POCACITO

european post-carbon cities of tomorrow

REPORT ON KEY PERFORMANCE INDICATORS

FINAL VERSION

INTELI – INTELLIGENCE IN INNOVATION, INNOVATION CENTRE

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

CO_2	Carbon Dioxide
CUNI	Center Charles University in Prague
EPBD	Energy Performance of Buildings Directive
EUROSTAT	Statistical Office of the European Union
FEEM	Fondazione Eni Enrico Mattei
GDP	Gross Domestic Product
GHG	Green House Gas
INTELI	Intelligence in Innovation; Innovation Centre
JR	Joanneum Research
KPI	Key performance indicators
PCI	Post-Carbon City Index
R&D	Research and Development

I EXECUTIVE SUMMARY

One of the main objectives of the POCACITO project is to produce a mechanism to assess and monitor the post-carbon city transition process. The Post-Carbon City Index (PCI) will be that tool. This document includes three main sub-chapters to introduce the core aspects of the selection and construction process of the Post-Carbon City Index. Table 1 includes all key performance indicators (KPI) by dimension and sub-dimension, as well as the measurement units and reference years used for data collection.

The report starts by presenting the main objectives and methodology used to design the PCI, which is based on a set of KPI. This section encompasses the conceptual model, dimensions and sub-dimensions, and data collection.

Then, a more detailed presentation of the key performance indicators introduces the concept of the PCI and explains how this index can be used as a monitoring tool by cities undergoing a post-carbon transition. This section includes a detailed description and justification of each indicator, dimension and corresponding sub-dimension. The scientific basis for the selection of each indicator is also extensively explained, as well as the identification of variables, reference year, and sources of information, among other aspects.

The conclusion summarises the main outcomes of the Post-Carbon City Index development process and highlights the most relevant milestones for the assessment procedures of the case study cities.

Table 1: List of key performance indicators

DIMENSION	SUB-DIMENSION	INDICATOR	UNIT	YEAR
SOCIAL	Social Inclusion	Variation rate of unemployment level by gender	Percentage	2003-2012
		Variation rate of poverty level	Percentage	2003-2012
		Variation rate of tertiary education level by gender	Percentage	2003-2012
		Variation rate of average life expectancy	Average Nº	2003-2012
	Public services and Infrastructures	Variation rate of green space availability	Percentage	2003 2012
	Governance effectiveness	Existence of monitoring system for emissions reductions	Yes/No Description	2013
ENVIRONMENT	Biodiversity	Variation rate of ecosystem protected areas	Percentage	2012
	Energy	Energy intensity variation rate	Toe/euro Toe	2003 2012

DIMENSION	SUB-DIMENSION	INDICATOR	UNIT	YEAR
		Variation rate of energy consumption by sectors	**Percentage**	**2003 2012**
	Climate and Air Quality	Variation rate of carbon emissions intensity	**Ton CO_2/euro Ton CO_2**	**2003 2012**
		Variation rate of carbon emissions by sector	**Ton CO_2**	**2003 2012**
		Exceedance rate of air quality limit values	**Nº**	**2010 2012**
	Transport and mobility	Variation share of sustainable transportation	**Percentage**	**2001 2011**
	Waste	Variation rate of urban waste generation	**Kg/person/year**	**2007 2012**
		Variation rate of urban waste recovery	**Percentage**	**2007 2012**
	Water	Water losses variation rate	**m^3/person/year**	**2003 2012**
	Buildings and Land Use	Energy-efficient buildings variation rate	**Percentage**	**2007 2012**
		Urban building density variation rate	**Nº/ km^2**	**2003 2012**
ECONOMY	**Sustainable economic growth**	Level of wealth variation rate	**eur/person**	**2003-2012**
		Variation rate of GDP by sectors	**Percentage**	**2003-2012**
		Employment by sectors variation rate	**Percentage**	**2003 2012**
		Business survival variation rate	**Percentage**	**2008,2009, 2010**
	Public Finances	Budget deficit variation rate	**Percentage of city's GDP**	**2003-2012**
		Indebtedness level variation rate	**Percentage of city's GDP**	**2003-2012**
	Research & Innovation dynamics	R&D intensity variation rate	**Percentage**	**2003-2012**

II INTRODUCTION

The POCACITO (Post-Carbon Cities of Tomorrow) project will develop a 2050 roadmap to support the transition of cities to a more sustainable or post-carbon future. The main methodology used in the initiative is collaborative research and participatory scenario building.

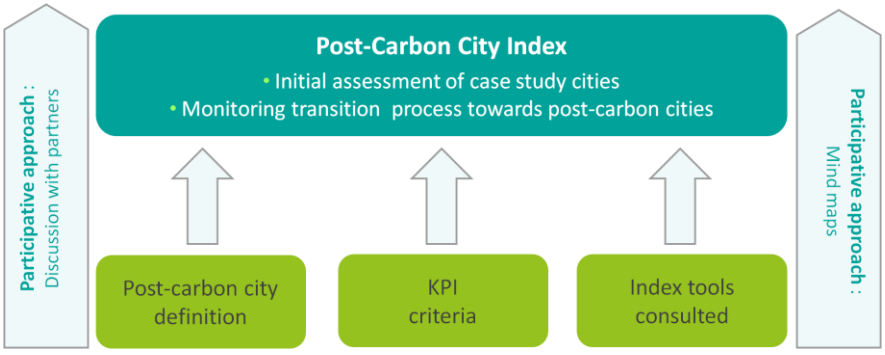
In order to use an evidence-based approach, 10 European case studies were selected – the project case studies: Barcelona, Copenhagen/Malmö, Istanbul, Lisbon, Litoměřice, Milan/ Turin, Offenburg and Zagreb.

An important step to achieve this goal is to produce an initial assessment of these case study cities. In particular, this diagnosis will be done through the use of a specific methodology comprising a set of key performance indicators – the Post-Carbon City Index (PCI).

The PCI combines indicators covering environmental, social and economic dimensions. Each dimension includes a set of sub-dimensions and each sub-dimension, a set of indicators. Globally, this conceptual model constitutes a holistic approach that allows the project partners to diagnose the situation of the case study cities with regard to their socioeconomic and sustainable dynamics. This tool will also allow cities to monitor the post-carbon transition process over the years.

Indicators were selected (Figure 1) taking into account: i) the definition of a 'post-carbon city'; ii) a set of existing indicators (see Table 2, page 7, of the "Methodological Guide for the Initial Assessment of Case Study Cities" (INTELI 2014)); and iii) a set of criteria defined by POCACITO partners, namely: relevance, clear message, data availability and data quality. Partners have participated in the indicator selection process by discussing indicators and developing mind maps. Three mind maps were produced to identify indicators that are highly correlated i.e., the indicators that "incorporate" more information – the most "substantial" indicators. The social mind map was produced by CUNI; the environmental mind map by INTELI, and the economic mind map by JR/FEEM (ATTACHMENT B – MIND MAPS).

Figure 1: Indicator selection process



The list of indicators according to the respective dimension and sub-dimension is available in this document, together with a factsheet providing an in-depth description of each indicator, which is also identified by an individual code.

An online platform to support the collection of data by case study partners will be available. The design of this platform is illustrated in this report.

III POST-CARBON CITY INDEX

III.I OBJECTIVES

The Post-Carbon City Index is a tool aimed at measuring societal transformations occurring within cities, which takes into account the interplay between different axes of diversity and the nexus between the social/spatial regimes. The index integrates a set of key performance indicators, which will allow a uniform collection of data, improve the comparison and support the identification of best practices in each case study city, covering environmental, social and economic aspects.

According to the Strategic Implementation Plan (European Commission 2013) of the European Innovation Partnership on Smart Cities and Communities, performance indicators and metrics are very important to measure and compare cities' progress.

The Post-Carbon City Index will contribute to the quantification of impacts as well as the qualitative scenario building and modelling (WP4 and WP5). Additionally, it will enable the comparison and monitoring of the case study cities in their realistic achievements (rather than prescriptive standards) of low-carbon targets, through the use of a specific quantitative analysis of environmental and socioeconomic metrics.

The assessment based on the Post-Carbon Cities Index will complement the results from the local scenarios and visions by enabling an analysis of common features and collecting significant inputs that will culminate in the construction of an EU 2050 Post-Carbon City Roadmap for a common future of European cities.

III.II METHODOLOGY

'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.

Since the case study cities of Barcelona, Copenhagen/Malmö, Istanbul, Lisbon, Litoměřice, Milan/Turin, Offenburg and Zagreb are very diverse and present different local circumstances, the POCACITO consortium considers it counterproductive to provide a narrow definition of post-carbon cities or to prescribe a list of necessary features, since this will vary according to each city. However, 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 (please see section II.II of the Common Approach Framework Document; Ecologic Institute 2014).

Cities are complex, adaptive, social-ecological systems (Ecologic Institute 2014) and cannot be fully understood by examining individual components; POCACITO moves away from analysing the three dimensions of sustainability as silos and towards a more comprehensive approach, as illustrated in

Figure 2. It assesses the relationships among factors and feedback loops of the entire system, analyses the dynamics of urban systems and identifies key features of post-carbon city transitions.

A set of post-carbon city key performance indicators related to these dimensions were developed to provide a common structure for analysis, and the guidelines for the initial assessment as a starting point for back-casting exercises (please see section III.I.3 of the Common Approach Framework Document; Ecologic Institute 2014), which will analyse how the parameters change during the transition process towards a post-carbon city. In doing so, stakeholders will be able to identify early warning signs of undesirable consequences based on current investments as well as cases where marginal changes are not sufficient (or even counterproductive) for reaching long-term goals.

III.II.1 CONCEPTUAL MODEL

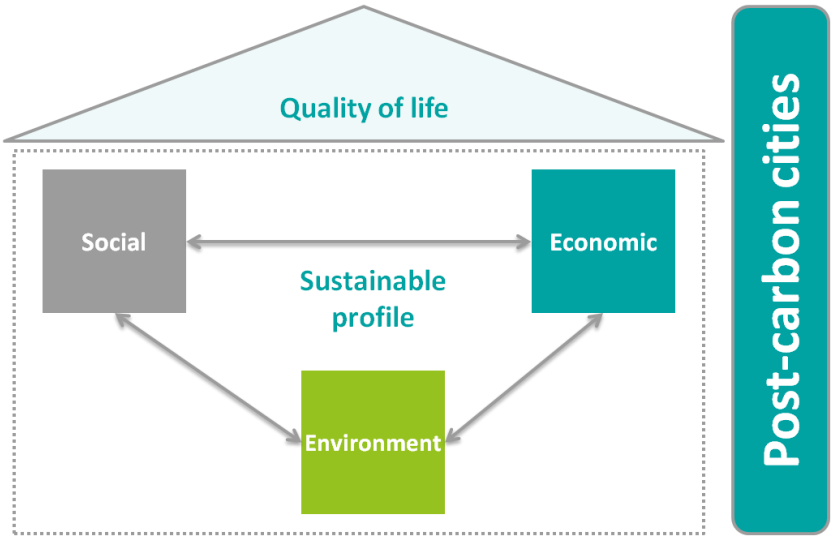
> "SUSTAINABLE ACTIVITY IS ... THAT LEVEL OF ECONOMIC ACTIVITY WHICH LEAVES THE ENVIRONMENTAL QUALITY LEVEL INTACT, WITH THE POLICY OBJECTIVE CORRESPONDING TO THIS NOTION BEING THE MAXIMISATION OF NET BENEFITS OF ECONOMIC DEVELOPMENT, SUBJECT TO MAINTAINING THE SERVICES AND QUALITY OF NATURAL RESOURCES OVER TIME" (EDWARD BARBIER AND MARKANDYA 1990, P 659).

An innovative approach of the interaction between the three pillars of sustainability in the context of POCACITO is summarized in Figure 2.

The Post-Carbon City Index helps cities monitor their transition process by evaluating their sustainable profile and policy responses, by making a diagnosis and characterisation of socioeconomic and environmental impacts, as well as an assessment of how effective existing sustainable policies and measures are enhancing urban environment resilience and contributing to the overall goal of transition to a post-carbon city.

The transition process has to create economic opportunities through strategies that address the challenges of economic growth, entrepreneurial activities and R&D dynamics. The transition process and the idealised sustainable profile of a post-carbon city have a common umbrella: the quality of life of their inhabitants. The standards of quality of life in terms of social vulnerability and equity, civil society and local amenities must be ensured throughout the process.

Figure 2: Conceptual model



III.II.2 DIMENSIONS AND SUB-DIMENSIONS

The conceptual model was conceived to use the quality of life as the main objective, since every step towards a post-carbon city has to guarantee the welfare of both inhabitants and future generations. It can be attained by constantly monitoring the sustainable profile of cities and adjusting policies using an adaptive management process, promoting the sustainable growth of cities.

> "ADAPTIVE MANAGEMENT IS DEFINED AS FLEXIBLE DECISION-MAKING THAT CAN BE ADJUSTED IN THE FACE OF UNCERTAINTIES AS OUTCOMES FROM MANAGEMENT ACTIONS AND OTHER EVENTS BECOME BETTER UNDERSTOOD. CAREFUL MONITORING OF THESE OUTCOMES BOTH ADVANCES SCIENTIFIC UNDERSTANDING AND HELPS ADJUST POLICIES OR OPERATIONS AS PART OF AN INTERACTIVE LEARNING PROCESS" (NATIONAL RESEARCH COUNCIL, 2004).

The POCACITO team organised the key performance indicators under the **social, environmental and economic dimensions**. All relationships, interconnections, feedback loops and redundancies from one dimension to another, including the sub-dimensions and indicators, were analysed in order to have an overview of the transition process without compromising the evaluation mechanism.

The dimensions and their sub-dimensions were designed to characterise the POCACITO view of a post-carbon city.

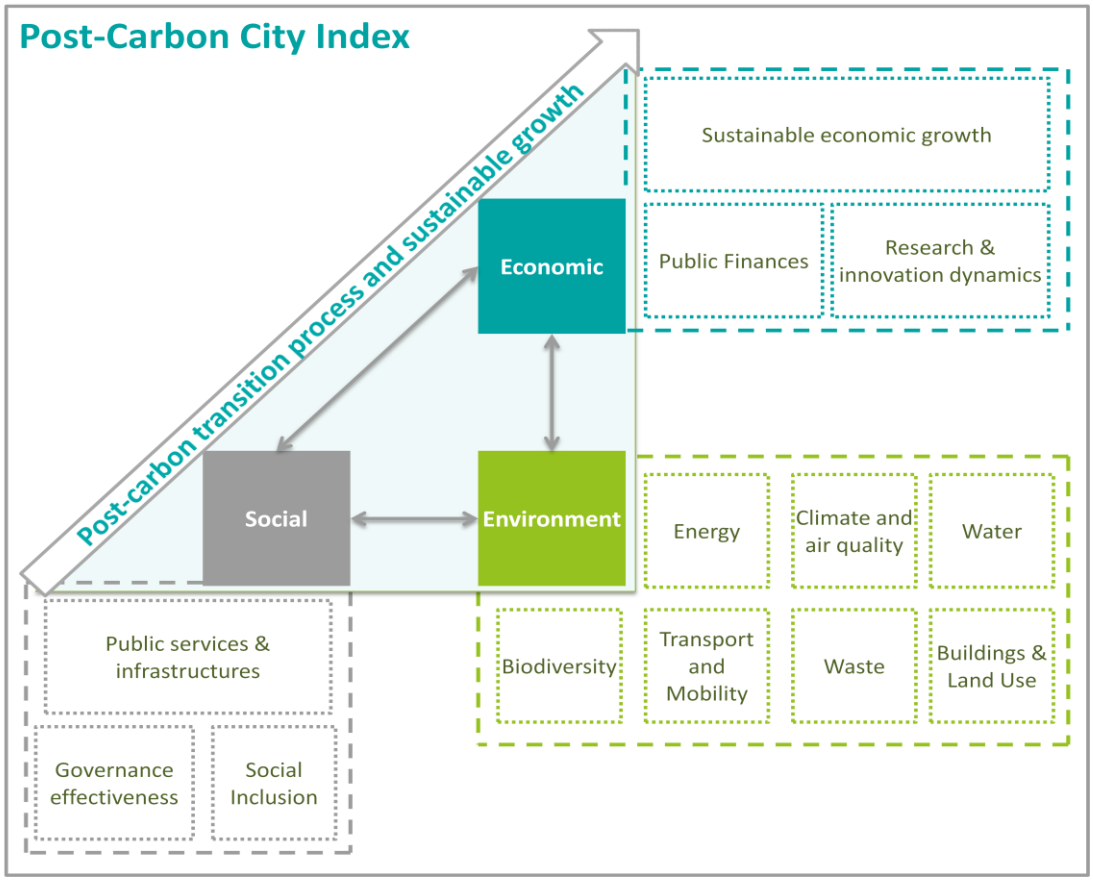
The **social dimension** is concerned with equity that is expected for all citizens, both within the current generation and also between generations during the transition process to post-carbon cities. The benefits for inhabitants that come out of living in a reduced carbon city are highlighted, showing that these cities are places where it is pleasant to live and 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 within 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 cities and assesses not only 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 energy efficiency, but also to address resources depletion associated with energy consumption. Post-carbon cities pay special attention to GHG and the 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 sustainable economic growth based on the wealth of cities and their inhabitants. It recognises that investments are crucial to promoting post-carbon cities, in particular those related to sustainable facilities. The labour market and the lifespan of companies are also 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 challenges during the transition process towards a post-carbon city. This dimension also includes the R&D expenditure because a city cannot become a post-carbon city without innovation.

Figure 3: Dimensions and sub-dimensions of the Post-Carbon City Index



For each sub-dimension, a set of indicators has been selected according to the criteria defined by the POCACITO team and taking into account the conceptual definition of post-carbon cities. The indicators selection process is described in section III.II.3 and the list of indicators in III.III.3.

III.II.3 INDICATORS SELECTION

The key performance indicators that compose the Post-carbon City Index aim to evaluate the performance of cities during the transition process. Through the literature review carried out, including also the Eurostat Sustainable Development Indicators and the Europe 2020 Strategy, along with the knowledge and experience of the POCACITO team, it was possible to produce an innovative mix of indicators.

A first set of indicators was proposed by INTELI taking into account the criteria of relevance, clear message, data availability and data quality. Some criteria have yes or no answers (y/n) and others are positively or negatively (+/-) scaled, ranging from "+++", "++" to "+" and "-", "--" to "---", in an attempt to keep the screening criteria short and manageable. The subcategories of the following 4 screening criteria (Relevance, Clear message, Data availability, Data quality) were used to help evaluate them. The following box describes the screening criteria in more detail.

Relevance (+/-)

- Is the indicator linked to our definition of an innovative post-carbon city? (+/-)
- Is the city able to influence the indicator on its own? (i.e., is the city level the right level?) (+/-)
- Is the indicator relevant for small cities as well as for megacities, does it respect the diversity of case study cities?
- Are there indicators included that enable one to measure development/transition scenarios' impacts (with regard to WP5 objectives)?

Clear message (y/n)

- Is the message of the indicator clear? (+/-)
- Is the meaning of the indicator substantial? (+/-)
- Are the name and the data of the indicator easily understandable? (+/-)
- Is the direction of the indictor clear? (y/n)

Data availability (+/-)

- Is the data available at the city level? (+/-)
- Is the data already collected? (y/n)
- What is the location/source of the data? (location)
- Is there free access? (y/n)
- For how long has the data been collected? (years)
- How often is the data collected? (/year)
- Are the city officials able to provide us with the data? (+/-)
- Is the data available for every city? (+/-)

Data quality (+/-)

- Reliability (+/-)
  - How consistent is the data?
- Validity (+/-)
  - Does it measure what it is intended to measure?
- Completeness (+/-)
  - Is the database complete or is data missing?
- Comparability (+/-)
  - E.g., is the data standardised?
- Transparency (+/-)
  - E.g., is it possible for other people to verify the data?
- Uncertainty (+/-)
  - How does the indicator deal with uncertainty?

The initial phase of the PCI's design and respective development process was supported by an in-depth analysis of several existing index systems related to the three dimensions (social, economic and environmental).

Table 2 provides a brief list of the index tools consulted, demonstrating the main features of the indices and their contribution to the PCI:

Table 2: Main features of the index consulted

TOPIC	DOCUMENT TITLE	MAIN FEATURES
Carbon Index	Vivid Economics, 2013, G20 low carbon competitiveness index: 2013 update	It measures the current capacity of each country to be competitive and to generate material prosperity for its residents in a low carbon world, based on each country's current policies and indicators.
	OECD/LEED, 2013, Green growth in the Benelux: Indicators of local transition to a low-carbon economy in cross-border regions	Based on the OECD Green Growth strategy, it monitors how the Benelux region is performing in the transition towards the pursuit of green economic growth and development, while preventing costly environmental degradation, climate change, biodiversity loss, and unsustainable natural resource use.
Sustainability Index	Economist Intelligence Unit, 2012, The Green City Index - A summary of the Green City Index research series	It includes a city's environmental diagnosis and performance benchmark on the most critical issues (pressures on energy and water resources, waste management, sewer systems, and transport networks, among others) of the urban environmental sustainability.
	Columbia University, Joint Research Centre European Commission, World Economic Forum, 2005,	It is a composite index tracking a diverse set of socioeconomic, environmental, and institutional indicators that characterize and influence

TOPIC	DOCUMENT TITLE	MAIN FEATURES
	Environmental Sustainability Index, Benchmarking National Environmental Stewardship Yale University	environmental sustainability at the national scale, resulting in trend analysis and performance targets.
	Columbia University, Joint Research Centre European Commission, World Economic Forum, 2012, Environmental Performance Index and Pilot Trend Environmental Performance Index Yale University	It is a quantifying and numerical ranking of how countries perform on high-priority environmental issues in two broad policy areas: environmental health, which measures environmental stresses to human health, and ecosystem vitality, which measures ecosystem health and natural resource management.
	Marcelino, M. et al., 2007, Indicators of the System of Sustainable Development - SIDS Portugal	It assess the country's progress in terms of sustainability, enabling the connection with the main levels of strategic decision – policies, plans and programs – at the national, regional and sectoral level, based on the OECD framework model Pressure-State-Response (PSR).
Smart Cities and Social Index	Selada, C. et al., 2012, Smart Cities Index	A composite indicator rank resulting from the simple average of 5 dimensions' scores to strategically position cities in terms of urban intelligence. A database of municipal information and knowledge to support the decision-making process of public authorities and economic and social actors was also developed.
	Department for Communities and Local Government, 2011, The English Indices of Deprivation 2010	A national statistical release to identify national and sub-national patterns of multiple deprivation, made up of several distinct dimensions or domains.
Europe 2020 Strategy	Taking stock of the Europe 2020 strategy for smart, sustainable and inclusive growth, 2010	European Union's ten year growth and jobs strategy comprising a set of EU headline targets that cover the following priorities: employment, research and development, climate/energy, education, social inclusion and poverty reduction.

In general, the indices consulted include a long list of indicators that is not possible to manage in the scope of the POCACITO project. Therefore, the team soon realized that it was not practical to use these indices in their original versions because it was mandatory to have a smaller group of indicators. To have fewer indicators it was crucial to select robust indicators that aggregated a diverse mix of information. Below we explain how the POCACITO team did that.

Moreover, these indices are essentially based on specific perspectives (specified in Table 2:) and objectives. Indeed, some of the indices include environmental, social and economic indicators, but not in the perspective of POCACITO targets, and not in an integrated approach for assessing the social, environmental and economic resilience of the citizens and city's economy to face the transition

process towards post-carbon cities. Moreover the cities should have a deep role in the transition process and consequently the capacity to influence all indicators.

In this context, the PCI is able to capture and monitor the 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 and also evaluate the process of transformation, which is necessary to respond to the multiple challenges of climate change, ecosystem degradation, social equity and economic pressures. Simultaneous, the PCI should monitor the adaptive capacity of the cities to reduce vulnerability as they restructure human-ecological and human-human relationships toward ecosystem health and a clean energy economy (Adger et al. 2005).

In the end, the PCI is based on a new mix of indicators that cities can influence to manage the resilience of the society during the transition process towards post-carbon cities.

A brief description of the indicator's selection process is provided below:

- A preliminary list of indicators based on the index tools consulted was presented to the POCACITO team in January 2014. It was decided that the number of indicators should be reduced and be revised according to the criteria detailed in section III.III.3;
- A second list of indicators proposed in February 2014 was discussed with all partners and organised into 3 thematic group meetings according to the 3 dimensions mentioned above (1st Group Meeting – Social; 2nd Group Meeting – Environmental; 3rd Group Meeting – Economic). Partners made several comments and suggestions covering all the dimensions and different aspects of the indicators (pertinence, geographical level, sources, new indicators, etc.);
- During the month of March 2014, mind maps were produced for each dimension of the PCI in order to identify the most "substantial" indicators, i.e., indicators that "incorporate" more information and with more correlations among them. This procedure enabled a reduction of indicators without losing explanatory power. The social mind map was produced by CUNI; environmental mind map by INTELI and economic mind map by JR/FEEM (ATTACHMENT B – MIND MAPS);
- During the month of April 2014, INTELI revised the list of indicators taking into account the inputs of all partners and taking advantage of the mind maps to analyse the relationships, interconnections and feedback loops among the indicators. The updated list was revised by EI and is described in detail in section III.III.3;
- During the project meeting in Milan (June 2014), it was possible to make a last review of the indicators, with contributions from the partners and members of the Advisory Board.

III.II.4 GEOGRAPHICAL BOUNDARIES

POCACITO focuses on towns, cities, megacities, metropolitan areas and urban clusters larger than 1 million people as well as small and medium-sized cities, each of them exhibiting different characteristics. Moreover, POCACITO aims to develop an evidence-based 2050 roadmap towards sustainable, liveable, affordable and prospering cities in a worldwide context. Therefore, the main goal of the PCI is to look at trends within each city and at their key challenges, rather than ranking cities. In that sense, different approaches can be found across the case study cities.

Having this assumption in mind, each case study city specified its geographical boundary and thus, the KPIs will be gathered according to these defined areas. If some indicators are not available for the chosen area, other broader geographic areas, such as NUTS 3 or NUTS 2, can be accepted if they are representative of the city situation. Thereby, the geographical boundary indicated by each partner corresponds to the most appropriate delimitation for the majority of the KPI to be collected in each case study city.

Any amendment concerning the geographical boundaries will be clarified during the case study initial assessments.

III.II.5 DATA COLLECTION

Case study city partners will collect the key performance indicators included in PCI. As stated in the Methodological Guide for Initial Assessment[1], methods for data gathering and collection comprise the following two approaches:

- Top-down approach – completion of the indicators list (Post-Carbon City Index) 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.

In ATTACHMENT A - Factsheets of indicators, you can find a factsheet for each indicator that includes its description and justification in order to clarify partners regarding the information that must be gathered. It also includes the units that should be used and some sources where the indicator can be available.

Typically, 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 are required). Whenever data is not available for those years, one should collect the earliest and the most recent years between 2003 and 2012. All indicators should be collected for the geographical boundary selected by the case study city partner, mainly at the city and municipality level. If an indicator is not available at this geographical level, then it will be collected for NUTS 3 or NUTS 2. 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.

To help case study partners organise the collection of data, an online platform was developed and can be accessed in the following link: http://pocacito.inteli.pt.

[1] INTELI. „Methodological Guide for the Initial Assessment“. Ecologic Institute, 2014

III.III KEY PERFORMANCE INDICATORS

III.III.1 QUALITY OF LIFE AND RESILIENCE

The PCI is a tool that allows the user to assess the quality of life of the citizens and the transition process towards post-carbon cities. This is possible because the PCI incorporates a set of key indicators that measure how citizens live in terms of social, economic and environment aspects.

Simultaneously, the resilience, i.e., the "capacity of an urban system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure, identity, and feedbacks" (Walker et al. 2004) is also captured by the PCI. The adaptive capacity of urban systems is the ability of stakeholders – i.e., human actors – to improve its resilience (Berkes and Folke 1998, Folke et al. 2004, Resilience Alliance 2005, Gallopin 2006, Lebel et al. 2006, Olsson et al. 2006[2]) to fluctuating environmental and socio-economic pressures, such as long-term changes in urban resident demographics, city and rural migration patterns, and potential city health concerns. The greater the quality of life of individuals, the greater their capacity to improve resilience should be. Moreover, the PCI also includes a set of indicators that state how resistant the system is to being changed and how close the current situation of the system is towards indicators related to energy consumption, intensity and efficiency, carbon emissions and modal share or indicators, such as the city budget and indebtedness.

III.III.2 PCI AS A MONITORING TOOL OF THE POST-CARBON CITY TRANSITION PROCESS

The PCI does not only allow the user to assess the aforementioned aspects at a given time, but also to monitor their progress. This is because the PCI includes only indicators that cities can influence – i.e., cities can define policies, develop strategies and take action to change the evolution of these indicators. As the PCI includes all of the issues identified above and the city can manage them, it is a crucial tool for monitoring the transition process towards post-carbon cities. By applying the PCI at different points in time, e.g., every year for regularity, the city can monitor the process of transition towards a post-carbon city, and, according to the analysis done each year, it may revise strategies and measures if necessary. If a city is not moving in the right direction (e.g., the level of pollution or energy consumption is growing while the level of green spaces per inhabitant is diminishing, the wealth and the employment is falling, public debt is growing, etc.) it can act on the necessary factors and put (or try to put) them in the right direction.

III.III.3 DESCRIPTION OF KEY PERFORMANCE INDICATORS

The following table summarises the key performance indicators by dimension and sub-dimension, their measurement units and reference years for data collection. Then a detailed description and justification for each indicator is presented, demonstrating the scientific quality and reasoning behind the selection process. A factsheet for each indicator is provided in ATTACHMENT A - Factsheets of indicators, which organises all this information.

[2] Ecologic Institute. "Common Approach Framework Document". Ecologic Institute, 2014.

Table 3: List of key performance indicators

DIMENSION	SUB-DIMENSION	INDICATOR	UNIT	YEAR
SOCIAL	Social Inclusion	Variation rate of unemployment level by gender	Percentage	2003-2012
		Variation rate of poverty level	Percentage	2003-2012
		Variation rate of tertiary education level by gender	Percentage	2003-2012
		Variation rate of average life expectancy	Average No.	2003-2012
	Public services and Infrastructures	Variation rate of green space availability	Percentage	2003 2012
	Governance effectiveness	Existence of monitoring system for emissions reductions	Yes/No Description	2013
ENVIRONMENT	Biodiversity	Variation rate of ecosystem protected areas	Percentage	2012
	Energy	Energy intensity variation rate	Toe/euro Toe	2003 2012
		Variation rate of energy consumption by sectors	Percentage	2003 2012
	Climate and Air Quality	Variation rate of carbon emissions intensity	Ton CO_2/euro Ton CO_2	2003 2012
		Variation rate of carbon emissions by sector	Ton CO_2	2003 2012
		Exceedance rate of air quality limit values	No.	2010 2012
	Transport and mobility	Variation share of sustainable transportation	Percentage	2001 2011

DIMENSION	SUB-DIMENSION	INDICATOR	UNIT	YEAR
	Waste	Variation rate of urban waste generation	**Kg/person/year**	**2007 2012**
		Variation rate of urban waste recovery	**Percentage**	**2007 2012**
	Water	Water losses variation rate	**m^3/person/year**	**2003 2012**
	Buildings and Land Use	Energy-efficient buildings variation rate	**Percentage**	**2007 2012**
		Urban building density variation rate	**No./ km^2**	**2003 2012**
ECONOMY	**Sustainable economic growth**	Level of wealth variation rate	**eur/person**	**2003-2012**
		Variation rate of GDP by sectors	**Percentage**	**2003-2012**
		Employment by sectors variation rate	**Percentage**	**2003 2012**
		Business survival variation rate	**Percentage**	**2008,2009,2010**
	Public Finances	Budget deficit variation rate	**Percentage of city's GDP**	**2003-2012**
		Indebtedness level variation rate	**Percentage of city's GDP**	**2003-2012**
	Research & Innovation dynamics	R&D intensity variation rate	**Percentage**	**2003-2012**

SOCIAL DIMENSION

A set of three sub-dimensions (**social inclusion, public services and infrastructures, and governance effectiveness**) was chosen to assess the social context of the post-carbon cities. Social inclusion sub-dimension was selected to demonstrate the post-carbon cities primary human rights (employment, education, health, for example) and the enhancement of social cohesion through the entire society. Public services and infrastructures characterise the basic sustainable public infrastructures necessary to maintain and improve the quality of life of citizens. Governance effectiveness was chosen to reflect the accomplishment of the city emissions target related to CO_2 emissions to become a highly energy-efficient and low carbon urban development.

In the sub-dimension of social inclusion, unemployment level by gender and level of poverty variation rates were both selected as headline standard indicators to evaluate the economic strength of the cities and the social resilience and equity of their inhabitants.

As stated by the more social-oriented indices consulted (Europe 2020 Strategy Indicators, English Indices of Deprivation, Portuguese Indicators System of Sustainable Development), high unemployment rates or divergences in gender are normally associated to economic fragilities and social vulnerability and inequality, thus corresponding to a less favourable context to tackle the challenges, difficulties and problems arising from the post-carbon transition process. All indices referred to emphasize this indicator as a headline measure to pursue an employability strategy and to set modernising and strengthening employment education and training policies and social protection systems by increasing labour participation, as well as raising corporate social responsibility among the business community.

The level of poverty represents one of the major headline indicators of the Europe 2020 strategy and intends to measure the social exclusion and inequalities in order to act upon the social and territorial cohesion. The expected benefits of the 2020 Strategy on growth and employability should be widely shared so that even people experiencing poverty and social exclusion should be able to live with dignity and take an active part in society.

The education level by gender gives information on two aspects. The increased entry of women into higher education is important to achieve a higher level of equity in the labour force. It is generally reported that poverty and social exclusion affects women more than men in many countries. However, numbers showing a higher level of tertiary education among women than men could overlook difficulties for women in entering the labour force.

Being an important social headline indicator regarded by the Europe 2020 strategy indicators, the tertiary education level by gender variation rate reveals that better educational levels by gender help employability and progress in labour market equity. Additionally, and according to the Europe 2020 strategy, this indicator is a key assessment element to measure the attainment of high educational levels that induces inclusive growth and empowering people through high levels of employment, investing in skills, fighting poverty and modernising labour markets, training and social protection systems to help citizens in anticipating, managing changes and building a cohesive society.

In order to address primary health concerns, average life expectancy variation rate was chosen as a key indicator for the characterization of life conditions and population health trends in a medium period of time.

For both social inclusion indicators, the time series (last ten years) considered were intentionally chosen to assess how the economies react to the economic crisis over a extend period of time.

Strictly related with the level of citizen's wellbeing is the indicator variation rate of green space availability that will show the most basic city green public services and infrastructures evolution over a ten-year period of time. As claimed by the Green City Index, the maintenance of urban green spaces contributes to the preservation of the natural environment within the city's boundaries and indirectly assesses the comprehensiveness of policies to contain the urban sprawl and promote the availability of green spaces.

To become a post-carbon city, cities should define their own targets related to CO_2 emissions and put them in place. Thereby, the indicator existence of monitoring system for emissions reductions was introduced and intends to check if cities are complying with the targets they set, evaluating the effectiveness of the policies and strategies implemented to reduce CO_2 emissions.

ENVIRONMENTAL DIMENSION

As explained in III.II.2 (Dimensions and sub-dimensions), the sub dimensions **energy, climate and air quality, transport and mobility and buildings and land use** were chosen to characterize the efficiency on energy usage and issues relating to climate change. The environmental dimension also focuses on biodiversity and resources depletion through the sub-dimensions **biodiversity**, **waste and water**.

As it was explained above, the biodiversity is also a focus of the environmental dimension. In fact, human activities have altered the world's terrestrial, freshwater and marine ecosystem throughout history, but in the last 50 years the extension and pace of these changes has intensified substantially (2012 EPI). Therefore, the indicator variation rate of ecosystem protected areas was included to show the evolution of high ecological value areas within a ten-year period of time. These areas are critical in preventing carbon atmospheric concentration and provide an important contribution to an overall strategy for climate change mitigation and protect species at risk of extinction. Biodiversity mapping was also a proposed indicator to monitor the existence of species during the transition process; however, it was dispensed because it was a very exhaustive indicator, comprising an inventory of all species of wild fauna and flora (marine and terrestrial).

For the sub-dimension energy, the indicator energy intensity variation rate was picked, as it is a very standard indicator, easy to calculate and understand. This kind of indicator is used on many other indicators systems, such as The Green City Index and SIDS 2007. At the country level, this indicator is available in EU statistical office database[3]. Energy intensity is a proxy of energy efficiency (therefore there is no need to have this indicator) and monitoring this indicator is very important because its dynamics reflects changes in energy efficiency and in the structure of the economy, i.e., understand which sectors are being more efficient regarding energy consumption, to produce wealth. That's why

[3] (http://epp.eurostat.ec.europa.eu/tgm/table.do?tab=table&init=1&language=en&pcode=tsdec360&plugin=1)

the indicator energy consumption by sector variation rate was also been introduced. It helps to identify whether there is decoupling between energy consumption and economic growth.

In order to determine whether the energy consumption is supplied by renewable sources or efficient energy conversion processes, the indicator carbon emission intensity variation rate was chosen. It gives information about which cities are emitting more CO_2 for producing wealth. Having in mind the contribution of sectors to sustainable economic growth, the indicator carbon emission by sector variation rate was added. It allows us to see the sectors in which more action should take place. In fact, GHG are emitted from a variety of human activities, including transportation, industrial agriculture, forestry, waste management, and energy generation, which is globally indicated as the sector responsible for the largest share of anthropogenic GHG emissions (2012 EPI). These indicators are very interesting because they embed the effects of CO_2 emission factor of electricity generation and the share of renewables on energy consumption, avoiding the use of so many indicators. Indeed, many arrows go towards this indicator in ATTACHMENT B – MIND MAPS. Carbon emissions of the economy is also a very common indicator, which can be found in the European Green City Index, 2012 Environmental Performance Index, SIDS 2007 and 2005 ESI.

Nevertheless, it is not only CO_2 emissions that are important to be addressed by post-carbon cities. The indicators exceedance rate of air quality limit values will assess the overall air quality pollutants, which have implications on public health and the citizen's quality of life (2012 EPI). Monitoring this indicator can help cities identify effective measures to reduce emissions at the local and regional level, having an active role on the mitigation of this huge problem. To prove its relevance, most of the indices (2012 EPI, European Green City Index, SIDS 2007 and 2005 ESI) include a dimension related to air quality; however, the concentration of pollutants is the most common way to show the results.

Therefore, cities have to put in practice strategies to reduce emissions and pollutants quickly. One of the most intensive energy consumers is the transportation sector and the most dominant method of passenger transport is the car. Thus, cities have to build a competitive transport system, increase mobility and remove major barriers in key areas. In fact, in March 2011, the European Commission adopted a White paper, the 'Roadmap to a single European transport area – towards a competitive and resource efficient transport system' (COM(2011) 144 final), which aims to build a competitive transport system, increase mobility, remove major barriers in key areas, fuel growth and increase employment. The indicator variation share of sustainable transportation allows cities to understand which strategies and policies should be developed in order to promote the use of more sustainable methods of transports, including walking and cycling. A similar indicator named *Use of non-car transport* is available on the European Green City Index, and measures the total percentage of the working population travelling to work on public transport, by bicycle and by foot. The EU statistical office database[4] could also contribute at the country level with the indicator Modal split of passenger transport.

The extension of the public transport network was also another indicator in the first pool of indicators, but the percentage of citizens that use them (which is measured in the variation share of

[4] (http://epp.eurostat.ec.europa.eu/portal/page/portal/transport/data/main_tables).

sustainable transportation) is somehow correlated with it because this percentage can only be significant if the city has a good public transport network.

Regarding waste, the renewed EU Sustainable Development Strategy (SDS) indicators has set the target of avoiding the generation of waste and enhancing efficient use of natural resources by applying the concept of life-cycle thinking and promoting reuse and recycling. Indeed, many indexes identify (such as the European Green City Index, SIDS 2007, SDS and 2005 ESI.) waste generation and recycling rates as important measures to reduce environmental stresses.

In a post-carbon city, the reduction of waste generation variation rate is desirable as well as strategies such as urban waste recovery variation rate. These indicators should be seen as an important opportunity to achieve a significant reduction on resources consumption, a major contribution to reduce the environmental impacts associated with proliferation of city waste production, and attain a better emission control linked to waste treatment process.

One of the most important resources that can be sparse in the future is fresh water due to factors such as population growth, air pollution deposition, climate change, land management and economic development (2012 ESI); thereby water losses variation rate belongs to the KPI final list. The adoption of measures for its optimal management shall be essential, ensuring the monitorization of its efficient supply.

The built environment components (buildings and land use patterns) are also extremely relevant aspects for cities' energy consumption trends and carbon footprints. A large share (40%) of the European Union total energy consumption and CO_2 emissions is assigned to the building sector. The Green City Index recognises its relevance by including a set of three indicators to assess the energy efficiency and energy consumption of buildings. In this context, the indicator energy-efficient buildings variation rate comes up and intends to evaluate the top-rated energy efficiency of the building stock, including both new and existing private buildings/homes, as well as all public buildings/units subjected to the energy certification system considered in the following EU legislative framework: Directive 2002/91/CE and Directive 2010/31/UE on the energy performance of buildings directive (EPBD). Renovation rates was also a proposed indicator because it evaluates how many buildings were subject to improvements, however it is hard to find data and define levels of renovation which allows us to compare the results among the cities. The sustainable construction and energy efficient housing are two indicators present in the Environmental mind map (ATTACHMENT B – MIND MAPS), but the Energy-efficient buildings also embraces then, therefore they weren't integrated in the final set of indicators.

However, the land use patterns considered on the urban density settings are also relevant factors that have enormous impacts on the cities' resilience to climate change adaptation. That's why the indicator urban building density variation rate was included to demonstrate the building pressure trend data and the territorial dynamics considered on the most recent territorial planning policies. These trends and the adoption of better urban planning policies are vital instruments for cities to react on the energy use and greenhouse gas emissions reduction and improve the resilience of the urban settlements to climate change impacts.

All the indicators should be collected for both years 2003 and 2012 in order to compare their evolution throughout this period. Whenever data is not available for those years, then, one should use those from the earliest and most recent years between 2003 and 2012. However, some

exceptions can be found. The Energy performance of buildings (EPBD) is the European norm which was first launched in 2012 and transposed to countries some years later, so the period of time for the indicator Energy-efficient buildings depends on the year that this European norm was transposed in each country. Also for the indicator urban building density variation rate, the data available in the census data of 2001 and 2011 was used.

ECONOMIC DIMENSION

A set of three sub-dimensions was chosen to assess the economic context of the cities. **Sustainable economic growth, public finances and R&I dynamics** were chosen to characterize the economic and business strength of the city and its innovation dynamics, and to examine the financial health of the city.

For the sub-dimension of sustainable economic growth, the level of wealth variation rate was used, as it is a standard indicator used by several indicators systems (Europe 2020 Strategy Indicators, G20 Low Carbon Index, among others), being easy to calculate, to understand and because it allows for comparing the level of wealth among partners. As stated by the G20 Low Carbon Index, the Gross Domestic Product (GDP) *per capita* is a measure to assess the economic prosperity persistent over time. Framing it on the Post-carbon cities context, cities that have high levels of GDP per capita and have adopted low carbon policies come towards the top of the low carbon competitiveness. Cities with a strong economic activity have normally more resilience to economic changes and uncertainty. It is also important to know the mix of urban sectors of activity, since a post-carbon city should be economically sustainable (as described in the POCACITO definition of post-carbon city) and consequently based on a diverse and flexible set of activities. A high concentrated economy is more susceptible to external shocks and crises, and therefore would have a lower resiliency to face future challenges. This is why the weight of the variation rate of the economic sectors in GDP was also selected, as a supplementary indicator of the Annual GDP per capita as a flagship of European competitiveness.

At a first stage and as shown in the social mind map, the Labour market and business demography sub-dimensions encompass three indicators that have also contributed to a sustainable economy. Employment contributes to economic performance, quality of life and social inclusion, making it one of the cornerstones of socioeconomic development. By assessing the employment by sectors variation rate one can identify which are the strongest sectors in the city. Notwithstanding, the entrepreneurial dynamics is crucial for a successful economy; this is why the business survival variation rate indicator is added in the context of the business demography. This kind of indicator can be found at the EU statistical office database[5] and in SIDS 2007. The creation of new enterprises and the closure of unproductive businesses can be seen as an important contributor to business dynamism. In a post-carbon city context, tracking an economic system can be seen as an opportunity to establish a new vibrant and flexible economy based on social entrepreneurship, green sectors and innovation dynamics.

[5] (http://epp.eurostat.ec.europa.eu/portal/page/portal/european_business/data/main_tables)

However for making public investments, promoting innovation, supporting policies directed to enterprises and citizens, promoting awareness campaigns in favour of environmental sustainability and energy efficiency, among many other measures, the city must have robust finances. For this reason the indicators budget deficit variation rate and indebtedness level variation rate were chosen. These indicators show in such way the city generates the necessary revenues to finance their activities, or if they need to seek external financial sources (indebtedness). Specifically for the indebtedness level, and regarding the nominations of the SIDS 2007, the accounting for the cumulative total of all bank lending's by local government is an important barometer for a sustainable and credible fiscal consolidation with effective weight reduction of public expenditure, so that the budget deficit does not exceed acceptable limits. Therefore, cities that are financially sustainable have more capacity to deal with the challenges of the transition process towards post-carbon cities.

The business dynamics depend also on the investment that knowledge institutions (universities, research centres) and enterprises have on research and development, especially if this research is directed to producing innovative products and tradable services. Therefore the indicator R&D intensity variation rate was added to the KPI. This indicator shows only the total of R&D expenditures as a percentage of the GDP and not the R&D by sector because the first one is easier to understand as it is a standard indicator of which data are available in the EUROSTAT statistics and is included in the Europe 2020 strategy. As stated by the EU 2020, the R&D expenditure represents one of the major drivers of economic growth in a knowledge-based economy by improving framework conditions and access to financing for research and innovation to help turn ideas into products and services that create growth and jobs.

The Economic Mind Map (ATTACHMENT B – MIND MAPS) also focuses greatly on the demographic dynamics. This hub has a number of branches, such as population growth, population projection and aging population. However, the cities cannot influence these indicators and consequently they were not selected to be part of the PIC. Moreover, Entrepreneurial dynamics, also included in ATTACHMENT B – MIND MAPS, was not included as a sub-dimension because two of the indicators that it includes (Green Jobs and Hubs of excellence for any given economic sector) are not easy to calculate for the cities.

All the indicators should be collected for the period 2003-2012 in order to display their evolution over this period. The objective is to check the consequence of the economic crisis in these indicators. This is why data before and after the crisis are needed. Only the data relating to the business survival variation rate indicator should be collected for the years 2008, 2009 and 2010, because the data for these indicators are only available for these years at the EU statistical office database[6].

[6] (http://epp.eurostat.ec.europa.eu/portal/page/portal/european_business/data/main_tables)

IV CONCLUSION

The Report on Key Performance Indicators explains in detail why the Post- Carbon City Index was built in the context of the POCACITO project. It specifies the importance of and reasons for its production as a tool for assessing the case study cities and for monitoring the transition process towards post-carbon cities. It also details the process of construction of the PCI, including the conceptual framework that supports it and its scientific basis, the dimensions and sub-dimensions of analysis and the indicator selection process.

The selection process describes how indicators were selected, and emphasizes the participation of all partnerships in this process, particularly with the production of mind maps for the three dimensions of analysis (social, environmental and economic) that show the correlation among indicators in each dimension.

Then, a detailed description and justification for each indicator is presented identifying the variables, the years of reference and the sources of information for each indicator, among others. The report also defines how and when the indicators will be collected.

Case study partners will then collect all the required data for each case study city and conduct the production of each case study assessment report.

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VI ATTACHMENTS

VI.I ATTACHMENT A - FACTSHEETS OF INDICATORS

SOC-01	Variation rate of unemployment level by gender
Dimension	Social
Sub-dimension	Social Inclusion
Variables	Harmonised unemployment rate by gender (2003-2012)
Units	Percentage
Geographical level	Municipality
Description	Evolution of the unemployment rate by gender between 2003 and 2012; time series of the last ten years (before and during the economic and financial crisis).
Justification	This indicator helps us evaluate the level of equity in the labour market and the vulnerability of women in society. Divergent unemployment rates for female and male unemployed are normally associated with inequity and social vulnerability of this gender group, labour market discrimination or weak female education levels. The evolution over the last ten years helps us identify if there is a stronger vulnerability of women.
Sources	National/Regional statistical databases

SOC-02	Variation rate of level of poverty
Dimension	Social
Sub-dimension	Social Inclusion
Variables	Percentage of people at risk of poverty or social exclusion (2003-2012)
Units	Percentage
Geographical level	NUTS 2 Region (EUROSTAT)
Description	According to the Eurostat definition, this indicator sums up the number of persons who are at risk of poverty, severely materially deprived or living in households with very low work intensity. It represents the evolution of the level of poverty between 2003 and 2012 by time series over the last ten years (before and during the economic and financial crisis).
Justification	This indicator is one of the headline indicators in the Europe 2020 strategy. The poverty issue is a milestone in the Europe 2020 strategy. One of the headline targets is "Reduction of poverty by aiming to lift at least 20 million people out of the risk of poverty or social exclusion" and "European platform against poverty" is one of the seven flagship initiatives. The eradication of poverty also remains a major challenge of sustainable development, and the social dimension is one of the pillars of the EU's Sustainable Development Strategy (EU SDS). A "post-carbon city" should be an inclusive city with low inequalities, where citizens want to live and work.

SOC-02 Variation rate of level of poverty

Sources	National/Regional Official Statistics; EUROSTAT databases: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=ilc_peps11&lang=en; by NUTS 2 Region
Notes	Persons at risk of poverty have an equivalence disposable income below 60% of the national median equivalent disposable income after social transfers. Material deprivation covers indicators relating to economic strain and durables. Persons are considered to be living in households with very low work intensity if they are aged 0-59 and the working age members in the household worked less than 20 % of their potential during the past year. This indicator is available at the National level and NUTS 2 regions in the EUROSTAT.

SOC-03 Variation rate of tertiary education level by gender

Dimension	Social
Sub-dimension	Social Inclusion
Variables	Percentage of Population with Tertiary Level of Education by gender (2003-2012)
Units	Percentage
Geographical level	Municipality
Description	Evolution of the tertiary education level of the population between 2003 and 2012; time series over the last ten years.
Justification	The education level by gender gives information on two aspects. The increased entry of women into higher education is important to achieve a higher level of equity in the labour force. It is generally reported that poverty and social exclusion affects women more than men in many countries. However, numbers showing a higher level of tertiary education among women than men may also hide women's difficulties in entering the labour force.
Sources	National/Regional statistical databases

SOC-04	Variation rate of average life expectancy
Dimension	Social
Sub-dimension	Social Inclusion
Variables	Average number of years of life expectancy (2003-2012)
Units	Average number
Geographical level	Municipality if available, or NUTS2
Description	Evolution of the average number of years of life expectancy between 2003 and 2012, time series over the last ten years.
Justification	Since this indicator reflects the equivalent years in full health that a person can expect to live based on the current mortality rates and the prevalence distribution of health states in the population, it will help to determine how climate change impacts could cause effects on the overall health of the population.
Sources	National/Regional statistical databases

SOC_05	Variation rate of green space availability
Dimension	Social
Sub-dimension	Public services and infrastructures
Variables	Variation rate of the surface area (km^2) of green (urban forests, parks or green spaces) public spaces for 2003 and 2012
Units	Percentage
Geographical level	Municipality
Description	The indicator aims to assess the variation rate of the surface area (km^2) of public green (urban forests, parks or green spaces) space availability for 2003 and for 2012.
Justification	Green spaces are directly associated with sustainability approaches. Besides the well-known environmental benefits of green spaces (such as increasing biodiversity, cleaning air pollutants, store and sequester carbon dioxide, reduce noise pollution, reduce urban heat island, and provide a general cooling effect) there are more complex positive influences on social behaviour, health and wellbeing, such as recreational benefits and an increase in people's sense of community.
Sources	City Council

SOC_06	Existence of monitoring system for emissions reductions
Dimension	Social
Sub-dimension	Governance effectiveness
Variables	Existence of a monitoring system for the city emissions reductions targets
Units	Yes/No Description
Geographical level	City
Description	This indicator aims to evaluate the existence of a monitoring system for emissions reductions to compute the rate of accomplishment of the city's emission target relating to CO_2 emissions. Therefore, it implies that the most updated cities' targets are known in order to calculate the rate of accomplishment in relation to that actual target.
Justification	This indicator is useful for assessing the **effectiveness of policies and strategies** adopted by cities in order to **reduce GHG emissions**, because it measures their accomplishment evolution over time. In fact, this indicator is in line with the well-known key indicators "20-20-20" EU targets, the climate and energy package which represents the European Union countries' commitment to become a highly energy-efficient and a **low carbon economy**. In this case, it is only applied for CO_2 emissions at the city level, taking into account the city's targets. Notwithstanding, POCACITO cities have to look beyond these short-term objectives: the 20-20-20 targets are no longer ambitious, since the project horizon is 2050. It would be expectable that cities' targets be periodically revised, becoming more and more ambitious as we get closer to 2050, being almost CO_2-neutral cities, with a carbon-free energy supply and high levels of energy efficiency being attained. By moving to a low-carbon society, the EU could be using around 30% less energy in 2050 than in 2005.
Sources	National officials statistics, Environmental statistics

ENV_01	Variation rate of ecosystem protected areas
Dimension	Environment
Sub-dimension	Biodiversity
Variables	Variation rate of the municipality surface area (km^2) covered by Natura 2000 network and national network of protected areas registered, in 2003 and 2012.
Units	Percentage
Geographical level	Municipality
Description	The indicator will determine the variation rate of the surface areas (km^2) covered by Natura 2000 Network and the National Network of Protected Areas, over the entire municipality surface area (km^2). The spatial data considered in the indicator will measure for both Natura 2000 and National Network of Protected Areas, the marine and terrestrial protected areas as a percentage over the total city surface area.
Justification	Protected areas are critical in preventing further carbon emissions and provide an important contribution to an overall strategy for climate change mitigation. Its terrestrial impacts can include shifting ranges of species and habitats, altered migration patterns and increased frequency and intensity of storms and flooding. Marine impacts can include rising sea levels and coastal erosion, increasing sea temperatures and altered habitats and migration patterns. Given the importance of protected areas in **biodiversity conservation and ecosystem resilience,** the gathering of viable data comprised in this indicator should constitute an important component of an ecosystem-based adaptation strategy for a post-carbon city.
Sources	National Institutes for Nature and Biodiversity Conservation European Environment Agency; NATURA 2000 network
Notes	The time frame considered in this indicator should include the spatial data of 2003 and 2012 to verify the recorded evolution. If the data in the aforementioned years are not available, please consider the available data of the most recent 10 years.

ENV_02	Energy intensity variation rate
Dimension	Environment
Sub-dimension	Energy
Variables	Annual primary energy consumption by GDP in 2003 and 2012
Units	toe/eur
Geographical level	Municipality
Description	The indicator measures the energy consumption of an economy and its overall energy efficiency, since it is the ratio of gross energy consumption and local GDP or GVA (gross value added). Cities with more energy intensity per local GDP means that they consume more energy to produce the same amount of goods measured in GDP units.
Justification	Energy intensity is only a proxy of **energy efficiency**, as it depends on numerous elements (such as climate, output composition, outsourcing of goods produced by energy-intensive industries, etc.). However, the energy intensity can decrease via improvements in energy efficiency such as changes in manufacturing industry processes, transportation methods and **consumer behaviour**. Energy efficiency programmes and regulations can also contribute to this. Monitoring of this indicator is very interesting because its dynamics reflect changes in energy efficiency.
Sources	National/Regional Official Statistics

ENV_03	Variation rate of energy consumption by sectors
Dimension	Environment
Sub-dimension	Energy
Variables	Primary energy consumption by sectors in 2003 and 2012
Units	Toe
Geographical level	Municipality
Description	The indicators measure the sum of primary energy consumption in industry, agriculture, services, transports, residential and others, and allow us to identify the sectors that are more energy intense and therefore need more action towards being more efficient.
Justification	Monitoring of this indicator is very interesting because its dynamics reflect changes in the structure of the economy, i.e. it allows us to understand which sectors are being more efficient regarding energy consumption, to produce wealth.
Sources	National/Regional Official Statistics

ENV_04	Variation rate of carbon emissions intensity
Dimension	Environment
Sub-dimension	Climate and Air Quality
Variables	CO_2 emissions intensity of the economy in 2003 and 2012
Units	ton CO_2/eur
Geographical level	Municipality
Description	This indicator assesses the carbon emissions due to energy consumption. It is the ratio between CO_2 emissions and local GDP or local GVA (gross value added).
Justification	As explained for energy intensity, the CO_2 emissions intensity of the economy identifies the cities where more CO_2 are emitted to produce wealth.

ENV_04	Variation rate of carbon emissions intensity
	The transition to a **low-carbon society** would boost economy thanks to the increase in **innovation and investment in clean technologies** and low- or zero-carbon energy. This transition can be assessed by monitoring the indicator Carbon emissions intensity. There are several GHGs, but to keep it simple we are only going to consider CO_2, because: 1 - the data relating to CO_2 are more common than for other GHGs; 2 - it is not necessary to calculate the CO_2 equivalent emissions for the other GHGs and; 3 - CO_2 is the widely representative pollutant source.
Sources	National official statistics Environment agencies
Notes	The indicator should include all greenhouse gases, but the availability of data makes it hard to include them. Moreover, the different greenhouse gases have to be weighted by their global warming potential, which would be even more difficult to work out the indicator.

ENV_05	Variation rate of carbon emissions by sector
Dimension	Environment
Sub-dimension	Climate and Air quality
Variables	CO_2 emissions of main sectors: industry, agriculture, services, transports, residential and others in 2003 and 2012
Units	ton CO_2
Geographical level	Municipality
Description	This indicator assesses the measurement of CO_2 emissions per sector: industry, agriculture, services, transports, residential and others, in 2003 and 2012.
Justification	This indicator helps identify the most inefficient sectors where more actions should take place in order to contribute to a sustainable economic growth. Reduction of CO_2 in the different sectors of activity (industry, agriculture, services, transports, residential and others) is one of the most important concerns related to emission reduction targets as agreed under the Kyoto Protocol. Understanding what is driving the CO_2 intensity can help identify successful policies for reducing the environmental impacts of each sector.

ENV_05	Variation rate of carbon emissions by sector
	The transition to a **low-carbon society** would boost economy thanks to an increase in **innovation and investment in clean technologies** and low-or zero-carbon energy. This transition can be assessed by monitoring the indicator Carbon emissions intensity. There are several GHGs, but for simplicity purpose we are only going to consider CO_2, because: 1 - the data related to CO_2 are more common than for other GHGs; 2 - it is not necessary to calculate the CO_2 equivalent emissions for the other GHGs and 3 - CO_2 is widely representative pollutant source. This indicator supports the indicator Carbon emissions intensity.
Sources	National official statistics Environment agencies
Notes	The indicator should include all greenhouse gases, but the availability of data makes it hard to include them. Moreover, the different greenhouse gases have to be weighted by their global warming potential, which would be even more difficult to work out the indicator.

ENV_06	Exceedance rate of air quality limit values
Dimension	Environment
Sub-dimension	Climate and Air Quality
Variables	Exceedance levels of air pollutants (O_3, NO_2 ,SO_2, $PM_{2.5}$ and PM_{10}) in 2010 and 2012
Units	number of days
Geographical level	Municipality if available, if not NUTS3 region
Description	The indicator quantifies the number of annually exceedances registered for the following pollutants: Ozone (O_3), Nitrogen Dioxide (NO_2), Sulphur Dioxide (SO_2), and particles with a diameter of 10 microns or less (≤ PM_{10}) and particles with a diameter of 2.5 microns or less (≤ PM2.5). According with the World Health Organization, the exceedance of air quality limit values considers the following exceeding values: - O3 threshold Information 100 µg/m3 8-hour mean - NO2 threshold Alert for 40 µg/m3 measured for annual mean and 200 µg/m3 1-hour mean - SO2 threshold Alert 20 µg/m3 24-hour mean and

ENV_06	Exceedance rate of air quality limit values
	500 µg/m3 10-minute mean - PM 2.5 threshold Alert 10 µg/m^3 annual mean and 25 µg/m3 24-hour mean - PM 10 threshold Alert 20 µg/m3 annual mean and 50 µg/m3 24-hour mean.
Justification	The air quality balance is a determining environmental component in a post-carbon city, in particular to **public health** and the **citizen's quality of life**. The effects of different air pollutants on health are reflected in the rise or aggravation of respiratory and cardiovascular diseases, particularly in sensitive populations such as children, elderly people and individuals with respiratory problems. The data provided by this indicator is an important tool to fight pollutants emissions and implement more effective measures to reduce emissions at the local and regional levels, as forms of protecting human health and the environment's resilience to climate change.
Sources	National Environment Agency AirBase - The European air quality database

ENV_07	Variation share of sustainable transportation
Dimension	Environment
Sub-dimension	Transport and mobility
Variables	Modal share of sustainable transportation (walk, bus, company or school collective transportation, metro/underground, train, bicycle, ship, other) for all travel (units: percentage of people by modal type) in 2001 and 2011.
Units	Percentage
Geographical level	Municipality
Description	This indicator provides details relating to trends for passenger transport in their travels. It measures the number of residents that use sustainable transportation methods such as bus, company or school collective transportation, metro/underground, train, bicycle, ship, walk or other methods in their travels.
Justification	The most dominant method of passenger transport is car, fuelled by a desire to have greater mobility and flexibility. The high reliance on the use of the car as a means of passenger transport across the EU

ENV_07	Variation share of sustainable transportation
	has contributed to an increased level of congestion and pollution in many urban areas and on many major transport arteries" (Eurostat). In March 2011, the European Commission adopted a White paper, the 'Roadmap to a single European transport area – towards a competitive and resource efficient transport system' (COM(2011) 144 final), which aims to build a competitive transport system, increase mobility, remove major barriers in key areas, fuel growth and increase employment. The monitoring and assess of this indicator allows cities to understand which strategies and policies should be developed in order to promote the use of more **sustainable modes of transports.**
Sources	National officials statistics CENSOS data

ENV_08	Variation rate of urban waste generation
Dimension	Environment
Sub-dimension	Waste
Variables	Total urban solid waste production in 2007 and 2012
Units	kg/person/year
Geographical level	Municipality
Description	The indicator is calculated on the total amount of city urban solid waste generated per capita in kilogram. The categorization of the city urban solid waste will cover the following waste classes: paper, plastic, glass, metals, textiles, and organics.
Justification	Waste represents an enormous loss of resources in the form of both materials and energy. The amount of city waste produced can be seen as an indicator of how efficient a society is, particularly in relation to the **use of natural resources** and waste treatment operations. In a post-carbon city, the reduction of waste generation will contribute both to the improvement of results obtained by the **selective waste collection** and will enhance a more **efficient waste management** and use of resources.
Sources	Municipal or Regional Waste Management Enterprise responsible for the management, recovery and treatment of the municipal waste produced.

ENV_09	Variation rate of urban waste recovery
Dimension	Environment
Sub-dimension	Waste
Variables	Percentage of recovered/treated waste in 2007 and 2012
Units	percentage
Geographical level	Municipality
Description	The indicator measures the total amount of city waste forwarded to a recovering/treatment system. The information on waste recovering/treatment system is broken down into five categories of final destination: material recycling; total incineration, including energy recovery; deposit onto or into land; and composting; and digestion.
Justification	The emissions associated with waste management can be significantly reduced through the prevention of waste production, multi-material and organic recovery. Therefore, the **urban waste recovery** in a post-carbon city context should be seen as an important opportunity to achieve a significant **reduction on resources consumption**, a major contribution to reduce the environmental impacts associated with the proliferation of city waste production, and attain a better emission control linked to waste treatment processes.
Sources	Municipal or Regional Waste Management Enterprise responsible for the management, recovery and treatment of the municipal waste produced

ENV_10	Water losses variation rate
Dimension	Environment
Sub-dimension	Water
Variables	Annual water losses in 2003 and 2012
Units	m^3/person/year
Geographical level	Municipality

ENV_10	Water losses variation rate
Description	The indicator determines the volume of water losses registered in public supply networks by inhabitant, for 2003 and for 2012. Therefore, the determination of the volumes of water losses at public water supply will determine the efficiency of the water supply.
Justification	The efficiency of water supply has impacts on the water resources balance, avoiding its future scarcity and drought periods. Since water must be regarded as an important component and a sparse future resource of a post-carbon city, the adoption of measures for its optimal management shall be essential for the **maintenance and balance of aquatic ecosystems**.
Sources	Municipal or Regional Services for Water and Sanitation

ENV_11	Energy-efficient buildings variation rate
Dimension	Environment
Sub-dimension	Buildings
Variables	Buildings with A and A+ classification of all certified buildings, in 2007 and 2012
Units	Percentage
Geographical level	Municipality
Description	The indicator intends to evaluate the top-rated energy efficiency of the building stock, including both new and existing private buildings/homes, as well as all public buildings/units subjected to the energy certification system considered in the following EU legislative framework: Directive 2002/91/CE and Directive 2010/31/UE on the energy performance of buildings directive (EPBD).
Justification	The building sector represents a large share (40%) of the European Union's total energy consumption. The increased energy needs for the building sector, along with the need to reduce CO2 emissions associated with this consumption, lead to the demand for effective mechanisms to reduce energy consumption, increase **energy efficiency** and promote the use of renewable energy in this sector. Through the energy rating certificates it is possible to conclude if there is or not a reduction of energy consumption and an increase of energy renewable sources in the building sector.
Sources	National Energy Agencies

ENV_12	Urban building density variation rate
Dimension	Environment
Sub-dimension	Buildings
Variables	Number of registered buildings in 2001 (Census Data) over the total surface area of land in the municipality, in nº/km^2; Number of registered buildings in 2011 (Census Data) over the total surface area of land in the municipality, in nº/km^2.
Units	Percentage
Geographical level	Municipality
Description	This indicator reflects the variation rate of the intensity of building development taking place between 2001 and 2011 over the total surface area of land in the municipality.
Justification	The measurement of the urban building density in a post-carbon city context is an important trend data to analyse how the cities react to urban density fluctuations and correlations with total energy consumption, high population spread, expansive real state, expanded carbon and ecological footprints, besides other urban systems.
Sources	National or regional official statistics

ECO_01	Level of wealth variation rate
Dimension	Economy
Sub-dimension	Sustainable economic growth
Variables	Annual GDP per capita (2003-2012)
Units	eur/person
Geographical level	Municipality
Description	Evolution of the GDP per total number of inhabitants (2003-2012); series of the last ten years. Gross domestic product (GDP) is a measure for the economic activity. It is defined as the value of all goods and services produced, minus the value of any goods or

ECO_01	Level of wealth variation rate
	services used in their creation. The Gross Value Added is also a measure of the goods and services produced in an area, industry or economy.
Justification	Cities with a strong economic activity are most prepared to face the challenges and difficulties of the transition process towards a "post carbon city". They normally have more resilience towards economic changes and uncertainty.
Sources	National/regional official statistics

ECO_02	Variation rate of GDP by sectors
Dimension	Economy
Sub-dimension	Sustainable economic growth
Variables	Weight of the economic sectors in GDP
Units	percentage
Geographical level	Municipality
Description	This indicator shows the contributions of the different economic activity sectors (NACE Rev. 2: Agriculture - section A, industry - sections B to F, services - sections G to U) (2003- 2012) for the GDP.
Justification	A post-carbon city should be based on a diverse and flexible economy, i.e. an economy that has significant activity in the three main economic sectors. A high concentrated economy in a sector is more susceptible to external shocks and crises, and consequently has a lower resilience towards challenges.
Sources	National/regional official statistics

ECO_03	Employment by sectors variation rate
Dimension	Economy
Sub-dimension	Labour market and business demography
Variables	Employment by economic activity sector (2003-2012)
Units	Percentage
Geographical level	Municipality
Description	This indicator shows the employment ratio by economic activity sectors (NACE Rev. 2: Agriculture - section A, industry - sections B to F, services - sections G to U) (2003- 2012). Series of the last ten years.
Justification	This indicator shows the dynamics of the labour market and is an important mechanism to monitor and measure the weight of the different economic sectors in the total of the employed population (2003-2012)
Sources	National/regional official statistics

ECO_04	Business survival variation rate
Dimension	Economy
Sub-dimension	Labour market and business demography
Variables	Ratio of companies surviving up to three years (of the total active companies) in 2008, 2009 and 2010
Units	Percentage
Geographical level	Municipality if available, if not NUTS3 regions
Description	The business demography covers a group of variables that demonstrate the characteristics and dynamics of the business population demography. Based on the analysis of the population of active companies, the counting and characteristics of company births and deaths are examined. In addition, the indicator also covers the impact of company births, through the analysis of new business developments established for a period of three years, in order to see

ECO_03	Employment by sectors variation rate
	how they survive and grow.
Justification	Nowadays, the creation of new companies and the closure of unproductive businesses can be seen as an important contributor to business dynamism. In a post-carbon city context, the tracking of an economic system can be seen as an opportunity to establish a new vibrant and flexible economy based on social entrepreneurship, green sectors and innovation distinction.
Sources	National official statistics Eurostat - Structural business statistics (NUTS3) (http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=bd_size_r3&lang=en)

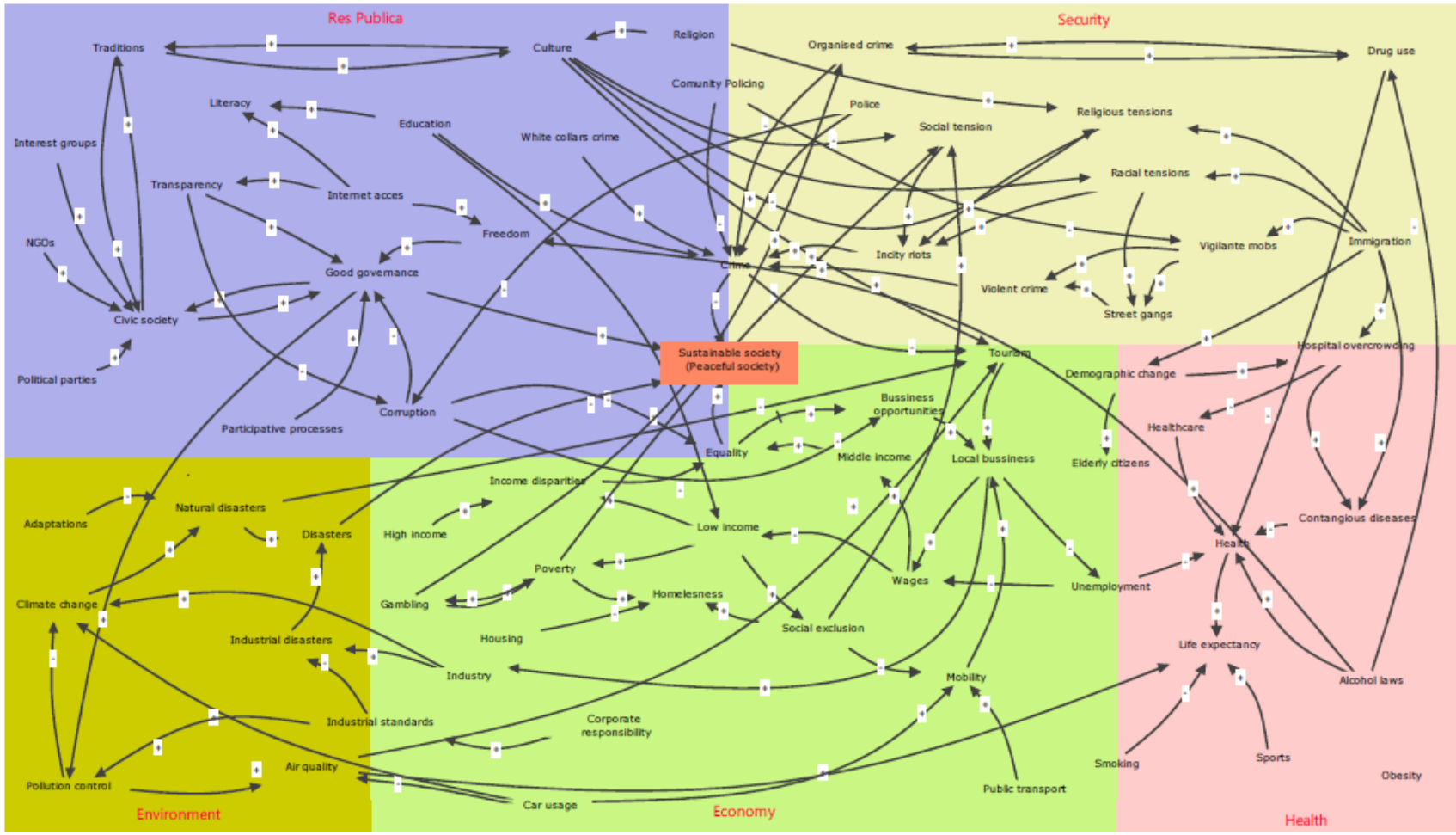
ECO_05	Budget deficit variation rate
Dimension	Economy
Sub-dimension	Public finances
Variables	Annual deficit by GDP (2003-2012)
Units	percentage of city´s GDP
Geographical level	Municipality
Description	This indicator shows how the cities generate the necessary revenues to finance their activities, or if they need to seek external financial sources (indebtedness). Evolution of annual budget deficit by GDP of the city – time series over the last ten years (2003-2012).
Justification	Cities that are financially sustainable have more capacity to deal with the challenges of the post-carbon city transition process.
Sources	City budget

ECO_06	Indebtedness level variation rate
Dimension	Economy
Sub-dimension	Public finances
Variables	Annual debt by GDP (2003-2012)
Units	percentage of city´s GDP
Geographical level	Municipality
Description	Evolution of the city's indebtedness - time series over the last ten years.
Justification	Cities with a lower level of indebtedness are more resilient to challenges in the context of a post-carbon transition process.
Sources	City budget

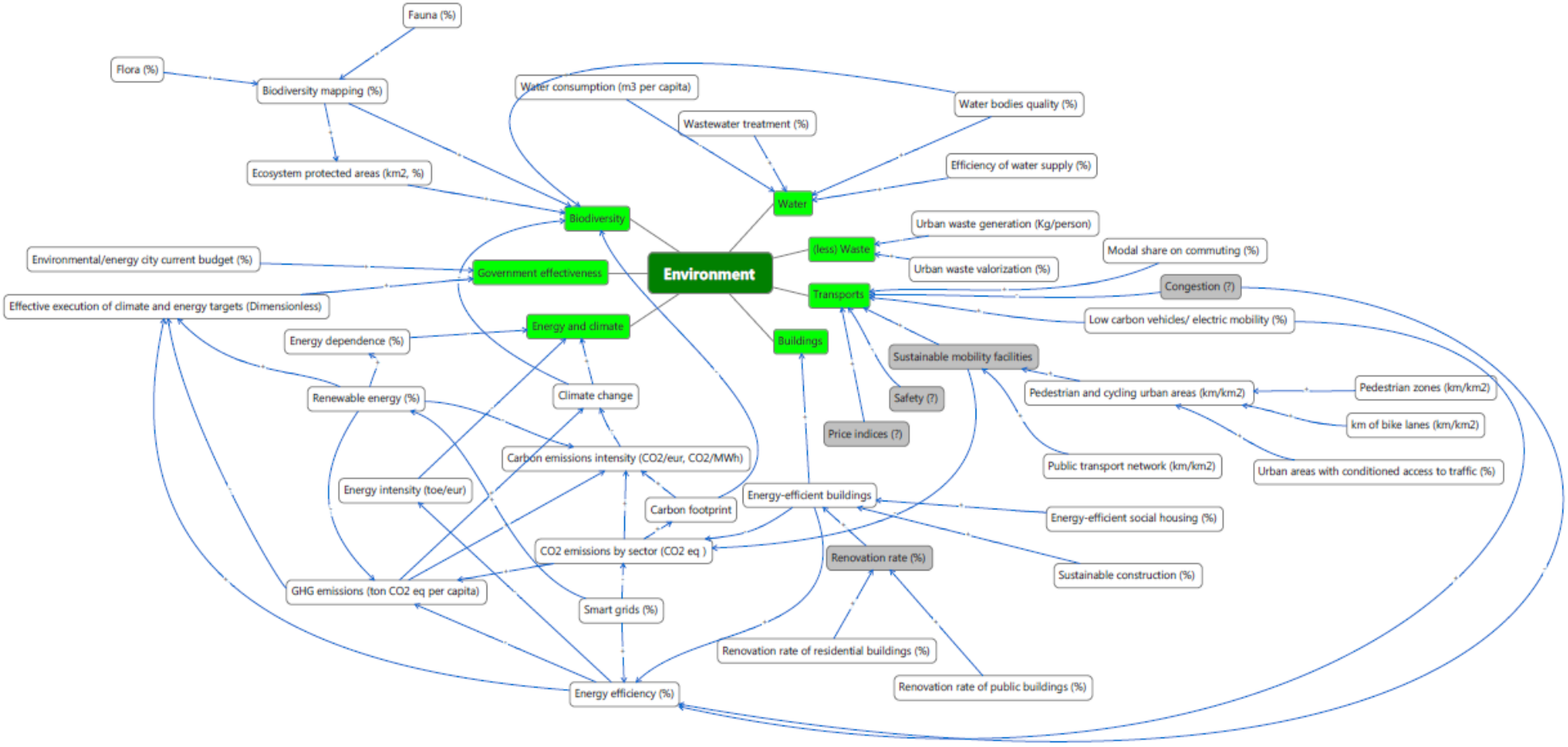
ECO_07	R&D intensity variation rate
Dimension	Economy
Sub-dimension	Research and innovation dynamics
Variables	Total R&D expenditure as a % of GDP in 2003-2012
Units	Percentage
Geographical level	Municipality if available, if not NUTS2 regions
Description	Total of R&D expenditures divided by the GDP in 2003-2012.
Justification	The level of R&D expenditures is normally associated with the level of competitiveness of an economic area (country, region or city); the R&D is the first step towards the innovation as an important element of a post-carbon society.
Sources	National official statistics Eurostat - Science and technology statistics (NUTS2)

VI.II ATTACHMENT B – MIND MAPS

SOCIAL MIND MAP



ENVIRONMENTAL MIND MAP



ECONOMIC MIND MAP