Project ICT 287534
Start: 2011-09-01
Duration: 36 months
Co-funded by the European Commission within the 7th Framework Programme

SEMANCO Semantic Tools for Carbon Reduction in Urban Planning

Deliverable 2.2
Strategies and Indicators for Monitoring CO_2 Emissions

Revision: 10
Due date: 2012-08-31 (m12)
Submission date: 2012-10-15
Lead contractor: Ramboll

Dissemination level		
PU	Public	X
PP	Restricted to other program participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	

Deliverable Administration & Summary					
No & name	**D2.2 Strategies and Indicators for Monitoring CO_2 Emissions**				
Status	Final	**Due**	M12	**Date**	2012-8-31
Author(s)	Nadeem Niwaz (Ramboll), Gonzalo Gamboa, Xavi Cipriano (CIMNE), Jørgen Hvid (Ramboll), David Lynch (NEA), Leandro Madrazo, Alvaro Sicilia (FUNITEC), Ilaria Ballarini (POLITO), Andreas Nolle (HAS), Tracey Crosbie (UoT)				
Editor	Jørgen Hvid (Ramboll), Chris Ennis (UoT)				
DoW	Strategies and indicators for monitoring CO_2 emissions and verifying impact in each case study; specifications of methods and tools to CO_2 reduction in the analysed case studies.				
Comments					

Document history

V	Date	Author	Description
1	2012-07-23	Nadeem Niwaz (Ramboll)	First draft of the report.
2	2012-07-30	Jørgen Hvid (Ramboll)	First draft of the report reviewed by Jørgen Hvid who has participated in the discussions regarding the development of D2.2 at General Meetings, Virtual meetings and Working meetings. Jørgen proposed some suggestions that have been implemented in the report.
3	2012-09-05	Nadeem Niwaz(Ramboll) Gonzalo Gamboa, Xavi Cipriano (CIMNE), Jørgen Hvid (Ramboll), David Lynch (NEA), Leandro Madrazo, Alvaro Sicilia (FUNITEC), Ilaria Ballarini (POLITO), Andreas Nolle (HAS)	Changes made after the general review carried out by project partners in the period from 31-07-2012 to 05-09-2012.
4	2012-09-11	Nadeem Niwaz (Ramboll) Leandro Madrazo (FUNITEC) Gonzalo Gamboa (CIMNE)	Changes made after the second general review carried out by project partners.
5	2012-09-15	Nadeem Niwaz (Ramboll) Leandro Madrazo (FUNITEC)	Changes made after the third review carried out by the project co-ordinator
6	2012-09-18	Gonzalo Gamboa (CIMNE)	The report includes the description of some frameworks to develop indicators and analyses their potential to be considered within the Semanco project. Also, it tries to align this document with D2.3.

7	2012-09-20	Jørgen Hvid (Ramboll)	Changes made dealing with comments raised in previous versions, it improves the section about strategies and it improves the link between the theoretical framework and the indicators selected.
8	2012-09-21	Gonzalo Gamboa (CIMNE)	It improves the previous version by checking the coherence between sections and with other deliverables (e.g. D2.3)
9	2012-10-11	Tracey Crosbie (UoT), Gonzalo Gamboa (CIMNE) Nadeem Niwaz (Ramboll) Jørgen Hvid (Ramboll)	It improves the previous version after first internal review by improving the language and the narrative of the report by rewriting and by restructuring some sections in the report. It also improves the academic content dealing with monitoring strategies.
10	2012-10-14	Chris Ennis (UoT), Gonzalo Gamboa (CIMNE) Nadeem Niwaz (Ramboll)	Minor changes made after second internal review. It improves the summary, references and the layout of the report.

Table of Contents

EXECUTIVE SUMMARY

Introduction

This report comprises the output of Task 2.2 *Strategies and indicators for data modelling and data analysis*. It provides a suggestion for strategies to monitor CO_2 emissions and a list of indicators that can be used to measure the performance of strategies to reduce CO_2 emissions. These indicators are grouped and linked to a set of key questions, which are relevant for strategies to plan, design and implement low-carbon urban developments.

The indicators identified in this report will be used to monitor and verify the impacts on CO_2 emissions in the demonstrations conducted in WP8. The definition of this set of multi-dimensional indicators is based on the accounting framework proposed in D2.3. The indicators identified are most relevant for the three case studies (Manresa, Newcastle and North Harbour). This is because the scope of the work undertaken in Task 2.2 is specific to the problems addressed in the case studies. However, the indicators identified are also relevant to typical urban planning projects. Thus while the indicators presented in this report do not cover all aspects of all urban planning projects, they are adequate for developing strategies for evaluating the energy performance and CO_2 emissions in many buildings, neighbourhoods and city development projects.

As the SEMANCO platform develops and more case studies/pilot projects are analysed by users/actors it may be necessary to reassess the indicators. This means that a key finding derived from the work of Task 2.2 is that it is necessary to ensure that the SEMANCO platform and associated tools are flexible enough to allow both the introduction of new indicators and the removal of obsolete indicators.

Monitoring strategies and indicators

Monitoring of CO_2 emissions is central to sustainable urban development to identify the extent to which the goal of carbon reduction is met. To do this, urban planning schemes must include a monitoring strategy. The strategies must be designed according to each particular case, taking into consideration issues such as availability of data, political relevance, etc.

Two strategic frameworks suggested by HEFCE (2010) and The International Council for Local Environmental Initiatives (ICLEI) in 1993, are described in this report. Both strategic frameworks for monitoring CO_2 emissions are valid for the SEMANCO-project since they are recommending the same approach (e.g. defining a carbon reduction target, establishing a baseline, selecting relevant indicators, proposing a carbon reduction implementation and management plan and defining a monitoring program).

The energy model and tools to be developed in WP4 and WP5 respectively should address and reflect the above monitoring strategies.

Subsequent to the above considerations the relevant indicators for monitoring CO_2 emissions in urban planning within the SEMANCO project have been structured and explained according to below fields:

- **Indicator number**
- **Indicator type**
- **Unit**
- **Extensive/Intensive**
- **Calculation method**

- **Input needed**
- **Key question(s) addressed in use case**
- **Benchmark description**
- **Benchmark score.**

A total of 62 indicators dealing with the following types have been introduced and explained:

- **Energy demand for final energy uses**
- **Demand for different energy carriers**
- **Energy distribution losses**
- **Energy carriers from renewable energy sources**
- **Renewable energy in the total electricity supply**
- **Share of local electricity carriers from renewable energy sources**
- **Share of local energy carriers from renewable energy sources**
- **CO_2 emissions and reduction compared to baseline**
- **Energy simulations in buildings**
- **Costs/Economics**
- **Fuel poverty.**

Detailed information about each indicator can be found in Appendix A.

1 INTRODUCTION

1.1 Purpose and target group

This report is the output of T2.2. Its purpose is to suggest strategies to monitor CO_2 emissions and provide a list of relevant indicators for energy efficient urban planning, which can be used to measure the performance of strategies to reduce CO_2 emissions. The definition of this set of multi-dimensional indicators is based on the accounting framework proposed in D2.3. The indicators identified in this report are mostly relevant for the scope of work undertaken in T2.2, namely the three case studies (Manresa, Newcastle and North Harbour). It is also relevant for typical urban planning. Thus, while the indicators presented in this report do not cover all aspects of all urban planning projects, they are more than adequate for evaluating the energy performance and CO_2 emissions in many urban development projects. As the SEMANCO platform develops and more case studies/pilot projects are analysed by users/actors it may be necessary to reassess the indicators used in these analyses. It is hence necessary to make the SEMANCO platform flexible enough to allow this[1].

The indicators identified in this report are grouped and linked to a set of key questions which are relevant for strategies to plan, design and implement low-carbon urban developments. They will be used to monitor and verify the impacts on CO_2 emissions in the demonstrations conducted in WP8.

1.2 Contribution of partners

Task 2.2 was discussed in detail by all project partners at both General Meetings (GMs) and technical workshops. Every partner has contributed to the development of a common understanding of the content and scope of this deliverable and the interface between the work presented and the other tasks, deliverables and work packages in the SEMANCO project (cf. Section 1.3). The main output from Task 2.2 is the indicator list embracing the key questions and the associated benchmark framework (see Appendix A). This was compiled following the process explained in Section 2.4.2.2.

1.3 Relations to other activities in the project

The SEMANCO project methodology is described in Section B1.3 of Annex I- *Description of the Work* (DoW) which is reproduced in Figure 1. Deliverable 1.8 – *Project Methodology* – summarises the methodology which has been developed to integrate the tasks carried out in the different work packages during the first year of the project work.

[1] The preliminary work of SEMANCO was presented at the "3rd Workshop on eeBuildings Data Models (Energy Efficiency Vocabularies)" organised by the European Commission in the context of the ECPPM conference which took place in Reykjavik in July 2012. One of the other on-going research projects working with indicators in relation to specific case studies/ pilot projects is the Cassandra project. The project aims to create the aggregation methodology and the framework of key performance indicators for scenario assessment that can affect system operation and company/environmental policies at different levels of abstraction, starting from a basic level (single consumer) and shifting up to large consumer areas (i.e. a city), as well as an expandable software platform that provide different energy stakeholders with the ability to model the energy market, in order to assess scenarios for their own purposes (http://www.cassandra-fp7.eu). One of the conclusions of this meeting was that indicators used in different projects should be homogenized. Hence, it is anticipated that D2.2 will be able provide some input to this homogenizing process.

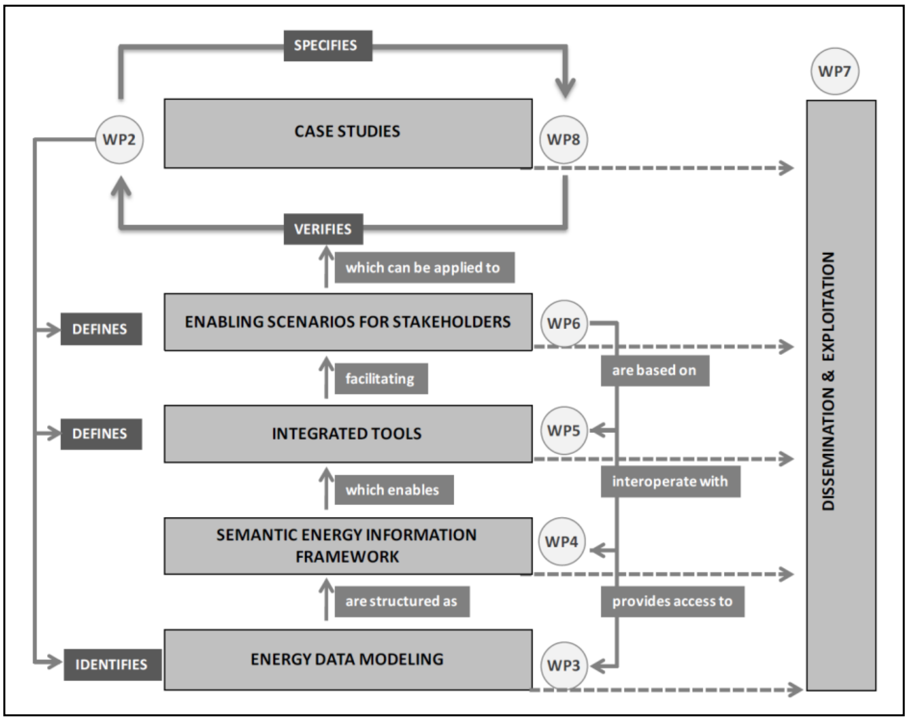

Figure 1. Structure of the work packages of SEMANCO and their interrelationships

With reference to D1.8, even though the original work-plan structure remains valid (see Figure 1), it has undergone some developments as a result of its implementation during the first year of the project. Essentially, we have moved from a linear approach of the technological development to a network of connections between the different project components. This approach has been found to be necessary due to the need for simultaneous development within the different WPs, their tasks and their related deliverables.

The simultaneous development of the different work packages and their tasks is accompanied by the concurrent elaboration of the related deliverables. In fact, the present D2.2 is carried out in parallel with the following deliverables:

- D2.3 - *Impact evaluation*, providing strategies for impact verification of the integrated tools and associated methodologies. The strategies will be applied in WP 8 in three yearly cycles.
- D3.1 - *Report on the accessible energy data*, which provides detailed characteristics of the identified data repositories for each scenario, including: domain, data structure, technical accessibility and availability (considering privacy and intellectual property rights).
- D6.4 - *Knowledge management system*, which has the aim to improve the interaction efficiency between the work packages and the components developed in the work packages.
- D8.1 - *Implementation plan development*, which provides a detailed implementation plan for each case study scenario including measurement parameters, indicators of success, contingency plans and key control points in the process.

As described in D1.8, ontology is at the core of the SEMANCO project. Building ontology involves integration of domains, data, indicators, tools, users, stakeholders, etc. The process to build ontology therefore requires a multiple approach to the project development to integrate the different dimensions and components involved. To facilitate the integration of the different areas of the project, a methodology based on "*Use cases*" has been adopted. A "*Use case*" is the bond connecting the tasks carried out in the different WPs. It also provides the bridge between the WPs and the demonstration scenarios.

A "*Case study*" refers to the delimitation of the research scope to some geographic locations and what they convey in terms of problem definition, stakeholders, and methods and so on. A "*Use case*", on the other hand, delimits a specific research problem which can be circumscribed to one or several case studies. The "*Use case*" is as a frame which encapsulates data, tools and users, as well as their interrelationships in order to achieve a strategic goal concerning carbon reduction. "*Use cases*" can be defined as single entities or as being part of a network of use cases. Each "*Use case*" is composed of a network of "*Activities*" which need to be performed to fulfil the goal of the "*Use case*". Some of the "*Activities*" are shared by several "*Use cases*".

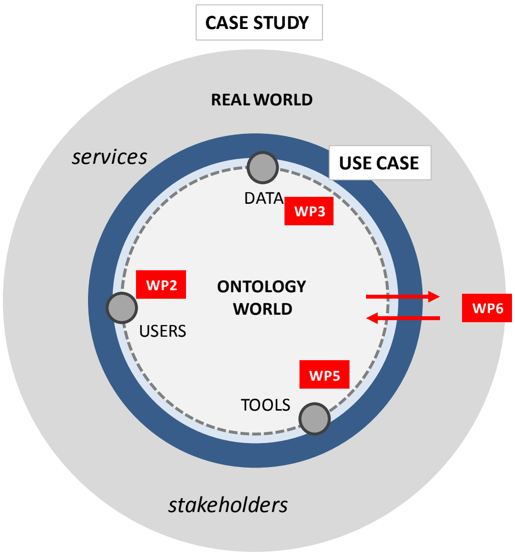

Figure 2. Integration of "Case Studies" and "Use Cases" in the development of the ontology[2]

As highlighted in Figure 2, the "Use case" methodology integrates the different WPs, including WP2. In particular, the role of WP2 in the "Use case" methodology regards the following issues:

- An analysis and definition of the problem domain in the three selected case-study areas to provide an evidence-based understanding of the strategies required to reduce CO_2 emissions, and to focus the scope of the research on the case studies (T2.1).
- Strategies and indicators for monitoring CO_2 emissions and verifying impact in each case study; specifications of methods and tools to CO_2 reduction in the analysed case studies (T2.2).
- Strategies which will enable verification of impacts of the integrated tools and associated methodologies, which will be then applied in WP8 in three yearly cycles (T2.3).

[2] D1.8 *Project Methodology (1)*

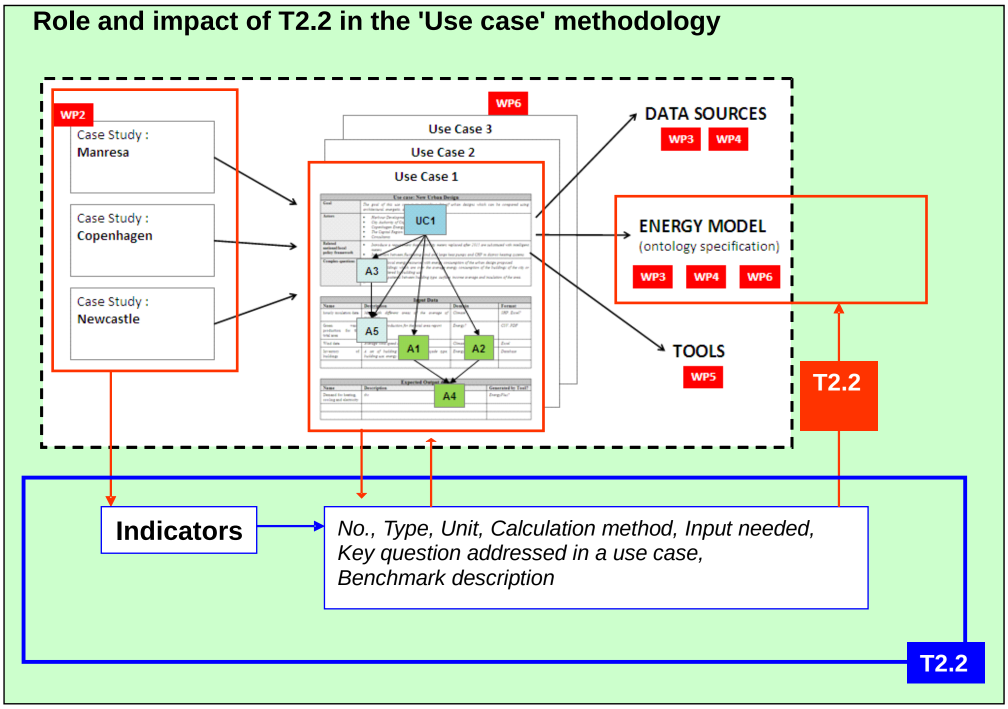

Figure 3. The role of Task 2.2 in the "Use case" methodology

In WP2, the role of Task 2.2 in the "Use case" methodology is to use the data provided (WP3) to calculate or simply determine relevant indicators in the Energy Model (WP4). Secondly to use the developed indicators to conduct an analysis required by the user (WP6) by using the relevant tools (WP5). These relationships are indicated in Figure 3. All this process is based on the guidelines and analytical framework proposed in D2.3.

The links and relations to other activities in the project suggested above have been illustrated in Figure 4 below:

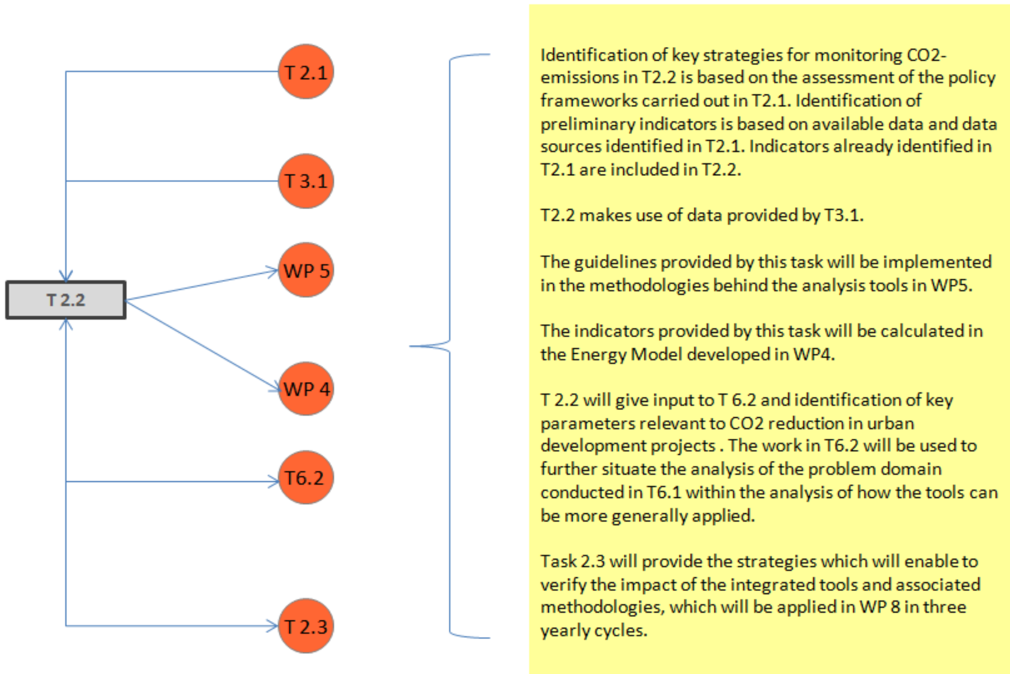

Figure 4. Interrelationships between Task 2.2 and other tasks and work packages

The strategies and indicators for monitoring CO_2 emissions developed in Task 2.2 make use of the data provided by T3.1 which was identified in T2.1 and has been documented in D3.1.

Strategies and indicators will be used in the development of the energy model provided by WP4 and tools provided by WP5 giving the stakeholders addressed in T6.1 the necessary tools to carry out the analyses in their urban development projects.

Strategies and indicators developed will also be used as input in T6.2 to further identify the key parameters relevant to CO_2 reductions in urban development projects. The work in T6.2 will be used to further situate the analysis of the problem domain conducted in T6.1 within the analysis of how the tools can be more generally applied.

T2.3 provides the analytical framework to define indicators, as well as the strategies to verify the impact of the integrated tools and associated methodologies, which are applied in WP 8 in three yearly cycles.

2 Strategies and Indicators

This chapter begins with a definition of the term indicator. It then reviews the different frameworks, guidelines and methodologies to be considered when developing indicators and strategies for monitoring CO_2 emissions. The chapter then moves on to discuss the work conducted in Task 2.2 in detail. To do so, it suggests the accounting framework to be used in the project and describes the relevant strategies and indicators for monitoring CO_2 emissions in an urban planning context.

2.1 What is an indicator?

Indicators are essential components in the overall assessment of progress towards sustainable development. Current definitions of indicators for sustainable development are particularly confusing. Different authors define indicators differently and there is a lack of consensus either in their definition or use.

The SEMANCO project adheres to the definition of an indicator given by Gallopín (1997). From this perspective indicators are *variables*, which is an operational representation of an attribute of a system. In other words an indicator is an image of an attribute defined in terms of a specific measurement or observation procedure. The value (i.e. the state of the variable) gives information on the condition and/or trend of an attribute (or attributes) of the system considered, which is expected to support decision-making at some level.

Many organisations have developed their own set of sustainability indicators. The UN-CDS (1999) addresses many relevant indicators in the area of social, environmental, economic and institutional sustainability. The theme of climate change and relevant indicators for emissions of greenhouse gases is described under the area "Environment". This document suggests the net emissions of the six greenhouse gases subject to the Kyoto protocol that drive climate change should be measured. In the same document, the theme of energy use and relevant indicators for annual energy consumption per capita, share of consumption of renewable energy resources and intensity of energy use are defined as aspects of economic sustainability. The indicators related to the theme of energy use are linked to different consumption and production patterns. However, while this document suggests a framework to describe indicators, it lacks a methodology to define such indicators.

OECD (2001) presents a set of environmental indicators with three explicit objectives:

1. To keep track of environmental progress,
2. To ensure that environmental concerns are taken into account in the formulation and implementation of public policies and
3. To ensure the integration of environmental concerns into economic policies through environmental accounting.

The work of the OECD with OECD countries has led to an agreement to use the pressure-state-response (PSR) model as a common harmonised framework. This work also identified and defined several sets of indicators based on their policy relevance, analytical soundness and measurability, and it has measured and published these indicators for a number of countries. The OECD regularly publishes environmental performance reviews based on this set of environmental indicators. These indicators are expected to contribute to follow-up work on the OECD's environmental strategy and to the broader objective of reporting on sustainable development.

In 2006, the EU launched its renewed Sustainable Development Strategy. It aims to reconcile economic development, social cohesion and protection of the environment. It considers measuring the progress towards sustainable development by means of a set of indicators (SDI) and a monitoring framework (Eurostat, 2011). According to Munda (2005), the term ‘development’ entails changes in the economy that are both quantitative (like the growth of gross domestic product) and also qualitative (social, institutional and political). On the other side, the concept intrinsically implies that there is only one possible model of development, i.e. the one of industrialised countries This raises the question of whether one answer can actually fit to all problems under all circumstances.

It is expected that a set of indicators mapping (or simplifying) a number of relevant properties of a system are of fundamental interest for decision-making. Indicators would enable us to assess conditions and trends, and monitor them against goals or targets, to compare across locations and situations and to provide early warning (Gallopín, 1997).

In general terms, to define indicators entails a “compression” process in which the information of a complex reality is simplified for use of indicators. First, a virtually infinite information space is reduced to a limited set of goals, narratives, attributes and representations to describe the “problem”. Next, further compression is accomplished through the selection of indicators that maps the selected relevant attributes of the system being analysed. The validity of the set of indicators depends on how well the virtually infinite information about the external world is compressed into a finite representation specific to the task at hand (Giampietro, 2010). In this regard, it is of fundamental importance to bear in mind the following issues when defining performance indicators:

- Quantitative analyses of future scenarios will always be affected by important doses of ignorance (e.g. several unknown issues about future situations) or, even worse, genuine ignorance (e.g. no knowledge about future situations at all). Nobody can predict the future; no matter how sophisticated are the models and hardware used to do so. Ignorance about the future is unavoidable. Therefore, the problem structuring and/or the issue definition of sustainability changes over time, entails that the set of performance indicators should be open for updating according to the relevant issues at stake in a given moment in time.
- The formal representation of the relevant attributes by means of a set of indicators should consider the existence of multiple identities at different scales. In other words, the numerical characterisations of different indicators are not reducible to each other. It has to do with what Munda (2004) calls technical incommensurability. That is, the relevant attributes of a complex environment cannot be reduced and expressed using only one unit of measurement, and inter/multi-disciplinary analyses are needed.
- The interpretation of the same set of indicators depends on values and their significance arises from the interpretations made about them. This is related to what Munda (2004) calls social incommensurability, i.e. there are different and legitimate conflicting values and interests in society. This issue calls for a preliminary semantic check when defining a problem structuring related to analysis of sustainability; a concept that cannot be defined in a substantive formal[3] way once and for all.

According to all of that, an indicator is not a number, but it is a shared meaning assigned to a variable within a given contextualisation of performance (adapted from Mayumi & Giampietro, 2006).

In general terms, desirable indicators are variables which summarise or simplify relevant information, make visible the phenomena of interest, as well as measure, evaluate and communicate relevant information. According to Moldan and Billharz (1998), the following universal requirements are desirable (from a practical point of view) properties for indicators:

- The values of the indicators must be measurable (or at least observable).

[3] By ‘formal’ we mean a set of attributes in relation to an observed system, a set of proxy variables and their relationships in the model representing how the observed system is supposed to behave

- Data must be either already available or they should be obtainable (through special measuring or monitoring activities).
- The methodology for data gathering, data processing, and construction of indicators must be clear, transparent and standardised.
- Means for building and monitoring the indicators should be available. This includes financial, human, and technical capacities.
- The indicators or sets of indicators should be cost effective, an issue often overlooked.
- Political acceptability at the appropriate level (local, national, international) must be fostered (indicators that are not acceptable by decision-makers are unlikely to influence decisions).
- Participation of, and support by, the public in the use of indicators is highly desirable, as one element of the general requirement of participation of the broader society in the quest for sustainable development.

The following section explores some such frameworks and tries to benefit from them in order to define adequate guidelines to be implemented in the SEMANCO project.

2.2 Frameworks, guidelines and methodologies to define indicators of performance

In general terms, there are no predefined frameworks, guidelines and methodologies or standard set of indicators to be used when developing energy efficient and low-carbon urban planning projects. However, we can find several analytical frameworks aimed at supporting the development and definition of performance indicators from which the SEMANCO project may benefit.

2.2.1 DPSIR framework

DPSIR stands for *Driving forces, Pressure, State, Impact* and *Response*. The roots of the DPSIR framework can be traced back to the Stress–Response framework developed by Statistics Canada in the late 1970s (Rapport and Friend, 1979). In the 1990s, this approach faced further development by, among others, OECD (1991, 1993) and United Nations (1996, 1999 and 2001).

DPSIR is a heuristic approach that can be used to help the perception and representation of causal relationships between social and environmental elements. DPSIR explicitly acknowledges the need for addressing the different dimensions of sustainability (it helps improv the quality of the mix of attributes and indicators used in integrated assessment), but it does not address the need of integrating the resulting changes in the different dimensions of sustainability in each of the elements of the cause-effect chain.

However, the causal relation individuated in this way is often perceived to be a simple one (one direction of causality associated with the given simplification of the perception/representation of the complex socio-environmental dynamics). The perception and representation of *Driving forces, Pressure, State, Impact* and *Response* factors and resulting indicators in the form of a linear causal relation is determined by the semantic choices of a spatio-temporal scale performed by those using the framework. For instance, in many applications of this framework, *State* and *Impact* indicators mainly focus on environmental issues (the environmental impact), and *Driving forces* are mostly limited to socio-economic activities (See Svarstad, Petersen, Rothmanc, Siepeld & Watzold, 2008). This is due to the difference in the scale of relevant processes taking place in both socio-economic and ecological systems. Quicker changes in socio-economic systems are easily perceived as causes of changes in ecological systems. However, on a different scale - e.g. when looking for long-term biophysical constraints - a different direction of causality should also be considered.

DPSIR facilitates the understanding of its analysis due to its simplicity, since the main discussion of relation in the general framework is done in semantic terms. But, at the same time it can limit the range of discursive views among the involved social actors when performing a semantic framing of the sustainability issues. This issue is extremely important when dealing with normative implications of the analysis. That is, a DPSIR implemented only by "experts" could leave aside some local understandings, referring to a perception from the inside of the socio-environmental dynamics in the evaluation exercise.

2.2.2 PSR framework

The *Pressure, State* and *Response* scheme was introduced in the seventies by OECD (OECD, 1993). The evaluation of DPSIR applies also to PSR. In fact, PSR refers to the first version of DPSIR; a sort of initial and more generic definition of this heuristic approach. The original idea of PSR was to force the analysts to focus on relevant relations in the analysis of the relation between environmental processes and socio-economic processes. Starting from a relevant way of studying this relation boosts the usefulness of the resulting issue definition and problem structuring.

Several organisations and institutions have used the PSR scheme in order to develop their own set of indicators. For instance, Hammond et al. (1995) additionally present a list of environmental indicators and point to the fact that a widely used framework for environmental indicators arises from a simple set of questions:

- What is happening to the state of the environment or natural resources? (State)
- Why is it happening? (Pressure)
- What are we doing about it? (Response)

The report also provides a conceptual framework to define indicators. This explicit conceptual model is aimed at guiding the development of environmental indicators. It describes the interactions between human activity and the environment by means of four groups of indicators:

- Resource depletion
- Pollution
- Ecosystem risks
- Environmental impact on human health

However, since this framework is an adaptation of the PSR scheme, it presents the same sort of drawbacks as the DPSIR framework.

2.2.3 STEEPV

STEEPV stands for *Social, Technology, Economics, Ecology, Politics* and *Values*. The STEEPV analysis evolved from ideas developed by the Johnson Research Associates in the early 1960s. Schwartz developed the idea further and developed the STEPV analysis in the early 1970s. This process was extended by Holroyd and Loveridge in 1975 into STEEPV (Loveridge, 2002)

This is another framework to be used for structured brainstorming or for developing indicators. It helps to explicitly consider different dimensions of sustainability and to tailor a given issue definition and problem structuring on the specificity context. It could be used within a participatory approach in order to guide the identification of relevant factors to be considered in a given situation/problem (See for instance Vinnari, 2007).

In brief, this analysis shows that the reviewed frameworks (DPSIR, PSR and STEEPV) are good for structured brainstorming and have certain potential to guide the definition of sustainability indicators. However, the same frameworks have the problem that they do not present a satisfactory way of dealing with the multiple attitudes and definitions of issues by stakeholders and the general public. In other words, they present a static view of the relevant issues at stake when dealing with socio-environmental problems.

Moreover, D2.3 has identified the challenges entailed by the existence of elements operating at different special and temporal scales in the energy efficient urban planning domain. D2.3 also defines the strategies to deal with those challenges and proposed the *fund-flow* model (Georgescu-Roegen, 1971) and the MuSIASEM approach (Giampietro, Mayumi & Ramos-Martin, 2009) as the basis for the accounting framework to be used within SEMANCO.

2.3 The accounting framework used in the SEMANCO project

2.3.1 Theoretical and methodological considerations

The problem of CO_2 emissions reduction is difficult to delimit to a particular geographical area. It is a systemic problem in which multiple dimensions and geographical scales need to be integrated. The description and analysis of an urban system can be carried out on different scales: at building, neighbourhood, district or city level. The existence of multiple scales conveys important challenges to be addressed in the analytical process concerning carbon emissions and it can be challenging to create indicators that in a relevant way address level of CO_2 emissions, related costs, etc. linked to the activities carried out in a specific area. The relevant aspect considered to perceive and represent the system would change depending on the chosen analytical scale. What is important to highlight is not the absence of a definitive answer to the key questions in a use case (see Section 1.3), but the importance of defining the scale of analysis according to the objectives of the analysis.

We can consider the city as a metabolic system; a system able to stabilize a coordinated inflow of matter and energy resources, producing a flow of waste: degraded matter and energy. In order to represent "our" urban system, we propose the use of *fund* and *flow* categories (Georgescu-Roegen, 1971): **Fund** categories refer to agents remaining "the same" over the duration of the representation (e.g. capital, people, land). **Flow** categories refer to elements appearing and/or disappearing over the duration of the representation (e.g. added value, water, energy, matter). On the time scale of the representation, funds transform input flows into output flows, and flows are either consumed or generated in order to reproduce the funds categories. We can say that *fund* categories represent *what the system is*, and *flow* categories indicate *what the system does*.

The flow-fund representation is based upon the use of extensive and intensive indicators. **Extensive indicators** are those that can be added. They characterize the size of the system and its compartments, in terms of either funds categories (e.g. hours of human activity or hectares of land) or flow categories (e.g. GJ of energy per year or hm^3 of water per year). **Intensive indicators** are those that represent a ratio: the pace of the metabolism in terms of a flow/fund or fund/fund ratios (e.g. flow of energy carriers per square metre, measured in kWh/m^2). They describe *how the system does what it does*.

2.3.2 Approach suggested in the SEMANCO project

As mentioned in Deliverable 2.3 *Impact evaluation*, we propose to use the Multi-scale Integrated Analysis of societal and Ecosystem Metabolism (Giampietro et al. 2009) as an accounting framework for the definition and development of indicators for energy efficient urban planning. According to this framework, we can represent a metabolic system by means of fund and flow categories as described in Section 2.3.1. Fund categories are allocated to the different compartments of the system in order to perform certain functions. For instance, land

and human time[4] are allocated to different socio-economic sectors in order to perform activities aimed at maintaining and reproducing the system. In doing so, fund categories make use and transform some input flow categories (e.g. energy, matter or added value) into output categories (e.g. added value, goods and services, degraded energy, solid and liquid waste). The MuSIASEM approach (Giampietro, Mayumi & Ramos-Martin, 2009) uses extensive and intensive variables (i.e. indicators), which can be up-scaled and down-scaled accordingly (see Section 4.1.1 of D2.3).

In the context of SEMANCO, the selection of fund categories will be restricted to land uses in the preliminary implementation round. But, how to select the relevant flow categories used by the system in order to maintain its reproduction? Figure 5 shows a representation of an urban environment by means of using fund and flow categories. As we can see, it is a simplified model, which presents a limited and very broad list of input and output flows, which can be relevant for a current evaluation of the metabolic pattern of a city or urban area. Also, it only shows two fund categories: land and human time. From here we can develop a set of relevant indicators such as the flows of water or electricity per year, and their intensive versions related to land and time uses.

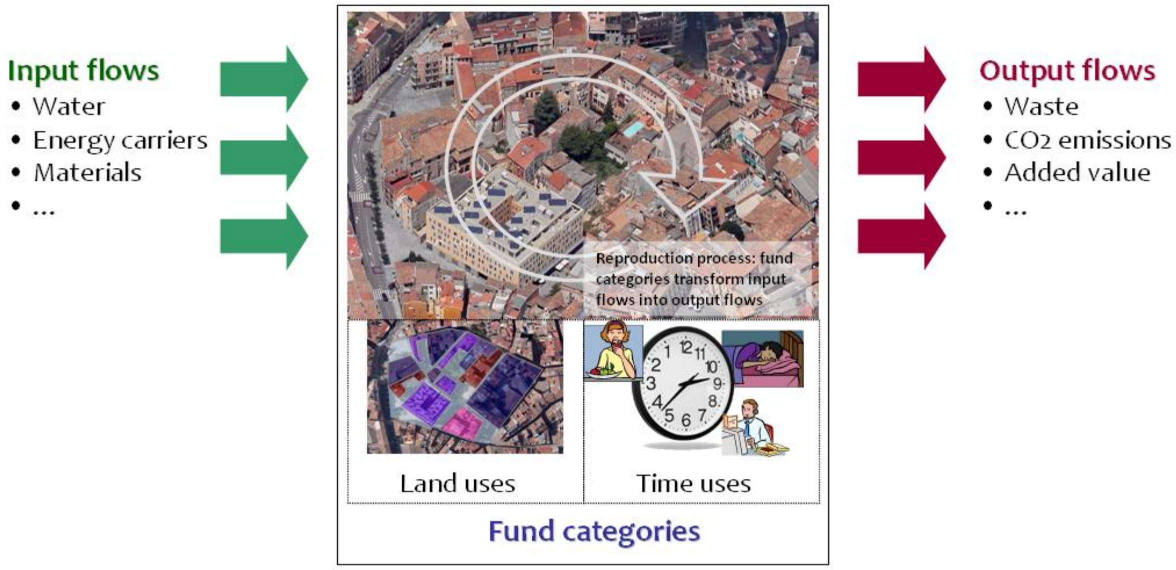

Figure 5. Fund-flow representation of an urban area

Here, we propose the following procedure to define a relevant set of indicators for assessing the performance of urban areas:

1. To categorise the urban area according to relevant fund categories.
2. To identify input and output flows that are relevant for the reproduction and maintenance of the system.
3. To determine input and output flows that go through the different fund categories

[4] As mentioned in D2.3, the use of human time as a fund category will be explored as part of T2.3; both to update the impact verification strategy (D2.4) and to set the objectives for the final verification (D2.5). This task will both look for information on time uses (e.g. time-use surveys) and evaluate the possibility to match time and land use categories. If that is possible, we will be able to calculate a sort of "per capita performance indicators". The difference between conventional *per capita* indicators and intensive indicators per unit of human activity (e.g. hour) is that the last enables us to up- and down-scale performance indicators (More detailed information can be found in D2.3).

across levels.

4. To calculate extensive indicators across categories and scales.
5. To calculate intensive indicators by means of dividing flow variables by their corresponding categories of fund variables.

The guidelines to define indicators presented here deal mainly with indicators that describe the metabolic performance of a system or of its compartments: the flows controlled by the elements of system and by the system itself, in absolute terms (extensive) and in relation to the land area in which the activity is performed (intensive).

However, we can think of a different type of indicator: the ones referring to the relationship between the elements of the system. For instance, and as mentioned previously, we may be interested in obtaining the distribution of income within a neighbourhood or of a city. In this case, we can include some indicators mapping the relationships between the elements of a system each time we aggregate the performance of lower level elements. Let us consider that we have calculated the "energy requirement for heating" in each building of a neighbourhood. Then, if we aggregate data in order to calculate the extensive indicator "energy requirement for heating" at neighbourhood level, the system would also provide an indication of the (in) equality within the neighbourhood in terms of energy use for heating.

2.4 Strategies and indicators for monitoring CO_2 emissions in urban planning

2.4.1 Relevant strategies

Monitoring of CO_2 emissions is central to sustainable urban development to identify the extent to which the goal of carbon reduction is met. To do this, urban planning schemes must include a monitoring strategy.

According to HEFCE (2010) this should include:

- Definition of carbon reduction targets
- A selection of relevant indicators, taking into consideration the above requirements
- Establishing a baseline of carbon emissions, including actual base year emissions and projected emissions based on 'Business as Usual'
- An implementation plan for reaching the targets set
- A carbon management plan, making clear responsibilities for monitoring and follow-up actions to be taken based on the results of the monitoring
- Defining a monitoring program, including for example
    - Planning stage: measurement/recording/calculation of the current indicator parameters; projection of indicator parameters to be a result of the plan implementation
    - Post-implementation: measurement or observation of the actual indicator parameters on a regular basis, e.g. annually.

It must also be noted that the monitoring of strategies must be designed according to each particular case, taking into consideration issues such as availability of data, political relevance, etc.

According to The International Council for Local Environmental Initiatives (ICLEI) that launched the Cities for Climate Protection (CCP) campaign in 1993 there are five steps that local governments can follow to develop a strategic initiative to reduce greenhouse gas emissions. These steps are called "milestones" and each local government that joins the CCP makes a political commitment to implement them:

- Milestone 1 – Conduct the greenhouse gas emissions analysis: baseline inventory and forecast of emissions growth
- Milestone 2 – Set the reduction target
- Milestone 3 – Develop and adopt the Local Action Plan
- Milestone 4 – Implement the Local Action Plan
- Milestone 5 – Monitor progress and report results

Under Milestone 5 CCP argues that formal procedures must be included for the monitoring of the implementation of the Local Action Plan including measuring results, incorporating the results of experience, keeping track of changing conditions, and taking advantage of new information and ideas. CCP suggests that the key monitoring and evaluation issues should include:

1. Tracking implementation that requires a system in which each entity or person responsible for a certain area provides periodic progress and problems reports to the person with overall responsibility for the plan.
2. Measuring results which requires following up on the sources and the data developed in preparing the baseline emissions analysis and the emissions projections. This is important to determine if the figures are changing in the way it was predicted. If not, is this because of inadequate program implementation, or were the measures adopted not adequate to begin with?

CCP suggests that tracking and measuring need to be routine activities that need to be scheduled and performed on a regular basis so that progress or the lack thereof can be determined at any time.

In our view both strategic frameworks described above for monitoring CO_2 emissions are valid for the SEMANCO project since they are recommending the same approach, although there is some difference in the order of the steps recommended (e.g. setting a reduction target before establishing a baseline inventory).

The energy model and tools to be developed in WP4 and WP5 respectively should address and reflect the strategic framework developed in this report. In practical terms it means that the users of the tools should be able to follow the process described in the frameworks suggested above (or a framework similar to these) and conduct their analysis accordingly. The energy model in SEIF should support this by providing the required calculations and simulations to conduct the analysis. The challenge in this regard is to establish the interface between what the SEIF does and what the tools developed in WP5 do and what has to be carried out by external tools. This problem will be further analysed in WP4 and WP5.

2.4.2 Relevant indicators

The indicators developed for SEMANCO are based on the definition of indicators presented in Section 2.1, on the frameworks, guidelines and methodologies described in Section 2.2, nad on the strategies for monitoring CO_2 emissions described in Section 2.4.1 following the Fund/Flow model of "*What the system is*" and "*What the system does*" based on extensive and intensive indicators described in Section 2.3.

However, before defining the set of indicators to be used within the SEMANCO project we first define the relevant scope (Section 2.4.2.1) and then we suggest the methodology and process of defining the indicators accordingly (Section 2.4.2.2).

2.4.2.1 Defining the use and scope of indicators within the SEMANCO project

Indicators are widely used within trade and industry, governments, etc. to measure the quality of a task, process or policy in relation to a defined target within a specific area. For this reason the incentive behind the use of indicators in any situation is a desire to meet certain future goals and targets linked to strategies on a local, national, regional or global level.

In the SEMANCO context, the focus is on carbon emission, use of energy carriers, primary energy and costs. The effects of carbon emission are implicitly given, for which reason we do not need to work with indicators of final impacts on the environment and the economy of carbon emissions or primary energy usage. This allows us to limit the indicators to the fields of carbon emissions, consumption of energy carriers and primary energy consumption and costs.

A preliminary set of indicators was identified in T2.1 and are included in T2.2. Indicators from other relevant research projects and urban planning projects are also included in Task 2.2 after verifying their adequacy according to the requirements established in D2.3. The issue of how the indicators can be applied at different scales has been addressed in Section 2.3.

The relevance of the different indicators has been explained and if a formula is required to calculate an indicator, it is suggested. Certain parameters of an indicator may be specific to the country addressed. Thus, each case study country will have to provide a local methodology/formula to calculate the indicator if this is the case. However, in general the indicators listed do not distinguish between countries, nor are they restricted to a specific scale (e.g. neighbourhood, city, municipal, regional) since it is assumed that the indicators developed are addressing the key questions and strategies related to energy efficient urban development and reduced CO_2 emissions at all scales and in all countries (at least at European level).

These measurable or calculated parameters typically develop over time and it is therefore necessary to set up benchmarks for the indicators and keep track of their development in different scenarios (e.g. in use cases, demonstration scenarios) within case studies and within a defined scope. Hence, indicators can be used to compare developments within certain areas as well as different scenarios and can be compared to predefined benchmarks as well. This study suggests appropriate benchmarks for some of the indicators in the three case studies and other relevant urban planning projects. Other indicators and benchmarks may be developed for other case studies if relevant. In case the user wants to monitor a project against local or national benchmarks, such benchmarks should be identified. Suggestion for such a common benchmark framework for indicators that could be applied for the three case studies and for urban development in general has been proposed.

2.4.2.2 Methodology and process of defining indicators

The methodology of defining indicators is given below:

1. Identification of key questions (from policy frameworks, urban planning objectives etc.)
2. Identification of relevant flows (energy carriers, energy losses, CO_2 emissions, costs etc.)
3. Definition of relevant indicator types
4. Definition of indicator list

The steps above are illustrated in Figure 6 below:

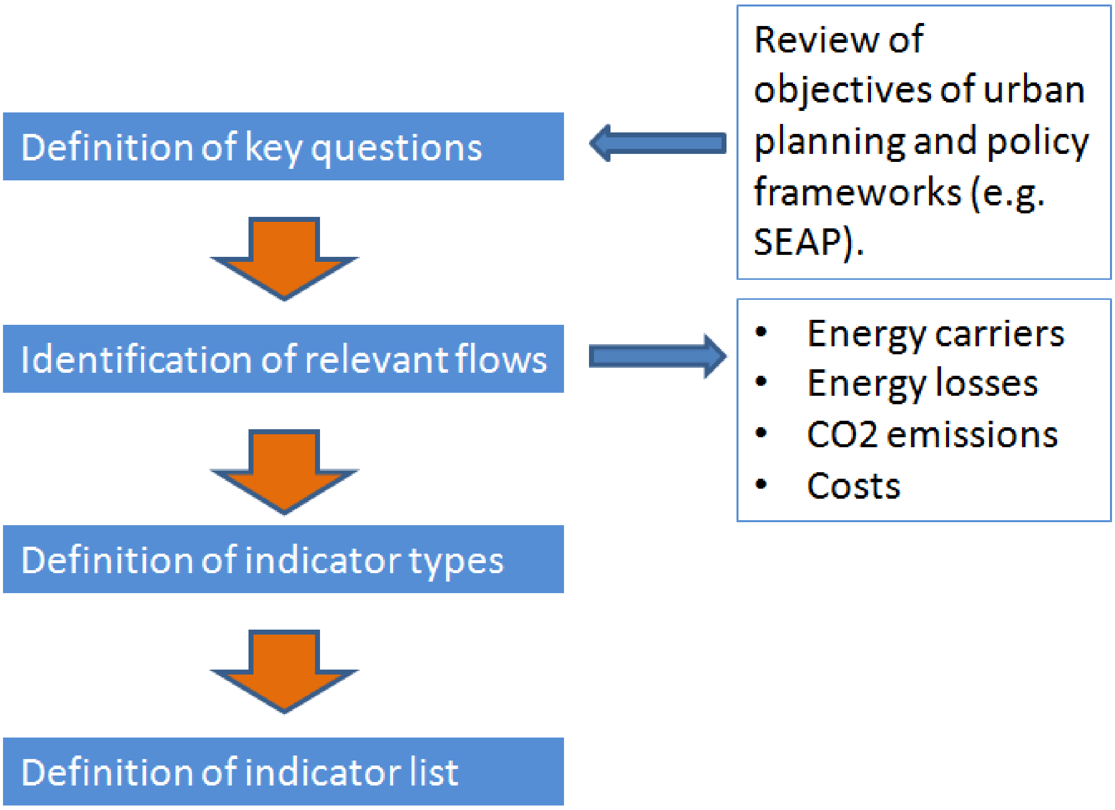

Figure 6. Methodology and process of defining indicators

2.4.2.2.1 Identification of key questions

Whilst keeping the scope defined in Section 2.4.2.1 in view, it is important to put the indicator into a context describing why the indicator is relevant and what targets are to be met. In order to do so, we have identified a set of key questions under each relevant flow category described previously. Hence, the key questions are actually addressing and defining the scope of the analysis, which has to be carried out by SEMANCO using the data and calculation methods provided in order to provide users/actors with certain answers related to energy efficient and low-carbon Urban Planning. A list of the key questions identified so far in the project is given below:

- <u>Demand for energy carriers for final energy uses</u>
  - What is the expected demand for energy carriers and the annual demand for energy carriers spent on specific energy uses?
  - What is the expected electricity demand per person?
  - What is the demand for domestic hot water at building level given a certain heating system?
  - What is the demand for space heating at building level given a certain heating system?
  - What is the demand for electricity for systems (lighting, ventilation, cooling, etc.) and appliances at building level?
  - What are the internal heat gains at building level from the climate conditions, appliances and human activity?

- Which primary heating fuel is being used by households within the target area?

- Energy carriers from renewable energy sources
  - What is the share of energy carriers produced from renewable energy sources?
  - What is the share of electricity produced locally by renewable energy sources?

- Energy carriers produced locally
  - What is the share of energy produced locally by renewable energy sources?

- Energy losses
  - What are the transfer losses at building level due to building fabric, construction type, installations, climate conditions and occupancy?
  - What is the energy efficiency based on type of fuel used for heating and electricity at building level?
  - What are the actual energy losses from the energy distribution networks (district heating, electricity, etc.)?

- CO_2 emissions
  - What is the total CO_2 emission per year in the building or urban area?
  - What is the average CO_2 emission coefficient for electricity expected to be in the city district?
  - What is the average CO_2 emission coefficient for heating expected to be in the city district?
  - What is the average CO_2 emission coefficient for cooling expected to be in the city district?

- Cost of energy supply
  - What are the production costs for the various electricity supply solutions, including local electricity plants?
  - What is the production costs expected for the various relevant heat supply solution, including local heat plants?
  - What is the cost of supply by energy carrier?
  - What are the investments and O&M costs of energy supply systems?
  - What are the investments costs of energy efficiency measures?
  - What is the energy efficiency and the cost of supplying the energy at building level?

- Distribution issues
  - What is the level of deprivation within the neighbourhood area compared with the municipality?
  - What is the level of deprivation at city level compared with other cities or within the country?
  - What is the percentage of fuel poor households at various levels?
  - Which is the percentage of buildings complying with high energy standards?

The answer to the key questions formulated above is directly related to the policy frameworks addressed in D2.1.

2.4.2.2.2 Identification of relevant flows

After identifying and reviewing key strategies for monitoring CO_2 emissions (from D2.1) and receiving inputs from the three case studies and other research projects and urban planning projects, we are able to identify a preliminary set of relevant flows going through the urban area under analysis:

- Flow of energy carriers for final energy uses
- Energy losses
- CO_2 emissions
- Cost of energy supply

2.4.2.2.3 Definition of indicator types

The indicator types identified for the SEMANCO project based on the three case studies and other relevant urban planning projects are given in the list below. The indicators in the list have been grouped according to these different types, which make sense in an urban planning context from an energy efficiency and CO_2 emissions point of view:

- Demand for primary energy sources
- Demand for energy carriers for final energy uses
- Energy distribution losses
- Energy carriers from renewable energy sources
- Renewable energy in the total electricity supply
- Share of local electricity from renewable energy sources
- Share of local energy carriers from renewable energy sources
- CO_2 emissions and reductions compared to the baseline
- Building energy demand
- Cost/Economics
- Fuel poverty

Hence, several indicators may be related to each type for different sub-categories or purposes.

Each indicator is given a unit where applicable (e.g. kWh/year, kWh/m^2, tCO_2e/year, €/year, etc.) and it is also indicated whether it is an Extensive or Intensive indicator (please see a detailed description of Extensive and Intensive indicators and fund-flow categories in Deliverable 2.3 *Impact evaluation*).

See example in Table 1 below:

Table 1.Example of describing indicators for a particular type

Indicator	**Type**	**Unit**	**Extensive/ Intensive**[5]
No.	*Energy demand for final energy uses*		
1	Domestic hot water	kWh/year	Extensive
2	Electric appliances	kWh/year	Extensive
3	Lighting	kWh/year	Extensive
4	Ventilation and humidification	kWh/year	Extensive
5	Space heating	kWh/year	Extensive
6	Cooling and dehumidification	kWh/year	Extensive

2.4.2.2.4 Definition of indicator list

Using the approach of addressing key questions as described in Section 2.4.2.2.1 and linking these to a set of relevant indicators makes it possible to develop a structured list of indicators relevant for the SEMANCO project. The list is introduced and described below and can be found in Appendix A.

Structure of indicator list

The structure of the list is given by the headings of the main columns which are:

- Indicator number
- Indicator type
- Unit
- Extensive/Intensive
- Calculation method
- Input needed
- Key question addressed in a use case
- Benchmark description
- Benchmark score

The purpose and content of each column in the list is explained below.

[5] **Extensive indicators** are those that can be added. They characterize the size of the system and its compartments, in terms of either funds categories (e.g. hours of human activity or hectares of land) or flow categories (e.g. GJ of energy per year or hm3 of water per year). **Intensive indicators** are those that represent a ratio: the pace of the metabolism in terms of flow/fund or fund/fund ratios (e.g. flow of energy carriers per square meter, measured in kWh/m^2). They describe how the system does what it does (please see a detailed description of Extensive and Intensive indicators and fund-flow categories in Deliverable 2.3 *Impact evaluation*).

Calculation methods

Some of the indicators can be further described and quantified according to a specific formula. Hence, a separate column is needed to indicate the calculation methodology behind the indicator as well as a column to indicate what input is needed to carry out the calculations.

See example in Table 2 below:

Table 2.Example of describing calculation method and input needed for indicator

Indicator	**Type**	**Unit**	**Calculation method**	**Extensive/ Intensive**	**Input needed**
No.	*Energy demand for final energy uses*				
1	Domestic hot water	kWh/year	The indicator is calculated from the following formula: kWh/year = total consumption of hot water (L/year) * energy use per litre of hot water (kWh/L)	Extensive	The total annual consumption of hot water and the energy use per litre hot water (kWh/litre)

As suggested earlier certain parameters of an indicator may be specific to the country addressed. Thus, each case study country will have to provide a local methodology/formula to calculate the indicator if this is the case

Input needed

The input needed to calculate or simply to determine the indicators will mainly come from the data and data sources identified first in D2.1 *Report of the case study* (available energy related data sources, scenario description) and further documented in D3.1 *Report on the accessible energy data* (characteristics of the identified data repositories for each scenario, including: domain, data structure, technical accessibility and availability considering privacy and intellectual property rights).

Key questions in a use case

As described in Section 2.4.2.2.1 the key questions in a use case is the main driver in compiling the list of indicators. However, since we are using a bottom-up approach and the fact that several indicators in the list can be linked to the same key question, this column appears to the right of the columns described above (see the full structure of the list in Appendix A).

An example of how indicators are linked to a key question is given below:

Table 3.Example of linking indicator with key question addressed in a use case

Indicator	Type	Unit	Extensive/Intensive	Calculation method	Input needed	Key question addressed in a use case
No.	*Renewable energy in the total electricity supply*					
29	Electricity from hydro-power	MWh/year	Extensive	The indicator is calculated from the following formula: MWh/year = total supply of electricity * share of energy type in the supply	The total supply of electricity is needed along with the share of hydro-power in the total electricity supply	What is the share of renewables in the total electricity supply?
30	Electricity from wind power	MWh/year	Extensive		The total supply of electricity is needed along with the share of wind power in the total electricity supply	
31	Electricity from PV	MWh/year	Extensive		The total supply of electricity is needed along with the share of PV in the total electricity supply	
32	Electricity from bio energy	MWh/year	Extensive		The total supply of electricity is needed along with the share of bio energy power in the total electricity supply	

2.4.2.2.5 Benchmark framework

The targets or vision driving the carbon reduction policy of a given urban area or region should preferably be expressed in terms of specific benchmarks of selected indicators. For example, the target of a 20% reduction in CO_2 emissions by year 2020 could be transformed into a benchmark of *x* tonnes of CO_2 emissions per year. If relevant, this benchmark could be disaggregated into specific benchmarks for CO_2 emissions in particular sectors, for CO_2 emission intensities in new residential buildings, etc. The choice of indicators to benchmark as well as the benchmark value should be guided by the purpose of the urban planning process, and it should reflect the level of ambition as well as the local constraints. For example, the North Harbour project worked with an ambition of developing a CO_2 neutral district. This follows the ambition of the Municipality of Copenhagen to become CO_2 neutral by 2025, and it is a realistic target considering the local conditions, including existing infrastructure, renewable energy potential available, etc. Similar benchmarks would not be relevant in the two other SEMANCO case studies.

The benchmark framework should be defined in the context of local ambitions and priorities and/or relative to the European policy framework as described in T2.1

There could be other analysis or scenarios for monitoring the developments defined by the user than the ones indicated above.

When setting the benchmarks, the planner may seek inspiration from several sources:

- National building energy performance regulation of existing and new buildings
- National targets of renewable energy, energy efficiency etc.
- Benchmark values developed by other cities, such as signatories to the Covenant of Mayors
- Known best-practice values

Indicators may develop over time and therefore also have a time dimension to be considered. For instance this will be reflected when calculating the indicator related to the CO_2 emission for a Municipality, which has committed itself to the Covenant of Mayors when reporting on the progress every second year. Hence, all indicators for parameters that may be related to the reduction of CO_2 emissions, e.g. the share of renewable energy in the total energy supply, implementation of energy efficiency measures will change over time.

As suggested in Section 1.3 the energy model developed in WP4 should be able to make the necessary calculations of indicators over time and the tools developed in WP5 should be able to illustrate the developments through graphs, etc.

Ideally, it should be possible to set up common benchmark definitions or descriptions for the case studies (e.g. Manresa, Newcastle and North Harbour) and score different demonstration scenarios within the case studies according to this benchmark description. However, in reality it may be difficult to do so because the scope of each case study is very different and the ambition levels in relation to reduced energy consumption, diffusion of renewable energy technologies and CO_2 reduction targets may be different. Also the availability of national data to calculate indicators according to the set benchmarks may be different from case to case.

Nevertheless, for this project we propose the following guidelines for the definition of benchmark values.

For energy simulations at neighbourhood, municipal and regional level

<u>Energy demand for final energy uses</u>

Average final energy consumption for appliances and systems according to national statistics could be used to set the benchmark. However, new appliances and systems for new and existing buildings should have the energy label A, A+ and A++ or simply be Best Available Technology (BAT).

<u>Demand for different energy carriers</u>

Average demand for different energy carriers per households and other type of buildings (offices, hotels, etc.) at national or regional level could be used to set the benchmark. New and renovated buildings applying strict energy standards should have a lower demand for energy carriers.

Energy distribution losses

It would be preferred if the energy losses from the distribution networks are as low as possible and thus improve the energy efficiency of the entire energy system. Energy losses below 10% from district heating and cooling networks can be considered an adequate benchmark. Energy losses below 5% from the electricity grid can also be considered as an expected value.

Energy carriers from renewable energy

Several EU Directives, policies, strategies and voluntary schemes (e.g. Renewable Energy Directive, Roadmap for Moving to a Competitive Low-Carbon Economy in 2050, Covenant of Mayors, etc.) are pushing towards a greater share of RE in the national and European energy supply systems. Benchmark values could address these Policy Frameworks (see description of Policy Frameworks in D 2.1).

Renewable energy in the total electricity supply

EU Directives such as the Renewable Energy Directive (and before this the Renewable Electricity Directive) are pushing towards more RE in the total electricity supply. But also the Energy Efficiency Directive has the aim of reducing total primary energy supply and hence increasing the share of RE in the total energy supply. Benchmark values could address these Policy Frameworks (see description of Policy Frameworks in D 2.1).

Share of local electricity carriers from renewable energy sources (RES)

Share of RES produced locally to supply cities with sustainable energy in order to make the cities CO_2-neutral or simply CO_2 friendly is getting more and more attention in the Master Plans for the cities. It is, however, not always cost effective to produce all the RES locally and it may be better to import RES to reach CO_2 targets. Benchmark values could address the optimal trade of between local and imported RES.

Share of local energy carriers from renewable energy sources (RES)

Share of RES produced locally to supply cities with sustainable energy in order to make the city CO_2 neutral or CO_2 friendly is getting more and more attention in the Master Plans for the cities. It is however not always cost effective to produce all the RES locally and it may be better to import RES to reach CO_2 targets. Benchmark values could address the optimal trade of between local and imported RES.

Total CO_2 emissions from the city district

It would be preferred if the annual CO_2 emissions from the city district was as low as possible.

CO_2 emissions from per square metre city district

It would be preferred if the CO_2 emissions per square metre from the city district was as low as possible.

CO_2 emissions from the electricity supply

The benchmark value for the CO_2 factor for electricity is determined through the choice of instruments (energy efficiency, renewable energy, etc.) that can contribute to the realisation of the target. The CO_2 factor should be documented through scenario analyses, welfare economics, corporate economics, etc.

CO_2 emissions from the heat supply

The benchmark value for the CO_2 factor for heat supply is determined through the choice of instruments (energy efficiency, renewable energy, etc.), which may contribute to the realisation of the target. The CO_2 factor should be documented through scenario analyses, welfare economics, corporate economics, etc.

Index of multiple deprivations (IMD) at neighbourhood level

As IMD is calculated each year, there will be a baseline for IMD before and after regeneration at neighbourhood level.

Index of multiple deprivations (IMD) at city level

As IMD is calculated each year, there will be a baseline for IMD before and after regeneration at city wide level.

Number and Percentage of Households in Fuel Poverty

Fuel Poverty data is available for previous years. Historical fuel poverty figures can be used as a baseline.

For Energy simulations at building level

Energy standards for buildings

Choice of energy standards for new buildings is based on welfare economic calculations, social aspects, building plan aspects and expectations to technology development.

Electricity consumption for households

Average electricity demand per person in households at national or regional level could be used to set the benchmark value.

Energy consumption for commercial buildings

Average energy demand for commercial buildings at national or regional level could be used to set the benchmark value.

Energy demand for domestic hot water

Average energy demand for domestic hot water at national or regional level could be used to set the benchmark value.

Energy demand for space heating

Average energy demand for space heating at national or regional level could be used to set the benchmark value.

Energy demand for electrical systems and appliances

Average energy demand for electrical systems and appliances at national or regional level could be used to set the benchmark value.

2.4.2.2.6 Total list of indicators

The previous Sections give an idea of how the list of indicators has been developed. At present the list includes a total of 62 indicators and is to be considered as work in progress, meaning that if other relevant indicators are identified during the project development, they will be included in the list (it may also be that indicators are omitted if they are no longer considered to be relevant).

The indicators have been listed below in order to give an overview over the type of indicators that have been included (see all information related to indicators in Appendix A).

Energy demand for final energy uses

1. Domestic hot water (kWh/year)

2. Electric appliances (kWh/year)
3. Lighting (kWh/year)
4. Ventilation and humidification (kWh/year)
5. Space heating (kWh/year)
6. Cooling and dehumidification (kWh/year)
7. Domestic hot water (kWh/m^2/year)
8. Electric appliances (kWh/m^2/year)
9. Lighting (kWh/m^2/year)
10. Ventilation and humidification (kWh/m^2/year)
11. Space heating (kWh/m^2/year)
12. Cooling and dehumidification (kWh/m^2/year)

Demand for different energy carriers

13. Electricity (kWh/year)
14. Diesel (kWh/year)
15. Gasoline (kWh/year)
16. Natural gas (kWh/year)
17. Heat (kWh/year)
18. LPG (kWh/year)
19. Electricity (kWh/m^2/year)
20. Diesel (kWh/m^2/year)
21. Gasoline (kWh/m^2/year)
22. Natural gas (kWh/m^2/year)
23. Heat (kWh/m^2/year)
24. LPG (kWh/m^2/year)

Energy distribution losses

25. Distribution losses from the district heating grid (%)
26. Transmission and distribution losses from the electricity grid (%)

Energy carriers from renewable energy sources

27. Share of electricity from RES (%)
28. Share of heat from RES (%)

Renewable energy in the total electricity supply

29. Electricity from hydro-power (MWh/year)
30. Electricity from wind power (MWh/year)
31. Electricity from PV (MWh/year)
32. Electricity from bio energy (MWh/year)

Share of local electricity carriers from renewable energy sources

33. Share of electricity produced locally (%)

Share of local energy carriers from renewable energy sources

34. Share of local energy carriers from RE sources (%)

CO_2 emissions and reduction compared to baseline

35. Total CO_2 emissions from the city district (tCO_2e/year)
36. Total CO_2 savings (%)
37. CO_2 emissions per square metre city district (tCO_2e/m^2/year)[6]
38. CO_2 savings per square metre (%)
39. CO_2 emissions from the electricity supply (tCO_2e/MWh)
40. CO_2 emissions from the heat supply (gCO_2/MJ)

Energy simulations in buildings

41. Energy standards for buildings (-)
42. Electricity demand for households (kWh/person/year)
43. Energy demand for commercial buildings (kWh/m^2/year)
44. Energy demand for domestic hot water (joules or kWh per year)
45. Energy demand for space heating (joules or kWh per year)
46. Energy demand for electrical systems and appliances (joules or kWh per year)
47. Heat gains (joules or kWh per year)
48. Heat transfers (joules or kWh per year)
49. CO_2 emissions (kg per year)
50. National rating (-)
51. Environmental Impact index (-)

Cost/Economics

52. Electricity cost (€/kWh)
53. Cost of heat supply (€/MJ)
54. Cost of energy supply by final energy use (€/year)
55. Investment costs (€)
56. Local economic effects depending of the chosen energy supply system (-)
57. Socio-economic effects depending of the chosen energy supply system (-)
58. CO_2 emissions in relation to the financial growth (tCO_2e/GDP in €)

Fuel Poverty

59. Index of multiple deprivation at neighbourhood level (n)
60. Index of multiple deprivation at city level (n)
61. Percentage of population with access to energy services – final energy use (%)
62. Number and Percentage of Households in Fuel Poverty (n/%)

[6] CO_2 emissions per m2 gross floor area in the city district

3 Conclusions

3.1 Contribution to the overall picture

To document the impact of interventions for energy efficient, low-carbon urban development it is necessary to have strategies for monitoring the progress. A strategy should include the relevant indicators, a baseline and a reduction target, as well as an implementation plan and a management plan. The management plan should include clear responsibilities for monitoring carbon reduction and acting upon the results.

The choice of indicators in the SEMANCO project is based on the use of fund and flow categories and the MuSIASEM approach. The focus of these indicators is on carbon emissions, use of energy carriers, primary energy and costs. The effects of carbon emissions are implicitly given. Therefore there is no need for indicators to measure the final impacts on the environment and the economy of carbon emissions or primary energy usage.

To address the actual goals or strategies related to indicators it is necessary to identify or develop benchmarks for indicators. Benchmarks need to reflect the goals set and should therefore be designed on a case by case basis.

This deliverable provides guidelines for data analysis, the identification of benchmarks for different indicators and desired targets and strategies to be achieved considering the policy frameworks and needs of users/actors.

The work presented in this deliverable frames the development of the energy model in WP4 and the tools of WP5.

3.2 Impact on other WPs and Tasks

The work carried out in Task 2.2 provides input for the energy model developed in WP4 and the tools developed in WP5. T6.2 will build on the findings of T2.2. This work will be reported in D6.2[7] to be submitted in month 24 of the project period.

3.3 Contribution to demonstration

The indicators identified in this report will be used to monitor and verify the impacts on CO_2 emissions in the implementation of the use cases in the demonstration scenarios conducted WP8.

3.4 Other conclusions and lessons learned

In the process of writing D2.2 is has been necessary to discuss the different project components and especially align the different tasks (T2.2, T2.3, T3.1 and T.8.1) to create a common understanding of the work to be carried out and to establish the interface between D2.2 and other tasks and work packages.

Also it was necessary to see how D2.2 could provide input to the use cases by addressing a set of key questions making suggestions as to which use cases they will be relevant to.

[7] D6.2 *Report on key parameters* (DoW): “This report will situate the stakeholder requirements presented in D6.1 within a wider context. To do so, it will compare them, to an analysis of current urban development projects within the EU with regards to the relative importance as well as political emphasis on the parameters determining the carbon foot print.”

4 REFERENCES

Allen Hammond, Albert Adriaanse, Eric Rodenburg, Dirk Bryant and Richard Woodward (1995). Environmental Indicators: A Systematic Approach to Measuring and Reporting on Environmental Policy Performance in the Context of Sustainable Development (pp. 11-12). World Resource Institute.

European Commission (EC). 2010. How to develop a Sustainable Energy Action Plan (SEAP) – Guidebook - Part 1. Covenant of Mayors. European Commission.

Eurostat, 2011. Measuring progress towards a more sustainable Europe. 2011 monitoring report of the EU sustainable development strategy. European Comission. Luxembourg

Gallopín, G., 1997. Indicators and Their Use: Information for Decision-making. In: Moldan, B. & Billharz, S. (Eds) Sustainability Indicators. Report of the project on Indicators of Sustainable Development. Scope 58.

Georgescu-Roegen, N., 1971. The Entropy Law and the Economic Process. Harvard University Press, Cambridge, MA

Giampietro, M., 2010. Integrated Assessment of Agricultural Sustainability: the Pros and Cons of Reductionism. Reports on Environmental Sciences. Institut de Ciència i Tecnologia Ambientales - Universitat Autònoma de Barcelona. Available at: http://www.recercat.net/bitstream/2072/96137/1/RepEnvSci_2010-01.pdf

Giampietro, M., Mayumi, K., Ramos-Martin, J., 2009. Multi-scale integrated analysis of societal and ecosystem metabolism (MuSIASEM): Theoretical concepts and basic rationale. *Energy* 34, 313–322

Hammond, A., Adriaanse, A., Rodenburg, E., Bryant, D., Woodward, R., 1995. Environmental Indicators: A Systematic Approach to Measuring and Reporting on Environmental Policy Performance in the Context of Sustainable Development. World Resources Institute. Available at: http://pdf.wri.org/environmentalindicators_bw.pdf. Accessed: 30-09-2012.

HEFCE, 2010, Carbon management strategies and plans, a guide to good practice.

Loveridge D., 2002. The STEEPV acronym and process - a clarification. Ideas in Progress 29. Policy Research in Engineering, Science and Technology. The University of Manchester. Mayumi, K., Giampietro, M., 2006. The epistemological challenge of self-modifying systems: Governance and sustainability in the post-normal science era. Ecological Economics 57(3), pp. 382-399.

Moldan, B. And Billharz, S., editors (1998) Sustainability indicators - Report of the project on Indicators of Sustainable Development. Sussex: John Wiley & Sons.Munda G., 2004. Social Multi-Criteria Evaluation (SMCE): Methodological foundations and operational consequences. Eur. J. Oper. Res. 158(3), 662–677.

Munda, G, 2005. Multiple criteria decision analysis and sustainable development. In: Figueira, J., Greco, S., Ehrogott, M. (Eds). Multiple Criteria Decision Analysis: State of the Art Surveys. International Series in Operations Research & Management Science. Vol. 78 pp.: 953-986.

Mayumi, K; Giampietro, M (2006). The epistemological challenge of self-modifying systems: Governance and sustainability in the post-normal science era. Ecological Economics. Vol. 57(3), pp.: 382-399

OECD, 1991. Environmental Indicators, a Preliminary Set. OECD, Paris.

OECD, 1993. Organisation for Economic Co-operation and Development (OECD) core set of indicators for environmental performance reviews. OECD Environment Monographs No. 83, Paris. Available at: http://www.oecd.org/dataoecd/32/20/31558547.pdf. (Access: 16/09/2012)

OECD, 2001. Environmental Indicators: Towards Sustainable Development. Organization for Economic Co-operation and Development. Environment. Available at: http://www.oecd.org/site/worldforum/33703867.pdf (Access: 16/09/2012)

Rapport D., Friend A., 1979. Towards a Comprehensive Framework for Environmental Statistics: a Stress–response Approach. Statistics Canada Catalogue 11-510. Minister of Supply and Services Canada, Ottawa.

Svarstad H., Petersenb L. K., Rothmanc D., Siepeld H., Watzold F., 2008. Discursive biases of the environmental research framework DPSIR, Land Use Policy 25: 116–125.

United Nations, 1996. Indicators of sustainable development. Division for Sustainable Development.

United Nations, 1999. Work Programme on Indicators of Sustainable Development of the Commission on Sustainable Development. Division for Sustainable Development, Department of Economic and Social Affairs, New York.

United Nations, 2001. Indicators of sustainable development: framework and methodologies. Background Paper No. 3, Commission on Sustainable Development, Division for Sustainable evelopment, Department of Economic and Social Affairs, New York.

United Nations Commission on sustainable Development – UN-CDS, 1999. Indicators of Sustainable Development: Guidelines and Methodologies. Commission on Sustainable Development, United Nations.

Vinnari M., 2007, The future of meat consumption — Expert views from Finland, Technological Forecasting & Social Change 75(6), pp. 893-904.

Virginia Sonntag-O'Brien (2000) Strategic framework for quantifying, monitoring, evaluating, and reporting local greenhouse gas emissions reductions. *Workshop on Best Practices in Policies and Measures, 11-13 April 2000, Copenhagen. The International Council for Local Environmental Initiatives (ICLEI).*

5 APPENDICES

APPENDIX A. List of indicators

Table A1. List of indicators incl. descriptive parameters, calculation methods, data input needed, key questions addressed and benchmark descriptions

Indicator	**Type**	**Unit**	**Calculation method**	**Extensive/Intensive**	**Input needed**	**Key question addressed in use cases**	**Benchmark description**
No.	***Energy demand for final energy uses***	***Unit***	***Calculation method***	***Extensive/Intensive***	***Input needed***	***Key question addressed in use cases***	***Benchmark description***
1	Domestic hot water	kWh/year	The indicator is calculated from the following formula: kWh/year = total consumption of hot water (L/year) * energy use per litre of hot water (kWh/L)	Extensive	The total annual consumption of hot water and the energy use per litre hot water (kWh/litre) is needed to find this indicator.	What is the expected final energy use of a scenario and the energy spent on different uses in kWh/year?	Average final energy consumption for appliances and systems according to national statistics could be used to set the benchmark. However, new appliances and systems for new and existing buildings should have the energy label A, A+ or A++ or simply be Best Available Technology (BAT).
2	Electric appliances	kWh/year	The indicator is calculated from the following formula: kWh/year = total numbers of electric appliances * average energy use per electric appliance per year. It may be possible to perform a more detailed calculation for instance by defining a set of electric appliances according to socio-economic characteristics.	Extensive	An average number of electric appliances per household, the number of household, and the average use of energy per electric appliance are needed to find this indicator.		
3	Lighting	kWh/year	The indicator is calculated from the following formula:	Extensive	The consumption of energy spend on		

Indicator	Type	Unit	Calculation method	Extensive/Intensive	Input needed	Key question addressed in use cases	Benchmark description
			kWh/year = kWh/m^2*total number of m2 (differentiating between households and office buildings)		lighting per m^2 along with the number of square metres is needed to find this indicator.		
4	Ventilation and humidification	kWh/year		Extensive	The consumption of energy spend on ventilation per m^2 along with the number of square metres is needed to find this indicator.		
5	Space heating	kWh/year		Extensive	The total annual consumption of energy spend on heating per m^2 for households and office buildings is needed to find this indicator along with the number of m^2 in households and office buildings in the scenario.		
6	Cooling and dehumidification	kWh/year		Extensive	The total annual consumption of energy spend on cooling per m^2 for households and office buildings is needed to find this indicator along with the number of m^2 in households and office buildings in the scenario.		
7	Domestic hot water	kWh/m^2/year	The indicator is calculated from the following formula: kWh/m^2 = total consumption of kWh /	Intensive	The annual consumption of hot water per square metre	What is the expected final energy use of a	Average final energy consumption for appliances and systems

Indicator	**Type**	**Unit**	**Calculation method**	**Extensive/Intensive**	**Input needed**	**Key question addressed in use cases**	**Benchmark description**
			total number of m² (differentiating between households and office buildings)		and the energy use per litre hot water (kWh/litre) is needed to find this indicator.	scenario and the energy spent on different energy uses in kWh per square metre?	according to national statistics could be used to set the benchmark. However, new appliances and systems for new and existing buildings should have the energy label A, A+ and A++ or simply be Best Available Technology (BAT).
8	Electric appliances	kWh/m²/year		Intensive	The total annual consumption of energy per m² spend on electric appliances is needed to find this indicator.		
9	Lighting	kWh/m²/year		Intensive	The total annual consumption of energy per m² spend on lighting is needed to find this indicator.		
10	Ventilation and humidification	kWh/m²/year		Intensive	The total annual consumption of energy per m² spend on ventilation is needed to find this indicator.		
11	Space heating	kWh/m²/year		Intensive	The total annual consumption of energy per m² spend on heating is needed to find this indicator.		
12	Cooling and dehumidification	kWh/m²/year		Intensive	The total annual consumption of energy per m² spend on cooling is needed to find this indicator.		
No.	***Demand for different energy carriers***	***Unit***	***Calculation method***		***Input needed***	***Key question addressed in use cases***	***Benchmark description***

Indicator	Type	Unit	Calculation method	Extensive/Intensive	Input needed	Key question addressed in use cases	Benchmark description
13	Electricity	kWh/year	The indicator is calculated from the following formula: kWh/year = total supply of energy type * share of energy type in the total energy supply	Extensive	Total annual consumption in kWh per energy form	What is the demand for different energy carriers in kWh/year?	Average demand for different energy carriers per households and other type of buildings (offices, hotels, etc.) at national or regional level could be used to set the benchmark. New and renovated buildings applying strict energy standards should have a lower demand for energy carriers.
14	Diesel	kWh/year		Extensive			
15	Gasoline	kWh/year		Extensive			
16	Natural gas	kWh/year		Extensive			
17	Heat	kWh/year		Extensive			
18	LPG	kWh/year		Extensive			
19	Electricity	kWh/m^2/year	The indicator is calculated from the following formula: kWh/m^2= total consumption of kWh / total number of m^2 (differentiating between households and office buildings)	Intensive	The total annual consumption of energy per m^2	What is the demand for different energy carriers in kWh/m^2?	Average demand for different energy carriers per households and other type of buildings (offices, hotels, etc.) at national or regional level could be used to set the benchmark. New and renovated buildings applying strict energy standards should have a lower demand for energy carriers.
20	Diesel	kWh/m^2/year		Intensive			
21	Gasoline	kWh/m^2/year		Intensive			
22	Natural gas	kWh/m^2/year		Intensive			
23	Heat	kWh/m^2/year		Intensive			
24	LPG	kWh/m^2/year		Intensive			
No.	***Energy distribution losses***	***Unit***	***Calculation method***		***Input needed***	***Key question addressed in use cases***	***Benchmark description***

Indicator	Type	Unit	Calculation method	Extensive/Intensive	Input needed	Key question addressed in use cases	Benchmark description
25	Distribution losses from the district heating grid	%	This indicator is calculated by comparing heat produced from the plant with the heat sold to the consumer	-	Total heat produced at the plant and heat sold to consumers. The local plant owner may be able to provide the figure in percentage.	What are the actual energy losses from the energy distribution nets (district heating, electricity, etc.)?	It would be preferred if the energy losses from the distribution networks are as low as possible and thereby improving the energy efficiency of the entire energy system.
26	Transmission and distribution losses from the electricity grid	%	This indicator is calculated by comparing electricity produced from the plant with the electricity sold to the consumer	-	Total electricity produced at the plant and electricity sold to consumers. These figures may often be obtained from the national electricity transmission company in the respective countries.		
No.	***Energy carriers from renewable energy sources***	***Unit***	***Calculation method***		***Input needed***	***Key question addressed in use cases***	***Benchmark description***
27	Share of electricity from RES	%	To calculating this indicator the following formula must be applied: Total renewable energy production divided by the total energy production	-	Production of renewable energy in the city district (kWh), production of other forms of energy (kWh) in the city district and the amount and share of renewable energy in the energy supply from outside the city district.	What is the share of renewable energy in the energy supply?	Several EU Directives, policies, strategies and voluntary schemes (e.g. Renewable Energy Directive, Roadmap for Moving to a Competitive Low-Carbon Economy in 2050, Covenant of Mayors etc) are pushing towards a greater share of RE in the national and
28	Share of heat from RES	%		-			

Indicator	Type	Unit	Calculation method	Extensive/Intensive	Input needed	Key question addressed in use cases	Benchmark description
							European energy supply systems (also see memo on Policy Frameworks submitted as input for D 2.1).
No.	***Renewable energy in the total electricity supply***	***Unit***	***Calculation method***		***Input needed***	***Key question addressed in use cases***	***Benchmark description***
29	Electricity from hydro-power	MWh/year	The indicator is calculated from the following formula: MWh/year = total supply of electricity * share of energy type in the supply	Extensive	The total supply of electricity is needed along with the share of hydro-power in the total electricity supply	What is the share of renewables in the total electricity supply?	EU Directives such as the Renewable Energy Directive (and before this the Renewable Electricity Directive) are pushing more RE in the total electricity supply. But also the Energy Efficiency Directive has the aim of reducing total primary energy supply and hence increasing the share of RE in the total energy supply.
30	Electricity from wind power	MWh/year		Extensive	The total supply of electricity is needed along with the share of wind power in the total electricity supply		
31	Electricity from PV	MWh/year		Extensive	The total supply of electricity is needed along with the share of PV in the total electricity supply		
32	Electricity from bio energy	MWh/year		Extensive	The total supply of electricity is needed along with the share of bio energy power in the total electricity supply		
No.	***Share of local electricity carriers***	***Unit***	***Calculation method***		***Input needed***	***Key question addressed in use***	***Benchmark description***

Indicator	**Type**	**Unit**	**Calculation method**	**Extensive/Intensive**	**Input needed**	**Key question addressed in use cases**	**Benchmark description**
	from renewable energy sources					***cases***	
33	Share of electricity produced locally	%	The indicator is calculated by dividing the annual production of renewable energy for electricity within the city district with the total annual production of energy for electricity within the city district.	-	Annual production of renewable energy for electricity and the annual production of energy for electricity, all within the city district.	What is the share of electricity produced locally by renewable energy sources?	Share of RE produced locally to supply cities with sustainable energy in order to make the city CO_2 -neutral or CO_2 -friendly is getting more and more attention in the Master Plans for the cities. It is however not always cost effective to produce all the RE locally and it may be better to import RE to reach CO_2 -targets. Maximum share of local RE giving the optimal cost effectiveness is preferred.
No.	***Share of local energy carriers from renewable energy sources***	***Unit***	***Calculation method***		***Input needed***	***Key question addressed in use cases***	***Benchmark description***
34	Share of local energy carriers from RE sources	%	The indicator is calculated from dividing the annual production of renewable energy within the city district with the total annual production of energy within the city district.	-	Annual production of renewable energy and the annual production of energy, all within the city district.	What is the share of energy produced locally by renewable energy sources?	Share of RE produced locally to supply cities with sustainable energy in order to make the city CO_2 -neutral or CO_2 -friendly is getting

Indicator	Type	Unit	Calculation method	Extensive/Intensive	Input needed	Key question addressed in use cases	Benchmark description
							more and more attention in the Master Plans for the cities. It is however not always cost effective to produce all the RE locally and it may be better to import RE to reach CO_2 -targets. Maximum share of local RE giving the optimal cost effectiveness is preferred.
No.	***CO_2 emissions and reduction compared to baseline***	***Unit***	***Calculation method***		***Input needed***	***Key question addressed in use cases***	***Benchmark description***
35	Total CO_2 emissions from the city district	tCO_2e/year	This indicator is calculated by adding CO_2e emissions from the city district within all sectors	Extensive	Emission factor and consumption for each type of energy consumed in the city district.	What are the total CO_2 emissions per year in the city district and what is the development compared to the baseline?	It would be preferred if the annual CO_2 emissions from the city district was as low as possible.
36	Total CO_2 savings	%	Emission savings per year with respect to a baseline.	-	The current CO_2 emissions per year and the baseline is relevant input for calculating this indicator		
37	CO_2 emissions from per square metre city district	tCO_2e/m^2/year	This indicator is calculated by finding the CO_2e emissions factor from electricity and heat supply and multiplying those with the consumption per m^2	Intensive	Emission factor and consumption for each type of energy per m2.	What are the total CO_2 emissions per square metre in the city district and what is the development compared to the	It would be preferred if the CO_2 emissions per square metre from the city district was as low as possible.
38	CO_2 savings per square metre	%	Emission savings per m^2 with respect to a baseline.	-	The current CO_2 emissions per m^2 and		

Indicator	Type	Unit	Calculation method	Extensive/Intensive	Input needed	Key question addressed in use cases	Benchmark description
					the baseline is relevant input for calculating this indicator	baseline?	
39	CO_2 emissions from the electricity supply	tCO_2e/MWh	The indicator is calculated using the values from the following formula: Average CO_2e-factor for electricity (gCO_2e/kWh) = (Electricity consumption in city district (kWh) * CO_2e-factor electricity-grid (gCO_2e/kWh) + Electricity production in city district (kWh)* CO_2 -factor city electricity (gCO_2e/kWh))/ (Electricity consumption in city district (kWh) + Electricity production in city district (kWh))	Intensive	Input needed is CO_2e-factors for electricity produced, the total electricity produced and total electricity consumed, all within the city district, along with CO_2 e-factors for electricity produced outside the city district.	What is the average CO_2 emission coefficient for electricity expected to be in the city district?	A target for reduction of GHGs for the city district as a geographic area is established. The benchmark value for the CO_2 factor for electricity is determined through the choice of instruments (energy efficiency, renewable energies.) that can contribute to the realisation of the target. The CO_2 factor will be documented through scenario analyses, welfare economics, corporate economics etc.
40	CO_2 emissions from the heat supply	g CO_2/MJ	The indicator is calculated using the values from the following formular: average CO_2 -factor for heat (gCO_2e/GJ) = (heat supply from grid (GJ) * CO_2 -factor heat-grid (gCO_2e/kWh) + Heat production in city district (GJ)* CO2 factor city heating (gCO_2e/GJ))/ (heat supply from grid (GJ) + Heat production in city district (GJ))	Intensive	Input needed is CO_2 emission-factors for heat produced, the total heat produced and total heat consumed, all within the city district, along with CO2emission-factors for heat produced outside the city district.	What is the average CO_2 emission coefficient for heating expected to be in the city district?	A target for reduction of GHGs for the city district as a geographic area is established. The benchmark value for the CO_2 factor for heat supply is determined through the choice of instruments (energy efficiency, renewable energy etc.) that can contribute to the realirealisation of

Indicator	Type	Unit	Calculation method	Extensive/Intensive	Input needed	Key question addressed in use cases	Benchmark description
							the target. The CO_2 factor will be documented through scenario analyses, welfare economics, corporate economics etc.
No.	***Energy simulations in buildings***	***Unit***	***Calculation method***		***Input needed***	***Key question addressed in use cases?***	***Benchmark description***
41	Energy standards for buildings	-	Energy standards for the specific country/ region. Zero-emissions standards, plus energy standards, etc.	-	Information about building type, square metre and building energy consumption	Which energy standards do new buildings have to comply with in the city district?	Choice of energy standard for new buildings is based on welfare economic calculations, social aspects, building plan aspects and expectations to technology development.
42	Electricity demand for households	kWh/person/year	Demands of electricity consumption per person in households for systems (ventilation, lighting etc.) and appliances (it-equipment, kitchen appliances etc.). Consumption is documented through scenario calculations	Intensive	Total building electricity consumption and number of persons occupied by building	What is the expected electricity consumption per person?	Average electricity demand per son in households at national or regional level could be used to set the benchmark value. New and renovated buildings applying strict energy standards should have a lower demand for electricity.
43	Energy demand for commercial buildings	kWh/m^2/year	Demand for specific energy consumption per square metre in commercial buildings for	Intensive	Total building energy consumption and square metres	To what degree has energy efficient solutions	Average energy demand for commercial buildings

Indicator	Type	Unit	Calculation method	Extensive/Intensive	Input needed	Key question addressed in use cases	Benchmark description
			heating, electricity and cooling. Consumption is documented through scenario calculations.			been implemented in commercial buildings, so the specific energy consumption for heating and electricity for e.g. lighting, ventilation and cooling is the lowest possible?	at national or regional level could be used to set the benchmark value. New and renovated buildings applying strict energy standards should have a lower demand for energy.
44	Energy demand for domestic hot water	Joules or kWh per year	The total demand for domestic hot water in litres using the National calculation methodology	Extensive	Type and details of heating system, controls, solar panels (if any)	What is the demand for domestic hot water at building level given a certain heating system?	Average energy demand for domestic hot water at national or regional level could be used to set the benchmark value. New and renovated buildings applying strict energy standards should have a lower demand for energy.
45	Energy demand for space heating	Joules or kWh per year	Total heat demand for heating of rooms in a dwelling using the National calculation methodology	Extensive	Type and details of heating system, controls, fabric, demand and internal temperatures, heat transfer coefficients, internal gains and heat losses	What is the demand for space heating at building level given a certain heating system?	Average energy demand for space heating at national or regional level could be used to set the benchmark value. New and renovated buildings applying

Indicator	Type	Unit	Calculation method	Extensive/Intensive	Input needed	Key question addressed in use cases	Benchmark description
							strict energy standards should have a lower demand for energy.
46	Energy demand for electrical systems and appliances	Joules or kWh per year	Total demand for electricity for lights and appliances using the National calculation methodology	Extensive	Type and details of lighting used, percentage low energy lights, types and level of use of electrical appliances	What is the demand for electricity for lights and appliances at building level?	Average energy demand for electrical systems and appliances at national or regional level could be used to set the benchmark value. However, new appliances and systems for new and existing buildings should have the energy label A, A+ og A++ or simply be Best Available Technology (BAT).
47	Heat Gains	Joules or kWh per year	Gains from solar, water heating, lights, appliances, cooking and metabolism using the National calculation methodology	Extensive	Type and details on the building fabric including walls, floors, windows and doors, occupancy and usage level of appliances and shading and sheltering levels	What are the internal heat gains at building level from the climate conditions, appliances and human activity?	N/A
48	Heat Transfers	Joules or kWh per year	Heat loss due to building fabric, construction type, ventilation, wind, occupancy and interzonal? temperature difference using the National calculation methodology	Extensive	Types and details of chimneys, flies, vents, mechanical ventilation and type of water storage and its insulation (if any)	What are the heat losses at building level due to building fabric, construction type, installations, climate conditions and occupancy?	N/A

Indicator	**Type**	**Unit**	**Calculation method**	**Extensive/Intensive**	**Input needed**	**Key question addressed in use cases**	**Benchmark description**
49	CO_2 emissions	Kg per year	Amount of CO_2 released corresponding to the amount of fuel and type of fuel used using the National calculation methodology.	Extensive	Type of fuel used and amount of energy consumed in kWh. Using empirical relations, the carbon emissions can be estimated	What are the CO_2 emissions at building level?	N/A
50	National rating (e.g. SAP)	-	National Calculation Method	-	Input parameters from National Calculation Model (e.g. SAP)	What is the energy efficiency and the cost of supplying the energy?	N/A
51	Environmental Impact Index (e.g. SAP)	-	National Calculation Method	-	Input parameters from National Calculation Model (e.g. SAP)	What is the efficiency based on type of fuel used for heating and electricity?	N/A
No.	***Cost/Economics***	***Unit***	***Calculation method***		***Input needed***	***Key question addressed in use cases***	***Benchmark description***
52	Electricity cost	€/kWh	The costs of implementation of electricity supply based on renewable energy (e.g. windmills, biomass plants etc.) is determined in relation to the expected ambition level for CO_2 -targets.The price per kWh for the chosen electricity supply solution is calculated on the basis of the combined investment costs, net present value of the operating costs over a 20 year period, including subsidies in the period in relation to the	Intensive	The total cost of supplying electricity (investments, running costs, profit margin, etc.) and the total amount of electricity produced.	What price per kWh is expected for the electricity supply solution, including locale electricity plants?	N/A

Indicator	Type	Unit	Calculation method	Extensive/Intensive	Input needed	Key question addressed in use cases	Benchmark description
			expected production.				
53	Cost of heat supply	€/MJ	The price per kWh for the chosen heat supply solution is calculated on the basis of the combined investment costs, net present value of the operating costs over a 20 year period, including subsidies in the period in relation to the expected production. Efficient heat supply solutions could be: Conversion from natural gas to district heating. CHP based on biomass Low temperature areas Efficient utilisation of the temperatures in the district heating grid.	Intensive	The total cost of supplying heat (investments, running costs, profit margin, etc.) and the total amount of heat produced from different sources.	What price per kWh is expected for the heat supply solution, including local heat plants?	N/A
54	Cost of energy supply by final energy use	€/year	The indicator is calculated by finding the annual costs of energy supply	Extensive	Annual supply costs	What is the cost of supply by final energy use?	N/A
55	Investment costs	€	The indicator is calculated by finding the investment costs in energy supply and energy efficient systems	Extensive	Investment costs	What are the investment costs?	N/A
56	Local economic effects depending of the chosen energy supply system	-	The must be an overall evaluation of the local economic effects of the chosen energy supply system. Local economic effects are not necessarily negative since the neighbourhoods, municipal or regional stakeholders are	-	The value of the local economic positive effects and the value of the negative effects along with a interest rate to calculate the net present value of the investment in the energy supply system	What are the social economic effects of the chosen energy supply system?	N/A

Indicator	Type	Unit	Calculation method	Extensive/Intensive	Input needed	Key question addressed in use cases	Benchmark description
			expected to play the role of framework creators, facilitators or partners. The investments could be provided by private investors and consumers. However, there should be expected increased investment costs for the local stakeholders e.g. in electric cars, information, and subsidies.		over a 20 year period		
57	Social economic effects depending of the chosen energy supply system	-	There must be an estimation of the overall evaluation of the social economic effects of the chosen energy supply system.	-	The value of the socio-economic positive effects and the value of the negative effects along with an interest rate to calculate the net present value of the investments in the energy supply system over a 20 year period		N/A
58	CO_2 emissions in relation to the financial growth	tCO_2e/GDP in €	This indicator is calculated from the development in CO_2 emissions from the city district and compared to the total financial growth in the area.	Intensive	Total CO_2 emissions and financial growth in a neighbourhood, municipal or regional level	How do the CO_2 emissions depend on the financial growth?	N/A
No.	***Fuel Poverty***	***Unit***	***Calculation method***		***Input needed***	***Key question addressed in use cases***	***Benchmark description***
59	Index of multiple deprivation (Neighbourhood level)	n	Income as an indicator is built into the index of multiple deprivations (IMD). The Indices of Deprivation attempt to measure a broad concept of 'multiple deprivation', made	-	Income/ housing/ crime and living environment scores and ranking from the index of multiple deprivation	What is the level of deprivation within the neighbourhood area compared with the	As IMD is calculated each year, we will have a baseline for IMD before and after regeneration, which could be used as

Indicator	Type	Unit	Calculation method	Extensive/Intensive	Input needed	Key question addressed in use cases	Benchmark description
			up of several distinct dimensions, or domains, of deprivation. The data is based on 38 separate indicators across seven domains: Income, Employment, Health and Disability, Education Skills and Training, Barriers to Housing and Other Services, Crime and Living Environment. IMD will enable us to identify the level of deprivation within the neighbourhood area compared with the municipality. Examining each of the indicators in this way will also help us to appreciate which of the multidimensional issues are particular prevalent in the area.			municipality?	benchmark values.
60	Index of multiple deprivation (City Level)	n	Income as an indicator is built into the index of multiple deprivations (IMD). The Indices of Deprivation attempt to measure a broad concept of 'multiple deprivation', made up of several distinct dimensions, or domains, of deprivation. The data is based on 38 separate indicators across seven domains: Income, Employment, Health and Disability, Education Skills and Training, Barriers to Housing and Other Services,	-	Income/ housing/ crime and living environment scores and ranking from the index of multiple deprivation	. What is the level of deprivation within the city area compared with other cities?	As IMD is calculated each year, we will have a baseline for IMD at city wide level, which could be used as benchmark values

Indicator	Type	Unit	Calculation method	Extensive/Intensive	Input needed	Key question addressed in use cases	Benchmark description
			Crime and Living Environment. IMD will enable us to identify the level of deprivation within the city area compared with other cities. Examining each of the indicators in this way will also help us to appreciate which of the multidimensional issues are particular prevalent in the city.				
61	Percentage of population with access to energy services (final energy use)	%	Social housing statistics from YHN accessed to illustrate the proportion of households heated by gas / electricity/ solid fuel / oil.	-	Household stock condition surveys	Which primary heating fuel is being used by households within the target area?	N/A
62	Number and Percentage of Households in Fuel Poverty.	n/%	Number and Percentage of (households) in fuel poverty. The percentage of fuel poor households is available at various levels: Lower Super Output Area, Ward and City Level.	-	DECC Annual Fuel Poverty Statistics	What is the percentage of fuel poor households at various levels?	Fuel Poverty data is available for previous years. We can use historical fuel poverty figures as a baseline, , which could be used as benchmark values.