INTEGRATED CASE STUDIES ASSESSMENT REPORT

INTELI – INTELIGÊNCIA EM INOVAÇÃO, CENTRO DE INOVAÇÃO

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<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>GDP</td>
<td>Gross domestic product</td>
</tr>
<tr>
<td>GVA</td>
<td>Gross value added</td>
</tr>
<tr>
<td>KPI</td>
<td>Key performance indicator</td>
</tr>
<tr>
<td>Toe</td>
<td>Tonne of oil equivalent</td>
</tr>
</tbody>
</table>
I INTRODUCTION

In the context of the POCACITO – “Post-carbon Cities of Tomorrow – Foresight for Sustainable Pathways towards liveable, affordable and prospering cities in a world context” project, this document intends to present an Integrated Case Studies Assessment Report, integrated in Task 3.3. – Case Studies Integrated Assessment and Benchmarking of WP3 – Initial Assessment.

In fact, the POCACITO project aims to develop a 2050 roadmap to support the transition of cities to a more sustainable or post-carbon future, through a collaborative research and participatory scenario building.

In order to use an evidence-based approach, 10 European case studies were selected: Barcelona, Copenhagen, Malmö, Istanbul, Lisbon, Litoměřice, Milan-Turin, Rostock and Zagreb. An important step to achieve the project’s goal is to produce an integrated assessment of case study cities in order to evaluate and make a comparison of the current situation of these cities as an input into the scenario development.

The data presented in this report was collected by the case study lead partners during the production of their individual assessment reports. Copenhagen was not included in the analysis due to late delivery of the report.

The document is divided in the following parts: approach and methodology; overview of the case study cities; key strategies and projects; integrated case study cities assessment; findings and key challenges; and conclusions.
II APPROACH AND METHODOLOGY

The development of the integrated assessment of the case study cities is based on the Initial Assessment Reports produced by the Case Study Leaders. A set of pre-defined KPI – Key Performance Indicators was used to make possible the comparison among cities.

II.I MODEL AND CONCEPT

‘Post-carbon cities’ were defined by the POCACITO team as a rupture in the carbon-dependent urban system, which has led to high levels of anthropogenic greenhouse gases, and the establishment of new types of cities that are low-carbon as well as environmentally, socially and economically sustainable. The term ‘post-carbon’ emphasises the process of transformation, a shift in paradigm, which is necessary to respond to the multiple challenges of climate change, ecosystem degradation, social equity and economic pressures.

Thus, it is assumed that the core components of post-carbon cities are in line with the three pillars of sustainability, comprising environmental, social and economic dimensions. However, cities are complex, adaptive, social-ecological systems (Ecologic Institute, 2014) and cannot be fully understood by examining individual components. For this reason, POCACITO moves away from analysing the three dimensions of sustainability as silos towards a more comprehensive and holistic approach.

Figure 1: Conceptual model

The social dimension is concerned about equity both in the current generation and between generations during the transition process to post-carbon cities, which is expected to be smooth for all citizens. The benefits for inhabitants that come out of living in a reduced carbon city are highlighted, showing that these cities are places where it is pleasant to live in and the values of equity and social inclusion are present. Special attention has been given to standards of living related to essential aspects such as education and health (for example, life expectancy and wellbeing). Unemployment rates and poverty are also issues to be addressed on the context of post-carbon cities. Public services
and infrastructures that are available for citizens are analysed, as well as aspects of governance and civic society, promoting the positive sense of culture and community.

The environment dimension investigates the sustainable profile of the cities and assesses not only the current impacts on the environment, but also during the transition processes, evaluating the environmental resilience of the cities. It is important to continuously adapt the strategies to follow in order to mitigate the negative impacts on the environment during the transition process. The environmental dimension covers the energy sector in general in order to promote not only the final energy efficiency but also the resources depletion associated with energy consumption. Post-carbon cities pay special attention to GHG emission and its contribution to climate change. Some energy intensive sectors are empathised, such as transportation/mobility and the buildings stock. Biodiversity and air quality are critical themes that also belong to this dimension. The concerns regarding waste and water are also evaluated.

The economic dimension emphasises the sustainable economic growth based on the wealth of the cities and their inhabitants. It recognises that investments are crucial to promoting post-carbon cities, in particular the ones related to sustainable facilities. The labour market and the life of the companies are taken into account to demonstrate the dynamics of a post-carbon economy in a green economy paradigm. Public finances are also analysed because the cities with a lower level of indebtedness are more prepared to face the challenges during the transition process towards a post-carbon city. This dimension also includes the R&D expenditure because no city can become a post-carbon city without innovation.

Figure 2: Dimensions and sub-dimensions of the Post-Carbon City Index

For each sub-dimension, a set of indicators has been selected which allows a uniform collection of data, improves the comparison and supports the identification of best practices in each case study city, covering environmental, social and economic aspects (ANNEX I).
The operational model for the production of the integrated case studies assessment report is illustrated in Figure 3.

**Figure 3: Methodological approach of the integrated assessment**

II.II  DATA LIMITATIONS

The integrated assessment report was produced based on the data collected by case study leaders in the initial assessment reports development process.

**Data collection rules – Initial assessment reports**

The selected methods for data gathering and collection comprise the following two approaches:

- **Top-down approach** – completion of the indicators list according to a review of main statistical findings, existing relevant strategic and planning documents, and legislation to assure an accurate quantitative data collection;

- **Bottom-up approach** – discussions with local authorities and other selected stakeholders should be used to complement the collection of quantitative data and enrich the contents of the case study assessment reports.

In general, most of the required data can be retrieved by national/regional statistical offices, government departments, environment and energy agencies, research institutes and non-governmental organisations. The data collection process depends on the availability of high quality and relevant data.

Moreover, all the indicators should be collected for both years 2003 and 2012 in order to compare their evolution throughout this period (sometimes, mainly for some economic and social indicators, time series were required). Whenever data is not available for those years, one should collect the earliest and the most recent years between 2003 and 2012.

The geographical boundaries of the initial assessment of each case study city should be defined by each case study leader, according to the objectives of the work and the limitations of data availability. All indicators should be collected for this geographical level, being privileged the
municipality level. If an indicator is not available at this geographical level, then it could be collected for NUT III or NUT II. If the data is only available at the national level, it is considered that it is not representative of the city, so it should be discarded.

The geographical levels selected by case study leaders and data collection limitations are identified in the following tables:

**Table 1: Case studies geographical level**

<table>
<thead>
<tr>
<th>CASE STUDY CITY</th>
<th>GEOGRAPHICAL LEVEL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barcelona</td>
<td>Metropolitan Area and NUT III</td>
</tr>
<tr>
<td>Istanbul</td>
<td>Municipality</td>
</tr>
<tr>
<td>Lisbon</td>
<td>Municipality</td>
</tr>
<tr>
<td>Litoměřice</td>
<td>City</td>
</tr>
<tr>
<td>Malmö</td>
<td>Municipality</td>
</tr>
<tr>
<td>Milan*</td>
<td>Municipality</td>
</tr>
<tr>
<td>Turin*</td>
<td>Municipality</td>
</tr>
<tr>
<td>Rostock</td>
<td>City</td>
</tr>
<tr>
<td>Zagreb</td>
<td>Municipality</td>
</tr>
</tbody>
</table>

* Milan and Turin were included in the same report.

**Table 2: Data collection limitations**

<table>
<thead>
<tr>
<th>CASE STUDY CITY</th>
<th>DATA COLLECTION LIMITATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barcelona</td>
<td>- Several geographical levels; municipality scale is not representative, only Metropolitan Area and NUT III</td>
</tr>
<tr>
<td></td>
<td>- Some data was collected for different time periods (unavailability of data)</td>
</tr>
<tr>
<td></td>
<td>- Some data was collected for different geographical scales (unavailability of data)</td>
</tr>
<tr>
<td></td>
<td>- No data for the following indicators: urban building density; GDP per sectors</td>
</tr>
<tr>
<td>CASE STUDY CITY</td>
<td>DATA COLLECTION LIMITATIONS</td>
</tr>
<tr>
<td>-----------------</td>
<td>-----------------------------</td>
</tr>
</tbody>
</table>
| Istanbul        | - Some data was collected for different time periods (unavailability of data)  
|                 | - Some data was collected for different geographical scales (unavailability of data)  
|                 | - Different data sources were used for different years, which can cause comparison problems  
|                 | - No data for the following indicators: budget deficit |
| Lisbon          | - Some data was collected for different time periods (unavailability of data)  
|                 | - Some data was collected for different geographical scales (unavailability of data)  
|                 | - GDP is not calculated at municipality level, which has a negative impact in the calculation of other indicators  
|                 | - No data for the following indicators: carbon emissions by sector; budget deficit |
| Litoměřice     | - Some data was collected for different time periods (unavailability of data)  
|                 | - The city level is not captured in most of the statistical databases  
|                 | - Some data was collected for different geographical scales (unavailability of data)  
|                 | - No data for the following indicators: urban building density; indebtedness level |
| Malmö          | - Some data was collected for different time periods (unavailability of data)  
|                 | - Some data was collected for different geographical scales (unavailability of data)  
|                 | - No data for the following indicators: urban waste recovery; water losses; energy-efficient buildings |
| Milan          | - Some data was collected for different time periods (unavailability of data)  
|                 | - Some data was collected for different geographical scales (unavailability of data) |
| Turin          | - Some data was collected for different time periods (unavailability of data)  
|                 | - Some data was collected for different geographical scales (unavailability of data) |
CASE STUDY CITY | DATA COLLECTION LIMITATIONS
---|---
Rostock | - Some data was collected for different time periods (unavailability of data)
  - Some data was collected for different geographical scales (unavailability of data)
  - No data for the following indicators: energy-efficient buildings

Zagreb | - Some data was collected for different time periods (unavailability of data)
  - Some data was collected for different geographical scales (unavailability of data)

Because of the referred limitations, the integration of data was difficult. The data was collected for different geographical scales and time periods. Moreover, some data wasn’t available. Countries present also different territorial structures. However, all the methodological problems are indicated in the analysis.
III OVERVIEW OF THE CASE STUDY CITIES

III.1 TERRITORY

The ten case study cities – Barcelona, Istanbul, Lisbon, Litoměřice, Malmö, Milan, Turin, Copenhagen, Rostock and Zagreb are located in nine different countries: Spain, Turkey, Portugal, Czech Republic, Denmark, Sweden, Italy, Germany and Croatia.

Figure 4: Case study cities

The cities present different size and characteristics, which makes the analysis and comparison more interesting.

Figure 5: Geopolitical elements

<table>
<thead>
<tr>
<th>CASE STUDY CITIES</th>
<th>GEOPOLITICAL ELEMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barcelona</td>
<td>2nd largest city in Spain, capital of Catalonia</td>
</tr>
<tr>
<td></td>
<td>2nd economic centre of Spain, after Madrid</td>
</tr>
<tr>
<td></td>
<td>Relevant port city</td>
</tr>
<tr>
<td></td>
<td>Important cultural centre in Europe</td>
</tr>
<tr>
<td></td>
<td>Touristic destination</td>
</tr>
<tr>
<td>CASE STUDY CITIES</td>
<td>GEOPOLITICAL ELEMENTS</td>
</tr>
<tr>
<td>-------------------</td>
<td>------------------------</td>
</tr>
</tbody>
</table>
| **Istanbul**      | Capital city (Turkey), mega city  
|                   | Strategic location: Istanbul extends over 2 continents – Asia and Europe; 4th Pan European Corridor ends in Istanbul  
|                   | Two important ports  
|                   | Cultural, economic and demographic dynamics |
| **Lisbon**        | Capital city and the largest city in Portugal  
|                   | Westernmost city in Europe, along the Atlantic coast  
|                   | Coastal city and touristic destination  
|                   | Strategic location: relation with Latin America, Africa and Asia, allowing access to 750 million consumers from Europe and Portuguese-speaking countries |
| **Litoměřice**   | Small city  
|                   | Northern part of Czech Republic  
|                   | 60 km North of the capital Prague |
| **Malmö**        | 3rd largest city in Sweden  
|                   | Southwest coast of Sweden  
|                   | Direct connection to Denmark via the Öresund bridge |
| **Milan**        | 2nd largest city in Italy, after Rome  
|                   | Administrative centre of the Lombardy region  
|                   | Northern part of Italy, midway between Po river and the foothills of the Alps  
|                   | Main industrial and commercial city in Italy  
|                   | Artistic and cultural centre |
| **Turin**        | 4th largest city in Italy  
|                   | Administrative centre of the Piedmont region  
|                   | Western part of the Po river, at the foothills of the Alps  
|                   | 3rd area in Italy in terms of GDP |
| **Rostock**      | Medium-sized city  
|                   | North-east of Germany by the Baltic sea  
|                   | Geographical region Northern Lowland  
|                   | Can be accessed by highway from Hamburg and Berlin in around 2 hours |
| **Zagreb**       | Capital city and the largest city in Croatia  
|                   | Northwest of the country, along the Sava river  
|                   | Excellent traffic connection between Central Europe and Adriatic Sea |

Istanbul has the biggest territorial area, followed by Zagreb and Malmö. The smallest municipalities are Lisbon and Litoměřice. However, Barcelona is the municipality with higher urban density, followed by Milan and Turin. Less dense municipalities are Rostock and Malmö.
Figure 6: Area (km$^2$), Municipality, 2013


Figure 7: Density (inhab./km$^2$), Municipality, 2013


III.II POPULATION

The number of inhabitants of the case study cities is very diverse: from around 14 million inhabitants of Istanbul to 24,000 of Litoměřice. It is worth of notice that Istanbul is a mega city, ranking 8 out of 78 OECD metropolitan regions in terms of population size and first for population growth since the mid-1990.
Foreign population is increasing in all cities, being Malmö, Barcelona, Milan and Turin the most cosmopolitan and diverse urban areas. Rostock and Litoměřice have only 4% of foreigners in their total population.

![Population chart](image)

**Figure 8: Population, Municipality, 2013**

![Foreign population chart](image)

**Figure 9: Foreign Population, Municipality, 2013**

The age structure of the population of the case study cities is similar, being recognised a trend towards ageing population. This trend is not so visible in Istanbul, with the following distribution of
the population: 23% (0-14), 71% (15-64) and 6% (over 65). Malmö is an exception: almost half of the population is under 35 (49%) and 71% of the households consist of single parent or single person households (2013).

![Population structure by age groups](Image)

**Figure 10:** Population structure by age group, Municipality, 2013

Note: Barcelona – Barcelona Metropolitan Area; Lisbon: 2011; Istanbul: 2012; Non comparable data available for Zagreb and Malmö.
IV STRATEGIES AND KEY PROJECTS

The majority of case study cities have defined some strategies and projects linked to sustainability, with a specific focus on energy and mobility.

Figure 11: Key strategic elements

<table>
<thead>
<tr>
<th>CASE STUDY CITIES</th>
<th>KEY STRATEGIC ELEMENTS</th>
</tr>
</thead>
</table>
| Barcelona         | To become at the forefront of the smart cities movement worldwide  
                      Award “European Capital of Innovation” (2014)  
                      Energy Improvement Plan of Barcelona (2002) - Strong strategy to reduce  
                      CO₂ emissions (energy efficiency and renewable energies)  
                      Energy, Climate Change and Environmental Quality Plan; adhesion to the  
                      Covenant of Mayors – 20% CO₂ emissions reduction till 2020  
                      Energy Observatory to monitor CO₂ emissions  
                      Adaptation Plan to protect city from climate change  
                      Majority of strategies defined for Barcelona Metropolitan Area |
| Istanbul          | Improvement in Public Transport and Popularisation of Usage Plan: new  
                      metro lines and railways; alternative transport modes; integrated mobility  
                      Reduction of carbon emissions in airports |
| Lisbon            | To become a smart city, integrating three strategic areas: sustainability,  
                      citizen participation and entrepreneurship; pole for creativity and innovation  
                      Atlantic business hub  
                      Award “European City of the Year” (2012) and “Entrepreneurship Region of the Year” (2015)  
                      Energy-Environmental Strategy; Sustainable Energy Action Plan (Covenant of Mayors) and signature of Mayors Adapt initiative (2013)  
                      Integrated Urban Renewal Strategy 2011-2024, with specific focus on energy efficiency  
                      Biodiversity strategy 2020 |
| Litoměřice        | Strategic development plan for the city 2030  
                      Member of national network of healthy towns and energy cities  
                      Energy plan: heating, public lighting, buildings, renewable energy; etc.  
                      Plan to build a new geothermal power plant (20 MWh) |
| Malmö             | Comprehensive Plan for Malmö, comprising economic, social and  
                      environmental issues  
                      Green plan: green areas, parks and recreational areas, biodiversity  
                      City Environmental Program  
                      Storm Water Strategy  
                      Traffic program (2012-2017): sustainable traffic system with focus on soft  
                      modes (pedestrian, biking, etc.)  
                      Energy strategy: focus on renewable energy |
Some anchor projects are presented below as good practices that can be adapted and replicated in other cities.

**Electric Mobility - Barcelona**

The project intends to turn electric vehicles into Barcelona’s standard mode of public and private transport for individuals and groups. It integrates the following components:

**Electric Taxis**: Barcelona will become the leader in the implementation of this type of vehicle in the realm of public transport.

**Electric buses**: Barcelona is a benchmark for this type of service. The city has the cleanest fleet of buses in Europe. All thanks to the introduction of and support for hybrid and compressed natural-gas-powered vehicles, as well as the installation of anti-pollution filters in diesel
vehicles. TMB is also collaborating with the company Siemens on hybridisation designs for buses and minibuses, to cover 100% of the bus routes.

**Car sharing using electric vehicles:**
Barcelona is establishing a new rental model for such vehicles, which will also improve the current system, as users will be able to pick up and drop off the vehicles wherever they wish.

**Electric motorbikes:** Barcelona already provides 150 recharge points for these vehicles as well as a newly installed electric motorbike station at the IESE Business School, which is currently functioning at full use.

**Bicing - Barcelona**
The project aims to achieve a safe and efficient means of transport with less impact on the environment.

Bicing was launched in 2007 as a complementary urban transport based on shared bicycle use. It has 420 stations spread round the city and 6,000 bikes.

Bicing is complemented by the BicingApp. This is a simple app that gives access to real-time user information such as bicycle availability and stations. Thanks to Barcelona Contactless technology, users can download the app by merely scanning the QR code or drawing their mobile close to the NFC chips placed in every station.

**Sensors for Urban Services - Barcelona**
The project brings order to the many municipal information systems and aims to integrate other information systems from the private sector.

Barcelona has been working for the last years in several pilot projects to install sensors in the city and to create platforms that allow the share of information and give it the proper use to citizens, city managers, businesses and professionals. Furthermore, there are different formats
of sensors, databases, new applications and designs generated both by public administration and private firms. Barcelona is creating an efficient and smart service delivery platform for citizens and municipal workers. This platform has a common data warehouse where the different sensors systems store their information. This system has been built through a public-private partnership model, developing a normalised model based on well-known standards.

Different pilot projects cover many applications to improve management of urban services. Some examples are sensors in solid waste containers (to report loading data to adjust schedules or routes), street sensors (occupancy of parking spaces and loading areas) for environmental control (air and noise pollution), humidity (for irrigation in public parks) and urban metering (of gas, water or power).

**SIIUR - Integral Solution for Urban Infrastructures - Barcelona**

The goal of the project is to better satisfy the needs of citizens and institutions, improve energy efficiency and reduce pollution and energy consumption.

SIIUR project is an innovative integration of urban infrastructure and services to manage cities in a more efficient, friendly and intelligent way. The high cost of operation and maintenance of street lighting is not only an economic problem but also an environmental concern. The application of measures such as control of lighting zones, regulation of the hours of lighting, improvements in facilities and an electrical analysis of the position of lamps results in costs savings of up to 40%.

Street lamps in the SIIUR project are equipped with LED technology to reduce cost and pollution. Lamps include sensors that process environmental information and detect presence, temperature, humidity, noise and pollution. These lights are connected to a Street Lighting Cabinet that centralises all communications and services (such as Fibre-optic cabling to the Home, Wi-Fi or Electrical Vehicle recharging stations), and sends the information to a central control centre. This new lighting system is located in Passatge Mas de Roda, with two main objectives: to test new more efficient lighting systems and to integrate technological features to develop a real smart city environment.

**Solar Potential Map - Lisbon**

The Lisbon Solar Potential Map was promoted by Lisboa E-Nova under the European Project POLIS – “Identification and Mobilisation of Solar Potentials via Local Strategies” (with the following city partners: Paris, Lyon, Munich, Malmö and Victoria). The project aimed at the evaluation of the potential solar installation of solar systems in the built heritage of Lisbon.

Lisbon Solar Potential Map, available online via Google Maps application,
covers all the buildings in Lisbon. It allows the identification of the preferable areas to invest in solar technologies and represents an efficient awareness tool, both for local authorities, investors and companies and citizens.

As a result of the project and cooperation between the various European partners, it was possible to identify measures that contribute to the definition of public policy at the level of development of municipal urban planning regulations, as well as new legal and financial mechanisms to encourage the adoption of solar technologies in the urban environment.

**Eco-neighbourhood Boavista Ambiente + - Lisbon**

The project aims at the reconversion and qualification of public space, implementation of measures to improve the energy performance of buildings and remodelling of some equipment in the social neighbourhood Boavista, including the municipal swimming pool.

Dissemination and awareness actions to the residents of the neighbourhood were also promoted, such as the launching of a challenge posed to 100 families to cooperate in order to enhance domestic savings of electricity, natural gas and water.

Within the Eco-neighbourhoods program supported by regional funds, an additional project is being funded in a neighbourhood in Vila Franca de Xira.
V INTEGRATED CASE STUDIES ASSESSMENT

V.I SOCIAL PERFORMANCE

UNEMPLOYMENT LEVEL BY GENDER

In general, from 2006 to 2012 unemployment rate has increased mostly because of the adverse effects of the economic and financial crisis. In this period, in Barcelona the variation of male’s unemployment rate was +239% and the variation of women unemployment rate was +158%. Exceptions are Istanbul, Rostock and Zagreb.

Figure 13: Evolution of unemployment rate by gender, 2006 and 2012

Note: Barcelona, Milan, Turin: NUT III; Istanbul, Lisbon, Rostock: NUT II; Malmö, Zagreb: Municipality; Information for Litoměřice not available.

TERCIARY EDUCATION LEVEL BY GENDER

Tertiary education rate is higher in Zagreb, followed by Malmö, Lisbon and Barcelona. Istanbul reports the lowest tertiary education level.
In 2009, Litoměřice and Zagreb (Croatia) presented the highest poverty rates, followed by Rostock and Barcelona. Istanbul reported a poverty rate of 14.9%.

A sharp increase in the poverty rate happened between 2008 and 2011 while a reversion of this trend can be appreciated from 2011 onwards, being Milan the exception.
Figure 16: Evolution of poverty rate, NUT II, 2005-2012
Note: Litoměřice: 2010; Zagreb – Croatia: NUT I; Non comparable data for Lisbon and Zagreb.

AVERAGE LIFE EXPECTANCY

In 2011, average life expectancy was higher in Milan, Barcelona and Turin (83 years old), followed by Malmö (81.7). Litoměřice (76), Istanbul (77.8) and Zagreb (78.1) reported lower average life expectancy. The difference between the best and the worst performer is expressive (7 years). However, between 2004 and 2011 average life expectancy has grown in all case study cities.

Figure 17: Evolution of average life expectancy, 2004 and 2011
GREEN SPACE AVAILABILITY

Malmö and Rostock present a high percentage of green space over total urban area, compared with the other case study cities.

Figure 18: Percentage of green space over total urban area, Municipality, 2009
Note: Rostock – 2012; Litoměřice – 2013; Lisbon – 2014; Non comparable data for Barcelona.

MONITORING SYSTEM FOR EMISSIONS REDUCTIONS

Barcelona, Malmö, Milan, Rostock, Turin and Zagreb have a monitoring system for emissions reduction.

Every municipality in the district of Barcelona calculates the emissions based on a common methodology, grounded on data from energy consumption in housing, transport and industry. The district of Barcelona has also introduced a further level of emissions monitoring by including emissions dependent on the water cycle and waste management, areas in which municipalities have direct influence. The monitoring system for emissions reduction in Turin has been implemented by the Province since 2000, and it has been enhanced since the adoption of SEAP in 2010. Malmö municipality has a target of 40% emissions reduction until 2030 compared to 1990. This is monitored and reported on a yearly basis in order to indicate whether the target will be fulfilled by 2030.

Rostock has developed and concluded a carbon neutrality plan “Masterplan 100% Climate Protection” at city level, with the goals to reduce CO2 emissions by 95% and energy consumption by 50% by 2050. Based on this plan, the climate department of the city is responsible for monitoring and providing the indicators and data structure for data collection of CO2 and energy consumption in the future. In Zagreb, there are currently six monitoring systems in the city territory for tracking emissions and air quality.
V.II  ECONOMIC PERFORMANCE

LEVEL OF WEALTH

Milan and Malmö have the highest level of GDP per capita among the case study cities. This position is followed by Rostock, Turin and Barcelona. Lisbon presents an expressive decrease in the level of wealth between 2007 and 2010.

![GDP per capita](image)

**Figure 19: Evolution of GDP per capita, NUT III, 2007 and 2010**

Note: Istanbul, Lisbon – NUT II; Rostock, Zagreb – Municipality.

EMPLOYMENT BY SECTORS

The profile of case study cities in terms of employment per sectors is similar. A higher and growing employment in the services sector is the common trend. Istanbul reports a higher importance of the industry sector when compared with the other cities.
**INDEBTEDNESS LEVEL**

The debt level in percentage of GDP is only relevant in Istanbul (31.7%). However, this value decreased to 13.4% in 2011 and 9.5% in 2012.

**Figure 20: Employment by economic sectors**

Note: Istanbul – NUT II; Rostock, Zagreb, Barcelona – Municipality; Milan, Turin, Lisbon – NUT III.

**Figure 21: Debt level (% GDP), 2010**
R&D INTENSITY

Malmö (3.2%) and Lisbon (2.48%) are the best performers in term of R&D expenditure as a percentage of GDP, followed by Rostock and Turin. The worst performer is Litoměřice (0.28%).

Figure 22: R&D expenditure as % of GDP, NUT II, 2011

Note: Malmö, Lisbon – NUT III; Lisbon – 2010.
V.III ENVIRONMENTAL PERFORMANCE

ECOSYSTEM PROTECTED AREAS

Litoměřice reports 92.1% of ecosystem protected areas as a percentage of total surface area, followed by Barcelona (28%).

![Ecosystem protected areas chart](image)

**Figure 23:** Ecosystem protected area (% total surface area), Municipality

Note: Milan – NUT II; Barcelona – Barcelona Metropolitan Area.

ENERGY INTENSITY

![Energy intensity chart](image)

**Figure 24:** Energy intensity (toe/M€)
Energy intensity is higher in Barcelona, followed by Zagreb and Turin. The general decrease in energy intensity is a trend in all case study cities.

ENERGY CONSUMPTION BY SECTOR
The profile of case study cities in terms of energy consumption by sectors is very diverse. In Milan, services present higher energy consumption in comparison with the other sectors. In Lisbon and Barcelona the higher energy consumer is the transport sector. In Turin and Malmö the residential sector dominates. With a different sectors classification, in Rostock industry, services and agriculture lead in terms of energy consumption, while in Zagreb are the residential and commercial sectors.

Figure 25: MILAN - Energy consumption by sectors
Figure 26: LISBON - Energy consumption by sectors

Figure 27: TURIN - Energy consumption by sectors
Figure 28: BARCELONA - Energy consumption by sectors

Figure 29: Malmö - Energy consumption by sectors
Figure 30: ZAGREB - Energy consumption by sectors

Figure 31: ROSTOCK - Energy consumption by sectors
CARBON EMISSIONS INTENSITY

Carbon emissions intensity is higher in Barcelona. The general decrease in carbon emission intensity is a trend in all case study cities.

Figure 32: Carbon emissions intensity

Note: Lisbon, Milan, Turin – NUT III; Barcelona – NUT II; Malmö, Rostock, Zagreb – Municipality.

CARBON EMISSIONS BY SECTOR

The profile of case study cities in terms of carbon emissions by sectors is very diverse. In Milan and Turin, services and residential sectors present higher carbon emissions in comparison with the other sectors. In Malmö road transport dominates. With a different classification, in Barcelona energy production lead in terms of carbon emissions, while in Litoměřice and Istanbul is the residential sector. Finally, in Zagreb industry sector is the higher producer of carbon emissions.
Figure 33: MILAN - Carbon emissions by sector, 2005 and 2010

Figure 34: TURIN - Carbon emissions by sector, NUT III, 2002 and 2011
Figure 35: MALMÖ - Carbon emissions by sector, 2000 and 2012

Figure 36: BARCELONA - Carbon emissions by sector, 2003 and 2012
Figure 37: ISTANBUL - Carbon emissions by sector, 2010

Figure 38: LITOMĚŘICE - Carbon emissions by sector, 2013
SUSTAINABLE TRANSPORTATION

The share of sustainable transportation (public transports, walk, and bike) in total modal share is higher in Istanbul, followed by Litoměřice. Malmö and Rostock residents use bicycle as an alternative transportation mode.
URBAN WASTE GENERATION
Urban waste production was higher in Turin and Milan in 2007. In 2011, Lisbon reported the highest urban waste generation. However, the decrease in the amount of this indicator is the general trend, with exception of Lisbon and Istanbul.

![Urban waste generation](image)

**Figure 41: Urban waste generation, 2007 and 2012**

URBAN WASTE RECOVERY
Urban waste recovery is higher in Rostock, Turin, Milan and Barcelona, being Lisbon, Zagreb and Istanbul the worst performers. The trend is towards the increase of urban waste recovery, with the exception of Lisbon.
Figure 42: Urban waste recovery, 2008 and 2012

WATER LOSSES
Water losses are bigger in Istanbul and Turin, being Lisbon and Rostock the best performers.

Figure 43: Water losses, 2012
Note: Barcelona – 2013
Urban buildings density is higher in Zagreb. The other case study cities report a similar urban density, being Malmö the less dense city.
VI KEY FINDINGS AND CHALLENGES

In the following table, key strengths and challenges are described per case study city.

Figure 45: Key strengths and challenges

<table>
<thead>
<tr>
<th>CITIES</th>
<th>STRENGTHS</th>
<th>CHALLENGES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barcelona</td>
<td>At the forefront of smart cities movement</td>
<td>Increased share of the population at risk of exclusion and poverty</td>
</tr>
<tr>
<td></td>
<td>Several strategies which are impacting carbon emissions</td>
<td>Increased level of unemployment</td>
</tr>
<tr>
<td></td>
<td>Sustainability strategies are being implemented: transports, green space,</td>
<td>Need to find a balance between the need to maintain it as a tourist centre,</td>
</tr>
<tr>
<td></td>
<td>waste and water management</td>
<td>while keeping its local character</td>
</tr>
<tr>
<td></td>
<td>Strong role of AMB as a coordinating body</td>
<td>Growing level of municipal indebtedness</td>
</tr>
<tr>
<td></td>
<td>Influx of young immigrants</td>
<td></td>
</tr>
<tr>
<td>Istanbul</td>
<td>Initial stage of development towards a post-carbon city</td>
<td>Population increase and growing urbanisation</td>
</tr>
<tr>
<td></td>
<td>Investments in public transportation</td>
<td>Sprawl of the city towards peripheries caused by growing population</td>
</tr>
<tr>
<td></td>
<td>Improvement of social performance</td>
<td>Air and environmental pollution; stress on natural protection areas and</td>
</tr>
<tr>
<td></td>
<td>Increase in level of wealth and economic attraction</td>
<td>forests</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Environmental performance as the weakest dimension and most underestimated</td>
</tr>
<tr>
<td></td>
<td></td>
<td>by city</td>
</tr>
<tr>
<td>Lisbon</td>
<td>Several strategies and plans are being implemented in the area of mobility</td>
<td>Loss of population in the city centre and aging people</td>
</tr>
<tr>
<td></td>
<td>and energy, but still with medium impact</td>
<td>Increase in unemployment and poverty levels</td>
</tr>
<tr>
<td></td>
<td>Reduction of pollutants and carbon emissions</td>
<td>Use of car as the privileged mode of transportation</td>
</tr>
<tr>
<td></td>
<td>Expressive reduction of water losses</td>
<td>Need to improve performance in waste management and recovery</td>
</tr>
<tr>
<td></td>
<td>Improvement of public finances</td>
<td>Need to invest in buildings renovation</td>
</tr>
<tr>
<td>Litoměřice</td>
<td>One of pioneer cities in Czech Republic aiming at energy efficiency and</td>
<td>Small city that is from large extent influenced by the development of</td>
</tr>
<tr>
<td></td>
<td>renewable energy production</td>
<td>higher territorial units</td>
</tr>
<tr>
<td></td>
<td>Ambition to become an energy self-sufficient city</td>
<td>Dependence on the availability of external financial resources</td>
</tr>
<tr>
<td></td>
<td>Emphasis on the geothermal power plant project</td>
<td></td>
</tr>
<tr>
<td>Malmö</td>
<td>Ambitious energy strategy</td>
<td>Economic inequity in the city</td>
</tr>
<tr>
<td></td>
<td>Sustainable transportation is on the right track</td>
<td>Segregated city with evidence of social unrest (high immigration numbers)</td>
</tr>
<tr>
<td></td>
<td>Innovative city with a positive trend in GDP per capita</td>
<td>No protocol to calculate the carbon footprint of the city</td>
</tr>
<tr>
<td></td>
<td>Young and multicultural city</td>
<td></td>
</tr>
</tbody>
</table>
### CITIES

<table>
<thead>
<tr>
<th>CITY</th>
<th>STRENGTHS</th>
<th>CHALLENGES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milan</td>
<td>Leading city in economic and social areas</td>
<td>Advantage compared to Italian cities in terms of environmental standards, but behind European average standards</td>
</tr>
<tr>
<td></td>
<td>Innovative city</td>
<td>Need to invest in the shift towards a zero-carbon paradigm and to increase civil awareness</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Poor air quality, high pollution</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Aged building stock</td>
</tr>
<tr>
<td>Turin</td>
<td>Innovative city</td>
<td>Increase in unemployment and decrease in GDP (due to strong specialisation)</td>
</tr>
<tr>
<td></td>
<td>Relevant share of green areas</td>
<td>High percentage of people in risk of poverty</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Poor air quality, high pollution</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Stock of debt is high</td>
</tr>
<tr>
<td>Rostock</td>
<td>Important measures to reduce environmental footprint</td>
<td>Weak infrastructure and social challenges regarding poverty and unemployment in the region</td>
</tr>
<tr>
<td></td>
<td>Improvement of air quality, waste and water management and sustainable mobility</td>
<td>Weak financial situation</td>
</tr>
<tr>
<td>Zagreb</td>
<td>Growing number of citizens and transition groups paving the way towards a post-carbon paradigm (bottom-up approach)</td>
<td>Lack of strategic planning</td>
</tr>
<tr>
<td></td>
<td>Participation in major EU and global initiatives aiming at CO₂ reduction</td>
<td>Need of social participation in the transition towards a post-carbon city</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Critical success factors: social – unemployment and poverty; environment – public transportation and municipal waste management; economic – GDP per capita, business survival and social entrepreneurship</td>
</tr>
</tbody>
</table>

On an empirical basis, we can identify three clusters of cities with different stages of development in the transition towards a post-carbon city:

**At the forefront of the transition towards a post carbon city:**
- Malmö
- Barcelona

**Intermediate stage of development in the transition towards a post-carbon city:**
- Lisbon
- Milan
- Turin
- Rostock

**Initial stage of development towards a post carbon city:**
- Istanbul
- Litoměřice
- Zagreb
VII CONCLUSIONS

The evaluation and comparison of the pre-defined Key Performance Indicators in the case study cities suggest that there is a global trend towards a post-carbon paradigm. However, cities present different development stages.

**Barcelona** is at the forefront of the smart cities movement. Several strategies towards a post-carbon city are being implemented by the Metropolitan Area, namely in the areas of energy, mobility, water and waste management, and biodiversity. The use of smart technologies to achieve this objective is a reality. However, unemployment and poverty are weaknesses that have been enhanced by the economic and financial crisis.

**Malmö** is a frontrunner in the transition towards a post-carbon city. An ambitious energy strategy is being implemented with positive impacts in carbon emissions and energy consumption. It is a young and multicultural city with reasonable economic and social performance.

**Lisbon** is in an intermediate stage of development in the transition towards a post-carbon city. Several strategies and projects have been launched in the areas of energy, mobility, and biodiversity but still with limited impacts. Due to economic and financial crisis, unemployment and risk of poverty are increasing.

**Milan** is in an intermediate stage of development in the transition towards a post-carbon city. It is a leading city in economic terms but the investment in environmental issues is comparatively lower. One of the major urban problems is pollution and poor air quality.

**Turin** is in an intermediate stage of development in the transition towards a post-carbon city. It is an innovative city, but it is being affected by unemployment and poverty due to strong specialisation. One of the major urban problems is pollution and poor air quality.

**Rostock** is in an intermediate stage of development in the transition towards a post-carbon paradigm. Important measures were adopted to reduce the environmental footprint of the city, namely in the areas of air quality, waste and water management and sustainable mobility with positive impacts.

**Istanbul** is in an initial stage of development towards a post-carbon city. Environmental performance is the weakest dimension and most underestimated by the city. The main problems are growing urbanisation, urban sprawl, pollution, and stress in natural protection areas. However, Istanbul is improving in economic and social terms, being a dynamic and vibrant city.

**Zagreb** is in an initial stage of development in the transition towards a post-carbon city. Some grassroots movements are in place, but strategic planning is weak. It is worth of notice the high qualification of the population, in comparison with other case study cities.

**Litoměřice** is in an initial stage of development in the transition towards a post-carbon city. It is a small city that is influenced by the development of higher territorial units. To become an energy self-sufficient city is the ambition, mostly based on the geothermal power plant future project.
Cities were generally affected by the economic and financial crisis, with negative consequences on unemployment and poverty.

However, case study cities are very different in terms of population size and economic, social and cultural dynamics, which makes the comparison difficult. Moreover, the majority of cities had problems on data collection; thus, the development of urban information systems is a recommendation for all case study cities.
### VIII  ANNEX

#### List of key performance indicators

<table>
<thead>
<tr>
<th>DIMENSION</th>
<th>SUB-DIMENSION</th>
<th>INDICATOR</th>
<th>UNIT</th>
<th>YEAR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Social Inclusion</td>
<td></td>
<td>Variation rate of unemployment level by gender</td>
<td>Percentage</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Variation rate of poverty level</td>
<td>Percentage</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Variation rate of tertiary education level by gender</td>
<td>Percentage</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Variation rate of average life expectancy</td>
<td>Average Nº</td>
<td></td>
</tr>
<tr>
<td>Public services and</td>
<td></td>
<td>Variation rate of green space availability</td>
<td>Percentage</td>
<td></td>
</tr>
<tr>
<td>Infrastructures</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Governance effectiveness</td>
<td></td>
<td>Existence of monitoring system for emissions reductions</td>
<td>Yes/No</td>
<td>Description</td>
</tr>
<tr>
<td>Biodiversity</td>
<td></td>
<td>Variation rate of ecosystem protected areas</td>
<td>Percentage</td>
<td></td>
</tr>
<tr>
<td>Energy</td>
<td></td>
<td>Energy intensity variation rate</td>
<td>Toe/euro</td>
<td>Toe</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Variation rate of energy consumption by sectors</td>
<td>Percentage</td>
<td></td>
</tr>
<tr>
<td>Climate and Air Quality</td>
<td></td>
<td>Variation rate of carbon emissions intensity</td>
<td>Ton CO2/euro</td>
<td>Ton CO2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Variation rate of carbon emissions by sector</td>
<td>Ton CO2</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Exceedance rate of air quality limit values</td>
<td>Nº</td>
<td></td>
</tr>
<tr>
<td>Transport and mobility</td>
<td></td>
<td>Variation share of sustainable transportation</td>
<td>Percentage</td>
<td></td>
</tr>
<tr>
<td>Waste</td>
<td></td>
<td>Variation rate of urban waste generation</td>
<td>Kg/person/year</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Variation rate of urban waste recovery</td>
<td>Percentage</td>
<td></td>
</tr>
<tr>
<td>DIMENSION</td>
<td>SUB-DIMENSION</td>
<td>INDICATOR</td>
<td>UNIT</td>
<td>YEAR</td>
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<td>-------------------------</td>
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</tr>
<tr>
<td>Water</td>
<td></td>
<td>Water losses variation rate</td>
<td>m3/person/year</td>
<td></td>
</tr>
<tr>
<td>Buildings and Land Use</td>
<td></td>
<td>Energy-efficient buildings variation rate</td>
<td>Percentage</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Urban building density variation rate</td>
<td>N°/ km2</td>
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<td>ECONOMY</td>
<td></td>
<td>Level of wealth variation rate</td>
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<td></td>
<td>Sustainable economic</td>
<td>Variation rate of GDP by sectors</td>
<td>Percentage</td>
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<td></td>
<td>growth</td>
<td>Employment by sectors variation rate</td>
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<td></td>
<td>Business survival variation rate</td>
<td>Percentage</td>
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<tr>
<td>Public Finances</td>
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<td>Budget deficit variation rate</td>
<td>Percentage of city’s GDP</td>
<td></td>
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<tr>
<td>Research &amp; Innovation</td>
<td></td>
<td>Indebtedness level variation rate</td>
<td>Percentage of city’s GDP</td>
<td></td>
</tr>
<tr>
<td>dynamics</td>
<td></td>
<td>R&amp;D intensity variation rate</td>
<td>Percentage</td>
<td></td>
</tr>
</tbody>
</table>