- **Open offices in medium cities of the interior territory**

Moreover, the COVID pandemic has introduced new ways of working, it is now quite common to work from home a few times a week. In territories like the Bask country with important daily work-home journeys, this constitutes a real manner to reduce GHG emissions due to mobility. To promote work from home, places offering good working

[39] « La ville du réemploi », interview of Aniss Tlemsamani, dixit.net, 2020
[40] « Impulser le métabolisme urbain », interview of Justine Emringer, dixit.net, 2021

conditions should be developed, because people do not have necessarily a good living environment that enables them to work well.

- **Open coworking areas offering good office furniture, good internet connection, areas to isolate oneself, and others to work in teams**

3.2. Make people want to live in remote places

This also requires attracting people to these cities, by improving the general quality of open spaces in medium remote cities. It has been proven that adding green to cities increases the feeling people have about it. People feel safer and more comfortable. All the more so as shadows created by trees reduced the heat island effect during summer, and impervious surfaces help rainfall water to go back to underground paths and follow the natural water cycle that has been broken because of soil artificialization. Thus, making cities greener has social and environmental benefits.

- **Add trees and vegetation in cities**

- **Make sidewalks and car parks impervious**

All of that will increase people working close to their living place and rebalance the territory's structure by highlighting the role of other cities than the coastal ones. But it will not prevent all journeys from remote places to the coast.

3.3. Change mobility means

Other opportunities to travel within the territory should be offered, addressing the needs of workers, going to work to the coast from the interior country, but also the tourists' ones. Much green mobility should then be fostered. There is a necessity to build a more efficient public transport network to reduce car use. Moreover, trains with electric motorization are way less carbon emitters. Their use should be encouraged.

- **Open new regular bus lines connecting cities, whatever their territorial importance**

- **Increase the number of trains traveling on the Bayonne – Hendaye, and Bayonne – Saint-Jean-Pied-de-Port sections**

- **Open a new railway line between Bayonne and Mauléon-Licharre, passing through Hasparren and Saint-Palais**

I imagined a bus network connecting all the main cities of the coast and of the interior, as well as minor suburban cities surrounding Bayonne, where many commuters live and travel daily to their workplace on the coast. Special attention must be put on those suburban cities if we want to limit the use of the private car, in aid of public transportation.

The design of this new bus network will allow connecting cities as detailed below in a relative short amount of time.

Travel time in minutes	Bayonne	Anglet	Biarritz	St-Jean-de-Luz	Hendaye	Mouguerre	Villefranque	Bassussarry	Ustaritz	St-Pée-sur-Nivelle	Ainhoa	Espelette	Cambo-les-Bains	Hasparren	Bidache	St-Palais	Iholdy	St-Martin-d' Arrossa	St-Etienne-de-Baïgorry	St-Jean-Pied-de-Port	Mauléon-Licharre	Tardets-SorholuS
Anglet	10																					
Biarritz	15	10																				
St-Jean-de-Luz	40	35	25																			
Hendaye	60	55	45	20																		
Mouguerre	10		25																			
Villefranque	15		35																			
Bassussarry	15		15	25	50		20															
Ustaritz	25		45	40			10	30														
Ste-Pée-sur-Nivelle	35		25	20	30			20	20													
Ainhoa	50		40				40	35	30	15												
Espelette	45						30		20		10											
Cambo-les-Bains	35		55	40			20	40	10	20	20	10										
Hasparren	35		55	60			20	40	20	40	35	25	15									
Bidache	35		50			25					60	50	40	25								
St-Palais	45		70	95		35			55	75				35	20							
Iholdy	60		80	70			45	65	40	50			30	25		20						
St-Martin-d'Arrosa	60		80	65				65	45	45			25									
St-Etienne-de-Baïgorry	75		95					80	60				40					15				
St-Jean-Pied-de-Port	75		95	80			70	80	60	60			40				25	15	30			
Mauléon-Licharre	70		95	115		60	90	120	80	95			75	70	45	25	45			40		
Tardets-SorholuS	85		110			75									60	40					15	
Ste-Engrâce																		75	90	60	40	25

Table 20. Travel time between main cities with the new bus network
Source: own production, Google maps

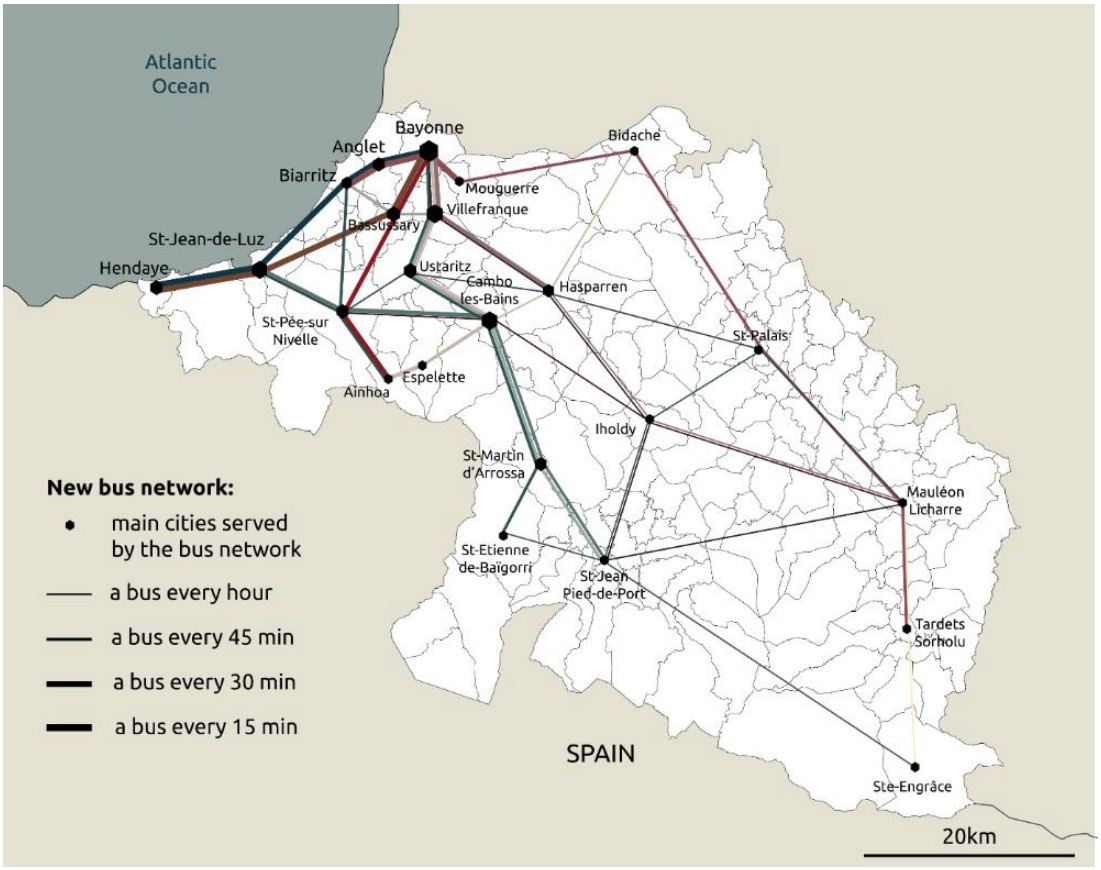


Figure 79. New bus network
Source: own production

Figure 80. New railway network
Source: Own production

But the bike and walking should also not be left behind. Their benefit for human health is another reason to encourage them.

- **Build safe bike lanes in cities**

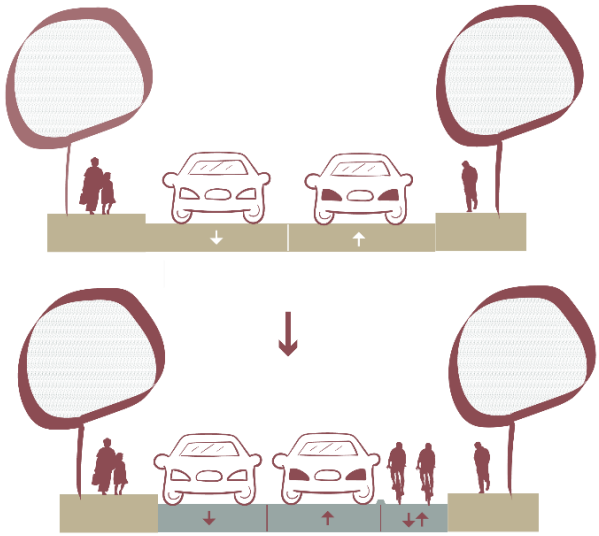


Figure 81. Example of street adaptation to bike lanes

Source: own production

Adding a bike lane implies narrowing the space for cars. This has also advantages on safety, as cars have to slow down when they cross each other. In addition, changing the road's aspect can have an impact on how drivers perceive it and therefore on the speed they will have on it. To secure even more the bike lane, a small separation can be made.

In Saint-Palais, the streets concerned by the addition of a bike lane are two-way, like the scheme above. They are more or less narrow, allowing to have more or less space for the bike lane.

- **Build a bike lane network connecting cities and allowing to appreciate the landscapes of the Bask country**

Outside cities, bike lanes should be completely separated from the road for safety reasons, as cars go faster.

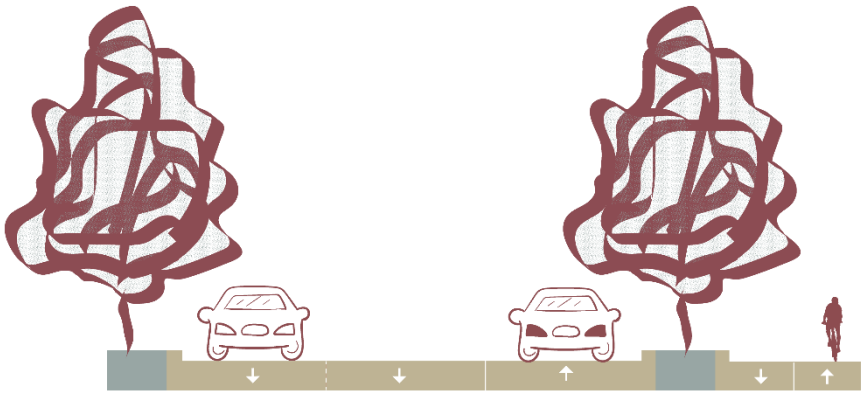


Figure 82. Bike lane outside cities

Source: own production

- **Limit cars in city centers, with car-free neighborhoods and car parks well located**

- **Promote the walking city with main services located in a circle of 500m, bigger infrastructures of entertainment and sport can stand in a circle of 1km**

- **Promote car-sharing while developing an app connecting people that make similar journeys, and building car-sharing areas where they can meet each other**

- **Encourage use of low-consuming cars: electric or hybrid cars with a financial bonus given to people owning one**

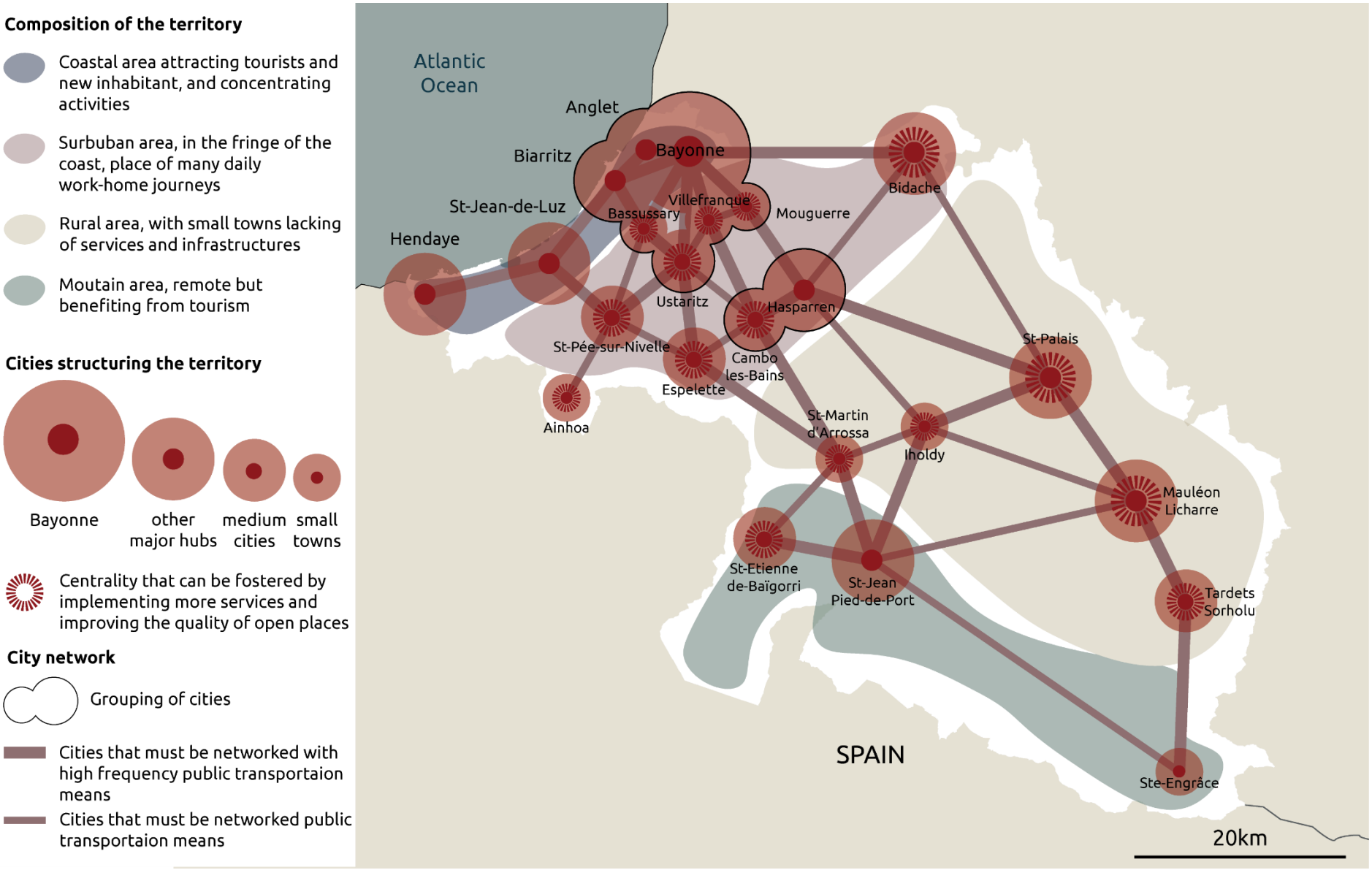


Figure 83. Mobility strategies for the Bask country
Source : own production

Saint-Palais study case

In Saint-Palais, we can forecast to make the central street pedestrian, the rue Thiers. Currently, this street is very narrow and one-way. Traffic is already not easy, and cars must most of the time use another journey to cross the city. As it is a shopping street, it is already a lot used by pedestrians, but nowadays sidewalks are narrow and the experience of crossing this street by foot is not enjoyable. Making this street fully pedestrian will create a feeling of safety while walking. It will also offer opportunities for new urban squares.

Figure 84. Saint-Palais study case
Source: own production

The rue Thiers will then encounter a real regeneration. This pedestrian street will also offer the space for a bike lane, thus fostering all soft mobilities. Car parks located not so far will enable people living further to come to enjoy this experience. Also, as this street is the heart of the city, it will be the perfect place to settle a coworking area, in a formerly abandoned building. It is also the opportunity to bring more vegetation to the city. And, as announced in the previous part, buildings on the street will be made higher by the addition of one floor preserving the original architecture.

Figure 85. View of Rue Thiers in Saint-Palais after regeneration.
Source: own production

4. Agriculture: toward food autonomy

4.1. An agriculture that emits less GHG

Agriculture is the Bask country is responsible for 38% of the greenhouse gas emissions. Many things can be done to reach an agriculture more respectful of its environment, not only by reducing the emissions but also by producing better products.

Today, the use of fertilizers emits nitrogen oxide into the atmosphere and also pollutes soils and underground water. It is a whole ecosystem that is fragilized by the excessive use of such products. The bio-agriculture is trying to put an end to those practices while stopping using fertilizers. It is also recommended to have covered soils continuously because soils are storing carbon that can be freed while moving the ground. Soil covering allows to fix carbon particles into the underground and prevents extra GHG emissions. In addition, growing vegetables in open fields has an impact on the climate on average nine times less than in the greenhouses. Concerning livestock, extensive breeding is better for the environment as well as for the animals than intensive breeding.

- **Communicate about those practices and their advantages to farmers**

- **Give a financial bonus to farmers using environment-friendly practices**

To encourage farmers to change their practices, it should be offered to them also services that help them sell their products

- **Connect bio farmers with grocer's shops**

- **Give them discounts on the rent of local market spots**

4.2. A circular metabolism of agriculture

Today, breeding animals and growing vegetables, fruits or cereals require a certain amount of intrants. Water and energy are needed, as well as fertilizers, hay, and other food for animals. Those products are mainly imported. According to data collected thanks to the Port of Bayonne, in 2019, 419,128 tons of fertilizers of various types have been received and redistributed throughout the territory. In 2015, the Climagri report estimated the in- and outflows generated by the Bask farm (see next page's figure).

Importation of such quantity has necessarily an impact on the environment, as its transportation emits GHG emission. In a logic of adapting the territory's metabolism to become more environment-friendly, those importations must be reduced. This can happen thanks to the reduction of intrants needed (for instance fertilizers as it has been seen in the precedent paragraph), but also thanks to a local production of them.

- **Foster local production of biofertilizers and food for animals**

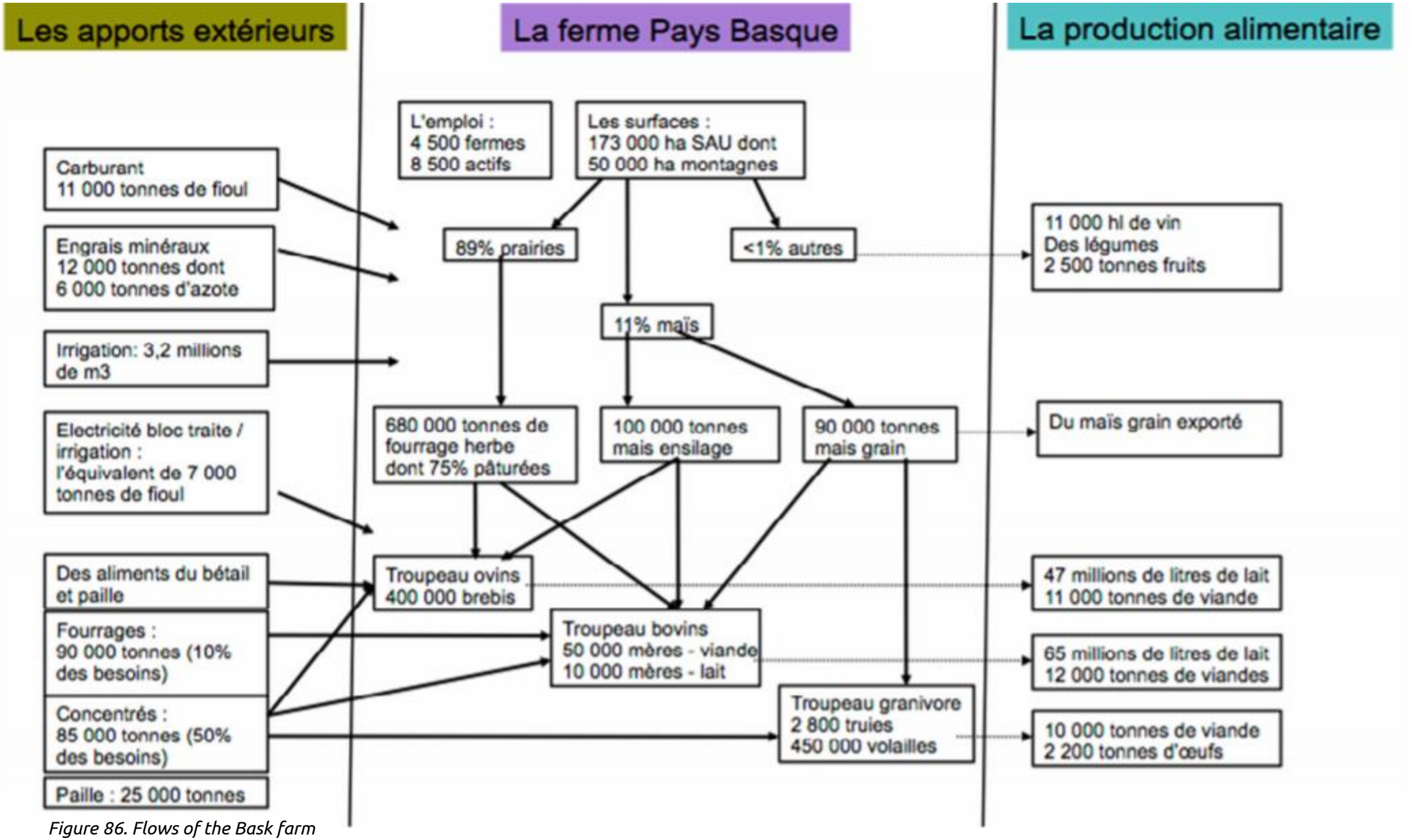


Figure 86. Flows of the Bask farm
Source: Climagri, Study for a climate-energy strategy of the agricultural and forestry sectors in the Bask country – EHLG and Solagro, 2015

4.3. Change the population food habits

Nowadays, around one-quarter of a person's environmental footprint is due to their diet. Certain foods are more impacting the environment than others because they require a huge amount of water and space to be produced (e.g., meat). Livestock uses indeed one-third of Earth's fresh water and covers 45% of the Earth's total land. Moreover, livestock is therefore responsible for desertification (1/3 of land is desertified due to livestock) and deforestation (91% of deforestation is due to breeding). It has been calculated that a vegan diet requires half less water, 18 times less land, and has a carbon footprint divided by two[41]. Other products also arrive at the top of the biggest footprint because they are produced on the other side of the globe, and their import by plane or boat is emitting a lot. Chocolate and coffee are for these reasons among the worst food consumption for the planet.

To reduce the environmental footprint of the Bask country and achieve the goal of the 2000-watt society, it seems obvious that effort must be made concerning food habits. The Bask Country benefits from a rich agriculture that produces every year food products (meat, dairy products, eggs, fruits and vegetables, corn, wine) and it must be taken as a strong tool to address this issue. Currently, the Bask food production is dedicated partly to the needs of the territory. But a relevant part of this production is also intended for export. With the objective of creating a better metabolism for the Bask country, the notion of food autonomy seems to be a key. It is a question of privileging the consumption of local products, compared to imported products. Farmers would rather sell their products on the Bask territory than export them. Thus, outflows are also reduced, and meanwhile, the GHG emissions linked to them.

To achieve this goal, it is necessary to make easier the meeting of local products with consumers, while building a path from production to consumption places.

- **Organize a shuttle collecting farm's production and bringing them to groceries**

- **Open grocer's shop only dedicated to those products in many cities throughout the territory**

Shuttles will go to most remote places to collect the products and prevent farmers to make the journey. As much as possible, the distribution of food will be made thanks to the railway, as it emits less. They will then distribute them in grocery shops dedicated to local products. Those shops will be in city centers of the main urban areas, but also in smaller towns of the interior country. The aim is of making those products accessible for any inhabitants of the territory wherever he lives.

A new balance must also be found in what is produced locally. To better address people's needs, the production should reflect what people eat. Thus, the production of meat is certainly too relevant currently, and should be lower to privilege fruits, vegetables, or animals' foods production. All the more so as, as we said before, the reduction of global meat consumption will have numerous benefits for the planet. The reduction of meat production will leave space for other production. In particular, the fruits and vegetable productions are not today sufficient in the territory to meet its population's needs. These

[41] WWF

types of production should take place in non-mountainous areas, that is to say in the North part of the territory. Eggs production could also be increased.

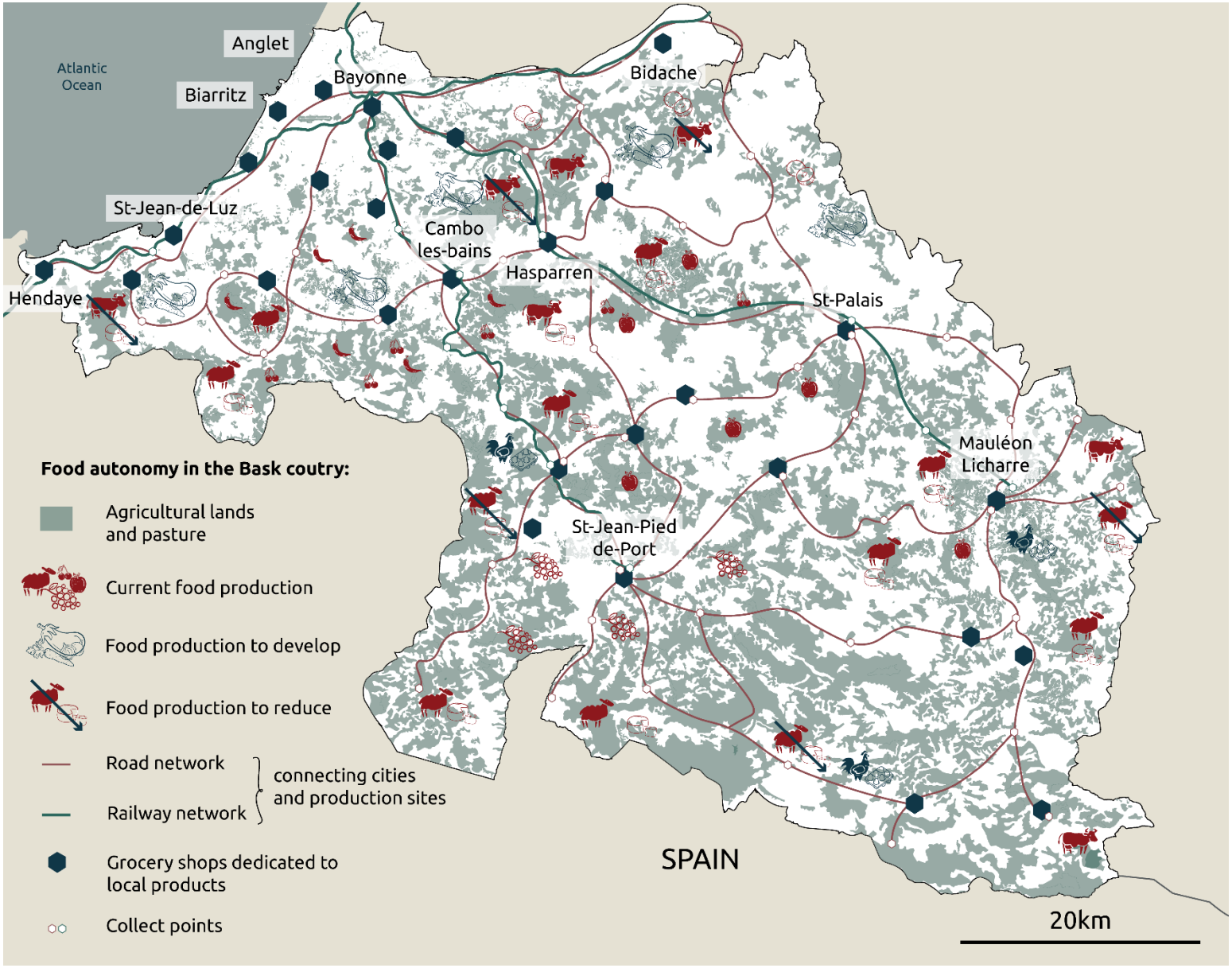


Figure 87. Food autonomy in the Bask country
Source: own production using EHLG and Chamber of agriculture data for current food production

Conclusion

This work brought me to explore the French Bask country, a territory in the South-West corner of France, bordered by the Atlantic Ocean and the Pyrenees' mountains. It is a territory well known in France as a vacation spot. Myself I went there for the first time for three days-vacation with my parents when I was a teenager. But more and more, the Bask country is also considered a real place to live. The Covid pandemic has changed the way people want to live, and many inhabitants of big metropolises now seek for a smaller scale life and take the opportunity of working from home to move to cities with more open spaces. The Bask country has then been targeted by new users, who come for a short stay or want to invest in the built heritage. Bayonne has by the way been elected in 2022 third most pleasant city in France.

But this increasing attractivity is creating issues and protests on the territory. The increasing demand for real estate is making the prices soaring. Cities are under pressure for building new residential units and services, with a significant environmental footprint, and agricultural lands are also finding themselves under the pressure of being turned into residential units.

The Bask country, with its strong cultural identity - language, sports, festivities, etc. – is not looking favorably to the changes the territory is undergoing. The touristic attractivity being concentrated on the coast, all the focus is given to this part, neglecting then the rest of the territory. A gap is widening between these two parts of the territory. The coast is told by the inhabitants of the interior of losing its identity and authenticity as more and more non-Bask rich people are settling there, pushing the Bask ones out of their land. The Bask people are claiming a rebalance of the relevance we give to the territory.

Giving relevance back to smaller towns of the interior would have benefits for the living population, but also to the environment. Indeed, today this polarization of the territory is the reason for many daily work-home journeys throughout the territory, as jobs are highly concentrated on the coast, and especially around Bayonne. This feature, in addition to an inefficient public transportation offer, explains why 82% of workers use their car daily to reach their workplace.

To solve those issues, a complete reconsideration of the territory's structure is needed. Metabolist approaches are new ways to look at a territory, taking into account not only how it is built, but also how things and people move in relation to the territory, and what moves the territory is creating to address its needs. This approach enables us to consider environmental issues, because pollution, greenhouse gas emissions, and waste are seen as results of the territory's functioning. I chose this approach for that: it enables to consider both needs of the territory to identify them and adapt the functioning to them, and the environmental footprint the territory has.

Working therefore on the concept of territorial metabolism and its adaptation to sustainability, I develop a new vision for the territory that will strengthen its identity and give priority to its population rather than to its touristic development. Going further, the various features of this strong identity will serve this intern development, while fostering a circular economy.

Thus, a new public transportation system is planned in order to enhance the use of greener mobility and reduce the one of cars. While developing smaller towns and making them also places of work, and not only places to live, I aim to limit long work-home journeys and put

the attention also on the interior part of the Bask country. Improving their outdoor quality will encourage people to settle there and not consider only on the coast. This will in addition enable densifying those cities, which has environmental advantages because it will lower energy consumption. Finally, agriculture, as a rich asset of the Bask identity, will be remodeled. Today Bask products are traded everywhere in the world and contribute to its renown. But they could be first of all dedicated to the territory's need: this will foster the identity, reduce food's footprint, and approach food autonomy.

To conclude, this work enabled us to understand deeply the functioning of the French Bask country, to identify its strengths as well as its weaknesses, and demonstrate how the metabolism can be used to solve the issues a territory is facing. Here we used territorial metabolism as a catalyzer for strength, which also acts to decrease the weaknesses.

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