Barcelona, a city committed to combating climate change

Ajuntament de Barcelona

Environmental Report **2013**

Introduction

This document covers the state of the environment in Barcelona, described in twelve chapters focusing on different aspects.

Each of these chapters defines the vision of the future for the city in its specific area, providing indicators and information on the present situation and listing the measures carried out in the last five years which have made it possible to get as far as we have. They also contain a statement of the measures already planned or envisaged for the near future which will help us to progress towards the vision of the future we aspire to.

The report does not provide an exhaustive compilation of the activities carried out but highlights the most relevant ones, either because they've brought about progress in environmental terms, because they enable us to understand how the city has developed or because they've made a great impact on citizens and good practices. It therefore contains some innovative, singular and emblematic measures which may also serve as inspiration for other cities. These are represented in the report in different ways depending on the type of measure in question.

The information provided is mainly on the work done by Barcelona City Council but, since many environmental aspects lie outside municipal competences, some of the data refer to other supralocal administrations as well as citizen involvement.

As far as possible, the content follows the guidelines laid down by the organisers of the European Green Capital initiative but it also provides details of other aspects that are considered to be priorities for the city, such as the vision for the future, work carried out with citizens, organisations and companies on a co-responsibility basis and the Smart City approach.

Compared with the previous report, this time we've attempted to bring in certain improvements by including graphics summarising each of the chapters, making it easier to read for those who only wish to leaf through, and by adding links to the most relevant sources of information throughout the document so that readers can read further on the topic. As in the previous edition, there is also an executive summary report.

Types of measures

- Planning and management
- Tools and actions in general
- Cooperation, international work, sharing experiences
- Improving knowledge, information, awareness and participation

Barometer 2013

Region

02º 07’ 31’’ E longitude

41º 25’ 10’’ N latitude

412 m above sea level

10,216 hectares municipality

158 inhab/ha density

29.10 km² green areas

4,395 m beaches

Climate

15.8 ºC annual average

35.1 ºC maximum

-1.6 ºC minimum

2,776.4 hours of sunshine per year

967.0 hPa average

987.2 hPa maximum

932.6 hPa minimum

69 % relative humidity

580.0 mm total

40.2 mm maximum rainfall

112 days of rain

9 days of storms

Population

1,611,822 inhabitants

4,788,422 inhabitants in the metropolitan region

82.6 % population Spanish

17.4 % population foreign

83 years life expectancy (2012)

8.2 birth rate

9.2 death rate

7,571,766 tourists

16,485,074 overnight stays

Social indicators

€18,700/year
disposable household income per capita

18.3 %
at risk of poverty (2011)

89.09 %
secondary education rate (2012-2013)

78.5 %
households with internet access

Economic indicators

€38.500
average GDP at market prices per inhabitant Base year 2000 (2013)

17.7 %
unemployment

78.0 %
participation rate

64.2 %
employment

Environmental indicators

18.1 m²/inhab
green areas

✓ *2003 - 17.39 m²/inhab*

16,782 GWh
total energy consumption (2012)

✗ *1999 - 15,664.78 GWh*

108.4 l/inhab per day
domestic water consumption

✓ *1999 - 137.5 l/inhab. per day*

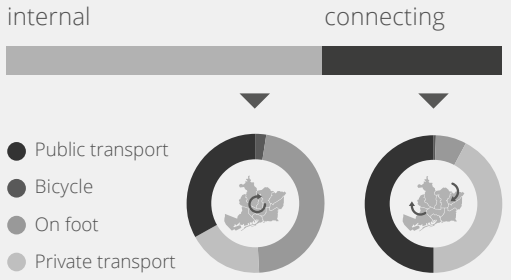
730,285 tonnes
urban solid waste

✓ *2003 - 860,338 tonnes*

36.2 %
separated waste collection

✓ *2003 - 23.95 %*

7.7 million
trips per day

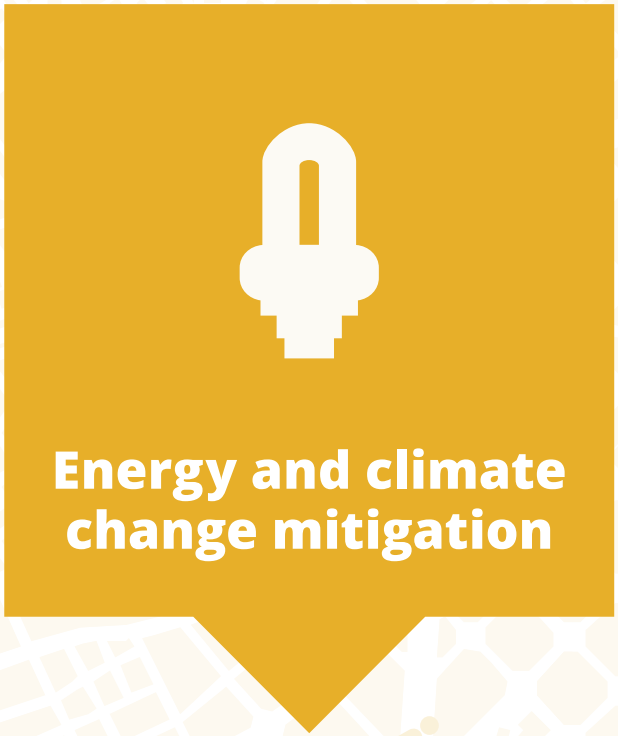


40 micrograms/m³
average annual level of NO_2

✓ *2003 - 55 micrograms/m³*

24 micrograms/m³
average annual particle level (PM_{10})

✓ *2008 - 36 micrograms/m³*



Energy and climate change mitigation

Barcelona, a city committed to combating climate change

Energy and climate change mitigation

Vision of the future

Becoming a self-sufficient city with zero emissions

Current situation

Final energy consumption (2012)

16.782 **GWh**

10.35 **MWh** per capita

Self-sufficiency

1999 **0.33 %**

2012 **2.08 %**

CO_2 emissions (2012)

1999 **3.19** **tonnes de CO_2** per capita

2012 **2.28** **tonnes de CO_2** per capita

Lines of work

Committed to combating climate change 'Signing of the Covenant of Mayors'

Innovation 'Electrifying vehicle fleets' 'Smart street lighting'

Self-generation 'Solar on new and renovated buildings' 'Renewable energies in municipal buildings'

Efficiency 'HVAC networks taking advantage of residual cold and heat'

Self-sufficiency and reducing emissions 'Energy Self-Sufficiency Plan'

1.1 Vision, challenges and opportunities

Vision of the future

In the fight against climate change, Barcelona wishes to become a self-sufficient city with zero emissions. That's why we need a change in the energy model to ensure guaranteed sustainability. To achieve this, we need to make progress in three key aspects: significantly reducing demand and consumption (savings and efficiency), increasing the generation of energy by means of local resources (renewable and residual sources) and thereby reducing dependence on fossil fuels, and optimising the networks of infrastructures already in place.

On its way to self-sufficiency and zero emissions, Barcelona needs to take advantage of the opportunities provided by aspects intrinsic to the city such as its mild climate, at the same time as having to overcome the challenges and difficulties involved in being a major economic force and complex urban area.

- **Barcelona, a densely populated Mediterranean city.** The city's 'Mediterranean character and its mild climate make life easier in terms of energy consumed for heating and its density helps us to take advantage of each kWh used for more people, unlike other cities. For these two reasons, Barcelona has a moderate energy consumption in comparison with other conurbations.
- **The urban heat island effect makes temperatures rise.** Despite the city's benign weather thanks to its Mediterranean climate, Barcelona's temperatures are rising, mainly through the heat island effect. This effect (which consists of a rise in temperatures in urban zones because of the heat retained in the paving and buildings) leads to changes in energy habits of those living in Barcelona, with a lower use of heating in housing, offices and services during winter but an increase in the use of air conditioning throughout the summer.
- **Barcelona, one of the country's major economic and tourist centres, the hub of a great deal of activity.** Barcelona's strategic location in the centre of the Mediterranean corridor and with one of the most important ports in the Mediterranean makes the city a great economic centre and transit zone. In fact, Barcelona's area of influence is not only the metropolitan area or the metropolitan region but practically the whole of Catalonia. Producing this enormous amount of activity requires significant energy consumption and greenhouse gas emissions are further aggravated by mobility.
- **Barcelona, a city of great social and multicultural complexity.** Even though the migratory process has been interrupted by the present economic situation, Barcelona is a highly diverse and complex city and has become home to a mix of very different cultures. This is something to be taken into consideration when assessing the city's trends in energy consumption as social conduct in terms of energy use is very closely associated with a society's energy consumption and each culture often perceives the use of energy differently.
- **At present there is no law supporting the use of renewable energies** by means of incentives and/or tax rebates as a result of the enactment of Royal Decree 1/2012, which abolished economic incentives for new electricity production installations under the special regime (for cogeneration, renewable energy sources and waste treatment).

1.2 General context and current situation

For years Barcelona has been committed to combating climate change, which is why energy management ⊕ and the reduction of greenhouse gas emissions are priorities on the city's political agenda.

Even so, Barcelona has the same underlying problems as many other cities: its energy consumption may be relatively low but it's still high overall as a whole and the sources of the energy consumed could be improved, with only 1.87% of all primary energy consumed coming from a renewable source. Barcelona must therefore reduce its dependence on external energy sources and foster local, renewable energy on a network basis; i.e. increase its self-sufficiency.

1.2.1 Electricity and natural gas, the main sources of energy

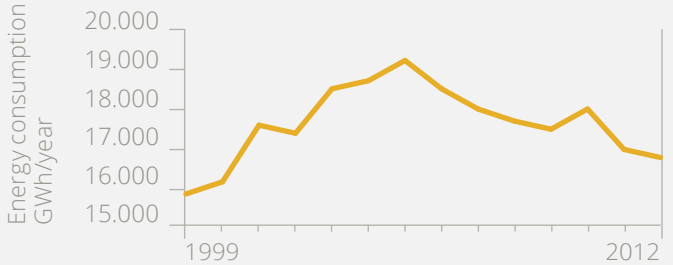
Over the last few years there has been an upward trend in energy consumption with consumption going from 15,664.78 GWh in 1999 to 18,036.88 GWh in 2010. This rise, however, has not been constant as the growth rate was in excess of 3% until 2005 whereas consumption gradually fell between 2005 and 2010, the year when it started to rise again. In 2012 total consumption stood at 16,782 GWh.

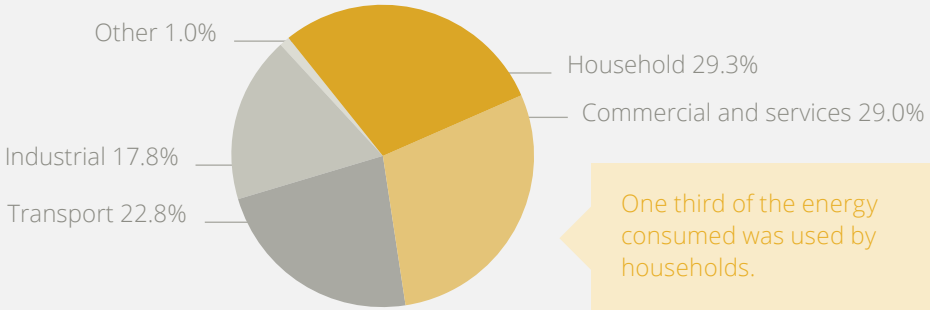
In 2012 the city of Barcelona's consumption per capita was 10.35 MWh/year

One third of all the energy consumed in 2012 was used by households: 29.3%, a further third being used by the commercial and services sector, with 29.0%. The remainder was used by industry (17.8%), transport (22.8%) and other sectors (1.0%).

As regards energy sources, 42.68% was electricity, 35.51% natural gas, 20.69% automobile petroleum and 1.12% Liquefied Petroleum Gases (LPG).

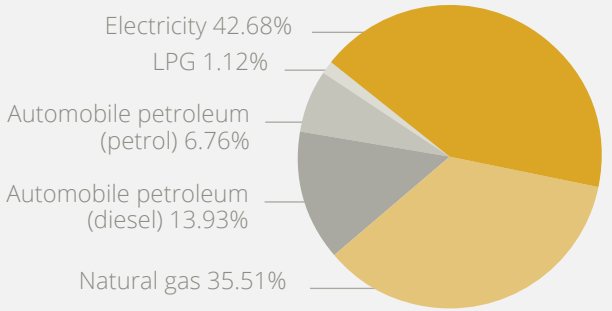
From 1999 energy consumption gradually increased until 2006, at which time it started to drop, except for 2010, when it rose once more





One third of the energy consumed was used by households.

In 2012, most of the energy consumed came from electricity and natural gas.



According to Catalonia's electrical mix for 2012 the energy source with greatest share of electricity generation is nuclear energy (55.42%). This is followed by generation in the form of natural gas at combined cycle power plants (16.17%), cogeneration (12.02%), hydroelectric generation (8.96%), wind power (5.15%) and other methods (2.28%).

In Barcelona's final energy consumption in 2012 this electricity consumption accounted for 42.7% of the total consumption. In terms of the source of the final energy consumed in Barcelona, 42.4% of the total final energy was produced by natural gas, 23.7% nuclear, 20.7% came from fossil fuels, 3.9% from hydraulic power, 5.1% from gas cogeneration, 2% from wind power and 0.3% from solar energy. It should be noted that, in 2008, solar energy represented 0.1% and wind power 0.6%.

Considering Spain as a whole, electricity was mainly generated by nuclear energy (22%), coal (20%) and wind power (18%). Other sources of energy are combined cycle power plants (14%), cogeneration (12%), and hydraulic power (9%).

In Barcelona and the Besòs area in 2012, 5,612 GWh of electricity was generated by large Ordinary Regime power plants, accounting for 78.3% of the electricity used in the city's final consumption. This highlights the continuing great dependence on fossil fuels. Even though there has been an improvement in electricity production facilities, emissions from electricity consumption have continued to grow due to the rise in consumption since 1999.

However, we should also note the progress made by the city of Barcelona in increasing the existing photovoltaic power, for example. This has gone from 2.5 kWp installed capacity in 1999 to 12.388 kWp in 2012.

1.2.2 The city's renewable and residual resources are growing

In 2012, around 350 GWh/year of the total energy consumed in the city of Barcelona came from renewable and/or residual energy from local sources, a share of 2.08%. Though small and clearly insufficient, this amount is still considerable, taking into account the starting point of 0.33% in 1999, involving a sizeable change after the first Energy Plan.

In 2012 Barcelona's self-sufficiency level, meaning the energy generated from local (renewable and residual) resources, as compared with the total energy consumed, was 2.08%.

0.8% of the energy consumed was renewable and generated locally, i.e. in the city itself. This 158.37 GWh/year of renewable energy was generated as follows:

Thermal solar energy: 49%
Photovoltaic solar energy: 10%
Biogas (inc. Garraf share): 32%
Mini hydraulic: 2%
Biomass: 8%

As far as electricity is concerned, 225.59 GWh of the city's total electricity consumption is considered to have been produced using local (renewable and residual) resources, which represents 3.15% of the electricity consumption of the city, 7,162.8 GWh.

Today Barcelona is one of the cities with largest area of solar panels (88,755 m^2 planned) and it has legislation making it compulsory to use solar energy in any new builds and restoration work. As regards photovoltaic solar energy, Barcelona has 12.39 MWp installed capacity.

1.2.3 Barcelona, one of the cities in the western world with the lowest emissions per capita

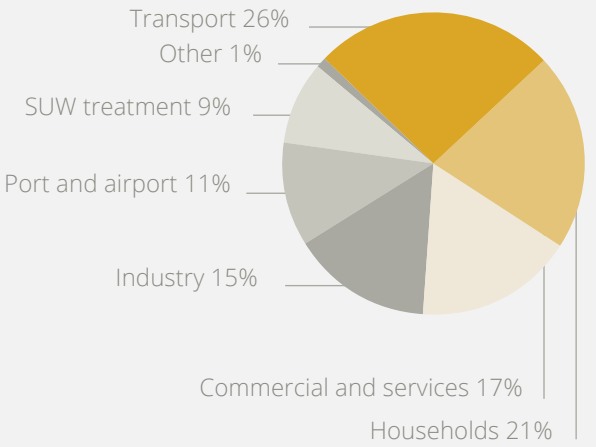
Barcelona is one of the cities with lowest greenhouse gas (GHG) emissions per capita in the western world. The efforts made to combat climate change, with measures to improve energy efficiency and savings and to promote renewable energy sources, are being rewarded with low levels of emissions.

In 2012 Barcelona emitted a total of 3,690,037 tonnes of CO_2, representing 2.28 tonnes CO_2-eq per capita, notably lower than the emissions rate in 1999 which was 3.19 tonnes CO_2-eq. From that year there was an upward trend until 2005, when it reached its ceiling with 3.44 tonnes CO_2-eq, and since then the trend has changed direction, turning downwards.

These emissions are mainly produced by the transport sector (26.46%), followed by households (21.45%) and the commercial and services sectors (17.28%). The rest is divided between industry (14.48%), the port and airport (10.93%), the processing of solid urban waste (8.88%) and other sectors (0.53%).

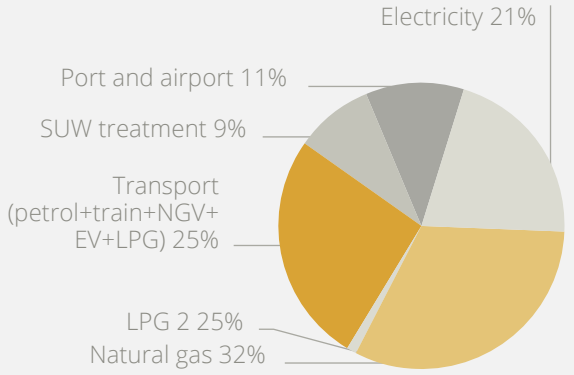
As for sources, 31.5% of the emissions stem from natural gas, 26.46% from transport, including petrol/diesel and electric vehicles (electric trains, natural gas vehicles, electricity for electric vehicles and liquefied petroleum gases) and 21.03% from electricity. The rest is emitted by the port and the airport (10.93%), by the processing of solid urban waste (SUW) (8.88%) and by liquefied petroleum gases (LPG) (1.15%).

In 2010 the emissions per capita produced by transport in Barcelona were 0.59 tonnes of CO_2/inhab. In 2012, greenhouse gas emissions from the consumption of energy were 0.219 kg of CO_2-eq/kWh final energy consumption.



In 2012, transport, followed by households, was the sector producing most emissions.

In 2012, natural gas was the energy source producing most emissions.



1.3 Measures taken to reduce energy consumption and mitigate climate change

True to its commitment to climate change mitigation, Barcelona has taken different planning measures over the last few years to create a general framework and route map marking out the strategic lines to be taken. It has also implemented energy-saving and efficiency measures and promoted the generation of renewable and local power.

1.3.1 Commitment and planning to combat climate change

Signing of the Covenant of Mayors in 2008

On 19 November 2008 Barcelona signed the Covenant of Mayors, once more taking part in the lobby of cities committed to combating climate change. As signatory, Barcelona City Council has undertaken to reduce, by 2020, the greenhouse gas (GHG) emissions of all services under its direct management by 20% compared with the emissions for 2008.

As a result of signing the Covenant of Mayors, Barcelona drew up its own Barcelona Action Plan for Sustainable Energy (PAES). This Plan covers all spheres of action under municipal rule and applies across the board to all areas involved in city and municipal administration. This action plan forms part of the Energy, Climate Change and Air Quality Plan 2011-2020 (PECQ).

Energy, Climate Change and Air Quality Plan 2011-2020 (PECQ)

This Plan reinforces the link between climate change and air quality, prioritising the management of demand and promoting participation among those involved, right from the initial stages. The Plan's main objective is to have reduced per capita greenhouse gas emissions by 23% in 2020 compared with the 2008 levels.

This Plan also applies across the board as it concerns measures in different spheres already being dealt with by other departments, and its structure is based on an initial introductory part common to two parallel programmes on different scales:

- A city programme: related to all the general aspects of the city, concerning both the Council's management and the behaviour and actions of citizens as a whole.
- A municipal programme: related to aspects that come directly under the Council. One of the main parts of the municipal programme is the Plan for the Energy Self-Sufficiency of Municipal Buildings (PAEEM), providing a specific response to compliance with the commitment stipulated in the Covenant of Mayors.

Plan for the Energy Self-Sufficiency of Municipal Buildings 2010-2020 (PAEEM)

The consumption of municipal buildings and installations accounts for around 10% of the total energy consumption associated with municipal activity and public transport. This Plan is therefore one of the mainstays of Barcelona's municipal programme in its Plan for Energy, Climate Change and Air Quality. The PAEEM is designed to save 2,355 tonnes of CO_2-eq/year in the power consumed at municipal facilities.

Barcelona Energy Self-Sufficiency Plan 2024

Bolstering Barcelona's strategy and goal to move towards energy self-sufficiency, the PECQ has made way for the Barcelona Energy Self-Sufficiency Programme. This works with the aim of achieving 10% energy self-sufficiency in 2024 by implementing energy-saving and efficiency measures with a view to reducing the city's energy consumption as far as possible, taking advantage of local renewable and/or residual resources in order to meet this consumption, thereby bringing generation closer to consumption and promoting widespread, local generation.

The PAEEM continues to play a fundamental role within this strategy.

1.3.2 Innovation and technology used to bring about energy savings and efficiency

The Barcelona Energy Agency has drawn up a study to analyse the contractual framework and to encourage the hiring of Energy Service Companies (ESCOs).

Measures for overcoming barriers to hiring ESCOs

Hiring Energy Service Companies (ESCOs), and public-private cooperation in general, is becoming an essential tool to improve the energy efficiency of installations, directly reducing energy consumption but also providing other advantages: transferring the risk of installations to the maintenance company, ongoing availability of technical expert advice; setting a stable budget and user satisfaction through the proper maintenance of the installations.

In spite of all this, hiring the services of this kind of company is still an extremely complex task today, requiring lengthy administrative and legal procedures because of the different legal barriers encountered. The Barcelona Energy Agency has produced a study entitled "Technical Assistance for appraising and overcoming the barriers encountered to hiring ESCOs by Barcelona City Council", providing an in-depth analysis of the contractual fra-

A lot of municipal facilities take advantage of the building's roof to install photovoltaic panels to produce electricity.

mework of ESCOs and proposing measures to overcome these barriers and encourage the hiring of ESCOs to implement energy efficiency measures in public buildings. Work is also being done on a tender for energy management based on the ESCO model for a large number of municipal buildings.

Promoting the regulation and control of buildings as an energy-saving and efficiency strategy

The optimisation of regulation and control is a key measure to implement energy-saving and efficiency strategies. This is an efficiency tool applicable to any kind of system (HVAC, lighting, office automation, communications, among others). It guarantees reductions in energy consumption with no drop in the quality of the service provided and lengthens the useful life of the installations, resulting in economic savings both by reducing the electricity bill and the maintenance required. In November 2011 the Barcelona Energy Agency published its "Basic Guide on energy efficiency in municipal buildings" which describes specific efficiency measures for buildings. It has also drawn up a communication protocol for the energy monitoring systems of buildings with the SENTILO municipal sensor platform and the Agency's own display platform. There are currently 37 municipal buildings being monitored, housing 43 services. It has also monitored municipal renewable energy installations (photovoltaic, mini-wind power, thermal solar facilities, etc.).

Installation of new smart street lighting in Barcelona

In accordance with the new General Plan for Lighting, in 2013 work started on installing new street lighting that is brighter, more efficient and uses new technology. The aims of this new lighting system are to prioritise pedestrians over road users, to improve lighting levels, incorporate systems for control and regulation that improve energy and functional efficiency and to personalise streets, buildings and monuments. Up to 2015, 15 million euros will have been invested to renew 100 street sections and 2,500 lighting points in the city.

1.3.3 Encouraging local energy generation to increase self-sufficiency

Consolidation of thermal solar energy for buildings

2011 saw the approval of a new Environment By-Law whose Title 8 specifies that thermal and photovoltaic solar energy systems must be installed. This applies to almost all new and renovated buildings in the city. Now thermal solar energy is a reality for new builds and renovated buildings, forming an integral part of their construction, like any other element. In 2012 Barcelona had 88,775 m^2 of planned thermal energy installations and thermal solar energy is still being promoted for the existing stock of buildings. Other uses are now also being promoted, particularly solar-powered HVAC, taking advantage of the fact that there's more solar radiation available (in the summer and at midday) when demand for air conditioning in buildings is at its peak.

Municipal renewable energy installations

Barcelona has been working on various renewable energy projects of different types, most applied to buildings and areas owned by the municipality. A large number of these projects aim to continue the public authority's promotion of the use of renewable energy resources and, at the same time, to make users of municipal facilities and citizens in general more aware of the technologies for and management of energy efficiency. Barcelona currently has a significant number of renewable energy installations, such as: photovoltaic power generators on municipal buildings and urban elements such as pergolas and shared constructions, thermal solar installations to produce domestic hot water, thermal solar installation for HVAC on the Perecamps building and at CEM Can Caralleu, geothermal systems for HVAC, a pilot hybrid photovoltaic and mini-wind installation on the roof of a block of flats and in a public area (Finestrelles lighting). It also has the first practically energy self-sufficient cemetery in the city with a thermal and a

photovoltaic solar installation plus battery, so that it can function every day of the year without being connected to the main grid.

1.3.4 New HVAC networks that take advantage of residual heat and cold

Consolidation and extension of Districlima, the first urban cold and heat distribution network in Barcelona

Districlima was built in 2002 to be used for heating, air conditioning and domestic hot water, taking advantage of the heat left over from the treatment of solid urban waste. Initially the project was located in the area developed to hold the 2004 Universal Forum of Cultures but has gradually been extended. Investment currently totals 97 million euros, 50 million of which come from public funding.

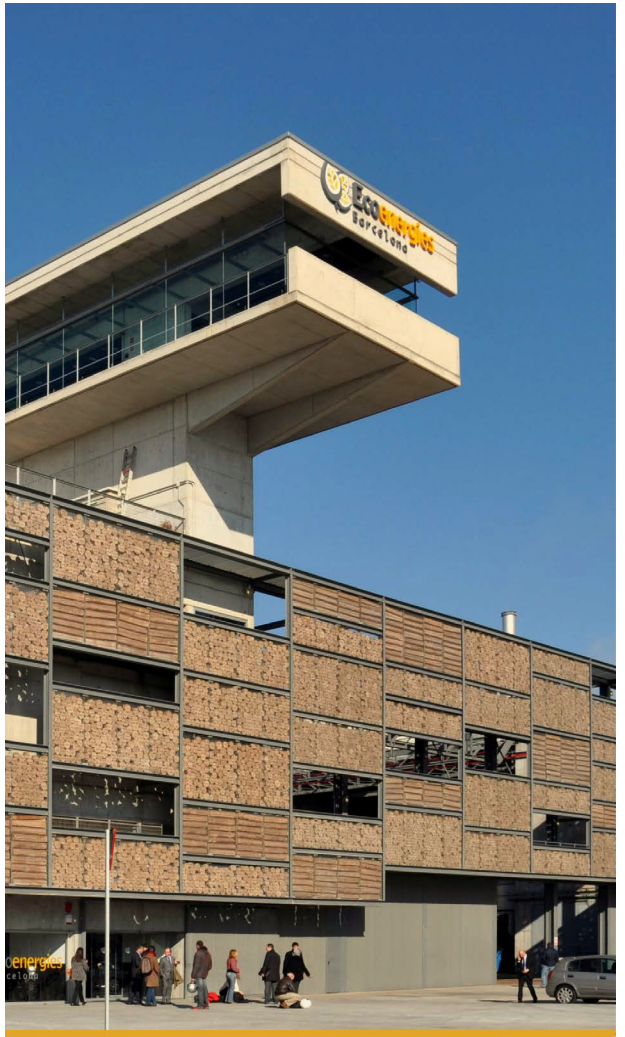
The energy capacity of the Districlima network is:
Total hot water: 90°, 52.2 MW
Total cold water: 5°, 73.7 MW
Recovery of 24 GWh/year of steam from the TERSA waste treatment plant.

Ecoenergies, recovery of cold energy from the regasification of liquefied natural gas at the Enagas plant

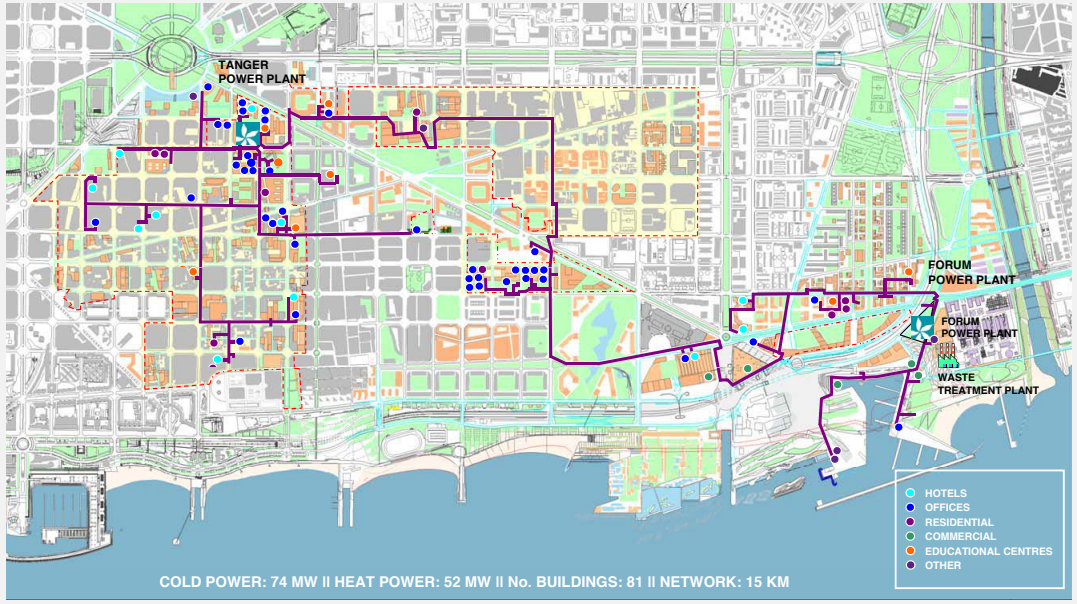
The port of Barcelona contains one of the largest regasification terminals in southern Europe, with a capacity of 625,000 m^3(N)/hour. The project makes use of the cold produced during the gasification process, which heats up liquefied natural gas using sea water. This project is being implemented in several phases; since 2011, the year when it started up, it has provided several clients with cold and heat. In the second phase, 30 MW of the cold produced by the port's regasification will be used. Barcelona also produces up to 15,000 tonnes of biomass from the city's public parks which can be used to generate energy.

9 clients are currently connected but a project has been started to connect Mercabarna to the network so that, by 2017, all the cold required by Barcelona's main market will be supplied using residual cold from the industrial process (the transformation of liquefied natural gas into natural gas).

The current capacity of Ecoenergies is:
Heat power under contract = 17.8 MW
Cold power under contract = 12.6 MW



The Ecoenergies plant at Barcelona port makes use of the cold produced by the regasification process.



The Districlima network has been expanded, reaching 13 km with 81 buildings connected in 2013.

The Ecoenergies network, which re-uses cold produced by the regasification process, is currently 7 km in length.

1.4 Future goals and measures

In addition to the goals established by the PECQ to reduce GHG emissions at a general level, Barcelona also wants to move towards self-sufficiency, thereby reducing its dependence on external energy sources, to this end promoting the presence of local, renewable and networked energy production. Among the many social and economic benefits, a reduction in the energy imported lowers dependence on fossil fuels, boosts the local economy by creating jobs associated with renewable energy sources and energy efficiency and positions Barcelona as a pioneering city in the installation and use of renewable systems in the urban environment, a task that is not always easy.

1.4.1 Planning the medium and long-term energy strategy

Barcelona Energy Self-sufficiency Plan

This instrument is the channel towards self-sufficiency. The Plan aims to maximise the generation of renewable energy within the city itself, as well as reduce the overall consumption of energy via efficiency measures. These two lines of action are the main strategic tool to improve efficiency and reduce greenhouse gas emissions, as well as the emission of other contaminants with a local effect.

The Plan aims to increase self-sufficiency, currently at a level of 1.9%, and fulfil the city's commitments regarding the targets set by the European Union to reduce emissions by 20% in 2020 and by 80% in 2050.

The Barcelona Self-Sufficiency Plan contains measures for the domestic sector, for transport, public spaces and the municipal area.

Monitoring installations is the first step to determining the energy consumption patterns of buildings and identifying energy-saving measures.

MAIN MEASURES FOR EACH OF THE AREAS OF ACTION

Domestic and tertiary sector

- Promote the reconditioning of buildings and their installations in energy terms
- Encourage self-sufficient buildings and blocks ⊕, with a zero energy balance
- Install renewable or residual energy sources into existing buildings
- Promote energy-saving and efficiency measures

Transport sector

- Encourage the implementation of electric and hybrid vehicles in the city's fleet of buses
- Promote the electrification of taxis, vans, commercial vehicles and motorbikes
- Redesign the distribution of goods, especially over "the last mile"

Public spaces and infrastructures

- Encourage DH&C micro-networks plus new connections for existing networks
- Incorporate thermal solar energy within the existing DH&C network
- Promote energy storage (heat and electricity)
- Encourage new installations of renewable energy sources (thermal solar, mini-wind, photovoltaic, offshore wind)

Municipal

- Develop the Energy Self-sufficiency Plan for Municipal Buildings
- Electrify the municipal fleets of vehicles
- Roll out the General Lighting Plan for Barcelona ⊕
- Install self-sufficient urban elements (bicycle rental sites, garden tool sheds, beach bars, etc)

Resilience and climate change adaptation

Barcelona is adapting to the risks and effects of climate change

Resilience and climate change adaptation

Vision of the future

Becoming a city that tackles risks and guaranteeing citizens' quality of life

Current situation

Climate change: Main impacts

- **+ 0.5º** by 2020
- **- 40%** rainfall in summer
- **x 2** frequency of downpours and droughts
- sea level **+ 20-60** cm by 2100

Main challenges

- Heatwaves
- Urban heat island effect
- Drought
- Floods
- Wildfires
- Coastal erosion
- Reduction in tourism
- Increase in demand for water
- Change in energy consumption patterns

Lines of work

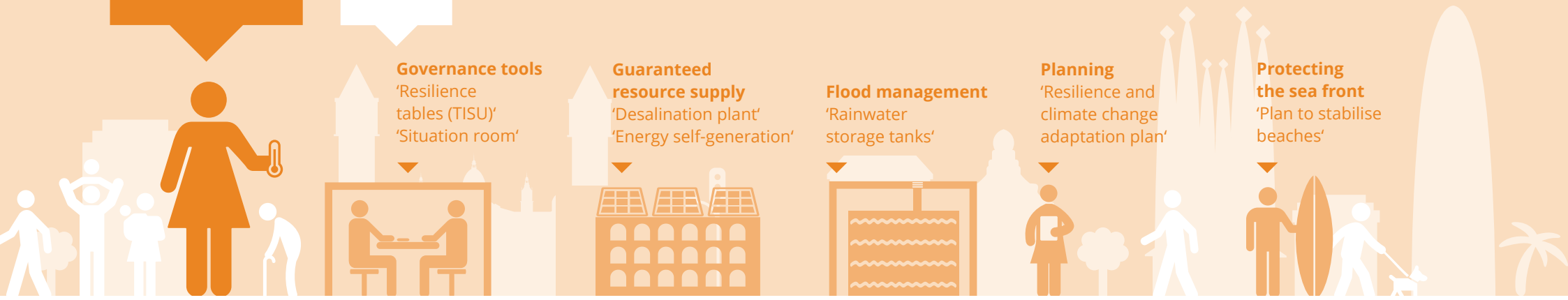
Governance tools
'Resilience tables (TISU)'
'Situation room'

Guaranteed resource supply
'Desalination plant'
'Energy self-generation'

Flood management
'Rainwater storage tanks'

Planning
'Resilience and climate change adaptation plan'

Protecting the sea front
'Plan to stabilise beaches'



2.1 Vision, challenges and opportunities

Vision of the future

Barcelona wants to be a city able to proactively tackle its challenges, impacts and crises, overcoming them while learning, getting stronger, adding value to the city and guaranteeing the quality of life of its citizens.

Located on the Mediterranean coast, Barcelona is a historical city with a dense, compact urban structure that's facing the challenges typical of a productive, dynamic city of the 21st century. Although a relatively small municipality, it's an important economic engine and the hub for one of the metropolitan areas with the largest population in Europe. Resilience management and climate change adaptation in this complex urban system involves overcoming challenges and maximising opportunities.

- **Resilience and adaptation require a paradigmatic change in governance**, that entails the incorporation of risk management and cost-benefit analysis in planning, being flexible when defining adaptive solutions given the uncertainty of future projections, a perspective on many different levels and work that crosses both disciplines and sectors. Barcelona has already embarked on this path and started to incorporate this vision in its policies in all areas.

- **New operational tools are required to reduce vulnerability and increase resilience**. The right mechanisms need to be provided to detect and assess risk early; preventing and/or reducing the impact of stress so that the city can continue to withstand and recover while maintaining its essential functions; improving response capacity and recovery time; providing information and tools to help in decision-making.

- **Barcelona has a significantly high level of risk due to its location on the Mediterranean coast**. According to the ESPON Climate project, Barcelona is heavily exposed to extreme climate effects (droughts, heatwaves, flooding). Some important economic activities such as tourism may be affected by the city becoming less appealing. At a metropolitan level, the large green area of Collserola will be affected by an increase in drought and the number of forest fires.

- **Barcelona is vulnerable to the effects of climate change**. It has a large concentrations of population and activities of great added value as well as highly dense infrastructures and facilities. Consequently, the material and personal costs resulting from climatological phenomena could be very high. Its infrastructure networks (transport, communications, water and energy) are also highly interdependent, so that any failures in the city's system could have a knock-on effect.

2.2 General context and current situation

Urban resilience is seen as the ability of an urban system to prevent, withstand and recover from any plausible hazard or risk. In 2007 Barcelona suffered a series of incidents that highlighted its vulnerabilities: problems with the high-speed train line, a severe threat of drought and particularly a cut in the electricity supply that lasted more than 3 days. The desire to reduce such vulnerabilities and their impact resulted in a new line of action aimed at improving urban resilience.

Although resilience concerns natural, technological and social aspects, this chapter will mainly deal with risks resulting from the climate and specifically aspects related to climate change adaptation.

A possible increase in sea level would lead to a loss of sand and beach area.

2.2.1. Barcelona, vulnerable to the impacts of climate change

Like a number of cities in the world, Barcelona is facing increasing risks from climate change. Cities are highly vulnerable to risks because they have high densities of population and services. It's difficult to quantify the long-term risk but the economic and personal costs of the increase in risk associated with climate change could be very high.

According to Catalonia's Meteorological Office (Servei Meteorològic de Catalunya), the Mediterranean zone where Barcelona and Catalonia are located will probably be one of the zones on earth that will undergo the most significant changes. The main risks forecast for Catalonia and Barcelona, and which have actually started to be felt in the last few years, are as follows:

- **Rising sea level**. The IPCC concludes that the sea level will increase by between 20 and 60 cm by 2100. This increase might be slightly lower in the Mediterranean as it's an enclosed sea. The stability of the beaches depends largely on land and sea deposits of sediment, which have decreased significantly over the last few years and the current situation is critical. It's estimated that 1 metre of beach is lost for every centimetre rise in the Mediterranean's level.

- **Rising temperatures**. The temperature in Catalonia is expected to rise until 2020 and might become 0.5 °C higher than the average for the end of the 20th century. The number of tropical nights has been growing at an ever-increasing rate since the 1980s, with an average trend for the whole of Catalonia of 1.7 days/decade, although this could reach 5 days/decade on the coast. A seasonal analysis shows that the most marked rise in temperature occurs in summer, with considerable heatwaves.

- **Change in the rainfall pattern**. The annual average reduction in rainfall, in general, will be from 5% to 15%, with possibly a slight increase in winter. This average reduction could reach 40% on the coast and in the summer. Downpours may become twice as frequent and their associated peak rainfall rates could increase by approximately 20%. Droughts may also double in frequency and maintain their intensity for longer periods.

Regional area	Air temperature at 2m (ºC)		Rainfall		Average windspeed at 10m	
	Scenario A2	Scenario B1	Scenario A2	Scenario B1	Scenario A2	Scenario B1
Coast and pre-littoral	+4.4	+2.3	-	-	-3%	-2.3%
Seasonal scale on the coast and pre-littoral						
Summer	The average air temperature might increase by +4ºC and average rainfall could decrease by 50% (Scenario A2)					
Spring	Average rainfall might decrease between -11% and -18%					
Autumn	Higher temperature but great uncertainty as to rainfall					
Extreme phenomena on the coast and pre-littoral						

→ More dry months and longer periods of drought
→ Significant reduction in very cold months
→ Big increase in frequency of very hot months
→ Greater likelihood of months with little wind

Scenario A2 (more unfavourable) and Scenario B1 (average)

Climate change is expected to lead to significant changes in air temperature, rainfall and windspeed.

2.2.2. Climate change presents new challenges for the city

The effects of climate change on the pattern of temperatures, rainfall and changes in biodiversity will impact the population, economy, resources, governance, infrastructures, coastline and civil protection services.

→ **Challenges to people's health**: due to the increase in frequency and intensity of heatwaves, made even worse by the urban heat island effect. This will affect air quality and might intensify heart, respiratory and allergic complaints. The most vulnerable are the elderly and children.

→ **Challenges to natural resources**: forest fires are expected to get worse and might significantly affect the Collserola Nature Park. An overall reduction in biodiversity is also expected with even more opportunities for new invasive species and a larger reduction in endemic species, as well as changes for flora and fauna dependent on wetlands as their habitat is more likely to dry out.

→ **Challenges to the coast:** the coast is already being substantially eroded as a result of stronger easterly winds and sea storms. Climate change will intensify this situation. Between 1988 and 2007, 3 million m^3 of sand was deposited on Barcelona's beaches to restore them. Groynes have also been built as part of the Beach Stability Plan.

→ **Challenges to economic activities**: tourism is one of the city's main economic activities, providing 10% of its GDP. A higher average temperature could affect this tourism. According to the PESETA Project,

fewer tourists are expected to arrive in the summer, preferring spring and autumn. Climate conditions will improve in northern Europe, which could reduce the number of tourists to the Mediterranean coast. In spite of the negative effect this would have on the economy, it would reduce tourism-related stress at certain times of the year.

→ **Challenges to resources such as water and energy**: current studies point to the demand for water rising by 5-12% due to a reduction in comfort, increase in evapotranspiration of vegetation, tourism, etc. Added to lower rainfall and smaller rivers, this will put a lot of pressure on available resources.

Regarding energy consumption, the number of days of heating is expected to fall while the days that air conditioning is used will rise. The net change in energy demand is difficult to predict but there will be considerable changes in the patterns. The challenges involve guaranteeing energy supply and the ability of infrastructures to adapt to these changes in consumption patterns.

Climate change poses a threat to urban infrastructures, such as treatment plants where the increase in torrential rainfall could outstrip their capacity.

→ **Challenges to waste water infrastructures**: the increase in intensity and frequency of torrential rainfall could outstrip the capacity of treatment plants and lead to floods. The waste water system needs to be expanded to be able to handle runoff, prevent floods and preserve water quality along Barcelona's coast.

→ **Challenges to governance**: the challenges resulting from climate change entail a paradigmatic change in terms of governance.

→ **Challenges to civil protection:** in its planning and the Municipal Action Plan, Barcelona has included recommendations and obligations from Catalonia's emergency plans, as well as having its own municipal emergency plans (PAEM), particularly those concerning heatwaves, lack of drainage (floods), forest fires, etc., and its Specific Municipal Emergency Plans (PEEM) ⊕ when supplies fail in electricity, gas, etc.

2.3 Measures taken to boost resilience and climate change adaptation

Most impacts resulting from climate change in Barcelona are phenomena that are already happening (droughts, floods, heatwaves, etc.) and what we expect are changes in frequency and intensity. In this respect, although Barcelona has yet to define its strategy of resilience and climate change adaptation, for some years now it has already been working to minimise such impacts.

2.3.1. Creating new tools to improve governance

Preliminary assessment of weak points in the supply of services

Barcelona City Council, via the different departments involved and with the collaboration of network owners and operators, carried out the 3S Project (Guaranteed Service Supply) to ensure that supply and interconnections between these and the different infrastructures in the urban systems all work properly.

Creation of a Resilience Department

The Council now has the organisational structure required to lead and coordinate urban resilience projects. The Resilience Department reports to the Adjunct Office for Infrastructures and Urban Coordination and its objective is to reduce the vulnerability of Barcelona city, improve its ability to respond and recover as quickly as possible and reduce the impact of critical situations.

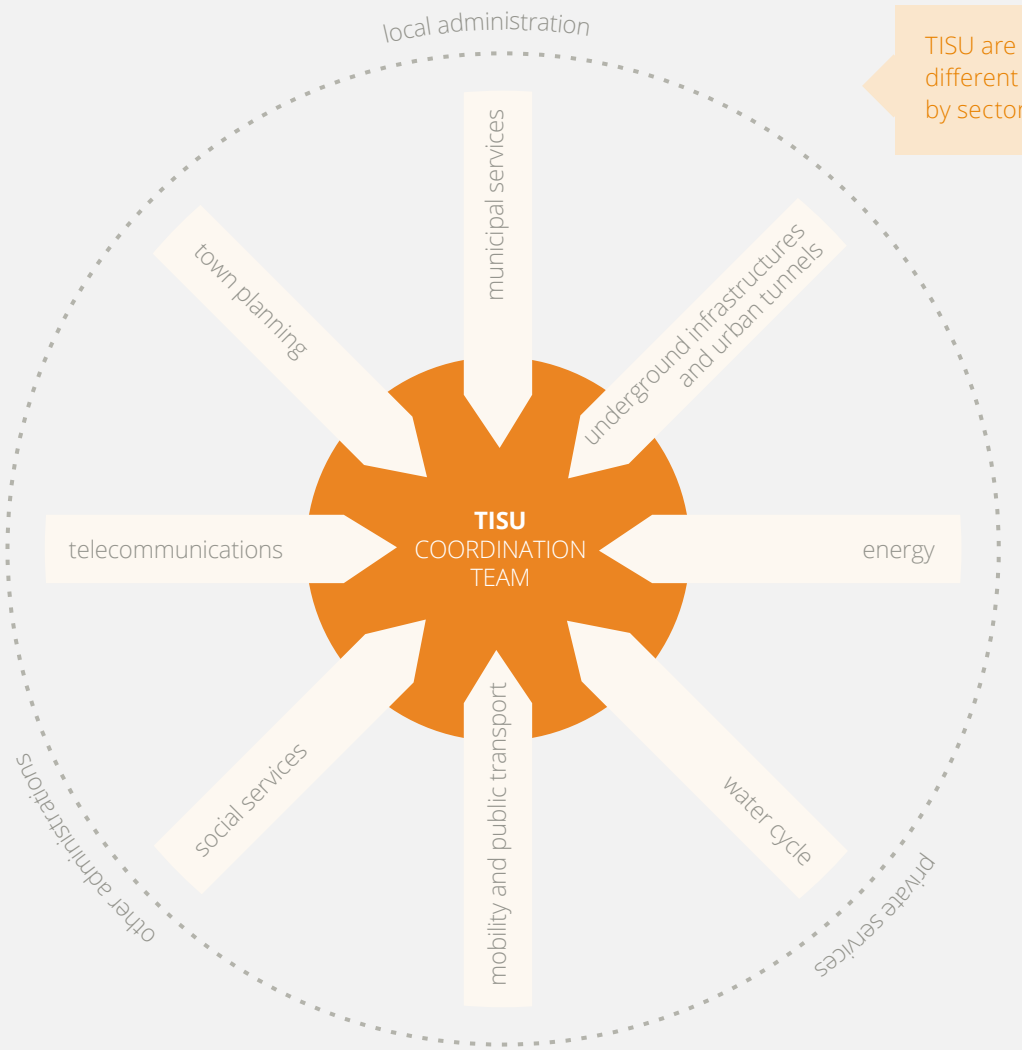
The department is based on the three areas that make up the cycle of continued improvement to create resilience. It manages incidents affecting the city's services via the Operations Centre, analyses the city's problems via the Situation Room (information management platform) and implements projects to reduce vulnerability and risk via Resilience Tables (TISU).

The 3S Project (Guaranteed Service Supply) relates to the supply networks (water, energy and telecommunications), health (sewerage, food, waste, environmental monitoring, social and health services and public health) and communications (public transport, mobility, infrastructures).

Creation of Resilience Tables (Urban Service Infrastructure Tables - TISU) to improve work across the board

In 2009 TISU were set up, organised into work groups by sector and carrying out specific projects in order to reduce any vulnerabilities identified. This methodology for working on resilience entails the cooperation of all agents involved and is based on four fundamental steps: 1) risk detection; 2) risk assessment; 3) assessment of resilience; and 4) building up resilience.

Apart from determining certain goals and an action plan to set about achieving them, each improvement project generated by this process must establish a monitoring and improvement system in order to evaluate its degree of success, thereby completing the cycle



TISU are organised into different work groups by sector

going from defining the project to communicating and updating it, with its subsequent redefinition, where applicable.

We should stress the value of these tables in terms of the change in working culture at the Council, thanks to the involvement of interest groups and the multi-sector and multidisciplinary work carried out.

Situation Room, the platform for analysing and managing information

Managing the city is a complex matter due to the large number of operators and agents involved, because of the obvious interdependencies to be found between the different urban systems and the way information is often managed in isolation. The Situation Room is a tool that provides new ways of managing and sharing information with all the agents involved. It enables the joint analysis of data which were previously not correlated and provides new knowledge for making decisions, in both the strategic and operative areas. It has vast potential, one currently operational example being that it can be consulted online. This is a lengthy process to which other services will gradually be added.

Sharing knowledge with other cities

Experiences and information can be shared by taking part in international projects and networks of cities and multilateral bodies. For example:

→ ICLEI, with projects such as Cities Adapt, Ramses, Open European Day and Resilient Cities.

→ The "City Resilience Profiling Programme" (CRPP) ⊕ , is now being implement via the UN-HABITAT offices in Barcelona. With the cooperation of ten cities, this programme seeks to identify a conceptual and practical framework for urban resilience, with software applications and an improvement in the implementation and monitoring of results.

→ UNISDR, with the 'Making Cities Resilient' campaign, which calls Barcelona a "role model city" in its infrastructures and urban services for the work carried out with TISUS, and has given it a place on the Steering Committee.

→ C40, a network of cities on Resilience and Risk Assessment of Risks stemming from climate change.

Barcelona has also prepared a benchmarking system on other cities' plans for adaptation to climate change ⊕ .

On a global scale, apparently different cities share comparable problems that increase the fragility of the systems and the impact on people. That's why it's important to encourage cities to share their experiences.

2.3.2. Prevention and support for people's health

Action Plan to Prevent the Effects of Heatwaves on Health (POCS) ⊕

Catalonia launched this Plan in 2004 and implements it annually with the aim of forecasting weather-related risk situations as early as possible, minimising the adverse effects on people's health and coordinating existing measures and resources. When the Plan is activated, the main measures which are carried out are:

→ Preventive operations for the vulnerable: this provides information on the risk status and monitors the situation through services that care for those at risk (Remote Assistance, Home-Based Care Service, social service centres, etc.). A number of measures are activated in order to prevent the most vulnerable people from going outside at times of greatest heat ('meals on wheels' arranged, extending activities at day centres for the elderly, etc.).

→ Specific operations on the street: a service made up of 21 professionals and 6 vehicles coordinated by Barcelona Social Emergency Centre (CUESB) goes out to provide, in the field, anyone at risk with care and advice. They distribute water to the homeless, inform them of the possibility of using the available air-conditioned reception centres, etc.

2.3.3. Fomenting environmental services for green areas

Creating a management and planning tool: the Plan for Green Spaces and Biodiversity 2020 ⊕

This strategic instrument defines the municipal authority's challenges, objectives and commitments as regards the preservation of green areas and biodiversity and how well city people know, enjoy and take care of such resources.

Improving knowledge of urban green spaces by establishing cooperation schemes with research centres

The Plan establishes lines of action intended to gain in-depth knowledge on the effect of climate change on natural vegetation, the selection of species in accordance with their water requirements and their ecological functions and the use of alternative water resources for watering the city's vegetation.

Microclimatic regulation and minimisation of the heat island effect

Plentiful vegetation provides shade, humidity and fresh temperatures, thereby improving the comfort of public space. That's why different green corridors are being designed *(see Chapter 4, urban green spaces and biodiversity ⊕)* and opportunities are being sought to provide a larger

area of vegetation (green roofs and walls). Barcelona has 65 hectares of roofing to be occupied, counting only buildings for public use, and 95.7 hectares if we add private amenities such as hotels, museums, clinics and schools. These green roofs and walls make a contribution to microclimate regulation by:

- Improving the heat insulation of buildings.
- Cooling down the atmosphere, thus improving the efficiency of solar panels.
- Holding back rainwater, cutting down the amount of water collected by the sewerage system and therefore also the pollutant content reaching treatment works, etc.

Preservation of biodiversity is a priority for the city.

2.3.4. Preserving biodiversity as an asset for the city

Preserving the biodiversity of species vulnerable to climate change

The Programme to protect amphibians is an example of this. According to the IUCN, 52% of amphibians are sensitive to climate change. In cooperation with the Galanthus association, Barcelona Zoo and Barcelona Uni-

The roof of the Northern Zone Library (or other municipal initiatives such as the Fàbrica del Sol) is a good example of how important this kind of roof garden can be.

versity (UB), a programme has been adopted since 2008 establishing protocols for action and management for personnel carrying out maintenance work in parks and gardens with ponds. This involves carrying out censuses, reintroducing individual specimens, enhancing habitats, removing exotic fauna from the ponds and disseminating the project to raise people's awareness and involve them. 158 toads, 146 tree frogs and 85 Perez's frogs have been released and 450 tadpoles have been rescued.

2.3.5. Planning and major works to guarantee water supply

Technical Plan for Making Use of Alternative Water Resources 2012-2015

This Plan points out the many existing resources that can potentially be taken advantage of, both in terms of groundwater resources and also water regenerated at El Prat Wastewater Treatment Plant. It also states that there are demands which can be met with these alternative resources and provides an analysis of the different types of non-drinking water and the quality requirements for different uses *(see Chapter 9. Water cycle ⊕).*

Building the desalination plant

On 20th July 2009 Barcelona's desalination plant in El Prat de Llobregat became operative. It has a production capacity of over 60 hm^3 of drinking water a year (25% of the water supplied to Barcelona and its metropolitan area) even though it's only running at 10% of its capacity at present, in order to carry out maintenance work on the installations.

Improvement of the system's redundancy

Carrying out building work to connect the header tanks for the 2 Llobregat – Besòs basins and drafting contingency plans for the different pressure coordinates in order to guarantee supply.

Municipal Action Plan for Drought Risk

This Plan helps to anticipate a drought and apply specific drastic measures to save water, as well as informing the public and making them duly aware of this. The measures taken by the Council (in a Level I Emergency Situation) generate savings of about 83,000 m^3/a month. Some of these involve reducing the hours that fountains are on, increasing the use of groundwater to 67% for cleaning the streets and for irrigation, etc.

Actions to raise awareness of reducing water consumption

(see Section 9.3.4 Awareness-raising campaigns ⊕)

2.3.6. Flood management and coastline protection

Improving the planning and management of the sewerage system

Progress has been made by implementing the system for remote controlled management and another was to create a specific TISU *(see 2.3.1 Creating new tools to improve governance ⊕)* to study the critical points of the network and, depending on the results obtained, to prioritise and plan investments to improve the drainage network.

Flood management with a network of underground tanks to collect rainwater or anti-USD (Unitary System Discharges)

In order to prevent rainwater from running directly into the sea, since this water is highly contaminated from city runoff, and also to prevent flooding, there is a network of tanks which retain this water. After the rainy period is over, the water is taken in a laminar flow to the water treatment plant, increasing the share of rainwater that's treated before being dumped in the sea. The water retained also has a lower contamination level thanks to the sedimentation caused during collection.

Annual rainfall in 2011 was 758 l/m^2, spread over 58 days of significant rain. The level of rainfall classed as an alert was reached on five occasions and the emergency level was triggered three times. In all this rain, the retention

tanks stopped the drainage network from being overloaded at the most critical flood points. They also meant that 1,784 tonnes of solid material suspended in the water did not have to be dumped into the sea, by treating 7.15 million m^3 of water.

Another step in flood management, which helps the rain falling in the city to permeate the subsoil and increase underground water reserves in higher, newly-developed zones, are Sustainable Urban Drainage Techniques (TEDUS), which make the peak flows laminar and reduce the volume of runoff. Ten green spaces have been designed with sustainable drainage techniques.

Managing the coastline via Barcelona's Beach Stability Plan

This Plan sets out to protect the city shoreline and prevent the loss of sand that takes place every year through the effect of storms at sea. The project consists of reinforcing the sea front in order to make sure the sand stays on the beaches, as well as guaranteeing the environmental quality of the water.

With a cost of 33,000,000 euros (financed by the Ministry of the Environment), the project covers a length of almost 5000 m of Barcelona's coastline. The project will be carried out in different phases and the first measures will be extensions and construction of groynes to counteract the sea currents that remove sand from the beaches, as well as supplying over 700,000 m^3 of additional sand.

2.3.7. Energy savings, efficiency and renewable sources, the keys to guaranteeing energy supply

Creating planning and management tools

The Plan for Energy Self-Sufficiency defines the strategies required to ensure increasing energy efficiency, the presence of renewable energies and the reduction of local emissions of pollutants.

As regards the Plan for the Energy Self-Sufficiency of Municipal Buildings, this considers measures to be taken at municipal facilities to reduce their energy consumption, accounting for 10% of the consumption of all municipal activity and public transport.

Barcelona's Lighting Improvement Plan has led to improvements in the management of the city's lights. Over the last few years the number of bulbs has increased while energy consumption has been cut by over 3.7 million KWh per year. The traffic lights system has also been renewed, now using LED technology.

Commitment to local energies through solar by-laws and reusing waste

Since 1999 Barcelona has had its own Thermal Solar By-Law, an internationally groundbreaking piece of legislation which makes it compulsory to include thermal solar panels on renovated buildings and new builds. In 2012 the Photovoltaic Solar By-Law also came into force.

The waste generated in Barcelona is also processed at different facilities in order to obtain energy. For example, at Sant Adrià del Besòs waste recycling plant they produce 16,900 kWh of heat and 108,000 kWh of cold a year. The ecoparks which serve the city also have installations to produce and make use of biogas to generate electricity and heat thanks to a cogeneration plant. These ecoparks generate 196,135,203 kWh a year by processing organic waste.

Improving energy efficiency with HVAC networks

As far as efficiency is concerned, we should note the production of electricity and the supply of cooling and heating by means of the new Ecoenergies power station in Zona Franca (currently being built). This combines different systems, making it particularly efficient: taking advantage of the cold left over from the Port regasification system and building a biomass and a tri-generation plant. The HVAC network at the Forum and 22@ zone (Districlima), which makes use of the heat produced by the Sant Adrià waste recycling plant, provides HVAC to a surface area of 360,000m^2, containing 49 service buildings and 4 residential blocks.

Improvement of incident management

Action protocols have been set up so that, in certain cases, any incidents which might be critical can be identified, notifying the services responsible in time for them to be able to determine the impact level, deal with the interdependence with other systems and thereby reduce any knock-on effect.

The Districlima network produces and distributes hot and cold water by making use of the incineration of urban waste and energy from seawater.

2.4 Future goals and measures

In recent years resilience and climate change adaptation have been a priority for the city, as can be seen in the large number of measures that have been carried out. However, there is still a long way to go, with measures designed to go on improving knowledge, improve planning and management and fulfil international commitments.

2.4.1. A commitment to an adaptation strategy

International commitment by joining the Covenant of Mayors for adaptation ⊕

This was assumed by Barcelona City Council, which signed this voluntarily. In accordance with the European Strategy on Adaptation to Climate Change (EC, 2013) the Council will undertake to implement a strategy of local adaptation (with a deadline of 2 years from when the covenant was signed).

The Covenant of Mayors on adaptation (Mayors Adapt) is a European initiative to get local authorities involved in adapting to climate change.

2.4.2. Planning to become a more resilient city

Plan for Resilience and Climate Change Adaptation, a basic planning and management tool

Barcelona is drawing up its Plan with the following objectives:

- → Involving all agents and improving interdepartmental and institutional liaison to tackle risks and build a more resilient and less vulnerable city.
- → Extending training, professional skills and personnel development in order to guarantee the availability of professionals qualified in critical recovery and resilience-building.
- → Incorporating the variables of resilience and climate change in planning, programmes and legislation and establishing criteria for making decisions.
- → Systemising and defining a methodology to identify and assess risks, as well as their impact on the economy, the environment and citizens.
- → Defining measures to take into account the protection, improvement and reinforcement of existing systems. After a crisis, rebuilding and updating methodologies in accordance with past experience.
- → Defining key actions to tackle the city's vulnerabilities, establishing the relevant responsibilities, resources and timelines.
- → Defining criteria and methodologies to prioritise the measures described, considering the uncertainties of risks and their consequences.
- → Defining a system to monitor resilience, improving the availability of data and producing information tools for better analysis (mapping, visualisation and communication systems).
- → Raising general awareness of resilience and climate change and getting the city's inhabitants involved through participatory projects.
- → Consolidating Barcelona as a forerunner in resilience in the Mediterranean region.

Ajuntament de Barcelona

For more information: **www.bcn.cat/mediambient**