Nantes | Hamburg | Helsinki

my SMART Life

Deliverable due date: M32 – July 2019

D1.17 TECHNO-ECONOMIC ANALYSIS OF EACH INTERVENTION PER PILOT (FINAL)

Transition of EU cities towards a new concept of Smart Life and Economy

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

Project Acronym	mySMARTLife
Project Title	**Transition of EU cities towards a new concept of Smart Life and Economy**
Project Duration	1st December 2016 – 30th November 2021 (60 Months)
Deliverable	D1.17 Techno-economic analysis of each intervention per pilot (FINAL)
Diss. Level	PU
Status	Working Verified by other WPs ■ **Final version**
Due date	31/07/2019
Work Package	WP1
Lead beneficiary	Tecnalia Research & Innovation
Contributing beneficiary(ies)	TEC, CAR, ESA, HEL, HAM, NAN, NBK
Task description	Task 1.4 is related to evaluating impacts in lighthouse (NAN, HAM, HEL) and follower cities (BYD, RIJ, PAL) from the social, economy and environmental field to understand the interaction of the different interventions as a system. These will be clear indicators for the cities to make decisions. These results, combined with their own SEAPs, their sustainable mobility plans, their open data strategy, and related tasks in this WP1 and with WP2, WP3, WP4 and WP6 will serve to develop the integrated urban plans of these cities as an application of the methodology that later will be replicated in the followers. In the subtask 1.4.3 Techno-economic analysis of the suggested interventions in the pilots will be carried out. ESA and the RTOs will support the municipalities to disaggregate the characterization of the value-chain for more accuracy when measuring indirect and induced effects at economy and social level.

Date	Version	Author	Comment
01/03/2018	0.1	Eneko Arrizabalaga (TEC)	Interim Version
11/05/2018	0.2	Eneko Arrizabalaga (TEC)	Initial structure and content
25/10/2018	0.5	Eneko Arrizabalaga (TEC) Carles Cervera, Francesc Pardo (ESA) Aurélien Henon (NBK) and contributions from CAR and the reviewer (HMU)	Intermediate version of the deliverable (M18)

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

15/06/2019	0.5	Eneko Arrizabalaga (TEC) Carles Cervera Francesc Pardo (ESA) Aurélien Henon (NBK) Carla Rodríguez (CAR) and the reviewer (HMU)	Final version of the deliverable sent for internal review
19/07/2019	0.5	Eneko Arrizabalaga (TEC) Carles Cervera Francesc Pardo (ESA) Aurélien Henon (NBK) Carla Rodríguez Contributions from NAN, HEL, HAM (CAR) and the reviewer (HMU)	Final version of the deliverable

Table of Content

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

Table of Figures

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

Table of Tables

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

Abbreviations and Acronyms

Acronym	Description
BaU	Business as usual
CAPEX	CAPital EXpenditures
CPA	Classification of Products by Activity
DH	District Heating
DHW	Domestic hot water
EV	Electric vehicles
GDP	Gross Domestic Product
GVA	Gross Value Added
IO	Input Output
LCC	Life Cycle Cost
OPEX	Operating expense
O&M	Operation and Maintenance
PV	Photovoltaic
RES	Renewable Energy Source
VA	Value Added
mySMARTLife	Transition of EU cities towards a new concept of Smart Life and Economy

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

1. Executive Summary

The main objective of mySMARTLife project is the demonstration of the Innovative Transformation Strategy concept through piloting different actions, considering advanced technologies, towards the global transformation of the urban life in the cities. The methodology that will be applied in the three Lighthouse cities will foster the replication of the foreseen actions, at different levels, in the follower cities and the smart city network that will be created during the project lifetime.

As a global vision, mySMARTLife will follow the approach presented in Figure 1.

Figure 1: Global vision of the mySMARTLife Project

This Urban Transformation Strategy aims to respond in a holistic and integrated way to the transformation process, overcoming the existing technical and non-technical barriers. During this process the technical support to the different phases is a critical issue. In this regard, the application of existing methods and tools, as well as the development and the adaptation of new methods is essential to provide the needed criteria for the prioritization of measures that will guide this transformation.

In this framework, the intermediate version of the deliverable (which was named D1.14) aimed to describe the methodology defined for the supply chain analysis of interventions, which is the base to develop technoeconomic analysis of interventions. The technoeconomic analysis of the interventions will evaluate the direct, indirect and induced socioeconomic effects associated to the implementation interventions in the three lighthouse cities of the project based on the Input Output (IO) tables.

This first step of the definition of the supply chain associated to each intervention will represent the main input for the impact assessment study. More precisely, this first step will generate the “shock” that will represent the increase of the endogenous demand in each city/region due to the deployment of the interventions of mySMARTLife project.

The simplified methodology proposed in this deliverable takes into account the cost breakdown of the main cost components of interventions, as well as an analysis of the local capabilities to produce and/or distribute the components that take part in the supply chain of each intervention. Finally, the type of stakeholder (public, private, etc.) who take part in each of the phases of the supply chain are also evaluated and taken into account for the analysis.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

2. Introduction

2.1 Purpose and target group

This deliverable is allocated within Task 1.4, which is related to evaluating impacts in lighthouse cities (NAN, HAM, HEL) from the social, economy and environmental field to understand the interaction of the different interventions as a system. The Advanced Integrated Urban Planning is divided in four stages, corresponding with the five deliverables of the task:

- **Deliverable 1.12:** This deliverable is related to the subtask 1.4.1 and is focused on the description of 3D models for each pilot which include the energy assessment of the area selected by each city. This is a key step that can be scaled-up to cover a larger area of the city so that it can serve to evaluated aspects that can feed to the different scenarios that will be evaluated for the cities in the subtask 1.4.2.
- **Deliverable 1.13:** This deliverable is related to the subtask 1.4.2 which is focused on the energy scenario development at city scale. The outcome described in the Deliverable 1.12 will be used for the definition of scenarios.
- **Deliverable 1.14:** This deliverable is related to the subtask 1.4.3 which is focused on the techno-economic assessment of the interventions that will be implemented in the lighthouse cities. The final version is named D1.17.
- **Deliverable 1.15 and 1.16:** These deliverables are related to the subtask 1.4.4 which is focused on the impact assessment and the comparative analysis of all interventions. Here, the outputs described in both deliverables D1.13 and D1.14 (D1.17 in its final version) will be completed with an energy and environmental assessment which will provide extra indicators and criteria that will be used for the prioritization of interventions in each lighthouse city.

Moreover, all the subtask and outputs described in the mentioned deliverables (focused on the lighthouse cities) will serve as a starting point for the replication plan for the four follower cities. Based on the experience gained, the entire process will be replicated in the Task 6.2 of the WP6 for the follower cities of mySMARTLife project.

The present deliverable is structured as follows:

Chapter 3: shows the overall methodological approach to the Advanced Integrated Urban Planning in mySMARTLife project, describing the relation between the different phases of the assessment for the lighthouse cities and the relation with the replication in the follower cities.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

Chapter 4: Introduces the supply chain analysis of interventions for the socioeconomic impact assessment and describes the summary of the methodology proposed in the project.

Chapter 5: Describes more in detail the methodology proposed for the supply chain analysis of interventions. This section includes the details for the methodology proposed for the supply chain analysis of interventions, including the disaggregation of costs per intervention, the assignment of each cost component with the corresponding subsector or commodity, the evaluation of the capacities for the manufacturing and distribution of each cost component (commodity/subsector) in each city and the identification of the main stakeholder related to each cost component.

Chapter 6: This chapter is focused on the supply chain analysis of the three lighthouse cities, which includes the main results of the data gathering process and the analysis for each of the phases of the methodology proposed.

Chapter 7: Describes the main conclusions obtained from the work carried out in the subtask 1.4.3.

Chapter 8: Shows the references of the literature consulted to develop the work.

2.2 Contributions of partners

Table 1 depicts the main contributions from participant partners in the development of this deliverable.

Table 1: Contribution of partners

Participant short name	Contributions
TEC	Overall methodological development and general redaction of the deliverable
CAR	General review of the content of the deliverable and participation on the general strategy of the subtask. Contribution with the initial cost breakdown of interventions. Support offered to cities during the data gathering process. Contributions in the redaction of the deliverable.
ESA	Contribution with the analysis of the socioeconomic and sectorial structure of each city/region (phase III of the methodology)
NBK	General review of the content of the deliverable and participation on the general strategy of the subtask. Contribution with the initial cost breakdown of interventions. Support offered to cities during the data gathering process. Contributions in the redaction of the deliverable.
HEL	Contribution (data provision) to the chapter 6

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

HAM	Contribution (data provision) to the chapter 6
NAN	Contribution (data provision) to the chapter 6
HMU	Overall review of the deliverable

2.3 Relation to other activities in the project

Table 2 depicts the main relationship of this deliverable to other activities (or deliverables) developed within the mySMARTLife project and that should be considered along with this document for further understanding of its contents.

Table 2: Relation to other activities in the Project

Deliverable Number	Contributions
D2.1	This deliverable provides the baseline information of Nantes demonstrator area
D3.1	This deliverable provides the baseline information of Hamburg demonstrator area
D4.1	This deliverable provides the baseline information of Helsinki demonstrator area
D1.12	This deliverable provides the compilation of the 3D models and energy demand calculation of the pilots of the three lighthouse cities
D1.13	This deliverable provides the compilation of the energy scenario for the following 10-20 years for the three lighthouse cities
D1.15	This deliverable provides comparative analysis of interventions based on impacts (per pilot) which will use some results of this deliverable
D6.6	This deliverable provides the techno-economic analysis of each intervention per follower city which will follow the methodology described in this deliverable

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

3. Overall methodological approach to the Advanced Integrated Urban Planning in mySMARTLife project

This section aims to provide a general overview of the overall methodological and modelling approach of the Advanced Integrated Urban Planning of mySMARTLife project. The figure below shows how each of the phases of the methodology corresponds with the different subtask of the Task 1.4 of the project and how each subtask contributes to the rest with their corresponding outcomes. The methodology is composed by four main phases that correspond with the main subtasks showed in Figure 2.

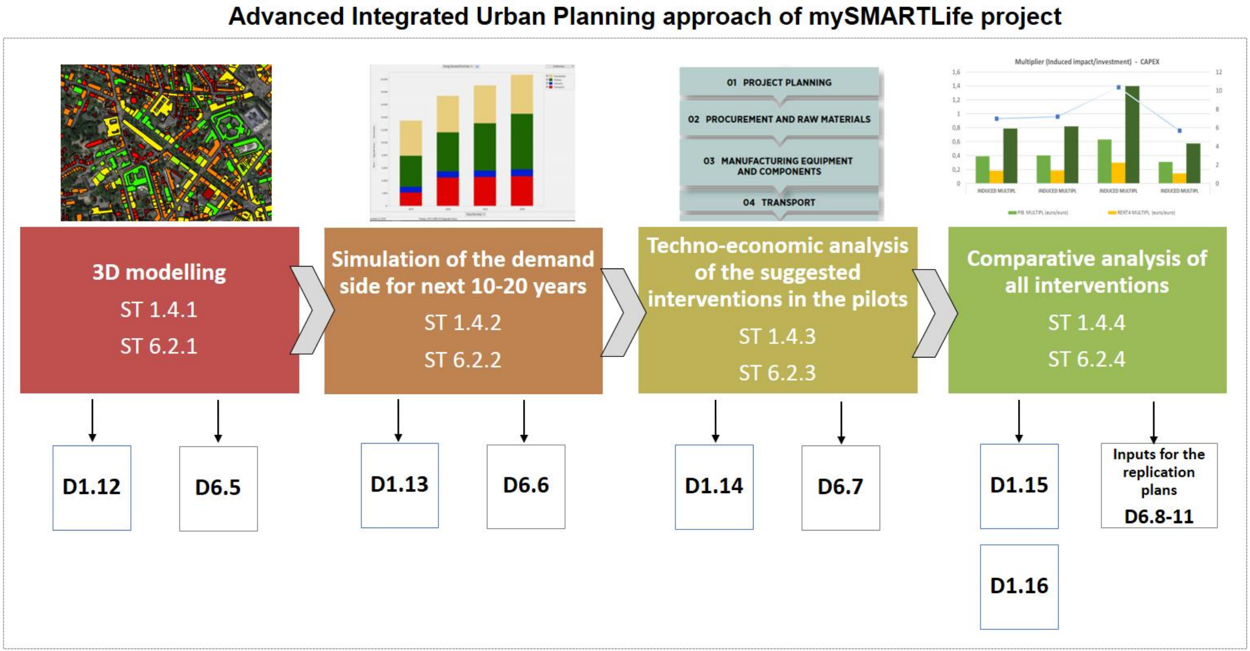

Figure 2: Methodological approach of the Advanced Integrated Urban Planning in mySMARTLife project.

It can be seen, that the entire process is applied to both the lighthouse and to the follower cities of the project. The analysis is first applied to lighthouse cities (in WP1) and with the experience gained and with the lessons learnt, it is applied in a second step to the follower cities of the project (in the subtasks specified within the WP6).

The **first phase** is focused on the **3D modelling and energy demand analysis** of the three lighthouse cities. The 3D modelling is applied at city scale to prepare the data available in the city in the way that is required for the energy modelling of the building stock. In this phase the area selected in each city is evaluated through an energy model. The energy modelling evaluates the energy demand of the building stock taking into account several characteristics that are specific for each building. The results of the

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

modelling provide the hourly energy demands (heating, cooling, Domestic hot water (DHW)) and the hourly electricity consumption (lighting, equipment, etc.) individually for each building but also in an aggregated way according to a classification depending on the construction period and use of the buildings. The procedure is carried out in a way that the model is calibrated so that it can be used for other areas of the city or for the entire city. The visual representation of the results allows a quick understanding of the energy needs of the city but also an initial idea of the refurbishment potential or the potential for the implementation of renewable energy technologies such as the solar thermal and the solar photovoltaic systems. This is a bottom-up modelling approach that provides some specific results that are useful for the scenario definition in the following phase of the methodology which follows a top-down approach to the city energy modelling. The main outputs of this phase are the deliverables D1.12 and D6.5.

The **second phase** of the modelling methodology is focused on **simulating the energy demand for the next 10-20 years for the city**. In this case the entire city is evaluated including not only the built environment but also the rest of the sectors of the city such as the industry and mobility. In this case other types of modelling tools are required to define the energy matrix of the city (Sankey diagram) for the base year. Then, the evolution of several characteristics (such as the evolution of the socioeconomic characteristics of the city; population, GDP, etc.) are evaluated for each city, establishing the interrelation between these parameters and the future energy needs of the city. This will allow to generate the Business as Usual (BaU) scenario for the city, which defines the expected evolution of the energy demands/consumptions of the different sectors of the city, as well as the required local energy generation or the energy import needs in the following years. This BaU scenario is the base for future evaluations of the expected impact of alternative efficient scenarios that can be proposed for the cities. As explained before, the potential results of the modelling in the first phase can serve to define some aspects of these alternative scenarios. The main outputs of this phase are the deliverables D1.13 and D6.6.

The **third phase** is focused on the **technoeconomic analysis of the suggested interventions in the pilots**. In this case a supply chain analysis is carried out for the interventions that can be implemented in the pilots, evaluating the disaggregation of the cost components that compose the intervention, as well as the existing capabilities at city/regional scale for the manufacturing or distribution of each component. Besides, an analysis of the socioeconomic structure of each city and its corresponding region is carried out in order to define the sectoral disaggregation that is required for the supply chain analysis. The result of this phase will be the specific “shocks” that will serve as input for the macroeconomic modelling that is carried out in the last phase of the methodology. Each intervention will be represented as a specific increase of the production of the corresponding subsectors in the region. The main outputs of this phase are the deliverables D1.14 (D1.17 in its final version) and D6.7.

Finally, the **fourth phase** is focused on the **comparative analysis of all the interventions based on the impact assessment results**. In this phase the impact assessment of each intervention is carried out based on the results of the previous phases. On the one hand, the shocks created in the third phase are

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

used to evaluate the potential impact associated to each intervention to generate a direct, indirect and induced effect in the development of several socioeconomic characteristics of the cities/regions such as the increase of the GDP or the employment. This information can also be combined with the results of the phases one and two which will provide an idea of the deployment potential of each type of intervention in the cities which will affect the final impact. Finally, this socioeconomic analysis for each intervention is combined with the expected energy and environmental impact analysis which will provide extra criteria that will be useful for the prioritization of the technologies. Here, a multicriteria methodology will be used to compare the different interventions for each city based on the expected impacts. The main outputs of this phase are the deliverables D1.15 and D1.16.

In the case of the follower cities, a similar process will be carried out to get a better understanding of the potential impact that the future implementation of actions can have in each follower city. This, as well as all the intermediate results obtained for the follower cities, will be important inputs for the replication plans (D6.8-11).

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

4. Supply chain analysis of interventions for the socioeconomic impact assessment

4.1 Introduction

Energy planning of cities is becoming an increasingly complex issue, especially in the phase of impact assessment of alternative energy transition scenarios. Although some studies highlight the necessity of quantitative methods based on the impact pathways, these frameworks are still in their infancy. These types of analysis are used in policy analysis studies but not at city scale energy planning. They are mainly used for a larger scale analysis such as national scale studies [1], [2].

Currently, energy planners need to use a wide variety of tools and complex methodologies which are difficult to combine. Several studies such as the one carried out by Mirakyan and De Guio [3] identify the necessity of evaluating city energy planning in an integrated way. Another study carried out by Mattoni et al. [4], identifies how the approach adopted in this type of analysis often is not as integrated as it should. Therefore, it can be said that city energy planning (an specially impact based analysis) is still complex mainly due to the lack of consensus on the way to prioritize the different energy technologies and interventions that can be potentially deployed in cities under a standardized method.

Focused on the impact assessment phase of the city energy planning, there are many options and approaches that can be adopted. Referring only to the sophisticated approaches (those approaches that are considered robust, detailed, and proper for modelling on the long-term), it can be said that the most common approaches are the ones which use the input-output tables, the computable general equilibrium, the hybrid models, and the econometric model-based approaches [1], [5]. Each of these approaches is very extensive and the detailed analysis of them is out of the scope of this subtask but the main differences between each of them are well documented and can be consulted in [6] and [7].

From these possibilities, the method that will be used in mySMARTLife project is included in the IO approach, as developed by [8]. These tables describe all the interaction between sectors in a national economy and explicitly reveal supply chain relationships. It is necessary to mention also that the basic IO models have some limitations such as that they do not consider aspects such as the interactions and the re-spending of household income in the economy [9].

In this case, the model used for the analysis is based on the simplified model (MIOCIM) developed by Kratena [10] which is adaptable to different countries and which solves some of the limitations of the simple IO model. This model allows a socioeconomic impact analysis in a broad sense of new investment projects. The methodology proposed is a simplification based on the results of a previous research [11].

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

The main input for the IO model considering the purpose of the study is the endogenous demand vectors, called 'shocks'. These vectors will be the main way to provoke a change in the regional model. The shocks are endogenous demand vectors that correspond to investments carried out during the implementation of each of the interventions that will be implemented in mySMARTLife project.

This is precisely where the supply chain of the intervention is useful since the construction of this "shock" will be carried out through the supply chain analysis characterization of each intervention.

The supply chain analysis is a technique that can be used for different purposes. However, in this case it is used for the analysis of the different interventions that will be implemented in lighthouse cities in the way that is needed to use it as input for a wider socioeconomic impact assessment. More precisely, supply chain analysis can be used for mapping and estimating among others, the material costs, the labor costs, and the profit margin for each of the components of the evaluated intervention across its supply chain. Figure 3 shows a general view of the main segments to be considered through the value chain and the activities included in each of them for the case of wind technology.

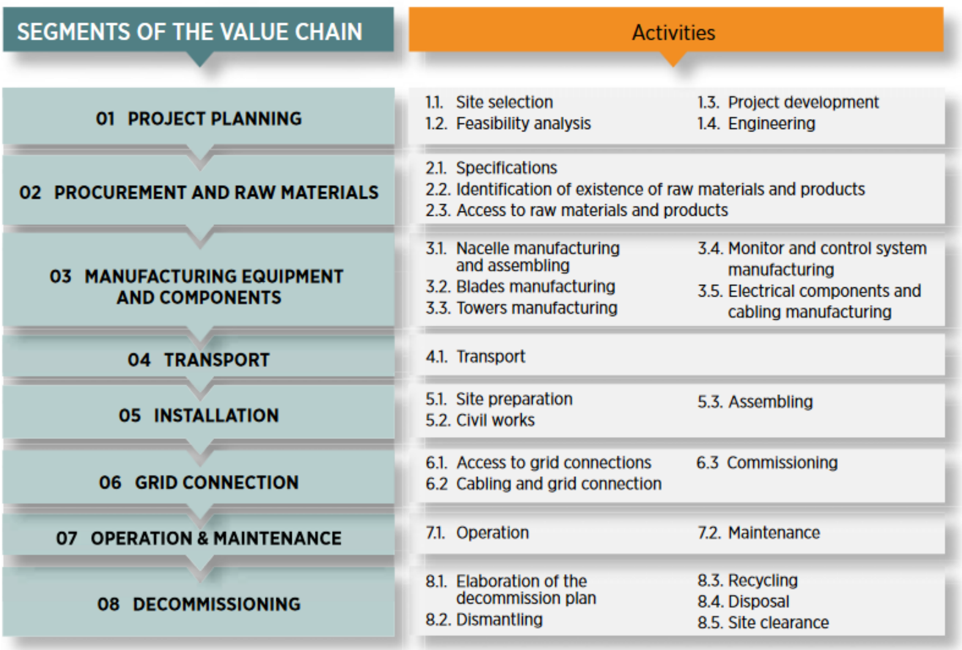

Figure 3: Segments of a wind energy project value chain. [12]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

4.2 Overall methodological approach to the supply chain analysis of interventions for the socioeconomic impact assessment

This section provides a summary of the methodological approach and the steps that need to be followed for the supply chain analysis of interventions (to generate the endogenous shock that represents the intervention) according to the methodology proposed in mySMARTLife project. Figure 4 shows the four main steps of the method. Besides, the fourth step is further described including the main sub-phases which are included in it.

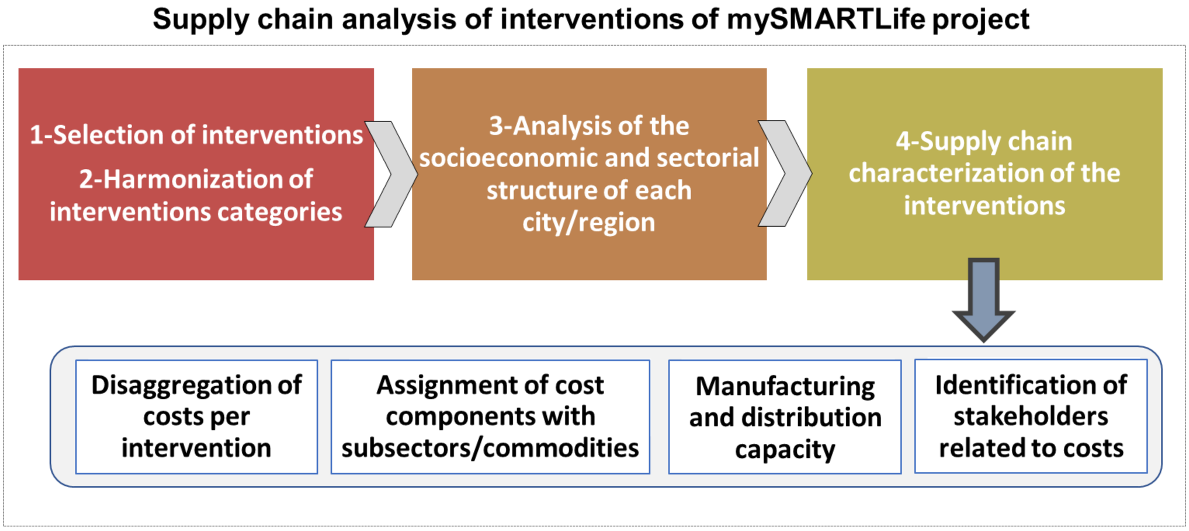

Figure 4: Methodological approach of the Advanced Integrated Urban Planning in mySMARTLife project.

Each of these steps are further explained in the following paragraphs.

Phase 1- Selection of interventions:

In this step each city must select the group of interventions that will be included in the technoeconomic analysis. The selection of interventions will be specific in each city according to the criteria that are described in the Section 5 “The methodology in detail Phase I”.

Phase 2- Harmonization of interventions categories:

Once that each city has selected the group of interventions that will be included in the analysis, in this step various intervention categories will be defined in order to harmonize as much as possible the analysis between the different cities. The main idea is to group each type of interventions under a common epigraph which will help to stablish a common approach for the evaluation of similar interventions. This step is further described in the Subsection 5.2.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

Phase 3- Analysis of the socioeconomic and sectorial structure of each city/region:

This step will provide a better understanding about the main socioeconomic characteristics of the city evaluated. However, the socioeconomic impact assessment will be based on the use of the extended Input-Output tables which in most of the cases are only available at national scale (which must be adapted to the regional level). Therefore, for this socioeconomic analysis two scales will be taken into account, the city and the regional scales.

Special attention needs to be paid to the sectoral structure of both the city and the region focused on the disaggregation of aspects such as the total Value Added (VA), the production and the employment in the different subsectors. This is an aspect that will be relevant and that will influence the way in which the disaggregation of cost per intervention will be carried out.

Phase 4- Supply chain characterization of the interventions:

This step is focused on the detailed characterization of the supply chain of each intervention and can be divided in the following four sub-phases:

- **Sub-phase 4.1. Disaggregation of costs per intervention**

  The first step is the disaggregation of the total cost of each intervention in the different cost components that compound it. The first disaggregation will consist in the distinction of the main phases of the supply chain: project planning, procurement and raw materials, manufacturing equipment and components, transport, installation, operation and maintenance and decommissioning.

  In the practice, it is observed that in most of the cases some of these cost components are difficult to obtain such as the cost of the decommissioning. Besides, some of these cost components are provided combined such as the cost of the procurement of the raw material, the manufacturing. Here, it is relevant to understand that depending on the aim of the project different level of disaggregation will be needed.

  In this case, the most limiting aspect for the level of detail of the results will the disaggregation level of the Input Output tables at national level combined with the level of disaggregation of the socioeconomic data at regional level. This means that although a higher level of detail could be obtained in the supply chain analysis stage, this would be lost when this information is introduced as an increase of the endogenous demand in the adapted IO tables.

- **Sub-phase 4.2. Assignment of each cost component with the corresponding subsector or commodity**

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

This sub-phase is focused on finding a correspondence between each cost component of the supply chain analysis of the interventions with one of the subsectors or commodities of the IO table of the city/region evaluated.

- **Sub-phase 4.3. Evaluation of the capacities for the manufacturing and distribution of each cost component (commodity/subsector) in each city**

This sub-phase is focused on evaluating and reflecting in the supply chain analysis whether the city and the region evaluated have the capacity in terms of existing companies or institutions that can respond to an increase of the need of the cost components (services, commodities, manufacturing of products, distribution of products, etc.)

The main aim is to get a better understanding of the dependency (in terms of imports of commodities, etc.) of each city for implementing each intervention.

- **Sub-phase 4.4. Identification of the main stakeholder related to each cost component**

Finally, this sub-phase aims to understand who is the main actor associated to each cost component of each intervention. This will allow to understand whether the investments are made by citizens, private companies or public bodies among others. This is an aspect that can affect the total impact associated to each intervention.

The process described is carried out in WP1 for the lighthouse cities of the project. The information and the conclusions obtained during this process will be useful also for the analysis of the follower cities in WP6. In the case of the follower cities the ex-ante impact assessment results obtained will be useful for identifying the specific interventions that could be prioritized according to the specific criteria of each city.

5. The methodology in detail

5.1 Phase I: Selection of interventions

The first phase of the methodology proposed is the selection of interventions for the analysis. This is a step that needs to be carried out by the city with the guidance of the modeler/analyst. The modeler should explain properly the purpose of the analysis, the relevance of selecting the most interesting interventions for the analysis, the type of results that will be obtained as output of the process and the main criteria that should be considered during the selection process.

Cities usually have a wide range of interventions that can be susceptible to be implemented in the following years. However, it needs to be considered that the analysis can be very time consuming not only for the analyst but also for cities mainly in the data gathering process. Therefore, cities must arrive to a compromise solution between the number of interventions evaluated in the technoeconomic analysis and the accuracy of the data provided and the results obtained.

The following criteria should be considered by cities for selection of interventions for the analysis:

- The interventions for the analysis should be representative in terms of investment for the city. The main reason is that in other cases the impacts created in the city and at regional level would not be very appreciable in the results.
- The interventions selected for the analysis should have a high potential of replication both at city and at regional level. This is related with the first criteria. It is possible that although an intervention has not a high associated investment, it has a high replicability potential which will increase the interest and the representativeness of the results of the analysis.
- The interventions selected for the analysis should be relevant for the city. An intervention can be relevant for the city due to very diverse reasons. For example, a city which bases its main economic activity in the information and communications technology industry could consider these types of interventions as interesting although there are not so relevant in terms of the total investment.
- Finally, singular interventions that will be implemented in the cities are also susceptible to be considered in some cases due to their singularity. The analysis carried out can provide some clues regarding its potential effects which are not commonly evaluated by cities.

Besides, it needs to be taken into account that for all the interventions selected an important requisite is that each city should have available the information that is required for the analysis. This information should be actual information if it is available for the time of the analysis.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

5.2 Phase II: Harmonization of interventions categories

The second phase proposed in the methodology is the harmonization of intervention categories. This step is not very time consuming but it is interesting in both cases; when a single city is evaluated and when the analysis includes the simultaneous evaluation of various cities.

In the first case, when the study is focused on the analysis of various interventions to be implemented in the same city, the harmonization of interventions into various categories can help to simplify the analysis. The main reason is that there are several interventions that can be very similar for this type of analysis (i.e. variations of the same type of technology or several interventions which involve the same technology). In this case, the type of analysis in terms of data gathering (which is detailed in the following sections) both for the characterization of the intervention and for the characterization of the sectoral and socioeconomic structure of the city treated can be used for more than one intervention.

In the second case, when the analysis is focused on the analysis of various interventions to be implemented in various cities, the harmonization of intervention into various categories can also be helpful for the analysis. In this case, although the analysis carried out for each city will be specific, using the same intervention categories to classify the different interventions will allow the identification of synergies between the way of characterizing interventions in different cities. This is relevant considering that the level of detail used for the disaggregation of the cost component of interventions should be similar in all the cities in order to allow a better analysis and comparison of the results obtained.

On the other hand, for the replication of the analysis of other cities, this step will be also useful to identify clearly the category of intervention that should be evaluated more in detail. This will be used in mySMARTLife project for the replication of the technoeconomic analysis for the follower cities in the Task 6.2 of the WP6, but also for other cities out of the project which are interested on replicating the analysis for their particular case.

5.3 Phase III: Analysis of the socioeconomic and sectorial structure of each city/region

This phase will provide a better understanding of the main socioeconomic characteristics of the city evaluated. However, the socioeconomic impact assessment will be based on the use of the extended Input-Output tables which in most of the cases are only available at national scale, which must be adapted to the regional level. Therefore, this socioeconomic analysis will be generally carried at two scales, at the city and the regional scales.

In general terms, special attention needs to be paid to the sectoral structure of both the city and the region focused on the disaggregation of aspects such as the total Value Added, the production and the employment in the different subsectors. This is an aspect that will influence the way in which the disaggregation of cost per intervention will be carried out and the level of detail of the results obtained.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

The following sub-sections will describe more in detail the procedure to be followed in this Phase III.

5.3.1 Data requirements at city and regional levels related to the supply chain analysis

The information requirements for the analysis depends on the type of input that will be needed for completing the socioeconomic impact assessment for each case study. In this case, the main aim of the analysis is the evaluation of the effects created in the city/region due to the implementation of interventions. As mentioned before, for the impact assessment the Input Output tables will be used, which consider the relation between the different sectors and commodities of the place evaluated. This analysis allows obtaining not only the direct effects created by the investments related to the interventions but also the indirect and induced effects created in the rest of the sectors.

Besides, it needs to be taken into account that the IO tables are commonly available at national level and only in some cases at regional level. This will limit the type of analysis that can be carried out in each case and requires some extra effort for the adaptation of the tables available only at national level to the reality of the region of which part the city is evaluated. However, this phase of the methodology is not focused on the definition and gathering of the information that is needed for the adaptation of these IO tables to the reality of the region, but is focused on the definition of the inputs that will be used to create the “shock” that will produce a change in the model. This shock represents the increase of the endogenous demand due to the investments related to the implementation of the interventions of the project in each city. All these aspects increase the necessity of data related not only at city scale but also at regional scale. Therefore, these two main scales will be considered in all the process for the analysis of each intervention.

As a first step of the method the analysis of the main characteristics of the city and its region associated needs to be carried out. Here, several aspects such as the differences in the socioeconomic structure of the city respect to the region are evaluated. In terms of the disaggregation requirements of the information, this should correspond as much as possible to the existing IO tables at national level to facilitate the process. Following this approach, the main socioeconomic characteristics, the Value Added of each sector of the city and the region as well as the employment structure or the sectoral production are evaluated in the following sections.

5.3.1.1 Step I: Socioeconomic analysis of the city/region evaluated

In the first step of this Phase III the city and the region in which the potential effects of the interventions will be evaluated need to be analyzed. This first socioeconomic analysis should include a descriptive summary of the socioeconomic characterization of the city and the region. Special attention should be paid to the similarities and differences between the structure of the city respect to the region to understand how the results obtained at regional scale can correlate with the potential effects created in the city. The information already collected in the baseline analysis of cities (in the context an energy planning study for

This project has received funding from the European Union‘s Horizon 2020 research and innovation programme under grant agreement No 731297.

the city) should be considered. However, this information should be completed with a more detailed analysis of aspects such as the ones showed in Table 3.

Table 3: Socioeconomic parameters to be considered in the initial analysis of the Phase III.

Population
Population
Female
Male
Population change (crude rate of net migration)
Population change (crude birth rate)
Population change (crude death rate)
Population change (crude rate of total population change)
Economic context
GDP
Gross value added (GVA)
Real growth rate of regional GVA
Sectors (industry, services, etc.)
Evolution
Laboral market
Workforce
Employment rates
Female
Male
Unemployment rates
Female
Male
Economic activity rates
Households
Number
Average
Income households
Other information
Technology and digital society

The parameters showed in Table 3 are useful for a quick socioeconomic analysis of the city and the region evaluated but the most interesting discussion should be related to the following aspects:

- Population evolution in the city respect to the region
- Sectoral structure differences between the city and the region
- Sectoral production differences between the city and the region
- Sectoral value-added differences between the city and the region
- Sectoral employment differences between the city and the region
- Household disposable income differences between the city and the region

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

5.3.1.2 Step II: Definition of the sectoral structure to be adopted for the technology supply chain analysis at city/regional level

After the general analysis of the socioeconomic structure of the city and the region (carried out in the first step of this Phase III) the analyst has a good overview of the context of each case study. Considering this information is important to complete the analysis with the definition of the sectoral structure that will used for the technology supply chain analysis at city/regional level.

As mentioned in the introduction, the main aspect that will limit the sectoral structure to be used for the supply chain disaggregation will be the initial Input Output data used for the analysis and the level of detail of the socioeconomic data at regional level which is used for the particularization of the national IO tables in the regional ones.

In order to standardize the use of the IO tables for the analysis in the case that there is no any specific table at regional level, it is recommender to use the public available IO tables of the World Input-Output Database (WIOD) [15].

The World Input-Output Database has been developed to analyze the effects of globalization on trade patterns, environmental pressures and socio-economic development across a wide set of countries. The database covers 27 EU countries and 13 other major countries in the world for the period from 1995 to 2009.

European Union			**North America**	**Asia and Pacific**
Austria	Germany	Netherlands	Canada	China
Belgium	Greece	Poland	United States	India
Bulgaria	Hungary	Portugal		Japan
Cyprus	Ireland	Romania		South Korea
Czech Republic	Italy	Slovak Republic	**Latin America**	Australia
Denmark	Latvia	Slovenia	Brazil	Taiwan
Estonia	Lithuania	Spain	Mexico	Turkey
Finland	Luxembourg	Sweden		Indonesia
France	Malta	United Kingdom		Russia

Figure 5: List of countries in WIOD-database.

This database provides a good and standardized starting point for the analysis. In all the cases the classification of sectors and commodities has been prepared according to the NACE codes. This is something to be taken into account for the preparation of the supply chain analysis since the main disaggregation level that can be provided in the supply chain characterization is limited to the number and classification of sectors of the IO tables that will be used for the analysis.

Table 4 shows the commodities classification used in the IO tables available in the WIOD database.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

Table 4: Classification of commodities in WIOD database based on the CPA Statistical Classification of Products by Activity.

CODE	Commodity
CPA_A01	Products of agriculture, hunting and related services
CPA_A02	Products of forestry, logging and related services
CPA_A03	Fish and other fishing products; aquaculture products; support services to fishing
CPA_B	Mining and quarrying
CPA_C10-C12	Food products, beverages and tobacco products
CPA_C13-C15	Textiles, wearing apparel and leather products
CPA_C16	Wood and of products of wood and cork, except furniture; articles of straw and plaiting materials
CPA_C17	Paper and paper products
CPA_C18	Printing and recording services
CPA_C19	Coke and refined petroleum products
CPA_C20	Chemicals and chemical products
CPA_C21	Basic pharmaceutical products and pharmaceutical preparations
CPA_C22	Rubber and plastics products
CPA_C23	Other non-metallic mineral products
CPA_C24	Basic metals
CPA_C25	Fabricated metal products, except machinery and equipment
CPA_C26	Computer, electronic and optical products
CPA_C27	Electrical equipment
CPA_C28	Machinery and equipment n.e.c.
CPA_C29	Motor vehicles, trailers and semi-trailers
CPA_C30	Other transport equipment
CPA_C31_C32	Furniture; other manufactured goods
CPA_C33	Repair and installation services of machinery and equipment
CPA_D35	Electricity, gas, steam and air-conditioning
CPA_E36	Natural water; water treatment and supply services
CPA_E37-E39	Sewerage; waste collection, treatment and disposal activities; materials recovery; remediation activities
CPA_F	Constructions and construction works
CPA_G45	Wholesale and retail trade and repair services of motor vehicles and motorcycles
CPA_G46	Wholesale trade services, except of motor vehicles and motorcycles
CPA_G47	Retail trade services, except of motor vehicles and motorcycles
CPA_H49	Land transport services and transport services via pipelines
CPA_H50	Water transport services
CPA_H51	Air transport services
CPA_H52	Warehousing and support services for transportation
CPA_H53	Postal and courier services
CPA_I	Accommodation and food services
CPA_J58	Publishing services
CPA_J59_J60	Motion picture, video and television programme production services, sound recording and music
CPA_J61	Telecommunications services
CPA_J62_J63	Computer programming, consultancy and related services; information services
CPA_K64	Financial services, except insurance and pension funding
CPA_K65	Insurance, reinsurance and pension funding services, except compulsory social security
CPA_K66	Services auxiliary to financial services and insurance services
CPA_L68	Real estate services
CPA_M69_M70	Legal and accounting services; services of head offices; management consulting services
CPA_M71	Architectural and engineering services; technical testing and analysis services
CPA_M72	Scientific research and development services
CPA_M73	Advertising and market research services
CPA_M74_M75	Other professional, scientific and technical services; veterinary services
CPA_N77	Rental and leasing services
CPA_N78	Employment services

This project has received funding from the European Union's Horizon 2020
research and innovation programme under grant agreement No 731297.

CPA_N79	Travel agency, tour operator and other reservation services and related services
CPA_N80-N82	Security and investigation services; services to buildings and landscape; office administrative, office
CPA_O84	Public administration and defense services; compulsory social security services
CPA_P85	Education services
CPA_Q86	Human health services
CPA_Q87_Q88	Social work services
CPA_R90-R92	Creative, arts and entertainment services; library, archive, museum and other cultural services; gambling
CPA_R93	Sporting services and amusement and recreation services
CPA_S94	Services furnished by membership organizations
CPA_S95	Repair services of computers and personal and household goods
CPA_S96	Other personal services
CPA_T	Services of households as employers; undifferentiated goods and services produced by households for
CPA_U	Services provided by extraterritorial organizations and bodies

On the other hand, Table 5 shows the classification of sectors used in the IO tables available in the WIOD database.

Table 5: Classification of sectors in WIOD database.

Sector	CODE
Crop and animal production, hunting and related service activities	A01
Forestry and logging	A02
Fishing and aquaculture	A03
Mining and quarrying	B
Manufacture of food products, beverages and tobacco products	C10-C12
Manufacture of textiles, wearing apparel and leather products	C13-C15
Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and	C16
Manufacture of paper and paper products	C17
Printing and reproduction of recorded media	C18
Manufacture of coke and refined petroleum products	C19
Manufacture of chemicals and chemical products	C20
Manufacture of basic pharmaceutical products and pharmaceutical preparations	C21
Manufacture of rubber and plastic products	C22
Manufacture of other non-metallic mineral products	C23
Manufacture of basic metals	C24
Manufacture of fabricated metal products, except machinery and equipment	C25
Manufacture of computer, electronic and optical products	C26
Manufacture of electrical equipment	C27
Manufacture of machinery and equipment n.e.c.	C28
Manufacture of motor vehicles, trailers and semi-trailers	C29
Manufacture of other transport equipment	C30
Manufacture of furniture; other manufacturing	C31_C32
Repair and installation of machinery and equipment	C33
Electricity, gas, steam and air conditioning supply	D35
Water collection, treatment and supply	E36
Sewerage; waste collection, treatment and disposal activities; materials recovery; remediation activities and	E37-E39
Construction	F
Wholesale and retail trade and repair of motor vehicles and motorcycles	G45
Wholesale trade, except of motor vehicles and motorcycles	G46
Retail trade, except of motor vehicles and motorcycles	G47
Land transport and transport via pipelines	H49
Water transport	H50
Air transport	H51
Warehousing and support activities for transportation	H52

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

Postal and courier activities	H53
Accommodation and food service activities	I
Publishing activities	J58
Motion picture, video and television programme production, sound recording and music publishing activities;	J59_J60
Telecommunications	J61
Computer programming, consultancy and related activities; information service activities	J62_J63
Financial service activities, except insurance and pension funding	K64
Insurance, reinsurance and pension funding, except compulsory social security	K65
Activities auxiliary to financial services and insurance activities	K66
Real estate activities	L68
Legal and accounting activities; activities of head offices; management consultancy activities	M69_M70
Architectural and engineering activities; technical testing and analysis	M71
Scientific research and development	M72
Advertising and market research	M73
Other professional, scientific and technical activities; veterinary activities	M74_M75
Rental and leasing activities	N77
Employment activities	N78
Travel agency, tour operator reservation service and related activities	N79
Security and investigation activities; services to buildings and landscape activities; office administrative, office	N80-N82
Public administration and defense; compulsory social security	O84
Education	P85
Human health activities	Q86
Social work activities	Q87_Q88
Creative, arts and entertainment activities; libraries, archives, museums and other cultural activities; gambling	R90-R92
Sports activities and amusement and recreation activities	R93
Activities of membership organizations	S94
Repair of computers and personal and household goods	S95
Other personal service activities	S96
Activities of households as employers; undifferentiated goods- and services-producing activities of households	T
Activities of extra-territorial organizations and bodies	U

Therefore, as a rule the disaggregation level of the technology evaluated from the supply chain point of view should consider as its main detailed disaggregation the classification of sectors or commodities considered in WIOD.

It is important to understand that in order to particularize the IO tables to the regional reality in each case, the classification of the data available at regional level will be the most limiting aspect. However, the supply chain analysis can be carried out following the national classification and then if necessary the correspondence between the data obtained for each intervention and the specific tables needs to be done by the analyst.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

5.4 Phase IV: Supply chain characterization of the interventions

Phase IV of the methodology proposed is the phase in which each of the interventions that will be evaluated in the study are characterized in detail. This section describes the main steps of the data gathering process that at the end will allow evaluating the supply chain of the technologies. This phase is composed by four main steps that are described more in detail in the following sub-sections.

5.4.1 Step I: Disaggregation of costs per intervention

The first step of the phase is focused on the disaggregation of the costs of the interventions. Here, the total cost of each intervention evaluated needs to be disaggregated according to the different cost components (understanding cost components as elements such as costs of design, operation and maintenance, etc.) in a similar way than in a Life Cycle Cost (LCC) analysis. Besides, the expected lifetime of the entire intervention and the specific lifetime of each components will be also collected/considered.

One of the main issues in this step is to know which is the main disaggregation level that should be used for the breakdown of the costs of each intervention. Here, the general rule to be applied would be to wonder if the new disaggregation level of the costs of the intervention provides a higher level of detail of the "shock" created, i.e. whether the new disaggregation changes the final distribution of costs between the different sectors. For example, it does not make sense to break down the cost of an electric component into subcomponents if all the costs of the new decomposition are located also in the electric sector. The only reason to do this would be that the new classification of costs allows to provide a higher detail about the origin (local or not) of the components.

Figure 6 serves as an example of the initial cost breakdown of interventions. It is focused mainly in the disaggregation of the costs of the CAPital EXpenditures (CAPEX) of the off-shore wind technology.

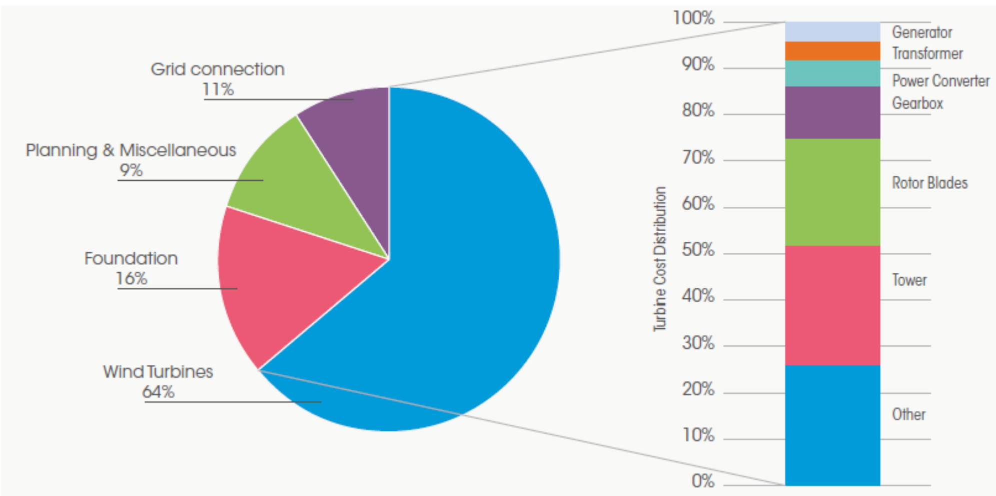

Figure 6: Capital costs breakdown example for the off-shore wind technology [16].

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

This type of studies can be used as mentioned before for the initial decomposition of the main costs of the interventions evaluated. Once that the initial cost breakdown is carried out by the analyst, it needs to be completed and refined with actual data available in each municipality. In this step, the investment plan and the economic viability studies should be used. Table 6 shows the treated data of the example which has been further disaggregated.

Table 6: CAPEX cost breakdown example for the offshore-wind technology

Main components	Cost breakdown
Generator	**2,2%**
Transformer	**2,2%**
Gearbox	**8,3%**
Rotor Blades	**14,2%**
Tower	**16,6%**
Steel	64,6%
Personal access & survival equipment	8,3%
Tuned damper	8,3%
Electrical system	12,5%
Tower internal lighting	4,2%
Fasteners	2,1%
Grid connection	**10,7%**
Grid connection	**0,3%**
Planning	**4,5%**
Construction costs	**4,5%**
Foundation	**16,0%**
other	**20,5%**
Rotor hub	1,4%
Rotor bearings	1,2%
Main shaft	1,9%
Main frame	2,8%
Yow system	1,3%
Pitch system	2,7%
Brake system	1,3%
Nacelle housing	1,4%
Power converter	5,0%
Cables	1,0%
Screws	1,0%

Based on this cost breakdown the analyst will have to interact with the municipality to gather the actual information related to the intervention evaluated.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

Table 7 represents a data gathering template provided in the project for gathering the required information in this step. It can be observed that not only CAPEX costs need to be considered. Here, the lifetime of the intervention, the Operating expense (OPEX) cost as well as the initial project costs need to be taken into account. The end of life phase (dismantling of the intervention) could also be considered at this stage if the data is available.

Table 7: Data gathering template (CAPEX and OPEX) for the disaggregation of costs per intervention

Project / intervention lifetime: XX years				
Cost breakdown	Costs	Unit	Specific lifetime of the component (years)	Total cost in the lifetime (including replacement)
Other project Costs		€		
Generator		€		
Transformer		€		
Gearbox		€		
Rotor Blades		€		
Tower		€		
Steel		€		
Personal access & survival equipment		€		
Tuned damper		€		
Electrical system		€		
Tower internal lighting		€		
Fasteners		€		
Grid connection		€		
Grid connection		€		
Planning		€		
Construction costs		€		
Foundation		€		
other		€		
Rotor hub		€		
Rotor bearings		€		
Main shaft		€		
Main frame		€		
Yow system		€		
Pitch system		€		
Brake system		€		
Nacelle housing		€		
Power converter		€		
Cables		€		
Screws		€		
O&M Grid electricity price (variable costs)		€/kWh		
O&M Grid electricity base price (fixed costs)		€/kWh		
O&M cost (materials)		€/year		
O&M cost (labor)		€/year		

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

End of life costs		€		

Besides, in the case of the CAPEX costs of the interventions the specific lifetime of each component and the total costs including all the replacements required during the lifetime of the intervention needs to be included.

5.4.2 Step II: Assignment of each cost component with the corresponding subsector or commodity

Once that the cost breakdown is completed, in the second step the assignment of each cost component with the corresponding subsector or commodity needs to be done. Both correspondences are valid (with the commodity or with the subsector) since the relation between the two classifications can be stablished in the following steps by using the IO tables. Therefore, each municipality and analyst should decide which is the best way to stablish the most direct relation with the cost breakdown of the interventions.

Following with the previous example, Table 8 shows the establishment of the relation between each of the cost components of the off-shore wind technology and the commodity classification provided by the WIOD and described in section 7. In this case the relation with the commodities classification has been defined based on the CPA Statistical Classification of Products by Activity [17]. CPA is the Standard Classification of Economic Products from Annex Regulation (EC) n. 451/2008 which has a hierarchical structure funded on different levels embedded in the activity code refer. This allows the consultation of the possible correspondence of each of the cost components defined in the previous step.

Table 8: Assignment of the cost component with the corresponding subsector or commodity for the off-shore wind technology.

Component	CODE	Commodity
Other project costs	CPA_K66	Services auxiliary to financial services and insurance services
Generator	CPA_C28	Machinery and equipment n.e.c.
Transformer	CPA_C27	Electrical equipment
Gearbox	CPA_C28	Electrical equipment
Rotor Blades	CPA_C25	Fabricated metal products, except machinery and equipment
Tower		
Steel	CPA_C25	Fabricated metal products, except machinery and equipment
Personal access & survival	CPA_C24	Basic metals
Tuned damper	CPA_C28	Machinery and equipment n.e.c.
Electrical system	CPA_C28	Electrical equipment
Tower internal lighting	CPA_C28	Electrical equipment
Fasteners	CPA_C25	Fabricated metal products, except machinery and equipment
Grid connection	CPA_C28	Electrical equipment
Grid connection	CPA_C25	Fabricated metal products, except machinery and equipment
Planning	CPA_M71	Architectural and engineering services; technical testing and analysis serv.
Construction costs	CPA_C33	Repair and installation services of machinery and equipment
Foundation	CPA_F	Constructions and construction works

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

Other		
Rotor hub	CPA_C28	Machinery and equipment n.e.c.
Rotor bearings	CPA_C28	Machinery and equipment n.e.c.
Main shaft	CPA_C28	Machinery and equipment n.e.c.
Main frame	CPA_C28	Machinery and equipment n.e.c.
Yow system	CPA_C28	Machinery and equipment n.e.c.
Pitch system	CPA_C28	Machinery and equipment n.e.c.
Brake system	CPA_C28	Machinery and equipment n.e.c.
Nacelle housing	CPA_C28	Machinery and equipment n.e.c.
Power converter	CPA_C28	Electrical equipment
Cables	CPA_C28	Electrical equipment
Screws	CPA_C28	Machinery and equipment n.e.c.
O&M Grid electricity price (variable costs)	CPA_D35	Electricity, gas, steam and air-conditioning
O&M Grid electricity base price (fixed costs)	CPA_D35	Electricity, gas, steam and air-conditioning
O&M cost (materials)	CPA_C28	Electrical equipment
O&M cost (labor)	CPA_C33	Repair and installation services of machinery and equipment
End of life costs	CPA_E37-E39	Sewerage; waste collection, treatment and disposal activities; materials recovery; remediation activities and other waste management services

This correspondence allows a better understanding of the place in which the costs of the interventions are allocated when an investment is done in the intervention evaluated. Once that the relation has been stablished, all the costs corresponding to each commodity or subsector will be grouped obtaining the final figure of the cost distribution per commodity in each city.

5.4.3 Step III: Evaluation of the capacities for the manufacturing and distribution of each cost component (commodity/subsector) in each city

The third step of Phase IV is focused on the analysis of the capacity of each city evaluated for the manufacturing and distribution of the components that are used in each intervention. The main aim of this step is to understand in which proportion the investment done due to the implementation of the evaluated intervention will be local or not. It is considered that if there is the capacity in the city/region give a response to the increased need of components this is counted as potential income for the local economy and will therefore affect the social wellbeing. This analysis will provide a better understanding of the potential of each of the interventions evaluated to improve the socioeconomic development of the city evaluated.

This analysis will be done taking into account the cost breakdown of the interventions carried out in the previous step and considering also the specific sectors and commodities that are involved for each case. The entire analysis will be carried out not only at city scale but also at regional scale. Therefore, the analysis of the existing capacities will be done first at city level but also at regional level because the IO tables that are used will be adapted to the regional level.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

Table 9 servers as the main data gathering template for the step III. Two main sections can be distinguished, the regional analysis and the city scale analysis. In both cases, municipalities must complete the table providing answers (YES/NO). In this step, the participation of industrial partners of each municipality is recommended to have a more realistic view of the capacities of the local industry to provide the required components and services.

Table 9: Table to be completed for the analysis of the capacities for the manufacturing and distribution of each cost component (commodity/subsector) in each city (the cost breakdown only shows the main components in order to simplify the table).

	Local (city level)		Regional level	
Cost breakdown	local producer? (YES/NO)	Local distribution / stockist? (YES/NO)	local producer? (YES/NO)	Local distribution / stockist? (YES/NO)
Other project Costs	(YES/NO)	(YES/NO)	(YES/NO)	(YES/NO)
Generator	(YES/NO)	(YES/NO)	(YES/NO)	(YES/NO)
Transformer	(YES/NO)	(YES/NO)	(YES/NO)	(YES/NO)
Gearbox	(YES/NO)	(YES/NO)	(YES/NO)	(YES/NO)
Rotor Blades	(YES/NO)	(YES/NO)	(YES/NO)	(YES/NO)
Tower	(YES/NO)	(YES/NO)	(YES/NO)	(YES/NO)
Grid connection	(YES/NO)	(YES/NO)	(YES/NO)	(YES/NO)
Grid connection	(YES/NO)	(YES/NO)	(YES/NO)	(YES/NO)
Planning	(YES/NO)	(YES/NO)	(YES/NO)	(YES/NO)
Construction costs	(YES/NO)	(YES/NO)	(YES/NO)	(YES/NO)
Foundation	(YES/NO)	(YES/NO)	(YES/NO)	(YES/NO)
other	(YES/NO)	(YES/NO)	(YES/NO)	(YES/NO)
O&M Grid electricity price (variable costs)	(YES/NO)	(YES/NO)	(YES/NO)	(YES/NO)
O&M Grid electricity base price (fixed costs)	(YES/NO)	(YES/NO)	(YES/NO)	(YES/NO)
O&M cost (materials)	(YES/NO)	(YES/NO)	(YES/NO)	(YES/NO)
O&M cost (labor)	(YES/NO)	(YES/NO)	(YES/NO)	(YES/NO)
End of life costs	(YES/NO)	(YES/NO)	(YES/NO)	(YES/NO)

5.4.4 Step IV: Identification of the main stakeholder related to each cost component

The step four of the Phase IV is focused on the identification of the main actors that are involved in each of the phases of the process. In this case the same cost breakdown classification is maintained as general structure. Therefore, this step will evaluate origin of all the payments that take part in the deployment of each intervention. In this regard, three main type of actor will be distinguished in order to separate the total cost of the intervention into different subsections. These three types are the followings;

- The percentage of the costs covered by public regional funding,

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

- The percentage of the costs covered by public funding out of the region,
- The percentage of the costs covered by paid by the citizens
- The percentage of the costs covered by private companies.

As a general rule, the same structure of costs used in previous steps will be used here (if this information can be obtained or estimated by components) in order to maintain the same level of detail. In the case that this information is not available with this level of detail, the simplification of estimating a percentage respect to the total costs that would be covered by each type of actor could be used and applied proportionally to all the costs.

Therefore, in the data gathering process of this step the template provided in Table 10 should be completed for each of the interventions evaluated.

Table 10: Table to be completed for the analysis of the main stakeholder related to each cost component (commodity/subsector) in each city (the cost breakdown only shows the main components in order to simplify the table).

			Who makes the payment?			
Cost breakdown	Costs	Unit	% paid with public funding (Out of the region)	% paid with public (Regional) funding	% paid by the individual (citizens)	% paid by private companies
Other project Costs		€				
Generator		€				
Transformer		€				
Gearbox		€				
Rotor Blades		€				
Tower		€				
Grid connection		€				
Grid connection		€				
Planning		€				
Construction costs		€				
Foundation		€				
other		€				
O&M Grid electricity price (variable)		€/year				
O&M Grid electricity price (fixed)		€/year				
O&M cost (materials)		€/year				
O&M cost (labor)		€/year				
End of life costs		€				

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

This step will allow to get a better understanding of the type of investments that are related to each intervention, distinguishing also who (public administration, citizens, etc.) is the main investor and beneficiary in each case. This step is carried out to provide a higher level of detail of the shock that represents the intervention evaluated.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

6. Supply chain analysis of the three lighthouse cities

6.1 Case of Helsinki

6.1.1 Phase I Selection of interventions

Based on the criteria described in section 5.1, the city of Helsinki has selected the interventions that are briefly described below. They have been chosen among the whole set of interventions of mySMARTLife project.

6.1.1.1 Electric vehicles: Electric Bus Up-take (140):

Large-scale up-take of electric buses in Helsinki region will take place in mySMARTLife, from three (3) e-buses (3/2016) to 12 e-buses (1/2017), to 140 e-buses (2020), to 260 e-buses (2022). The target plan for the Helsinki region transport authority is to have 30% of the bus fleet electric by 2025 (390 e-buses), and 10% of fleet electric by 2020.

For the current analysis the focus is on the 140 e-buses that are to be available in Helsinki by 2020, but figures reflected in the tables are from a single bus, so that it is better understood and the costs are clearer. The comprehension could be distorted if the data of the 140 e-buses are intended to be analyses as a whole.

The selection of this action has been motivated by being very representative at investment terms for the city, it also has a high potential of replication and it is significant for the city and its inhabitants.

6.1.1.2 Charging points: Electro-mobility charging node:

An innovative electromobility charging node, which integrates fast charging for e-bus, fast charging for the city maintenance fleet and commercial logistic fleet, charging of the autonomous e-buses will be implemented. Currently there are separate systems for charging the electric buses and no charging stations for commercial electric maintenance fleet machinery and commercial logistics trucks or other commercial vehicles.

The charging node will be set up in project area to support the maintenance fleet and autonomous e-buses uptake. An innovation intervention is to chart out the technical, operational and innovation aspects for scaling up such multi-use commercial electric vehicles charging nodes for wider market up-take of the systems.

This action is representative in terms of investment for the city, but above all it is an intervention with a high potential of replication and it is relevant for the future development of the city.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

6.1.1.3 Smart demand response system. Smart lights control in Viikki environment House:

Implementation of building automation system to couple the need of energy production and heat and electricity grids production in the Viikki Environment House office building. The aim is to provide good lighting, temperature and air condion for building users when using smart demand response systems. It is used to audit energy consumption and indoor air quality and comfort in Environment House, and to understand how the buildings are operated in heating /cooling/ intermediate seasons. It will also contribute to reduced maintenance need due to automated response.

The selection of this intervention is due to their potential of replication both at city and regional level in any building in which is important to know or control these factors, and for its positive energy impact.

6.1.1.4 Retrofitting of Merihaka-Vilhonvuori; Building (12) and flat (1323) retrofitting and 167 with smart thermostats:

The installation of smart controls for management at apartment level heat and electricity demand is key intervention in the retrofitting. For the retrofitting and domotics up-take, the project executes pilot-in-a-pilot approach with first planning the action and demonstrating the solution at pilot buildings (167 flats), and then further uptaking the solution to the rest of the district with a commercially viable business model.

These 167 flats will be equipped with a system that includes smart thermostats connected to the District Heating (DH) through IoT and cloud-based intelligence to load balance the network. Data will be used to study more transparent and usage dependent cost sharing in heating. Smart home/away functionality and smart management of electricity consumption concept is designed with the residents as part of the demonstration implementation, as these are expected to lower the total energy consumption. Dwelling implementations together are expected to lower the total energy consumption by 10-15%.

As the previous intervention, this is not very relevant one in terms of investment of the city but it is because of its high potential to be replicated and its relevance at city level in terms of energy savings.

6.1.1.5 Smart public space (street) lighting:

A dynamic, adaptive LED-based outdoor lighting system to replace the current gas-discharged lamps has been up-taken in Zone 2, Kalasatama in 2016-2017, followed by mySMARTLife intervention in Korkeasaari (Zoo) 2017-2018. Currently the gas-discharge lamp network adapts to lighting conditions on city-level. The dynamic lighting up-take adapts the lighting to micro-level, e.g. to follow the pedestrian/bicycle presence, and other local conditions. In Kalasatama the smart lighting solution is already co-designed with the residents and consists of for example navigation and communication features in addition to energy savings. Also, the lamp post infrastructure will be connected to the urban platform.

The selection of this action is motivated by its relative relevance in terms of the city's investment, and also by its high replicability potential at all levels as well as by the relevance for the city itself.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

6.1.1.6 Solar power plant implementation (500 kWp) for Messukeskus, Helsinki Expo and Convention Centre:

A partially visitor crowd-funded solar power plant will be uptaken for Messukeskus, Helsinki Expo and Convention Centre. It is based on the business model of already existing Suvilahti and Kivikko citizen crowd-funded solar power plants.

This intervention has been selected by the relevance of its investment for the city and by the importance for the city, also by its potential of replication both locally and regionally. It should also be noted that it is a singular intervention for its innovative business model, which has also been taken into account for its selection.

6.1.2 Phase II Harmonization of interventions categories

With the aim of homogenizing as much as possible the technoeconomic analysis not only for the case of the lighthouse cities but also for the follower cities of the mySMARTLife project, the interventions mentioned above could be classified in the following intervention categories:

- **Mobility interventions**
  - Electric vehicles
  - Charging infrastructure
- **Energy efficiency for buildings:** Including all interventions related to the improvement of the efficiency of the systems integrated in the buildings as well as the interventions related to the improvement of the characteristics of the building envelope.
  - Improvement of the characteristics of the building envelope
  - Smart meters and control
  - Efficient energy generation technologies
- **Public lighting**
- **Renewable energy technologies**
  - Solar:
    - Solar thermal
    - Solar photovoltaic
    - Solar hybrid technologies
  - Wind:
    - Large wind turbines

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

- Micro-turbines

According to the intervention categories described above, the interventions pre-selected in the lighthouse cities can be classified as it is showed in Table 11.

Table 11: Categorization of interventions into intervention categories for the example described.

Intervention	Intervention category
Electric vehicles: Electric Bus Up-take (140)	Mobility interventions: Electric vehicles
Charging points: Electro-mobility charging node	Mobility interventions: Charging infrastructure
Smart demand responde system. Smart lights control in Viikki Environment House	Energy efficiency for buildings: Smart meters and control
Retrofitting of Merihaka-Vilhonvuori; Building (12) and flat (1323) retrofitting and 167 with smart thermostats	Energy efficiency for buildings: Smart meters and control
Smart public space (street) lighting	Public lighting
Solar power plant implementation (500 kWp) for Messukeskus, Helsinki Expo and Convention Centre	Renewable energy technologies: Solar photovoltaic

6.1.3 Phase III Analysis of the socioeconomic and sectorial structure of each city/region

In the case of the city of Helsinki, the analysis should include both the city and the region in which is located (Helsinki-Uusimaa region). Therefore, all the analysis compares the main characteristics of both scales.

The city of Helsinki has a total **population** of 628.208 inhabitants (11,5% of total population in Finland). In terms of gender, Helsinki has 297.151 (47,30%) male and 331.057 (52,70%) female. Regarding the population structure, Helsinki has a quite balanced one, almost 45% of inhabitants are under 35 years old; in terms of absolute values, the most significant age group is 25-34, with a total number of 118.848 (18,92%) inhabitants [13].

The life expectancy average at birth of Helsinki's population is 81 years, 78,2 for male and 83,8 for female (2017, Facts about Helsinki). In terms of fertility and deaths, the crude birth rate[1] and the crude death rate[2] for the city are 10,08 and 8,20 respectively [13].

For the Helsinki-Uusimaa region[3], there is a total population of 162.0261 inhabitants (29,5% of total population in Finland). In terms of gender, the region has 787.495 (48,60%) male and 832.766 female (51,40%). Uusimaa presents also a quite balanced age structure, 66,1% of population are between 16 and

[1] The crude birth rate is the ratio of the number of live births during the year to the average population in that year. The value is expressed per 1 000 persons.
[2] The crude death rate is the ratio of the number of deaths during the year to the average population in that year. The value is expressed per 1 000 persons.
[3] The data from the region follows the NUTS classification. In the case of Helsinki-Uusumaa, the data used is from NUTS 2 and 3

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

64 for years (2017, Facts about Helsinki). The life expectancy average for the region is 82 years old, 79,2 for male and 84,5 for female. In terms of fertility and deaths, the crude birth rate and the crude death rate for the region are 10,05 and 7,40 respectively (2016, Eurostat. Regions and cities. City statistics).

In terms of **citizenship**, Helsinki has 570.601 (90,80%) national inhabitants. Among the population without finish citizenship, the city has 57.607 (9,2%) inhabitants, 23.680 (3,8%) from EU countries and 33.927 (5,40%) from non-EU countries (2016, Eurostat. Regions and cities. City statistics). Regarding the non-EU countries, the most representative ones are Asia (60%) and Africa (26%) (2017, Statistical Yearbook of Helsinki). For the case of the region, this concentrates almost 55% of the entire foreign language population. In 2014, there were about 117.00 foreigners' citizens living in Uusimaa[4]. In Helsinki, there are 156.620 families with total children of 127.469. From the whole families, 79.809 (50%) are couples – married or unmarried – without children and 76.811 (49%) have children. Among those families with children, the most common family structure are married couples, 40.497 (52%), followed by mother and children, 21.338 (28%) (2017. Statistical Yearbook of Helsinki). Regarding households, the average size of households is 1.9 persons (2016, Eurostat. Regions and cities. City statistics) with a total number of 321.328 dwellings households (2017, Statistical Yearbook of Helsinki). This is quite a low average. One of the principle reason for this average is because 48,20% of total households are constituted just from one member. Obviously, the low fertility rate constitutes a principle reason too. In terms of households' wealthy, the median for the disposable monetary income of households is 32.720 € [14].

In the case of Uusimaa, the average persons per household for the region is quite like the city, 2,1 persons, with a total number of 679.301 dwellings households. As for the city of Helsinki, the region presents also a high percentage of one-member dwellings household, 42% (2017, Facts about Helsinki).

The **income of households** (in euro per inhabitant) measured in terms of primary incomes by national income is 28.700 €. This measure decreases to 22.700 € when looking at the disposable income.

Regarding **education**[5], almost 50% of the population aged between 25 and 64 years old high tertiary education (university and higher education centers), 32,16% secondary education (upper secondary education, post-secondary) and 17,84% low or non-education (less than primary, primary or lower secondary education (2016, Eurostat. Regions and cities. City statistics). In the case of the region, 51,60% has tertiary education, 36,60% secondary education (non tertiary), and 11,70 has less than primary, primary or lower secondary education [13].

In terms of the **labor market**, the economically active population is constituted by 341.043 (54,29%) inhabitants, 164.794 (48,32%) for male and 176.249 (51,68%) for female. Considering the active population, the unemployment rate is 11,90%, 13,40% for male and 10,60% for female. In the case of the region, the economically active population is constituted by 871.800 (54%) inhabitants, 443.500 (51%) for

[4] https://kotouttaminen.fi/en/immigrants-in-uusimaa

[5] The education levels follow the International Standard Classification of Education ISCED

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

male and 428300 (49%) for female. Taking into account the active population, the unemployment rate is 7,4%, 7,5% for male and 7,2% for female [13].

6.1.4 Phase VI Supply chain characterization of the interventions

All the interventions that are being evaluated in the current study are characterized in detail in this section under the four steps that follow.

6.1.4.1 Step I Disaggregation of costs per intervention

As explained in above section 5.4.1, this step is the first approach to the disaggregation of the costs of each intervention. In order to clarify and better understand the different costs breakdown, there is a classification in three cost categories: design and acquisition phase (which includes CAPEX costs), operation phase (which corresponds to OPEX costs) and disposal phase. The costs included in the design and acquisition phase are those that only occur once in the project lifetime or the number of times they need to be replaced (if their lifetime is less than the project one). This is why it is especially important to include the specific lifetime of each component. In the operation phase the costs included are those given throughout the whole project lifetime (usually per year), such as the electricity price or the Operation & Maintenance ones. The disposal phase is about calculating the end of life of the most important components, or the recycling cost of the most polluting ones. This is a very ambitious phase and difficult to achieve since the data in many cases for these cutting-edge interventions is not available because no previous experiences have been evaualted in detail. The following tables include the main characteristics of the interventions evaluated.

- **Intervention 1: “Electric vehicles: Electric Bus Up-take (140)”**

This intervention consists in the progressive implantation of electric buses to the Helsinki fleet, analyses the costs of a single bus. This is because with the progressive implementation, costs may vary to some extent throughout the different years in which the implementation occurs, as well as the models of the buses or any of its components broken down.

Table 12: Cost breakdown related to cost categories according to a LCC analysis for the intervention 1

Cost categories	Cost breakdown	Cost breakdown (%)
Design and acquisition phase	E-vehicle cost (without the battery cost)	51,48%
	Battery cost	15,44%
	E-vehicle charger cost	30,89%
	Grid connection works	2,06%
	Taxes	0,00%
Operation phase	Grid electricity price (variable costs of the electricity)	0,00%
	Grid electricity base-price (fixed costs)	0,12%
	Operation & Maintenance cost (materials)	0,00%

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

	Operation & Maintenance costs (labour)	0,00%
	Tax (Fee per year)	0,00%
	Insurance costs (Fee per year)	0,00%
Disposal phase	Scrap value of vehicle	0,00%
	Battery recycling cost	0,00%

Table 13: Data gathering template (CAPEX and OPEX) for the disaggregation of costs for the intervention 1

Project / intervention lifetime: 20 years				
Cost breakdown	Costs	Unit	Specific lifetime of the component (years)	Total cost in the lifetime (including replacement)
E-vehicle cost (without the battery cost)	500.000,00	€	20	500.000,00 €
Battery cost	50.000,00	€	7	150.000,00 €
E-vehicle charger cost	300.000,00	€	20	300.000,00 €
Grid connection works	20.000,00	€	-	20.000,00 €
Taxes	0,00	€		- €
Grid electricity price (variable costs of the electricity)	0,05	€/kWh	20	- €
Grid electricity base-price (fixed costs)	5,00	€/month	240 months	1.200,00 €
Operation & Maintenance cost (materials)	To be updated	€/year	20	- €
Operation & Maintenance costs (labour)	To be updated	€/year	20	- €
Tax (Fee per year)	0,00	€/year	20	- €
Insurance costs (Fee per year)	0,00	€/year	20	- €
Scrap value of vehicle	0,00	€		- €
Battery recycling cost	0,00	€		- €

The data of the tables above take also into account the information by bus so as not to distort the figures and make it difficult to understand, and since the years of implementation are different the costs of the 140 e-buses at a single time should not be taken into account.

As reflected in the Table 13, costs of the operation phase are quite unknown, since this is a pilot intervention and some of these costs (insurance, operation and maintenance, etc.) are difficult to evaluate at the moment. Disposal phase is also unknown right now since it is an innovative intervention and how the different components will be recycled or reutilized in some way few years ahead are unknown at this time. But taken into account that these figures can't be too large in comparison with the costs that are already available (the most relevant and expensive components), the action can be evaluated quite correctly.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

To understand the procedure, it is very important the intervention lifetime figure, which is 20 years in this case. The costs of the intervention will be evaluated for a bus during that period of time. It follows that the battery will have to be replaced twice (so its cost is multiplied by 3) and the final cost for this component includes the purchase of three batteries. The fixed costs of the grid electricity price are 5 € per month, which is also multiplied by the 240 months of life of this project.

Taxes for the Design & Acquisition phase are 0,00 € because electric vehicles are tax-exempt from this registration tax, and they are also free for the taxes of the Operation phase (e-vehicles neither pays the circulation tax). Disposal phase does not have available data since it is a very innovative intervention and there have not yet been experiences on which to be able to estimate any figure.

- **Intervention 2: "Charging points: Electro-mobility charging node"**

This intervention analyses the costs of the implementation of an electro-mobility charging node for the charging of the buses and the maintenance and commercial logistic fleet. As it is an innovative intervention starting from scratch, the cost breakdown includes the costs of the design, the different pieces needed and the mounting and installation. In the operation phase there are included grid electricity prices and Operation and Maintenance costs.

For the disposal phase there are no costs known for this intervention, since it is very innovative and it is unknown what will be done with the generated waste or how the materials can be reused when their estimated lifetime is finished.

Table 14: Cost breakdown related to cost categories according to a LCC analysis for the intervention 2

Cost categories	Cost breakdown	Cost breakdown (%)
Design and aquisition phase	Design and engineering costs	8,73%
	External charger connector housing cost	12,90%
	Water-cooled charging cable cost	9,11%
	DC and communication cabling cost	1,02%
	Delivery and installation costs	15,10%
Operation phase	Construction/ Foundation works	7,59%
	Grid electricity price (variable costs of the electricity)	0,00%
	Grid electricity base-price (fixed costs)	9,11%
	Operation & Maintenance cost (materials)	9,11%
	Operation & Maintenance costs (labour)	27,32%
Disposal phase	End of life costs	0,00%

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

Table 15: Data gathering template (CAPEX and OPEX) for the disaggregation of costs for the intervention 2

Project / intervention lifetime: 20 years

Cost breakdown	Costs	Unit	Specific lifetime of the component (years)	Total cost in the lifetime (including replacement)
Design and engineering costs	11.500,00	€		11.500,00 €
External charger connector housing cost	17.000,00	€	20	17.000,00 €
Water-cooled charging cable cost	3.000,00	€	5	12.000,00 €
DC and communication cabling cost	1.350,00	€	20	1.350,00 €
Delivery and installation costs	19.900,00	€		19.900,00 €
Construction/ Foundation works	10.000,00	€	20	10.000,00 €
Grid electricity price (variable costs of the electricity)	0,05	€/kWh	20	- €
Grid electricity base-price (fixed costs)	50,00	€/month	240 months	12.000,00 €
Operation & Maintenance cost (materials)	600,00	€/year	20	12.000,00 €
Operation & Maintenance costs (labour)	1.800,00	€/year	20	36.000,00 €
End of life costs	0,00	€		- €

As it is showed in the Table 15, in design and acquisition phase there are some costs that occur once in a lifetime (the design and engineering costs and delivery and installation ones), so they have not been assigned a specific lifetime in that corresponding column. The rest of components have their specific lifetime and it has been related with the intervention lifetime to do the analysis, which is 20 years. Thus, the water-cooled charging cable cost is multiplied by 4 to calculate the total cost in its lifetime because it is supposed a specific lifetime of 5 years so it will be necessary to replace it three times (plus the first acquisition) in the project lifetime (20 years).

In operation phase, the construction (and foundation) works are a cost that will also take place once in the lifetime of the project, so, as in the previous phase, no specific lifetime has been assigned to that column. The variable price of electricity could not be obtained because it is not a constant value and as the action has not been started there is no data to be able to make an estimate. In addition, it has to take into account that these electrical costs are not typical of the charging station but the expense that the vehicles will make when they are recharged, so that these expenses would most conveniently be within the operating expenses of the recharged electric vehicles. The cost that would be more relevant for this intervention is the fixed electricity one, which is charged monthly and had been taken into account for the 240 months of the project lifetime. There are also Operation and Maintenance (O&M) costs of materials and labour that has been multiplied by the 20 years of the lifetime of the project.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

The disposal phase could not be calculated because there are no data about the end of life of the components of this interventions or about how to recycle them.

- **Intervention 3: "Smart demand response system. Smart lights control in Viikki Environment House"**

This intervention analyses the implementation of the smart control in Viikki Environment House within IoT Thermostats installed.

Table 16: Cost breakdown related to cost categories according to a LCC analysis for the intervention 3

Cost categories	Cost breakdown	Cost breakdown (%)
Design & Acquisition phase	IoT Thermostats (Including installation) cost	64,80%
	Lithium batteries cost	2,62%
	Smart heat management, predictive maintenance and work for battery change cost	9,73%
	WIFI extension (for IoT devices) cost	11,06%
Operation phase	Operation & Maintenance cost (materials)	2,36%
	Operation & Maintenance costs (labour)	9,43%
Disposal phase	Scrap value of thermostat	0,00%

Table 17: Data gathering template (CAPEX and OPEX) for the disaggregation of costs for the intervention 3

Project / intervention lifetime: 4 years				
Cost breakdown	Costs	Unit	Specific lifetime of the component (years)	Total cost in the lifetime (including replacement)
IoT Thermostats (Including installation) cost	24.210,00	€	10	26.631,00 €
Lithium batteries cost	538,00	€	2	1.076,00 €
Smart heat management, predictive maintenance and work for battery change cost	4.000,00	€		4.000,00 €
WIFI extension (for IoT devices) cost	4.545,45	€		4.545,45 €
Operation & Maintenance cost (materials)	242,10	€/year	4	968,40 €
Operation & Maintenance costs (labour)	968,40	€/year	4	3.873,60 €
Scrap value of thermostat	0,00	€		- €

In design and acquisition phase, the total number of IoT Thermostats is 269, and this figure is taken into account for the costs of the thermostats and for the batteries. Each thermostat has a cost of 90 €, and its specific lifetime is about 10 years, so it will be enough with a single purchase for the whole project lifetime, which is 4 years. Although no replacement will be needed, a security coefficient (1,1) has been taken into

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

account in order to ensure that possible additional costs that may occur due to failures of parts of the hardware are taken into account. This causes the total cost column to multiply the cost of the IoT Thermostats by 1,1.

The batteries have a cost of 2,00 € each, and have a specific lifetime of 2 years, so in this case they will have to be replaced in the middle of the intervention, so their cost is multiplied by two. Smart heat management and WIFI extension are costs that only take place during the implementation phase, so they don’t have a specific lifetime figure assigned in the corresponding column.

Operation phase is reduced compared to other interventions since, being devices that work with battery, no electricity costs are produced. In this phase, only O&M costs in materials and labour take place, whose figures are given per year and multiplied by the four years of lifetime of the project.

Regarding disposal phase, it is unknown the way in which thermostats can be recycled since they can be reconditioned several times to extend their useful life and it is a very innovative intervention, so the scrap value of thermostats cannot be calculated for now.

- **Intervention 4: “Retrofitting of Merihaka-Vilhonvuori; Building (12) and flat (1323) retrofitting and 167 with smart thermostats”**

This intervention is about calculating the costs of implementation of smart thermostats connected to a District Heating during a period of 3 years.

Table 18: Cost breakdown related to cost categories according to a LCC analysis for the intervention 4

Cost categories	Cost breakdown	Cost breakdown (%)
Design & Acquisition phase	Smart thermostats cost	21,08%
	Adapter set cost	3,67%
	Gateway cost	15,11%
	Temperature sensor (ambient) cost	7,22%
	Temperature sensor (heating water) cost	11,79%
Operation phase	Operation & Maintenance cost (materials + labour)	41,12%
Disposal phase	Scrap value of thermostat	0,00%

This project has received funding from the European Union‘s Horizon 2020 research and innovation programme under grant agreement No 731297.

Table 19: Data gathering template (CAPEX and OPEX) for the disaggregation of costs for the intervention 4

Project / intervention lifetime: 3 years				
Cost breakdown	Costs	Unit	Specific lifetime of the component (years)	Total cost in the lifetime (including replacement)
Smart thermostats cost	85,56	€/unit	3	36.987,59 €
Adapter set cost	14,88	€ /unit	3	6.432,62 €
Gateway cost	144,34	€/unit	3	26.514,52 €
Temperature sensor (ambient) cost	68,94	€/unit	3	12.665,01 €
Temperature sensor (heating water) cost	112,59	€/unit	3	20.683,15 €
Operation & Maintenance cost (materials + labour)	24.048,00	€/year	3	72.144,00 €
Scrap value of thermostat	0,00	€		- €

The initial costs of the components included in the Table 19 are specified in an unitary way (by element), so to calculate the total cost of each component it is multiplied the unit cost by the number of units needed. Unitary prices include VAT 24%.

In the design and acquisition phase, unitary priced are multiplied by the total number of each component to obtain the total cost. As the project lifetime is 3 years, it is not going to be necessary to replace any component since the specific lifetime of all the components is longer than the project duration. But a security coefficient has been taken into account for possible unforeseen occasional costs that may occur due to hardware failures. This is a coefficient of 10% that has been added in the total cost column, when costs have been multiplied by 1,1.

Smart thermostats number of units is 393 to be implemented in the 167 apartments. The number of thermostats is higher than the number of apartments because there are more than one per apartment since depending on the size of the flat, the amount of water radiators is different, being 393 the total count of these radiators in which smart thermostats are going to be installed. An adapter set is needed for each smart thermostat installed, so the number of them is also 393.

Gateway, as well as the temperature sensors (both ambient and heating water), are needed one per apartment, so the total amount are 167 as there is the total number of flats.

In operation phase, as in the previous intervention, there are no grid electricity costs, so the disaggregation is reduced to the Operation and Maintenance costs, which are 12 € per user by month, so to obtain the annual value has been multiplied by the 167 users (number of apartments) and by the months in a year. In the total cost column this value has been obtained for the 3 years of project lifetime.

Disposal phase could not be completed since it is unknown what the scrap value of the thermostats may be.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

- **Intervention 5: "Smart public space (street) lighting"**

This intervention aimed to install dynamic and adaptive LED lighting in smart public spaces, analyses the cost of the different components that intervene in the implementation of smart street lamps. Tables 20 and 21 show the main information gathered for the intervention 5.

Table 20: Cost breakdown related to cost categories according to a LCC analysis for the intervention 5

Cost categories	Cost breakdown	Cost breakdown (%)
Design & Acquisition phase	Lamp and lamp driver cost	27,11%
	Lamp post cost	1,59%
	Light sensor cost	0,71%
	Cabinet controller cost	26,99%
	Central controller cost	1,90%
	Energy sensors for Cabinets cost	1,91%
	Relay unit cost	2,14%
	Installation works	15,66%
Operation phase	Grid electricity price	3,51%
	Operation & Maintenance cost (materials + labour)	18,49%
Disposal phase	End of life costs	0,00%

Table 21: Data gathering template (CAPEX and OPEX) for the disaggregation of costs for the intervention 5

Project / intervention lifetime: 15 years

Cost breakdown	Costs	Unit	Specific lifetime of the component (years)	Total cost in the lifetime (including replacement)
Lamp and lamp driver cost	22.667,20	€	15	31.734,08 €
Lamp post cost	1.326,80	€	15	1.857,52 €
Light sensor cost	593,96	€	15	831,54 €
Cabinet controller cost	22.568,00	€	15	31.595,20 €
Central controller cost	1.587,20	€	15	2.222,08 €
Energy sensors for Cabinets cost	1.599,60	€	15	2.239,44 €
Relay unit cost	1.790,56	€	15	2.506,78 €
Installation works	13.094,40	€		18.332,16 €
Grid electricity price	0,11	€/kWh	15	4.110,00 €
Operation & Maintenance cost (materials + labour)	36,08	€/year /unit	15	21.648,00 €
End of life costs	0,00	€		- €

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

Design and acquisition phase prices include VAT 24%. The component cost column of the Table 21 reflects the prices of the total items. Single costs of the different elements have been multiplied by the number of components implemented and by 1,24 to get prices with VAT, so the following unitary prices have not the VAT included.

The lamps with the lamp drivers have a unit cost of 457 €, and there are 40 of them installed in the intervention. Lamp post unitary cost is 107 €, with 10 of them installed. There is a single light sensor installed with a price of 479 €. The 10 cabinet controllers installed have a cost of 1820 € each one. The single central controller implemented has a cost of 1280 €. 20 energy sensors are needed for the cabinets with a cost of 64,5 € each one. The number of relay units is 4, and each one has a price of 361,00 €.

Installation work is the last component from this long list and has not being assigned a specific lifetime since it is an expense that only occurs once at the beginning of the project. The rest of the components of this first phase have a specific lifetime similar to that of the project (15 years), so they are not considered replacement of any of these elements. However, and to take into account unforeseen hardware failures, they have all multiplied by 1,4 in the Total cost column, as a security coefficient since there are no cost assigned to replace the components.

Operation phase has only two components, the grid electricity, given as a single total cost, and the O&M cost, including materials and labour, calculated from an annual fee of 36,08 € per unit, which is multiplied by the number of years of the intervention and by the total number of elements (40 lamps).

End of life costs, which corresponds to disposal phase, are not known since this intervention is very innovative and there is no data to make even an estimate.

- **Intervention 6: "Solar power plant implementation (500 kWp) for Messukeskus, Helsinki Expo and Convention Centre"**

This intervention consisting of the implementation of solar power plant, analyses the cost of the different components needed for the installation and maintenance of 1589 solar photovoltaic panels during a project lifetime of 25 years.

It is a power plant purchased as a complete solution for a price of 378.800,00 €, which is 469.712,00 € including VAT. This is the total cost of the design and acquisition phase, which has been disaggregated into components with their corresponding figure, which represent, in turn, a percentage of this total cost of the acquisition phase. As shown in the Table 22, the percentages of the first purchase are shown below (which are different from the percentages of the complete intervention). Solar PV panels represent the 41%, 9% corresponds to the inverter, 31% of this expense corresponds to the mounting system and

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

installation, 6% corresponds to other installations (electricity) and the remaining 13% corresponds to other costs as the planning and project management.

Table 22: Cost breakdown related to cost categories according to a LCC analysis for the intervention 6

Cost categories	Cost breakdown	Cost breakdown (%)
Design & Acquisition phase	Solar PV panel cost	31,68%
	Inverter cost	13,91%
	Installation works	23,96%
	Planning and project management cost	10,05%
	Electric installation cost	4,64%
Operation phase	Operation & Maintenance cost (materials + labour)	10,20%
Disposal phase	Panels recycling cost	5,57%

Within the disaggregation showed in the Table 22, there are a few components that are needed only once in the entire project (installation works, planning and project management, and electric installation. It is estimated that the solar panels will not have to be replaced during the project, since they have a longer useful life than that of the intervention. So the only component that will need to be replaced during the 25 years of duration of this project is the inverter, whose specific lifetime is 15 years, so it has multiplied by 2 in the total cost column.

Table 23: Data gathering template (CAPEX and OPEX) for the disaggregation of costs for the intervention 6

Project / intervention lifetime: 25 years

Cost breakdown	Costs	Unit	Specific lifetime of the component (years)	Total cost in the lifetime (including replacement)
Solar PV panel cost	192.581,92	€	25	192.581,92 €
Inverter cost	42.274,08	€	15	84.548,16 €
Installation works	145.610,72	€		145.610,72 €
Planning and project management cost	61.062,56	€		61.062,56 €
Electric installation cost	28.182,72	€		28.182,72 €
Operation & Maintenance cost (materials + labour)	2.480,00	€/year	25	62.000,00 €
Panels recycling cost	33.831,08	€		33.831,08 €

In the operation phase there is only the O&M component, including materials and labour, calculated from a 2000 € fee per year without VAT, in which VAT has been added in the cost column of the Table 23, and this cost has been multiplied by the 25 years of project lifetime in the Total cost column.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

The recycling cost is calculated from the price known of the recycling cost for electric and electronic components, since there are no specific recycling systems for solar power plants in Finland because the plants are so young. So, the recycling cost for electricity and electronic components is 1,01 €/kg, and as Solar Power plant of Messukeskus has 1589 panels and each panel is 17 kg, it is obtained the end of life cost by multiplying: 17 kg/panel x 1589 panels x 1,01 €/kg. Mounting systems which are made in aluminium doesn't need to be recycling as they will be able to be sold forward. All of these costs of the disposal phase are calculated from the current prices since the prices in 25 years are not known for now.

6.1.4.2 Step II Assignment of each cost component with the corresponding subsector or commodity

In this step (detailed in section 5.4.2), the correspondence between the different components of the interventions and the commodity is established, using the IO tables based on the CPA Statistical Classification of Products by Activity. With this correspondence, a better understanding of the costs breakdown is achieved, so that its subsequent evaluation at city level is also facilitated. As the disaggregation of the components of the different actions, as well as the obtaining of their costs, is sufficiently clarified and explained one by one in Step I, in this second Step only the tables appear with the corresponding relation of the component with the commodities. The following Tables (24-29) show the main characteristics for each intervention.

- **Intervention 1: "Electric vehicles: Electric Bus Up-take (140)"**

Table 24: Assignment of the cost component with the corresponding subsector or commodity for the intervention 1.

Component	CODE	Commodity
E-vehicle (without the battery)	CPA_C29	Motor vehicles, trailers and semi-trailers
Battery	CPA_C27	Electrical equipment
E-vehicle charger	CPA_C27	Electrical equipment
Grid connection works	CPA_C33	Repair and installation services of machinery and equipment
Taxes	CPA_K64	Financial services, except insurance and pension funding
Grid electricity price (variable costs of the electricity)	CPA_D35	Electricity, gas, steam and air-conditioning
Grid electricity base-price (fixed costs)	CPA_D35	Electricity, gas, steam and air-conditioning
Operation & Maintenance (materials)	CPA_C27	Electrical equipment
Operation & Maintenance (labour)	CPA_C33	Repair and installation services of machinery and equipment
Tax (Fee per year)	CPA_K64	Financial services, except insurance and pension funding
Insurance (Fee per year)	CPA_K65	Insurance, reinsurance and pension funding services, except compulsory and social security
Scrap value of vehicle	CPA_E37-E39	Sewerage; waste collection, treatment and disposal activities; materials recovery; remediation activities and other waste management services
Battery recycling	CPA_E37-E39	Sewerage; waste collection, treatment and disposal activities; materials recovery; remediation activities and other waste management services

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

- **Intervention 2: "Charging points: Electro-mobility charging node"**

Table 25: Assignment of the cost component with the corresponding subsector or commodity for the intervention 2.

Component	CODE	Commodity
Design and engineering	CPA_M71	Architectural and engineering services; technical testing and analysis services
External charger connector housing	CPA_C27	Electrical equipment
Water-cooled charging cable	CPA_C27	Electrical equipment
DC and communication cabling	CPA_C27	Electrical equipment
Delivery and installation	CPA_C33	Repair and installation services of machinery and equipment
Construction/ Foundation works	CPA_F42	Constructions and construction works for civil engineering
Grid electricity price (variable costs of the electricity)	CPA_D35	Electricity, gas, steam and air-conditioning
Grid electricity base-price (fixed costs)	CPA_D35	Electricity, gas, steam and air-conditioning
Operation & Maintenance (materials)	CPA_C27	Electrical equipment
Operation & Maintenance (labour)	CPA_C33	Repair and installation services of machinery and equipment
End of life	CPA_E37-E39	Sewerage; waste collection, treatment and disposal activities; materials recovery; remediation activities and other waste management services

- **Intervention 3: "Smart demand response system. Smart lights control in Viikki Environment House"**

Table 26: Assignment of the cost component with the corresponding subsector or commodity for the intervention 3.

Component	CODE	Commodity
IoT Thermostats (Including installation)	CPA_C26	Computer, electronic and optical products
Lithium batteries	CPA_C27	Electrical equipment
Smart heat management, predictive maintenance and work for battery change	CPA_J62_J63	Computer programming, consultancy and related services; information services
WIFI extension (for IoT devices)	CPA_J61	Telecommunications services
Operation & Maintenance (materials)	CPA_C27	Electrical equipment
Operation & Maintenance (labour)	CPA_C33	Repair and installation services of machinery and equipment
Scrap value of thermostat	CPA_E37-E39	Sewerage; waste collection, treatment and disposal activities; materials recovery; remediation activities and other waste management services

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

- **Intervention 4: "Retrofitting of Merihaka-Vilhonvuori; Building (12) and flat (1323) retrofitting and 167 with smart thermostats"**

Table 27: Assignment of the cost component with the corresponding subsector or commodity for the intervention 4.

Component	CODE	Commodity
Smart thermostats	CPA_C26	Computer, electronic and optical products
Adapter set	CPA_C27	Electrical equipment
Gateway	CPA_C26	Computer, electronic and optical products
Temperature sensor (ambient)	CPA_C26	Computer, electronic and optical products
Temperature sensor (heating water)	CPA_C26	Computer, electronic and optical products
Operation & Maintenance (materials + labour)	CPA_C33	Repair and installation services of machinery and equipment
Scrap value of thermostat	CPA_E37-E39	Sewerage; waste collection, treatment and disposal activities; materials recovery; remediation activities and other waste management services

- **Intervention 5: "Smart public space (street) lighting"**

Table 28: Assignment of the cost component with the corresponding subsector or commodity for the intervention 5.

Component	CODE	Commodity
Lamp and lamp driver	CPA_C27	Electrical equipment
Lamp post	CPA_C25	Fabricated metal products, except machinery and equipment
Light sensor	CPA_C26	Computer, electronic and optical products
Cabinet controller	CPA_C26	Computer, electronic and optical products
Central controller	CPA_C26	Computer, electronic and optical products
Energy sensors for Cabinets	CPA_C26	Computer, electronic and optical products
Relay unit	CPA_C27	Electrical equipment
Installation works	CPA_C33	Repair and installation services of machinery and equipment
Grid electricity price	CPA_D35	Electricity, gas, steam and air-conditioning
Operation & Maintenance (materials + labour)	CPA_C33	Repair and installation services of machinery and equipment
End of life	CPA_E37-E39	Sewerage; waste collection, treatment and disposal activities; materials recovery; remediation activities and other waste management services

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

- **Intervention 6: "Solar power plant implementation (500 kWp) for Messukeskus, Helsinki Expo and Convention Centre"**

Table 29: Assignment of the cost component with the corresponding subsector or commodity for the the intervention 6.

Component	CODE	Commodity
Solar PV panel	CPA_C25	Fabricated metal products, except machinery and equipment
Inverter	CPA_C27	Electrical equipment
Installation works	CPA_C33	Repair and installation services of machinery and equipment
Planning and project management	CPA_M71	Architectural and engineering services; technical testing and analysis services
Electric installation	CPA_C33	Repair and installation services of machinery and equipment
Operation & Maintenance (materials + labour)	CPA_C33	Repair and installation services of machinery and equipment
Panels recycling	CPA_E37-E39	Sewerage; waste collection, treatment and disposal activities; materials recovery; remediation activities and other waste management services

6.1.4.3 Step III Evaluation of the capacities for the manufacturing and distribution of each cost component (commodity/subsector) in each city

Tables (30-35) included in this section describe the main characteristics related to the capacities for the manufacturing and distribution of each cost component (commodity/subsector) in the city. This is a relevant aspect that influences the import share of each component and therefore the actual increase of the local production of commodities.

- **Intervention 1: "Electric vehicles: Electric Bus Up-take (140)"**

Table 30: Analysis of the capacities for the manufacturing and distribution of each cost component (commodity/subsector) for the intervention 1

Cost breakdown	Local (city level)		Regional level	
	Local producer? (YES/NO)	Local distribution / stockist? (YES/NO)	Local producer? (YES/NO)	Local distribution / stockist? (YES/NO)
E-vehicle cost (without the battery cost)	NO	NO	YES	YES
Battery cost	NO	NO	NO	NO
E-vehicle charger cost	NO	NO	YES	YES
Grid connection works	YES	YES		
Taxes				
Grid electricity price (variable costs of the electricity)	YES	YES		
Grid electricity base-price (fixed costs)	YES	YES		
Operation & Maintenance cost (materials)				
Operation & Maintenance costs (labour)				

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

Tax (Fee per year)				
Insurance costs (Fee per year)				
Scrap value of vehicle				
Battery recycling cost				

For the components indicated with a YES in the local production and distribution, the specific localized companies are Helen Sähköverkko Oy for the Grid connection works, and Helen Oy for the Grid electricity (both variable and fixed costs). Regarding the components identified with producers and distributors at the regional level, the planned companies are Linkker for the electric vehicles (e-buses) and Plugit Finland for the chargers of the e-vehicles.

- **Intervention 2: "Charging points: Electro-mobility charging node"**

Table 31: Analysis of the capacities for the manufacturing and distribution of each cost component (commodity/subsector) for the intervention 2

Cost breakdown	Local (city level)		Regional level	
	Local producer? (YES/NO)	Local distribution / stockist? (YES/NO)	Local producer? (YES/NO)	Local distribution / stockist? (YES/NO)
Design and engineering costs	NO	NO	NO	
External charger connector housing cost	NO	NO	NO	
Water-cooled charging cable cost	NO	NO	NO	
DC and communication cabling cost	NO	NO	NO	
Delivery and installation costs	NO	NO		
Construction/ Foundation works	YES	YES		
Grid electricity price (variable costs of the electricity)	YES	YES		
Grid electricity base-price (fixed costs)	YES	YES		
Operation & Maintenance cost (materials)	NO	NO	NO	NO
Operation & Maintenance costs (labour)	NO	NO	NO	NO
End of life costs				

The specific companies for those components that have been identified as having local production and distribution are Stara for the construction and foundation works, and Helen Oy for the grid electricity (within the operation phase), for both variable and fixed costs of the electricity. Apart from these two local companies, there is no company identified in the region for the production of the other components, the company in charge of all of them is Ekoenergetyka Polska, a Polish company, and, therefore, from outside from the country itself.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

- **Intervention 3: "Smart demand response system. Smart lights control in Viikki Environment House"**

Table 32: Analysis of the capacities for the manufacturing and distribution of each cost component (commodity/subsector) for the intervention 3

Cost breakdown	Local (city level)		Regional level	
	Local producer? (YES/NO)	Local distribution / stockist? (YES/NO)	Local producer? (YES/NO)	Local distribution / stockist? (YES/NO)
IoT Thermostats (Including installation) cost	NO	YES	NO	YES
Lithium batteries cost	NO	YES	YES	YES
Smart heat management, predictive maintenance and work for battery change cost	YES	YES	YES	YES
WIFI extension (for IoT devices) cost	YES	YES	YES	YES
Operation & Maintenance cost (materials)				
Operation & Maintenance costs (labour)				
Scrap value of thermostat				

Two local companies have been identified for the production and distribution of two components of this intervention. Fourdeg Oy will take over the Smart heat management and predictive maintenance, and SuomiCOM Oy is the company in charge of the WIFI extension for IoT devices. At regional level, one more has been identified, Valostore Oy, responsible for the manufacture of lithium batteries,

- **Intervention 4: "Retrofitting of Merihaka-Vilhonvuori; Building (12) and flat (1323) retrofitting and 167 with smart thermostats"**

Table 33: Analysis of the capacities for the manufacturing and distribution of each cost component (commodity/subsector) for the intervention 4

Cost breakdown	Local (city level)		Regional level	
	Local producer? (YES/NO)	Local distribution / stockist? (YES/NO)	Local producer? (YES/NO)	Local distribution / stockist? (YES/NO)
Smart thermostats cost	NO	NO	YES	YES
Adapter set cost	NO	NO	YES	YES
Gateway cost	NO	NO	YES	NO
Temperature sensor (ambient) cost	NO	NO	YES	
Temperature sensor (heating water) cost	NO	NO	YES	
Operation & Maintenance cost (materials + labour)	NO	NO	YES	
Scrap value of thermostat				

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

For this intervention no local companies have been identified that can take the production of any of the components.

As for regional level, several specific companies have been identified, Danfoss for the Smart thermostats and the adapter set, NQ as regional producer of the gateway. Fibaro for the temperature sensors (both ambient and heating water), and Salusfin will handle the Operation and Maintenance (including both materiales and labour).

- **Intervention 5: "Smart public space (street) lighting"**

Table 34: Analysis of the capacities for the manufacturing and distribution of each cost component (commodity/subsector) for the intervention 5

Cost breakdown	Local (city level)		Regional level	
	Local producer? (YES/NO)	Local distribution / stockist? (YES/NO)	Local producer? (YES/NO)	Local distribution / stockist? (YES/NO)
Lamp and lamp driver cost	NO	YES	NO	NO
Lamp post cost	NO	YES	NO	NO
Light sensor cost	NO	YES	NO	NO
Cabinet controller cost	NO	YES	NO	NO
Central controller cost	NO	YES	NO	NO
Energy sensors for Cabinets cost	NO	YES	NO	NO
Relay unit cost	NO	YES	NO	NO
Installation works	YES	NO	NO	NO
Grid electricity price				
Operation & Maintenance cost (materials + labour)				
End of life costs				

In this intervention, no local or regional producers have been identified for any of the components, except for the installation works, which will be commissioned by a local company. However, they do have local distributors for all the components.

- **Intervention 6: "Solar power plant implementation (500 kWp) for Messukeskus, Helsinki Expo and Convention Centre"**

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

Table 35: Analysis of the capacities for the manufacturing and distribution of each cost component (commodity/subsector) for the intervention 6

Cost breakdown	Local (city level)		Regional level	
	Local producer? (YES/NO)	Local distribution / stockist? (YES/NO)	Local producer? (YES/NO)	Local distribution / stockist? (YES/NO)
Solar PV panel cost	NO	NO	NO	NO
Inverter cost	NO	NO	YES	YES
Installation works	NO	NO	YES	YES
Planning and project management cost	YES	YES	YES	YES
Electric installation cost				
Operation & Maintenance cost (materials + labour)				
Panels recycling cost				

For this intervention a local company has been located for the production (and distribution) of the planning and project management: Helen Ldt. at a regional level, ABB will take care of the inverter, and Green Energy Finland will take care of the installation works. The production and distribution of Solar PV panels is from outside the region, a company even outside Europe, JA Solar.

6.1.4.4 Step IV Identification of the main stakeholder related to each cost component

Tables 36-41 included in this section describe the main characteristics related to the main stakeholder related to each cost component in the city. This is a relevant aspect considering that it shows who is making the investments.

- **<u>Intervention 1: “Electric vehicles: Electric Bus Up-take (140)”</u>**

Table 36: Analysis of the main stakeholder related to each cost component (commodity/subsector) for the intervention 1

Cost breakdown	Costs	Unit	Who makes the payment?			
			% paid with public funding (Out of the region)	% paid with public (Regional) funding	% paid by the individual (citizens)	% paid by private companies
E-vehicle cost (without the battery cost)	500.000,00	€	0 %	0 %	0 %	100 %
Battery cost	50.000,00	€	0 %	0 %	0 %	100 %
E-vehicle charger cost	300.000,00	€	0 %	100 %	0 %	0 %
Grid connection works	20.000,00	€	0 %	100 %	0 %	0 %
Taxes	0,00	€	0 %	0 %	0 %	0 %

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

Grid electricity price (variable costs of the electricity)	0,05	€/kWh	0 %	0 %	0 %	100 %
Grid electricity base-price (fixed costs)	5,00	€/month	0 %	100 %	0 %	0 %
Operation & Maintenance cost (materials)	0,00	€/year	0 %	0 %	0 %	0 %
Operation & Maintenance costs (labour)	0,00	€/year	0 %	0 %	0 %	0 %
Tax (Fee per year)	0,00	€/year	0 %	0 %	0 %	0 %
Insurance costs (Fee per year)	0,00	€/year	0 %	0 %	0 %	0 %
Scrap value of vehicle	0,00	€	0 %	0 %	0 %	0 %
Battery recycling cost	0,00	€	0 %	0 %	0 %	0 %

- **<u>Intervention 2: "Charging points: Electro-mobility charging node"</u>**

Table 37: Analysis of the main stakeholder related to each cost component (commodity/subsector) for the intervention 2

			Who makes the payment?			
Cost breakdown	Costs	Unit	% paid with public funding (Out of the region)	% paid with public (Regional) funding	% paid by the individual (citizens)	% paid by private companies
Design and engineering costs	11.500,00	€	100 %	0 %	0 %	0 %
External charger connector housing cost	17.000,00	€	100 %	0 %	0 %	0 %
Water-cooled charging cable cost	3.000,00	€	100 %	0 %	0 %	0 %
DC and communication cabling cost	1.350,00	€	100 %	0 %	0 %	0 %
Delivery and installation costs	19.900,00	€	100 %	0 %	0 %	0 %
Construction/ Foundation works	10.000,00	€	100 %	0 %	0 %	0 %
Grid electricity price (variable costs of the electricity)	0,05	€/kWh	0 %	50 %	0 %	50 %
Grid electricity base-price (fixed costs)	50,00	€/month	0 %	100 %	0 %	0 %
Operation & Maintenance cost (materials)	600,00	€/year	0 %	100 %	0 %	0 %
Operation & Maintenance costs (labour)	1.800,00	€/year	0 %	100 %	0 %	0 %
End of life costs	0,00	€	0 %	0 %	0 %	0 %

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

- **Intervention 3: "Smart demand response system. Smart lights control in Viikki Environment House"**

Table 38: Analysis of the main stakeholder related to each cost component (commodity/subsector) for the intervention 3

			Who makes the payment?			
Cost breakdown	Costs	Unit	% paid with public funding (Out of the region)	% paid with public (Regional) funding	% paid by the individual (citizens)	% paid by private companies
IoT Thermostats (Including installation) cost	24.210,00	€	0 %	100 %	0 %	0 %
Lithium batteries cost	538,00	€	0 %	100 %	0 %	0 %
Smart heat management, predictive maintenance and work for battery change cost	4.000,00	€	0 %	100 %	0 %	0 %
WIFI extension (for IoT devices) cost	4.545,45	€	0 %	100 %	0 %	0 %
Operation & Maintenance cost (materials)	242,10	€/year	0 %	0 %	0 %	0 %
Operation & Maintenance costs (labour)	968,40	€/year	0 %	0 %	0 %	0 %
Scrap value of thermostat	0,00	€	0 %	0 %	0 %	0 %

- **Intervention 4: "Retrofitting of Merihaka-Vilhonvuori; Building (12) and flat (1323) retrofitting and 167 with smart thermostats"**

Table 39: Analysis of the main stakeholder related to each cost component (commodity/subsector) for the intervention 4

			Who makes the payment?			
Cost breakdown	Costs	Unit	% paid with public funding (Out of the region)	% paid with public (Regional) funding	% paid by the individual (citizens)	% paid by private companies
Smart thermostats cost	85,56	€/unit	34 %	0 %	33 %	33 %
Adapter set cost	14,88	€ /unit	34 %	0 %	33 %	33 %
Gateway cost	144,34	€/unit	34 %	0 %	33 %	33 %
Temperature sensor (ambient) cost	68,94	€/unit	34 %	0 %	33 %	33 %
Temperature sensor (heating water) cost	112,59	€/unit	34 %	0 %	33 %	33 %
Operation & Maintenance cost (materials + labour)	24.048,00	€/year	0 %	0 %	12 %	88 %
Scrap value of thermostat	0,00	€	0 %	0 %	0 %	0 %

- **Intervention 5: "Smart public space (street) lighting"**

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

Table 40: Analysis of the main stakeholder related to each cost component (commodity/subsector) for the intervention 5

Cost breakdown	Costs	Unit	% paid with public funding (Out of the region)	% paid with public (Regional) funding	% paid by the individual (citizens)	% paid by private companies
			Who makes the payment?			
Lamp and lamp driver cost	22.667,20	€	0 %	100 %	0 %	0 %
Lamp post cost	1.326,80	€	0 %	100 %	0 %	0 %
Light sensor cost	593,96	€	0 %	100 %	0 %	0 %
Cabinet controller cost	22.568,00	€	0 %	100 %	0 %	0 %
Central controller cost	1.587,20	€	0 %	100 %	0 %	0 %
Energy sensors for Cabinets cost	1.599,60	€	0 %	100 %	0 %	0 %
Relay unit cost	1.790,56	€	0 %	100 %	0 %	0 %
Installation works	13.094,40	€	0 %	100 %	0 %	0 %
Grid electricity price	0,11	€/kWh	0 %	0 %	0 %	0 %
Operation & Maintenance cost (materials + labour)	36,08	€/year /unit	0 %	0 %	0 %	0 %
End of life costs	0,00	€	0 %	0 %	0 %	0 %

- **Intervention 6: "Solar power plant implementation (500 kWp) for Messukeskus, Helsinki Expo and Convention Centre"**

Table 41: Analysis of the main stakeholder related to each cost component (commodity/subsector) for the intervention 6

Cost breakdown	Costs	Unit	% paid with public funding (Out of the region)	% paid with public (Regional) funding	% paid by the individual (citizens)	% paid by private companie s
Solar PV panel cost	192.581,92	€	20 %	0 %	15 %	65 %
Inverter cost	42.274,08	€	20 %	0 %	15 %	65 %
Installation works	145.610,72	€	20 %	0 %	15 %	65 %
Planning and project management cost	61.062,56	€	20 %	0 %	15 %	65 %
Electric installation cost	28.182,72	€	20 %	0 %	15 %	65 %
Operation & Maintenance cost	2.480,00	€/year	0 %	0 %	0 %	0 %
Panels recycling cost	33.831,08	€	0 %	0 %	0 %	0 %

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

6.2 Case of Nantes

6.2.1 Phase I Selection of interventions

Based on the criteria described in section 5.1, the city of Nantes has selected the interventions that are briefly described below. They have been chosen among the whole set of interventions of mySMARTLife project.

Here are the actions selected for the supply chain analysis:

- Electric buses deployment
- Retrofitting of one multi-owner building (envelope and systems)
- Smart Lighting deployed in outdoor environment
- Solar PV Plant deployed on a public building (MIN): 30 000m2 PV, 5 MWc
- Digital boiler installations

6.2.2 Phase II Harmonization of interventions categories

With the aim of homogenizing as much as possible the technoeconomic analysis not only for the case of the lighthouse cities but also for the follower cities of the mySMARTLife project, the interventions mentioned above could be classified in the following intervention categories:

- **Mobility interventions**
  - Electric mobility
- **Energy efficiency for buildings:** Including all interventions related to the improvement of the efficiency of the systems integrated in the buildings as well as the interventions related to the improvement of the characteristics of the building envelope.
  - Retrofitting of buildings
- **Public lighting**
  - Smart Lighting
- **Renewable energy technologies**
  - Solar PV
  - Energy recovery systems (e.g. digital boiler)

According to the intervention categories described above, the interventions pre-selected in the lighthouse cities can be classified as it is showed in Table 42.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

Table 42: Categorization of interventions into intervention categories for the example described.

Intervention	Intervention category
Electric buses deployment	**Mobility interventions**
Retrofitting of one multi-owner building (envelope and systems)	**Energy efficiency for buildings**
Smart Lighting deployed in outdoor environment	**Public lighting**
Solar PV Plant deployed on a public building (MIN): 30 000m2 PV, 5 MWc	**Renewable energy technologies**
Digital boiler installations	**Renewable energy technologies**

6.2.3 Phase III Analysis of the socioeconomic and sectorial structure of each city/region

In the case of the city of Nantes, the analysis should include both the city and the region in which is located (Pays de la Loire region). Therefore, all the analysis compares the main characteristics of both scales.

The city of Nantes has a total **population** of 619.240 inhabitants (9,2% of total population in France). In terms of gender, Nantes has 296.500 (47,88%) male and 619.240 (52,12%) female. Regarding the population structure, 47,20% of inhabitants are under 35 years old; in terms of absolute values, the most significant age group is 25-34, with a total number of 87.262 (14,09%) inhabitants, followed by the age group 45-54, with a total number of 80.506 (13%) inhabitants, and by the age group 35-44, with a total number of 70.698 (12,87%) inhabitants [13]. In terms of fertility and deaths, the crude birth rate[6] and the crude death rate[7] for the city are 12,80 and 6,50 respectively.

For the Pays de la Loyre region[8], there is a total population of 3.742.638 inhabitants (5,6% of total population in France). In terms of gender, the region has 1.823.283 (48,72%) male and 1.919.335 for female (51,28%). In terms of age structure population, 716.735 (19,15%) inhabitants are less than 15 years old, 2.300.649 (61,47%) inhabitants are from 15 to 64 years old, and 725.254 (19,37%) inhabitants are over 65 years old. The average age of the population is 41.3 years old. In terms of fertility and deaths, the crude birth rate and the crude death rate for the city are 12,80 and 6,50.

[6] The crude birth rate is the ratio of the number of live births during the year to the average population in that year. The value is expressed per 1 000 persons.

[7] The crude death rate is the ratio of the number of deaths during the year to the average population in that year. The value is expressed per 1 000 persons.

[8] The data from the region follows the NUTS classification. In the case of Pays de la Loyre, the data used is from NUTS 2

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

In terms of **citizenship**, Nantes has 589.869 (95,30%) national inhabitants. Among the population without French citizenship, the city has 29.371 (4,74%) inhabitants. Regarding the whole population, 1,1% are from EU countries and 3,6% are from non-EU countries (2016, Eurostat. Regions and cities. City statistics). Regarding the background, almost 35% of the population has a migration background. This percentage increases up to 51,3% for inhabitants under 118 years old with migration background.

In Nantes, households have an average size of 2,10 persons. From the total number of households, 42,10% are one-person households. In terms of **households' wealthy**, for the case of the region, the income of households (in euro per inhabitant) measured in terms of primary incomes by national income is 20.500 €. This measure decreases to 18.500€ when looking at the disposable income.

Regarding **education levels**[9] in Nantes, 45,41% of the population aged between 25 and 64 years old has high tertiary education (university and higher education centers), 37,77% secondary education (upper secondary education, post-secondary) and 13,83% low or non-education (less than primary, primary or lower secondary education (2016, Eurostat. Regions and cities. City statistics). In the case of the region, taking into account the whole population, 32,20% has tertiary education, 49,70% secondary education (non tertiary), and 18,10 has low or non-education[13].

In terms of the **labor market**, the economically active population is constituted by 304.302 (49,14%) inhabitants, 154.446 (50,75%) for male and 149856 (49,25%) for female. Considering the active population, the unemployment rate is 13,30%, 13,40% for male and 13,30% for female. In the case of the region, the unemployment rate is 8,8%, 8,7% for male and 8,9% for female.

6.2.4 Phase VI Supply chain characterization of the interventions

All the interventions that will be evaluated in the current study are characterized in detail here, under the five subsections that follow.

6.2.4.1 Step I Disaggregation of costs per intervention

As explained in the previous section 5.4.1, in this first step the disaggregation into components and costs is carried out, which is the first stage of each intervention.

A classification in three cost categories has been made in order to clarify and better understand the different costs breakdown incurred for each of the interventions. This classification is composed of three phases: design and acquisition, operation and disposal phase.

[9] The education levels follow the International Standard Classification of Education ISCED

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

The costs of the first phase are those corresponding to CAPEX costs, which take place only once during the project lifetime or the number of times they must be replaced (when the useful life of the components is less than that of the project).

In the operation phase the costs included are those given throughout the project lifetime (per year generally), such as the grid electricity costs, taxes, insurances or the Operation & Maintenance ones.

In the disposal phase, the end of life of the most important components or those with the greatest impact due to their contamination degree or their complex recycling are calculated. As mentioned before it is an ambitious phase and difficult to achieve for some innovative interventions that have not yet had experiences in the recycling of its components, so it is sometimes impossible to estimate any figure in this regard.

The following tables (43-47) show the main characteristics regarding the supply chain cost distribution for each of the interventions evaluated.

- **Intervention 1:** Electric buses deployment

Table 43: Data gathering template (CAPEX and OPEX) for the disaggregation of costs for the intervention 1

Project / intervention lifetime: 12 years				
Cost breakdown	Costs/unit	Nb Units	Specific lifetime of the component (years)	Total cost in the specific lifetime (including replacement)
E-vehicle cost (without the battery cost)	1 100 000	22	20 to 30	24 200 000
Battery estimated cost	200 000	22	7 to 12	4 400 000
E-vehicle charger cost (one charging point) (600kW)	350 000	13	30	4 550 000
Design Charging point (one charging point)	30 000	13	-	390 000
E-véhicle mobile charging system (22kW)	58 000	1	30	58 000
Electical sub-station for two 600kW charging points (average)	320 000	6		1 920 000
Civil Works sub station for two 600kW charging points (average)	140 000	6	-	840 000
Grid connection	20 000	1		20 000
Taxes	-	-	-	-
Insurance	-	-	-	-
Grid electricity price (variable and fixed costs of the electricity + transport)	0,085	€ /kWh	-	-

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

Significant operation & Maintenance cost (materials and labour)	20 000	€/year.bus	-	-
Significant Operation & Maintenance cost (materials and labour)	2 500	€/year.charger	-	-

- **<u>Intervention 2:</u>** Retrofitting of one multi-owner building

Table 44: Data gathering template (CAPEX and OPEX) for the disaggregation of costs for the intervention 2

Project / intervention lifetime: 30 years			
Cost breakdown	Costs	Unit	Specific lifetime of the component (years)
Insulation of the walls	1 219 800	€	50
Insulation of ground floor	44 378	€	50
Insulation of the roof	46 945	€	50
Replacement of windows	318 673	€	30
Replacement of railings & metalworking	179 513	€	50
Electricity works (displacement of electrical networks)	12 478	€	-
Thermostatic valves	46 872	€	20
Replacement of the ventilation system	151 467	€	15
Connection to the district heating network	30 384	€	-
Networks balacing and sludge removal	12 512	€	-
Heaters and 1 individual hot-water tank	11 105		-
Inspection office &Health and Safety Officer	16 754	€	-
Architect / Technical design + construction site supervision	125 794	€	-
Property management company costs	21 676	€	-
Insurance costs	32 030	€	-
District heating cost (energy supply)	25 000	€/year	-
District heating cost (operation & maintenance)	11 100	€/year	-

- **<u>Intervention 3:</u>** Smart Lighting

Table 45: Data gathering template (CAPEX and OPEX) for the disaggregation of costs for the intervention 3

Project / intervention lifetime: 20 years			
Cost breakdown	Costs	Unit	Specific lifetime of the component (years)
LORAWAN BASE STATION (x1)	1499	€	20
InteliLIGHT FRE-220-NEMA (x50)	3950	€	10
InteliLIGHT FRE-220-P (x22)	1518	€	15
InteliLIGHT FRE-220-M (x17) + ANT601 (x19)	1400	€	10

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

Remote technical support for 1 year	238,2	€	-
Access to Intelilight Software	1	€/node/year	-
Access to LoRaWan Network	1	€/node/year	-
SIM Card contract	9,5	€/month	-

- **Intervention 4:** Solar PV Plant deployed on a public building (MIN)

Table 46: Data gathering template (CAPEX and OPEX) for the disaggregation of costs for the intervention 4

Project / intervention lifetime: 30 years				
Cost breakdown	Costs	Unit	Specific lifetime of the component (years)	Total cost in the lifetime (including replacement)
Solar PV panels	264 000	€	20 years	312000
Inverters and monitoring	38 000	€	10 years	94000
Other electrical equipment	90 400	€	-	-
Structure sizing studies and supports of the structure	150 000	€	-	-
Structure	124 000	€	-	-
Grid connection cost	11 000	€	-	-
Site management +studies + labour costs	85 350	€		-
Project development (legal, administrative, external provisions)	94 300	€	-	-
Communication and citizens mobilisation costs	30 600	€	-	-
Operation & Maintenance costs (labour)	19 100	€/year	-	-
Tax (Fee per year)	700	€/year	--	-
Insurance costs (Fee per year)	3 400	€/year	-	-
End of life costs of the panels	990	€	-	-

- **Intervention 5:** Digital boiler

Table 47: Data gathering template (CAPEX and OPEX) for the disaggregation of costs for the intervention 5

Project / intervention lifetime: 15 years			
Cost breakdown	Costs	Unit	Specific lifetime of the component (years)
Digital boiler Tebios	14 900	€	unknown
Water tank			15
Cooling system			15
Electrical box			-
Expansion tank			10
Pumps			10
Calories meter DIEHL Sharky 775			15
Energy supply contract over 15 years	15 000	€	-

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

6.2.4.2 Step II Assignment of each cost component with the corresponding subsector or commodity

As in the previous cases, this section includes several tables per each intervention which show the assignment of each component of the interventions with the corresponding commodity according to the commodity classification of the WIOD.

This is precisely the information that will allow making the conexion with the model for the socioeconomic impact assessment.

The following tables (48-52) show the main characteristics regarding the Assignment of the cost component with the corresponding subsector or commodity for each of the interventions evaluated.

- **Intervention 1: Electric buses deployment**

Table 48: Assignment of the cost component with the corresponding subsector or commodity for the intervention 1

Component	CODE	Commodity
E-vehicle cost (without the battery cost)	CPA_C29	Motor vehicles, trailers and semi-trailers
Battery estimated cost	CPA_C27	Electrical equipment
E-vehicle charger cost (one charging point) (600kW)	CPA_C27	Electrical equipment
Design Charging point (one charging point)	CPA_C27	Electrical equipment
E-véhicle mobile charging system (22kW)	CPA_C27	Electrical equipment
Electical sub-station for two 600kW charging points (average)	CPA_C27	Electrical equipment
Civil Works sub station for two 600kW charging points (average)	CPA_C33	Repair and installation services of machinery and equipment
Grid connection Taxes	CPA_K64	Financial services, except insurance and pension funding
Insurance	CPA_K65	Insurance, reinsurance and pension funding services, except compulsory and social security
Grid electricity price (variable and fixed costs of the electricity + traansport)	CPA_D35	Electricity, gas, steam and air-conditioning
Significant operation & Maintenance cost (materials and labour)	CPA_C33	Repair and installation services of machinery and equipment
Significant Operation & Maintenance cost (materials and labour)	CPA_C33	Repair and installation services of machinery and equipment

- **Intervention 2: Retrofitting of one multi-owner building**

Table 49: Assignment of the cost component with the corresponding subsector or commodity for the intervention 2

Component	CODE	Commodity

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

Insulation of the walls	CPA_C31_C32	Furniture; other manufactured goods
Insulation of ground floor	CPA_C31_C32	Furniture; other manufactured goods
Insulation of the roof	CPA_C31_C32	Furniture; other manufactured goods
Replacement of windows	CPA_C31_C32	Furniture; other manufactured goods
Replacement of railings & metalworking	CPA_C25	Fabricated metal products, except machinery and equipment
Electricity works (displacement of electrical networks)	CPA_C33	Repair and installation services of machinery and equipment
Thermostatic valves	CPA_C33	Repair and installation services of machinery and equipment
Replacement of the ventilation system	CPA_C33	Repair and installation services of machinery and equipment
Connection to the district heating network	CPA_C33	Repair and installation services of machinery and equipment
Networks balacing and sludge removal	CPA_C33	Repair and installation services of machinery and equipment
Heaters and 1 individual hot-water tank	CPA_C27	Electrical equipment
Inspection office &Health and Safety Officer	CPA_N80-N82	Security and investigation services; services to buildings and landscape; office administrative, office support and other business support services
Architect / Technical design + construction site supervision	CPA_M71	Architectural and engineering services; technical testing and analysis services
Property management company costs	L68	Real estate activities
Insurance costs	CPA_K65	Insurance, reinsurance and pension funding services, except compulsory and social security
District heating cost (energy supply)	CPA_G47	Retail trade services, except of motor vehicles and motorcycles
District heating cost (operation & maintenance)	CPA_C33	Repair and installation services of machinery and equipment

- **Intervention 3: Smart Lighting**

Table 50: Assignment of the cost component with the corresponding subsector or commodity for the intervention 3

Component	CODE	Commodity
LORAWAN BASE STATION (x1)	CPA_C27	Electrical equipment
InteliLIGHT FRE-220-NEMA (x50)	CPA_C27	Electrical equipment
InteliLIGHT FRE-220-P (x22)	CPA_C27	Electrical equipment
InteliLIGHT FRE-220-M (x17) + ANT601 (x19)	CPA_C27	Electrical equipment

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

Remote technical support for 1 year	CPA_C33	Repair and installation services of machinery and equipment
Access to Intelilight Software	CPA_C26	Computer, electronic and optical products
Access to LoRaWan Network	CPA_C26	Computer, electronic and optical products
SIM Card contract	CPA_C26	Computer, electronic and optical products

- **Intervention 4: Solar PV Plant deployed on a public building (MIN)**

Table 51: Assignment of the cost component with the corresponding subsector or commodity for the intervention 4

Component	CODE	Commodity
Solar PV panels	CPA_C25	Fabricated metal products, except machinery and equipment
Inverters and monitoring	CPA_C27	Electrical equipment
Other electrical equipment	CPA_C27	Electrical equipment
Structure sizing studies and supports of the structure	CPA_M71	Architectural and engineering services; technical testing and analysis services
Structure	CPA_C33	Repair and installation services of machinery and equipment
Grid connection cost	CPA_C33	Repair and installation services of machinery and equipment
Site management +studies + labour costs	CPA_M71	Architectural and engineering services; technical testing and analysis services
Project development (legal, administrative, external provisions)	CPA_M71	Architectural and engineering services; technical testing and analysis services
Communication and citizens mobilisation costs	CPA_M71	Architectural and engineering services; technical testing and analysis services
Operation & Maintenance	CPA_C33	Repair and installation services of machinery and equipment
Tax (Fee per year)	CPA_K64	Financial services, except insurance and pension funding
Insurance costs (Fee per year)	CPA_K65	Insurance, reinsurance and pension funding services, except compulsory and social security
End of life costs of the panels	CPA_E37-E39	Sewerage; waste collection, treatment and disposal activities; materials recovery; remediation activities and other waste management services

- **Intervention 5: Digital boiler**

Table 52: Assignment of the cost component with the corresponding subsector or commodity for the intervention 5

Component	CODE	Commodity
Digital boiler Tebios	CPA_C27	Electrical equipment
Water tank	CPA_C25	Fabricated metal products, except machinery and equipment
Cooling system	CPA_C27	Electrical equipment
Electrical box	CPA_C27	Electrical equipment
Expansion tank	CPA_C25	Fabricated metal products, except machinery and equipment
Pumps	CPA_C28	Machinery and equipment n.e.c.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

Calories meter DIEHL Sharky 775	CPA_C27	Electrical equipment
Energy supply contract over 15 years	CPA_G47	Retail trade services, except of motor vehicles and motorcycles

6.2.4.3 Step III Evaluation of the capacities for the manufacturing and distribution of each cost component (commodity/subsector) in each city

This section describes the main characteristics of the city related to the capacities for the local manufacturing and distribution of each component which is used in each intervention. In this step the same breakdown of components and costs described in previous steps for each intervention is maintained.

The following tables (53-57) show the main characteristics regarding the capacities for the manufacturing and distribution of each cost component for each of the interventions evaluated.

- **<u>Intervention 1: Electric buses deployment</u>**

Table 53: Analysis of the capacities for the manufacturing and distribution of each cost component (commodity/subsector) for the intervention 1

Cost breakdown	Local (city level)		Regional level	
	local producer? (YES/NO)	Local distribution / stockist? (YES/NO)	local producer? (YES/NO)	Local distribution / stockist? (YES/NO)
	To be further developed			

- **<u>Intervention 2: Retrofitting of one multi-owner building</u>**

Table 54: Analysis of the capacities for the manufacturing and distribution of each cost component (commodity/subsector) for the intervention 2

Cost breakdown	Local (city level)		Regional level	
	local producer? (YES/NO)	Local distribution / stockist? (YES/NO)	local producer? (YES/NO)	Local distribution / stockist? (YES/NO)
Insulation of the walls	NO	NO	NO	NO
Insulation of ground floor	NO	NO	NO	NO
Insulation of the roof	NO	NO	YES	YES
Replacement of windows	NO	NO	YES	YES
Replacement of railings & metalworking	YES	YES	YES	YES
Electricity works (displacement of electrical networks)	NO	NO	NO	NO

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

Thermostatic valves	NO	NO	NO	NO
Replacement of the ventilation system	NO	NO	NO	NO
Connection to the district heating network	NO	NO	NO	NO
Networks balacing and sludge removal	NO	NO	YES	YES
Heaters and 1 individual hot-water tank	NO	NO	YES	YES

- **Intervention 3: Smart Lighting**

Table 55: Analysis of the capacities for the manufacturing and distribution of each cost component (commodity/subsector) for the intervention 3

Cost breakdown	Local (city level)		Regional level	
	local producer? (YES/NO)	Local distribution / stockist? (YES/NO)	local producer? (YES/NO)	Local distribution / stockist? (YES/NO)
LORAWAN BASE STATION (x1)	NO	NO	NO	NO
InteliLIGHT FRE-220-NEMA (x50)	NO	NO	NO	NO
InteliLIGHT FRE-220-P (x22)	NO	NO	NO	NO
InteliLIGHT FRE-220-M (x17) + ANT601 (x19)	NO	NO	NO	NO
Remote technical support for 1 year	NO	NO	NO	NO
Access to Intelilight Software	NO	NO	NO	NO
Access to LoRaWan Network	NO	NO	NO	NO
SIM Card contract	NO	NO	NO	NO

- **Intervention 4: Solar PV Plant deployed on a public building (MIN)**

Table 56: Analysis of the capacities for the manufacturing and distribution of each cost component (commodity/subsector) for the intervention 4

Cost breakdown	Local (city level)		Regional level	
	local producer? (YES/NO)	Local distribution / stockist? (YES/NO)	local producer? (YES/NO)	Local distribution / stockist? (YES/NO)
Solar PV panels	YES	YES	YES	YES
Inverters and monitoring	NO	NO	NO	NO

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

Other electrical equipment	NO	YES	NO	YES

- **Intervention 5: Digital boiler**

Table 57: Analysis of the capacities for the manufacturing and distribution of each cost component (commodity/subsector)

Cost breakdown	**Local (city level)**		**Regional level**	
	local producer? (YES/NO)	Local distribution / stockist? (YES/NO)	local producer? (YES/NO)	Local distribution / stockist? (YES/NO)
Digital boiler Tebios	NO	NO	NO	NO
Water tank	NO	NO	NO	NO
Cooling system	NO	NO	NO	YES
Electrical box	NO	NO	NO	NO
Expansion tank	NO	-	NO	-
Pumps	NO	NO	YES	YES
Calories meter DIEHL Sharky 775	NO	NO	NO	NO

6.2.4.4 Step IV Identification of the main stakeholder related to each cost component

This step (explained in section 5.4.4 above) aims to analyze the actors involved in the investment of the different components of the actions, indicating it with a percentage of their contribution with respect to the total cost of each component.

This step continues with the same disaggregation of costs and components of the interventions as those of the previous steps. The following Tables (58-62) include the analysis of the main stakeholder related to each cost component of each intervention.

- **Intervention 1: Electric buses deployment**

Table 58: Analysis of the main stakeholder related to each cost component (commodity/subsector) for the intervention 1

Cost breakdown	Costs	Unit	Who makes the payment?			
			% paid with public funding (Out of the region)	% paid with public (Regional) funding	% paid by the individual (citizens)	% paid by private companies
E-vehicle cost (without the battery cost)	24 200 000	€	20 %	80 %	0 %	0 %
Battery estimated cost	4 400 000	€	20 %	80 %	0 %	0 %
E-vehicle charger cost (one charging point) (600kW)	4 550 000	€	20 %	80 %	0 %	0 %

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

Design Charging point (one charging point)	390 000	€	20 %	80 %	0 %	0 %
E-véhicle mobile charging system (22kW)	58 000	€	20 %	80 %	0 %	0 %
Electical sub-station for two 600kW charging points (average)	1 920 000	€	20 %	80 %	0 %	0 %
Civil Works sub station for two 600kW charging points (average)	840 000	€	20 %	80 %	0 %	0 %
Grid connection	20 000	€	20 %	80 %	0 %	0 %

- **Intervention 2: Retrofitting of one multi-owner building**

Table 59: Analysis of the main stakeholder related to each cost component (commodity/subsector) for the intervention 2

Cost breakdown	Costs	Unit	% paid with public funding (Out of the region)	% paid with public (Regional) funding	% paid by the individual (citizens)	% paid by private companies
Insulation of the walls	1 219 800	€	0%	38%	60%	2%
Insulation of ground floor	44 378	€	0%	38%	60%	2%
Insulation of the roof	46 945	€	0%	38%	60%	2%
Replacement of windows	318 673	€	0%	38%	60%	2%
Replacement of railings & metalworking	179 513	€	0%	38%	60%	2%
Electricity works (displacement of electrical networks)	12 478	€	0%	38%	60%	2%
Thermostatic valves	46 872	€	0%	38%	60%	2%
Replacement of the ventilation system	151 467	€	0%	38%	60%	2%
Connection to the district heating network	30 384	€	0%	38%	60%	2%
Networks balacing and sludge removal	12 512	€	0%	38%	60%	2%
Heaters and 1 individual hot-water tank	11 105	€	0%	38%	60%	2%
Inspection office &Health and Safety Officer	16 754	€	0%	9%	91%	0%
Architect / Technical design + construction site supervision	125 794	€	0%	9%	91%	0%
Property management company costs	21 676	€	0%	9%	91%	0%
Insurance costs	32 030	€	0%	0%	100%	0%
District heating cost (energy supply)	25 000	€	0%	0%	100%	0%
District heating cost (operation & maintenance)	11 100	€	0%	0%	100%	0%
End of life costs	No	-	-	-	-	-

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

	information					

- **<u>Intervention 3: Smart Lighting</u>**

Table 60: Analysis of the main stakeholder related to each cost component (commodity/subsector) for the intervention 3

Cost breakdown	Costs	Unit	% paid with public funding (Out of the region)	% paid with public (Regional) funding	% paid by the individual (citizens)	% paid by private companies
LORAWAN BASE STATION (x1)	1499	€	0%	0%	0%	100%
InteliLIGHT FRE-220-NEMA (x50)	3950	€	0%	0%	0%	100%
InteliLIGHT FRE-220-P (x22)	1518	€	0%	0%	0%	100%
InteliLIGHT FRE-220-M (x17) + ANT601 (x19)	1400	€	0%	0%	0%	100%
Remote technical support for 1 year	238,2	€	0%	0%	0%	100%
Access to Intelilight Software	1	€/node/year	0%	0%	0%	100%
Access to LoRaWan Network	1	€/node/year	0%	0%	0%	100%
SIM Card contract	9,5	€/month	0%	0%	0%	100%

- **<u>Intervention 4: Solar PV Plant deployed on a public building (MIN)</u>**

Table 61: Analysis of the main stakeholder related to each cost component (commodity/subsector) for the intervention 4

			Who makes the payment?			
Cost breakdown	Costs	Unit	% paid with public funding (Out of the region)	% paid with public (Regional) funding	% paid by the individual (citizens)	% paid by private companies
Solar PV panels	264 000	€	0%	5%	92%	3%
Inverters and monitoring	38 000	€	0%	5%	92%	3%
Other electrical equipment	90 400	€	0%	5%	92%	3%
Structure sizing studies and supports of the structure	150 000	€	0%	100%	0%	0%
Structure	124 000	€	0%	5%	92%	3%
Grid connection cost	11 000	€	0%	5%	92%	3%
Site management +studies + labour costs	85 350	€	0%	5%	92%	3%
Project development (legal, administrative, external provisions)	94 300	€	0%	5%	92%	3%
Communication and citizens mobilisation costs	30 600	€	0%	0%	0%	100%
Operation & Maintenance costs (labour)	19 100	€/year	0%	5%	92%	3%
Tax (Fee per year)	700	€/year	0%	5%	92%	3%

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

Insurance costs (Fee per year)	3 400	€/year	0%	5%	92%	3%
End of life costs of the panels	990	€	0%	0%	0%	100%

- **<u>Intervention 5: Digital boiler</u>**

Table 62: Analysis of the main stakeholder related to each cost component (commodity/subsector) for the intervention 5

			Who makes the payment?			
Cost breakdown	Costs	Unit	% paid with public funding (Out of the region)	% paid with public (Regional) funding	% paid by the individual (citizens)	% paid by private companies
Digital boiler Tebios	14900	€	0%	0%	0%	100%
Water tank	-	-	0%	0%	0%	100%
Cooling system	-	-	0%	0%	0%	100%
Electrical box	-	-	0%	0%	0%	100%
Expansion tank	-	-	0%	0%	0%	100%
Pumps	-	-	0%	0%	0%	100%
Calories meter DIEHL Sharky 775	-	-	0%	0%	0%	100%
Energy supply contract over 15 years	15000	€	0%	0%	0%	100%

6.3 Case of Hamburg

6.3.1 Phase I Selection of interventions

Based on the criteria defined in section 5.1, the city of Hamburg has selected a series of actions for the techno-economic analysis that haven been briefly described below. These actions have been chosen among all the Hamburg interventions for mySMARTLife project.

6.3.1.1 Electrical vehicles: Electrification of Company owned vehicles fleet (12 e-cars for authority fleet and 10 e-cars for VHH vehicle fleet):

The public authority vehicle fleet of the borough of Bergedorf and VHH will be renewed and electrified with a total of 22 e-cars. This is to achieve sustainable urban development in cities through zero-emission mobility, for which it is very important to electrify vehicles that are mainly used within city centres, in order to reduce air pollution sustainably.

The selection of this action has been motivated by being representative at investment terms for the city, it also has a high potential of replication, has a significant importance for the city and as example for citizens.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

6.3.1.2 Charging infrastructure for e-bus fleet (16 electric buses):

A charging station will be implemented with the objective of loading buses slowly over a period of about five hours. This recharging should be done at night at the depot at “Curslacker Neuer Deich”. This has advantages as the smaller dimensions of the network, the charging infrastructure and the purchase of more favourable prices of electricity from the grid. The charging stations at the depot are aimed to be flexible and provide both the ability to charge slowly for smaller loads on the grid as well as fast charging of up to 150 kW if operationally necessary.

This intervention is very representative in terms of investment for the city, but above all it is an intervention with a high potential of replication and it is relevant for the future development of the city.

6.3.1.3 Smart Street lighting (30 lamps):

An adaptive lighting for the new planned bicycle route will be implemented in the new construction area “Schleusengraben”. Therefore 30 lighting assets will be implemented with LED lighting and partially with cyclist and pedestrian detection, a cyclist counter, control units to manage the adaptive lighting as well as WIFI.

The selection of this action is motivated by its relevance in terms of the city’s investment, and also by its high replicability potential at all levels in addition to its relevance for the city itself and its inhabitants.

6.3.1.4 On “Bergedorf-Süd” area: Humble lamppost retrofitting of lamps (40):

This action will enhance current infrastructure towards less energy consumption. In the City area of Hamburg-Bergedorf (streets “Reinbecker Redder” and “Weidemoor”). 40 lamppost will be replaced with new LED lighting.

The selection of this intervention is due to their potential of replication at city level, since it is not very relevant in terms of investment of the city, what can be at the same time an example of a low investment with a great positive energy impact.

6.3.1.5 Large wind turbines (13 MW):

Wind farm located close to the energy campus at Schleusengraben, and built by an University of Applied Sciences (HAW Hamburg). It contains five turbines with a nominal power of 13 MW. The wind farm and its large scale battery will be used to do electricity ancillary services.

This intervention has been selected because of its high relevance in terms of investment for the city, and because it has a great importance for the city, as well as its potential of replication both locally and regionally. It has also been taken into account that it is a singular intervention due to its innovative business model.

This project has received funding from the European Union‘s Horizon 2020 research and innovation programme under grant agreement No 731297.

6.3.2 Phase II Harmonization of interventions categories

With the aim of homogenizing as much as possible the technoeconomic analysis not only for the case of the lighthouse cities but also for the follower cities of the mySMARTLife project, the interventions mentioned above could be classified in the following intervention categories:

- **Mobility interventions**
  - Electric vehicles
  - Charging infrastructure
- **Energy efficiency for buildings:** Including all interventions related to the improvement of the efficiency of the systems integrated in the buildings as well as the interventions related to the improvement of the characteristics of the building envelope.
  - Improvement of the characteristics of the building envelope
  - Smart meters and control
  - Efficient energy generation technologies
- **Public lighting**
- **Renewable energy technologies**
  - Solar:
    - Solar thermal
    - Solar photovoltaic
    - Solar hybrid technologies
  - Wind:
    - Large wind turbines
    - Micro-turbines

According to the intervention categories described above, the interventions pre-selected in the lighthouse cities can be classified as it is showed in Table 63.

Table 63: Categorization of interventions into intervention categories for the example described.

Intervention	Intervention category
Electrical vehicles: Electrification of company owned vehicles fleet (12 e-cars for authority fleet and 10 e-cars for VHH vehicle fleet)	Mobility interventions: Electric vehicles
Charging infrastructure for e-bus fleet (16 electric buses)	Mobility interventions: Charging infrastructure

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

Smart street lighting (30 lamps)	Public lighting
On “Bergedorf-Süd” area: Humble lamppost retrofitting of lamps (40)	Public lighting
Large wind turbines (13 MW)	Renewable energy technologies: Large wind turbines

6.3.3 Phase III Analysis of the socioeconomic and sectorial structure of each city/region

In the case of Hamburg, the analysis should include both the city and the region (Hamburg’s region). Therefore, all the analysis compares the main characteristics of both scales.

The city of Hamburg has a total **population** of 1.787.408 inhabitants (2,6% of total population in Germany). In terms of gender, Hamburg has 873.062 (48,85%) male and 914.346 (51,15%) female. Regarding the population structure, almost 42% of inhabitants are under 35 years old; in terms of absolute values, the most significant age group is 25-34, with a total number of 297.453 (16,64%) inhabitants, followed by the age group 45-54, with a total number of 276.765 (15,48%) inhabitants [13] . In terms of fertility and deaths, the crude birth rate[10] and the crude death rate[11] for the city are 11,20 and 10,00 respectively. For the Hamburg’s region[12], there is a total population of 3.243.171 inhabitants (3,92% of total population in Germany). In terms of gender, the region has 1.588.963 (49%) for male and 1.654.208 for female (51%). In terms of age structure[13] population, 397.819 (12,42%) inhabitants are less than 15 years old, 1.886.576 (59%) inhabitants are from 15 to 64 years old, and 490.973 (15,33%) inhabitants are over 65 years old. The average age of the population is 42,1 years old (2017. Region statistics)[14]. In terms of fertility and deaths, the crude birth rate and the crude death rate for the city are 11,10 and 9,60 respectively.

In terms of **citizenship**, Hamburg has 1.525.156 (85,30%) national inhabitants. Among the population without German citizenship, the city has 262.252 (14,7%) inhabitants. Regarding the whole population, 3,8% are from EU countries and 5,40% are from non-EU countries [13]. Regarding the background, almost 35% of the population has a migration background. This percentage it increases up to 51,3% for inhabitants under 118 years old with migration background.

In Hamburg, there are 1.034.071 households with an average size of 1.8 persons. From the total number of households, 562.712 (54,4%) are one-person households and 184.234 (17,8%) are households with children. From those with children, 46.547 (25,3%) are single households (2017. Region statistics). For

[10] The crude birth rate is the ratio of the number of live births during the year to the average population in that year. The value is expressed per 1 000 persons.

[11] The crude death rate is the ratio of the number of deaths during the year to the average population in that year. The value is expressed per 1 000 persons.

[12] The data presented represents the metropolitan area.

[13] There is a number of 426.537 (13,32%) of inhabitants with age missing values.

[14] region.statistik-nord.de/detail/10000000000000/2/

This project has received funding from the European Union‘s Horizon 2020 research and innovation programme under grant agreement No 731297.

the case of the region, the **income of households** (in euro per inhabitant) measured in terms of primary incomes by national income is 30.600 €. This measure decreases to 23.900€ when looking at the disposable income (2016, Eurostat. Regions and cities. City statistics).

Regarding **education levels**[15] in Hamburg, 30,94% of the population aged between 25 and 64 years old has high tertiary education (university and higher education centers), 53,62% secondary education (upper secondary education, post-secondary) and 15,43 low or non-education (less than primary, primary or lower secondary education[13]. In the case of the region, taking into account the same age group, 36,40% has tertiary education, 49,40% secondary education (non-tertiary), and 14,20 has low or non-education.

In terms of the **labor market**, the economically active population is constituted by 956.820 (53,53%) inhabitants, 500.200 (52,28%) for male and 456.620 (42,72%) for female. Considering the active population, the unemployment rate is 4,2%, 4,6% for male and 3,7% for female.

In the case of the region, the unemployment rate is 4,1%, 4,5% for male and 3,6% for female.

6.3.4 Phase IV Supply chain characterization of the interventions

All the interventions that will be evaluated in the current study are characterized in detail here, under the four subsections that follow (This phase is described in detail in section 5.4).

6.3.4.1 Step I Disaggregation of costs per intervention

As explained in the previous section 5.4.1, in this first step the disaggregation into components and costs is carried out, which is the first stage of each intervention.

A classification in three cost categories has been made in order to clarify and better understand the different costs breakdown incurred for each of the interventions. This classification is composed of three phases: design and acquisition, operation and disposal phase.

The costs of the first phase are those corresponding to CAPEX costs, which take place only once during the project lifetime or the number of times they must be replaced (when the useful life of the components is less than that of the project).

In the operation phase the costs included are those given throughout the project lifetime (per year generally), such as the grid electricity costs, taxes, insurances or the Operation & Maintenance ones.

In the disposal phase, the end of life of the most important components or those with the greatest impact due to their contamination degree or their complex recycling are calculated. It is an ambitious phase and

[15] The education levels follow the International Standard Classification of Education ISCED

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

difficult to achieve for some innovative interventions that have not yet had experiences in the recycling of its componetns, so it is sometimes impossible to estimate any figure in this regard.

- **Intervention 1: "Electrical vehicles: Electrification of company owned vehicles fleet (12 e-cars for authority fleet and 10 e-cars for VHH vehicle fleet)"**

E-cars (12) for authority fleet

Table 64: Cost breakdown related to cost categories according to a LCC analysis for the intervention 1

Cost categories	Cost breakdown	Cost breakdown (%)
Design & Acquisition phase	E-vehicle cost (without the battery cost)	48,36%
	Battery cost	15,18%
	Charger cost	2,22%
	Grid connection works (electrical grounding)	2,97%
	Grid connection works (house connection)	7,03%
	Taxes	0,00%
Operation phase	Grid electricity price	19,86%
	Operation & Maintenance cost (materials + labour)	4,38%
	Tax (Fee per year)	0,00%
	Insurance costs (Fee per year)	0,00%

E-cars (10) for VHH vehicle fleet

Table 65: Cost breakdown related to cost categories according to a LCC analysis for the intervention 1

Cost categories	Cost breakdown	Cost breakdown (%)
Design & Acquisition phase	E-vehicle cost (included battery cost)	95,48%
	Charger cost	3,41%
	Grid connection works	0,00%
	Taxes	0,00%
Operation phase	Grid electricity price (variable costs of the electricity)	1,10%
	Grid electricity base-price (fixed costs)	0,00%
	Operation & Maintenance cost (materials)	0,00%
	Operation & Maintenance cost (labour)	0,00%
	Tax (Fee per year)	0,00%

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

	Insurance costs (Fee per year)	0,00%

E-cars (12) for authority fleet

Table 66: Data gathering template (CAPEX and OPEX) for the disaggregation of costs for the intervention 1

Project / intervention lifetime: 3 years

Cost breakdown	Costs	Unit	Specific lifetime of the component (years)	Total cost in the lifetime (including replacement)
E-vehicle cost (without the battery cost)	207,00	€/month	3	89.424,00 €
Battery cost	65,00	€/month	3	28.080,00 €
Charger cost	4.100,00	€	-	4.100,00 €
Grid connection works (electrical grounding)	5.500,00	€	-	5.500,00 €
Grid connection works (house connection)	13.000,00	€	-	13.000,00 €
Taxes	0,00	€	0	- €
Grid electricity price	85,00	€/month	3	36.720,00 €
Operation & Maintenance cost (materials + labour)	2.700,00	€/year	3	8.100,00 €
Tax (Fee per year)	0,00	€/year	3	- €
Insurance costs (Fee per year)	0,00	€/year	3	- €

E-cars (10) for VHH vehicle fleet

Table 67: Data gathering template (CAPEX and OPEX) for the disaggregation of costs per intervention

Project / intervention lifetime: 3 years

Cost breakdown	Costs	Unit	Specific lifetime of the component (years)	Total cost in the lifetime (including replacement)
E-vehicle cost (included battery cost)	98,36	€/month	3	35.409,60 €
Charger cost	1.265,00	€	3	1.265,00 €
Grid connection works	0,00	€		- €
Taxes	0,00	€		- €
Grid electricity price (variable costs of the electricity)	0,18	€/kWh	1500km/3years	409,50 €
Grid electricity base-price (fixed costs)	583,55	€/kWh by month		- €
Operation & Maintenance cost (materials)	0,00	€/year	3	- €
Operation & Maintenance cost (labour)	0,00	€/year	3	- €
Tax (Fee per year)	0,00	€/year	3	- €
Insurance costs (Fee per year)	0,00	€/year	3	- €

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

This intervention is about calculating and analysing the costs and implementation of electric cars in the authority and VHH fleets. The action has been divided into two ones since they are very different in terms of their components and costs, and the companies involved are also different (each one with its own prices). However, in both interventions the disposal phase has been removed since the e-cars are leased and the city of Hamburg does not have to take charge of its end of life or recycling any component.

In both cases, the leasing rate per car has been obtained per month (although note the difference between the first ones, which do not include the battery, while the rate of the second one already has the battery price included), so to obtain the Total cost during the project lifetime (3 years) has multiplied this monthly cost by the 36 months of the intervention and by the number of leased vehicles in each case, as it is done with the monthly cost of the battery in the case of the vehicles for the authority fleet.

In the first phase analysed, the design and acquisition one, there are some components that have not been assigned a specific lifetime since they only take place once during the intervention period, such as the charger or the grid connection works. In addition, in the case of the VHH vehicle fleet, the cost of the grid connection works is not counted because they already exist. Costs attributed as grid connection works in the case of the vehicles for authority fleet are due to 10 charging points necessary for the operation of these electric vehicles (among others) and whose cost has been divide into electrical grounding on one side and house connection by other.

Also in both cases, there are no taxes neither for the acquisition phase nor for the operation one, since electric vehicles are tax-exempt by the German regulations. In the case of insurance costs (operation phase), they are also not taken into account since the possible damages are paid directly from the authority budget.

In the operation phase of the e-cars for authority fleet, the grid electricity price is provided per month and per car, so for the calculation of the final price is multiplied by the 36 months of duration of the project and by the 12 cars that are going to be implemented.

A special service has also been hired for the O&M (taking into account that trenching and pipe laying works are carried out from this maintenance), and its cost is given per year.

The operation phase in the case of the VHH vehicle fleet is somewhat different, since they do not take into account the O&M costs of the vehicles (the leasing company is in charge) or those of the charging points (as well as the cost of its installation has not been taken into account because it already existed). So for this phase there are only the costs of grid electricity, calculated based on what is estimated to travel these cars in the period 3 years of the project.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

- **Intervention 2: "Charging infrastructure for e-bus fleet (16 electric buses)"**

Table 68: Cost breakdown related to cost categories according to a LCC analysis for the intervention 2

Cost categories	Cost breakdown	Cost breakdown (%)
Design & Acquisition phase	Planning cost	16,06%
	External charger connector cost	1,39%
	Transformer cost	6,85%
	Grid connection works	10,71%
	Charging station network management software cost	6,00%
Operation phase	Construction/Foundation works	53,54%
	Grid electricity price	0,00%
	Operation & Maintenance cost (materials + labour)	4,08%
Disposal phase	End of life costs	1,37%

Table 69: Data gathering template (CAPEX and OPEX) for the disaggregation of costs for the intervention 2

Project / intervention lifetime: 30 years				
Cost breakdown	Costs	Unit	Specific lifetime of the component (years)	Total cost in the lifetime (including replacement)
Planning cost	750.000,00	€	30	750.000,00 €
External charger connector cost	65.000,00	€	30	65.000,00 €
Transformer cost	320.000,00	€	30	320.000,00 €
Grid connection works	500.000,00	€		500.000,00 €
Charging station network management software cost	280.200,00	€		280.200,00 €
Construction/Foundation works	2.500.000,00	€		2.500.000,00 €
Grid electricity price	0,18	€/kWh		- €
Operation & Maintenance cost (materials + labour)	6.350,00	€/year	30	190.500,00 €
End of life costs	64.000,00	€		64.000,00 €

In this intervention, the implementation of a charging infrastructure for the electric bus fleet is analysed. This intervention is quite important in terms of investment since all the components that intervene from the beginning of its planning are taken into account and it has been planned with a project lifetime of 30 years.

Within the design and acquisition phase there are some components that only take place at the beginning of the intervention, so a specific lifetime have not been assigned to them. These components are the

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

planning, the grid connection works and the charging stations network management software. For the external charger connector and the transformer, it has been estimated to have a specific lifetime similar to that of the project, so replacements for these components are not taken into account.

For the operation phase, the construction costs (which occur once in the entire project), and the O&M costs, which include materials and labour have been considered. These last ones are given per year and having been multiplied by the 30 years of duration of the project. The costs of electricity, however, are difficult to estimate. On the one hand because the price can vary as more infrastructure is installed or added to the network and raise their demand of electricity.

On the other hand, the charging infrastructure itself does not need electricity beyond that consumed by electric vehicles while charging, so this consumption should be taken into account as the operation costs of these vehicles and not within this current intervention.

In the disposal phase the costs of end of life of the charging point have been estimated.

- **Intervention 3: "Smart street lighting (30 lamps)"**

Table 70: Cost breakdown related to cost categories according to a LCC analysis for the intervention 3

Cost categories	Cost breakdown	Cost breakdown (%)
Design & Acquisition phase	Lamp pole cost (5m)	20,12%
	Luminaire cost (including LED cost)	17,70%
	Sensor for cyclist and pedestrian detection cost	0,46%
	Cyclist counting point (with sensor) cost	42,91%
	Control units to manage the adaptative lighting cost	0,54%
	Control units to manage WIFI cost	0,00%
	Installation works (first erection of the lamp pole)	14,48%
Operation phase	Grid electricity price	2,28%
Disposal phase	Scrap value of the lamp cost (materials)	1,51%

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

Table 71: Data gathering template (CAPEX and OPEX) for the disaggregation of costs for the intervention 3

Project / intervention lifetime: 2 years

Cost breakdown	Costs	Unit	Specific lifetime of the component (years)	Total cost in the lifetime (including replacement)
Lamp pole cost (5m)	250,00	€/lamp	25	7.500,00 €
Luminaire cost (including LED cost)	220,00	€/luminaire	20	6.600,00 €
Sensor for cyclist and pedestrian detection cost	170,00	€/sensor	12	170,00 €
Cyclist counting point (with sensor) cost	8.000,00	€/point	12	16.000,00 €
Control units to manage the adaptive lighting cost	200,00	€/unit	12	200,00 €
Control units to manage WIFI cost	-			- €
Installation works (first erection of the lamp pole)	180,00	€/pole	25	5.400,00 €
Grid electricity price	14,19	€ lamp	2	851,40 €
Scrap value of the lamp cost (materials)	18,75	€/lamp	0	562,50 €

This intervention is aimed to calculate the costs of the implementation of 30 smart street lamps during a 2 years period time. Since it is a very short period of time in which the intervention will be analysed, there are no components that must be replaced.

In the design and acquisition phase, both the price of the lamp poles and that of the luminaires (LED) are given in a unitary way, with which to calculate the final price multiplied by the total number of lamps to be installed (30 lamps). To calculate the specific lifetime of the luminaires, it has been estimated that these LEDs have a duration of 80.000 to 100.000 hours lit, and that after a year some 4.300 hours are on. Hence, its useful life is estimated in about 20 years and, of course, does not have to be replaced during the project lifetime of 2 years.

Among the rest of the elements of this first phase, there is a sensor for cyclist and pedestrian detection, whose price is given in an unitary watt and only one unit is installed; a cyclist counting point, whose price per unit is multiplied by the 2 units that are going to be implemented; a single control unit to manage the adaptive lighting; and another control unit to manage WIFI, of which there is no data available since the offer for these components has not yet been made. The installation works cost has also been given in a unitary way for each lamp, so it has been multiplied by the 30 lamps of the intervention.

In the operation phase, only the price of the grid electricity has been included, given by lamp and per year, which has been multiplied by both data (30 lamps and 2 years) to obtain this total cost. Maintenance costs have not been taken into account because in the case of this intervention it is understood that these costs are already included in the lifetime of the single components (the replacement of any of the components in

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

the event of damage or at the end of their service life are included in the total cost in the lifetime, including the replacement).

Disposal phase has included the scrap value cost (material) of the lamps. There is no cost for the dismantling and removal of the old lamps because in the case of change it will be a new lamp installed and it includes the withdrawal expenses, so these cost can't be separated. Scrap value of the lamps is a cost given by lamp and multiplied by the total number of lamps to achieve the total cost of this component.

- **Intervention 4: "On "Bergedorf-Süd" area: Humble lamppost retrofitting of lamps (40)"**

Table 72: Cost breakdown related to cost categories according to a LCC analysis for the intervention 4

Cost categories	Cost breakdown	Cost breakdown (%)
Design & Acquisition phase	Lamp post cost (without the LED cost)	44,39%
	LED cost	4,22%
	Lamp driver cost	5,55%
	Installation works	33,39%
Operation phase	Grid electricity price	8,40%
Disposal phase	Scrap value of the lamp cost (materials)	4,16%

Table 73: Data gathering template (CAPEX and OPEX) for the disaggregation of costs for the intervention 4

Project / intervention lifetime: 32 months

Cost breakdown	Costs	Unit	Specific lifetime of the component (years)	Total cost in the lifetime (including replacement)
Lamp post cost (without the LED cost)	82,80	€/lamp	25	3.312,00 €
LED cost	19,00	€/lamp	20	1.520,00 €
Lamp driver cost	25,00	€/lamp	25	1.000,00 €
Installation works	150,00	€/lamp		6.000,00 €
Grid electricity price	14,19	€ lamp	32 months	1.513,00 €
Scrap value of the lamp cost (materials)	18,75	€		750,00 €

The case of this intervention is very similar to the previous one, in which the costs of the retrofitting of 40 humble lampposts in the Bergedorf-Süd area will be analysed over a period of 32 months.

For the first phase, as in the previous intervention, the costs are obtained per lamp, so that all the costs of this acquisition phase are multiplied by the total number of installed lamps, which are 40 in this case.

For the LED the same thing also happens, the estimation is about 4.300 house lit by year, so it will not be necessary to replace them in the period of 32 months (less than 3 years) since its total duration would be about 80.000 to 100.000 hours.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

The other elements of this phase would be the lamp posts themselves, the lamp drivers (there are one per lamp) and the installation works, as explained above, all unit costs multiplied by the 40 lamps for the total cost.

Grid electricity in the operation phase has the same cost as in the previous intervention. Its price is given by lamp and year, in this case multiplied by the 40 lamps and by 32/12 to obtain the cost in the 32 months of the project lifetime.

There are no O&M costs because it is assumed that these expenses are already included in the figures of their lifetime and what has been estimated of duration until they need to be replaced.

Disposal phase has only included the scrap value of the lamps because it is the most relevant cost and the only one known at this moment.

- **Intervention 5: "Large wind turbines (13 MW)"**

Table 74: Cost breakdown related to cost categories according to a LCC analysis for the intervention 5

Cost categories	Cost breakdown	Cost breakdown (%)
Design & Acquisition phase	WEA (wind energy turbine) cost	57,66%
	Battery cost	11,86%
	Grid connection works / Civil engineering cost	1,75%
	Planning and project management cost	3,72%
Operation phase	Construction/Foundation works	3,76%
	Operation & Maintenance (battery) cost (founding period)	0,66%
	Operation & Maintenance cost (materials + labour)	20,59%
Disposal phase	End of life costs	0,00%

Table 75: Data gathering template (CAPEX and OPEX) for the disaggregation of costs per intervention for the intervention 5

Project / intervention lifetime: 25 years				
Cost breakdown	Costs	Unit	Specific lifetime of the component (years)	Total cost in the lifetime (including replacement)
WEA (wind energy turbine) cost	3.500.000,00	€	25	17.500.000,00 €
Battery cost	1.200.000,00	€	10	3.600.000,00 €
Grid connection works / Civil engineering cost	530.000,00	€	-	530.000,00 €
Planning and project management cost	1.130.000,00	€	-	1.130.000,00 €

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

Construction/Foundation works	1.140.000,00	€	-	1.140.000,00 €
Operation & Maintenance (battery) cost (founding period)	100.000,00	€/year	2	200.000,00 €
Operation & Maintenance cost (materials + labour)	250.000,00	€/year	25	6.250.000,00 €
End of life costs				- €

This intervention is about calculating the cost of the installation of five large wind turbines with a nominal power of 13 MW during a project lifetime of 25 years.

Within the phase of design and acquisition, the wind energy turbines are given as a single cost (added cost of all its components since there was no available disaggregated data) per wind turbine, so it has to be multiplied by the 5 wind turbines that are going to be installed, and no replacement is needed since the lifetime of the wind turbines is similar to those 25 years of the project lifetime.

The battery was got by another research project and installed at the wind farm as part of that project to test the instantaneous reserve and other types of control energy in combination with the wind farm. They are currently negotiating to keep the battery at the wind farm for a longer period, but, for this study, battery cost is consider as an independent cost of that project (it is not known how the negotiations will end or how long this battery can be used), and with the estimated duration of this type of batteries (10 years), two replacements will be needed for the 25 years of lifetime of the intervention, so the cost of the battery is multiplied by 3 to obtain the total cost in batteries during the project.

In addition, in the operation phase, the O&M costs of the battery have been counted as going to be paid by the same regional funding program of the above mentioned research project. This cost has been taken into account only during the founding period (2 years).

In order to finish with the design and acquisition phase, grid connection and civil engineering works have also been included, as well as those of planning and project management, to which all of them have not been assigned a specific lifetime since they only take place once, at the beginning of the intervention. The same happens with the construction and foundation works, included within the operation phase.

As explained above, some O&M costs for the battery have been included in the operation phase over a period of two years. But O&M costs have also been included, both for materials and labour, for the rest of the components during the 25 years of project lifetime.

Disposal phase does not have available data since it is a very innovative intervention and there have not yet been experiences on which to be able to estimate any figure about the end of life or recycling of any component.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

6.3.4.2 Step II Assignment of each cost component with the corresponding subsector or commodity

As in the previous cases, this section includes several tables (Tables 76-81) per each intervention which show the assignment of each component of the interventions with the corresponding commodity according to the commodity classification of the WIOD.

This is precisely the information that will allow making the conexion with the model for the socioeconomic impact assessment.

- **Intervention 1: "Electrical vehicles: Electrification of company owned vehicles fleet (12 e-cars for authority fleet and 10 e-cars for VHH vehicle fleet)"**

E-cars (12) for authority fleet

Table 76: Assignment of the cost component with the corresponding subsector or commodity for the intervention 1

Component	CODE	Commodity
E-vehicle (without the battery)	CPA_C29	Motor vehicles, trailers and semi-trailers
Battery	CPA_C27	Electrical equipment
Charger	CPA_C27	Electrical equipment
Grid connection works (electrical grounding)	CPA_C33	Repair and installation services of machinery and equipment
Grid connection works (house connection)	CPA_C33	Repair and installation services of machinery and equipment
Taxes	CPA_K64	Financial services, except insurance and pension funding
Grid electricity price	CPA_D35	Electricity, gas, steam and air-conditioning
Operation & Maintenance (materials + labour)	CPA_C27	Electrical equipment
Tax (Fee per year)	CPA_K64	Financial services, except insurance and pension funding
Insurance (Fee per year)	CPA_K65	Insurance, reinsurance and pension funding services, except compulsory and social security

E-cars (10) for VHH vehicle fleet

Table 77: Assignment of the cost component with the corresponding subsector or commodity for the intervention 1

Component	CODE	Commodity
E-vehicle (included battery)	CPA_C29	Motor vehicles, trailers and semi-trailers
Charger	CPA_C27	Electrical equipment
Grid connection works	CPA_C33	Repair and installation services of machinery and equipment
Taxes	CPA_K64	Financial services, except insurance and pension funding
Grid electricity price (variable costs of the electricity)	CPA_D35	Electricity, gas, steam and air-conditioning

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

Grid electricity base-price (fixed costs)	CPA_D35	Electricity, gas, steam and air-conditioning
Operation & Maintenance (materials)	CPA_C27	Electrical equipment
Operation & Maintenance (labour)	CPA_C33	Repair and installation services of machinery and equipment
Tax (Fee per year)	CPA_K64	Financial services, except insurance and pension funding
Insurance (Fee per year)	CPA_K65	Insurance, reinsurance and pension funding services, except compulsory and social security

- **Intervention 2: "Charging infrastructure for e-bus fleet (16 electric buses)"**

Table 78: Assignment of the cost component with the corresponding subsector or commodity for the intervention 2

Component	CODE	Commodity
Planning	CPA_M71	Architectural and engineering services; technical testing and analysis services
External charger connector	CPA_C27	Electrical equipment
Transformer	CPA_C27	Electrical equipment
Grid connection works	CPA_C33	Repair and installation services of machinery and equipment
Charging station network management software	CPA_J62_J63	Computer programming, consultancy and related services; information services
Construction/Foundation works	CPA_F42	Constructions and construction works for civil engineering
Grid electricity price	CPA_D35	Electricity, gas, steam and air-conditioning
Operation & Maintenance (materials + labour)	CPA_C33	Repair and installation services of machinery and equipment
End of life	CPA_E37-E39	Sewerage; waste collection, treatment and disposal activities; materials recovery; remediation activities and other waste management services

- **Intervention 3: "Smart street lighting (30 lamps)"**

Table 79: Assignment of the cost component with the corresponding subsector or commodity for the intervention 2

Component	CODE	Commodity
Lamp pole (5m)	CPA_C25	Fabricated metal products, except machinery and equipment
Luminaire (including LED cost)	CPA_C27	Electrical equipment
Sensor for cyclist and pedestrian detection	CPA_C26	Computer, electronic and optical products
Cyclist counting point (with sensor)	CPA_C26	Computer, electronic and optical products
Control units to manage the adaptative lighting	CPA_C26	Computer, electronic and optical products
Control units to manage WIFI	CPA_C26	Computer, electronic and optical products

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

Installation works (first erection of the lamp pole)	CPA_C33	Repair and installation services of machinery and equipment
Grid electricity price	CPA_D35	Electricity, gas, steam and air-conditioning
Scrap value of the lamp (materials)	CPA_E37-E39	Sewerage; waste collection, treatment and disposal activities; materials recovery; remediation activities and other waste management services

- **Intervention 4: "On "Bergedorf-Süd" area: Humble lamppost retrofitting of lamps (40)"**

Table 80: Assignment of the cost component with the corresponding subsector or commodity for the intervention 4

Component	CODE	Commodity
Lamp post (without the LED)	CPA_C25	Fabricated metal products, except machinery and equipment
LED	CPA_C27	Electrical equipment
Lamp driver	CPA_C26	Computer, electronic and optical products
Installation works	CPA_C33	Repair and installation services of machinery and equipment
Grid electricity price	CPA_D35	Electricity, gas, steam and air-conditioning
Scrap value of the lamp (materials)	CPA_E37-E39	Sewerage; waste collection, treatment and disposal activities; materials recovery; remediation activities and other waste management services

- **Intervention 5: "Large wind turbines (13 MW)"**

Table 81: Assignment of the cost component with the corresponding subsector or commodity for the intervention 5

Component	CODE	Commodity
WEA (wind energy turbine)	CPA_C25	Fabricated metal products, except machinery and equipment
Battery	CPA_C27	Electrical equipment
Grid connection works / Civil engineering	CPA_C33	Repair and installation services of machinery and equipment
Planning and project management	CPA_M71	Architectural and engineering services; technical testing and analysis services
Construction/Foundation works	CPA_C33	Repair and installation services of machinery and equipment
Operation & Maintenance (battery)	CPA_C33	Repair and installation services of machinery and equipment
Operation & Maintenance (materials + labour)	CPA_C33	Repair and installation services of machinery and equipment
End of life	CPA_E37-E39	Sewerage; waste collection, treatment and disposal activities; materials recovery; remediation activities and other waste management services

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

6.3.4.3 Step III Evaluation of the capacities for the manufacturing and distribution of each cost component (commodity/subsector) in each city

This section describes the main characteristics of the city related to the capacities for the local manufacturing and distribution of each component which is used in each intervention. In this step the same breakdown of components and costs described in previous steps for each intervention is maintained.

- **Intervention 1: "Electrical vehicles: Electrification of company owned vehicles fleet (12 e-cars for authority fleet and 10 e-cars for VHH vehicle fleet)"**

E-cars (12) for authority fleet

Table 82: Analysis of the capacities for the manufacturing and distribution of each cost component (commodity/subsector) for the intervention 1

Cost breakdown	Local (city level)		Regional level	
	Local producer? (YES/NO)	Local distribution / stockist? (YES/NO)	Local producer? (YES/NO)	Local distribution / stockist? (YES/NO)
E-vehicle cost (without the battery cost)	NO	YES	NO	YES
Battery cost	NO	YES	NO	YES
Charger cost	NO	NO	NO	YES
Grid connection works (electrical grounding)	YES	YES	YES	YES
Grid connection works (house connection)	YES	YES	YES	YES
Taxes				
Grid electricity price	YES			
Operation & Maintenance cost (materials + labour)				
Tax (Fee per year)				
Insurance costs (Fee per year)				

E-cars (10) for VHH vehicle fleet

Table 83: Analysis of the capacities for the manufacturing and distribution of each cost component (commodity/subsector) for the intervention 1

Cost breakdown	Local (city level)		Regional level	
	Local producer? (YES/NO)	Local distribution / stockist? (YES/NO)	Local producer? (YES/NO)	Local distribution / stockist? (YES/NO)
E-vehicle cost (included battery cost)	NO	YES	NO	YES
Charger cost	NO	NO	NO	YES
Grid connection works	YES			

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

Taxes				
Grid electricity price (variable costs of the electricity)	YES			
Grid electricity base-price (fixed costs)				
Operation & Maintenance cost (materials)				
Operation & Maintenance cost (labour)				
Tax (Fee per year)				
Insurance costs (Fee per year)				

For the e-cars for the authority fleet, no manufacturer have been located in the city or in the region for electric vehicles, batteries and chargers, however, local distributors have been located and they have been involved. As for the grid connection works, both electrical grounding and house connection, have been taken by the local company Stromnetz Hamburg.

The case of the e-cars for VHH vehicle fleet is quite similar to that previous one, without manufacturers located in the region for the e-vehicles.

- **Intervention 2: "Charging infrastructure for e-bus fleet (16 electric buses)"**

Table 84: Analysis of the capacities for the manufacturing and distribution of each cost component (commodity/subsector) for the intervention 2

Cost breakdown	**Local (city level)**		**Regional level**	
	Local producer? (YES/NO)	Local distribution / stockist? (YES/NO)	Local producer? (YES/NO)	Local distribution / stockist? (YES/NO)
Planning cost	NO	NO		
External charger connector cost	NO	NO		
Transformer cost	NO	NO		
Grid connection works	YES	YES		
Charging station network management software cost	NO	NO		
Construction/Foundation works	YES	YES		
Grid electricity price				
Operation & Maintenance cost (materials + labour)				
End of life costs				

No local or regional producers or distributors have been located for the external charger connector, the transformer or the management software.But there is local production and distribution by Stromnetz

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

Hamburg for the grid connection works, and also for the construction and foundation works, by the company Wisag.

- **Intervention 3: “Smart street lighting (30 lamps)”**

Table 85: Analysis of the capacities for the manufacturing and distribution of each cost component (commodity/subsector) for the intervention 3

Cost breakdown	Local (city level)		Regional level	
	Local producer? (YES/NO)	Local distribution / stockist? (YES/NO)	Local producer? (YES/NO)	Local distribution / stockist? (YES/NO)
Lamp pole cost (5m)	NO	NO	YES	YES
Luminaire cost (including LED cost)	NO	NO	NO	NO
Sensor for cyclist and pedestrian detection cost	NO	NO	NO	NO
Cyclist counting point (with sensor) cost	NO	NO	NO	NO
Control units to manage the adaptative lighting cost	NO	NO	NO	NO
Control units to manage WIFI cost	NO	NO		
Installation works (first erection of the lamp pole)				
Grid electricity price				
Scrap value of the lamp cost (materials)				

No local producer or distributor has been located for any of the components of the intervention.

As for the regional level, only one company has been located that will be incharge of the production and distribution of the lamp poles: Europoles. The luminaires (including the LEDs) will be occupied by a company that operates at European level but also in Germany: Sustainder Deutschland GmbH.

- **Intervention 4: “On “Bergedorf-Süd” area: Humble lamppost retrofitting of lamps (40)”**

Table 86: Analysis of the capacities for the manufacturing and distribution of each cost component (commodity/subsector) for the intervention 4

Cost breakdown	Local (city level)		Regional level	
	Local producer? (YES/NO)	Local distribution / stockist? (YES/NO)	Local producer? (YES/NO)	Local distribution / stockist? (YES/NO)
Lamp post cost (without the LED cost)			YES	YES
LED cost			NO	NO
Lamp driver cost			NO	NO

This project has received funding from the European Union‘s Horizon 2020 research and innovation programme under grant agreement No 731297.

Installation works				
Grid electricity price				
Scrap value of the lamp cost (materials)				

In this intervention only one company at regional level has been located to take the production and distribution of the lamp posts.

- **Intervention 5: "Large wind turbines (13 MW)"**

Table 87: Analysis of the capacities for the manufacturing and distribution of each cost component (commodity/subsector) for the intervention 5

Cost breakdown	Local (city level)		Regional level	
	Local producer? (YES/NO)	Local distribution / stockist? (YES/NO)	Local producer? (YES/NO)	Local distribution / stockist? (YES/NO)
WEA (wind energy turbine) cost	NO	YES	NO	YES
Battery cost	NO	NO	NO	NO
Grid connection works / Civil engineering cost				
Planning and project management cost				
Construction/Foundation works				
Operation & Maintenance (battery) cost (founding period)				
Operation & Maintenance cost (materials + labour)				
End of life costs				

This last intervention does not have local or regional producers. Only local distributors for wind turbines have been located.

However, the production of these wind turbines is in charge of the German company Nordex (located in Rostock), and the company in charge of the batteries is BECK, located in southern Germany.

6.3.4.4 Step IV Identification of the main stakeholder related to each cost component

Through this step (explained in section 5.4.4 above) the actors involved in the investment of the different components of the actions are analyzed, indicating it with a percentage of their contribution with respect to the total cost of each component.

This step continues with the same disaggregation of costs and components of the interventions as those of the previous steps.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

- **Intervention 1: "Electrical vehicles: Electrification of company owned vehicles fleet (12 e-cars for authority fleet and 10 e-cars for VHH vehicle fleet)"**

E-cars (12) for authority fleet

Table 88: Analysis of the main stakeholder related to each cost component (commodity/subsector) for the intervention 1

Cost breakdown	Costs	Unit	% paid with public funding (Out of the region)	% paid with public (Regional) funding	% paid by the individual (citizens)	% paid by private companies
E-vehicle cost (without the battery cost)	207,00	€/month	0 %	0 %	0 %	100 %
Battery cost	65,00	€/month	0 %	0 %	0 %	100 %
Charger cost	4.100,00	€	0 %	0 %	0 %	100 %
Grid connection works (electrical grounding)	5.500,00	€	0 %	0 %	0 %	0 %
Grid connection works (house connection)	13.000,00	€	0 %	0 %	0 %	0 %
Taxes	0,00	€	0 %	0 %	0 %	0 %
Grid electricity price	85,00	€/month	0 %	0 %	0 %	100 %
Operation & Maintenance cost (materials + labour)	2.700,00	€/year	0 %	0 %	0 %	0 %
Tax (Fee per year)	0,00	€/year	0 %	0 %	0 %	0 %
Insurance costs (Fee per year)	0,00	€/year	0 %	0 %	0 %	0 %

E-cars (10) for VHH vehhicle fleet

Table 89: Analysis of the main stakeholder related to each cost component (commodity/subsector) for the intervention 1

Cost breakdown	Costs	Unit	% paid with public funding (Out of the region)	% paid with public (Regional) funding	% paid by the individual (citizens)	% paid by private companies
E-vehicle cost (included battery cost)	98,36	€/month	0 %	0 %	0 %	100 %
Charger cost	1.265,00	€	0 %	0 %	0 %	100 %
Grid connection works	0,00	€	0 %	0 %	0 %	0 %
Taxes	0,00	€	0 %	0 %	0 %	0 %
Grid electricity price (variable costs of the electricity)	0,18	€/kWh	0 %	0 %	0 %	100 %
Grid electricity base-price (fixed costs)	583,55	€/kWh by month	0 %	0 %	0 %	0 %
Operation & Maintenance cost (materials)	0,00	€/year	0 %	0 %	0 %	0 %

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

Operation & Maintenance cost (labour)	0,00	€/year	0 %	0 %	0 %	0 %
Tax (Fee per year)	0,00	€/year	0 %	0 %	0 %	0 %
Insurance costs (Fee per year)	0,00	€/year	0 %	0 %	0 %	0 %

- **<u>Intervention 2: "Charging infrastructure for e-bus fleet (16 electric buses)"</u>**

Table 90: Analysis of the main stakeholder related to each cost component (commodity/subsector) for the intervention 2

			Who makes the payment?			
Cost breakdown	Costs	Unit	% paid with public funding (Out of the region)	% paid with public (Regional) funding	% paid by the individual (citizens)	% paid by private companies
Planning cost	750.000,00	€	0 %	0 %	0 %	0 %
External charger connector cost	65.000,00	€	40 %	0 %	0 %	60 %
Transformer cost	320.000,00	€	40 %	0 %	0 %	60 %
Grid connection works	500.000,00	€	40 %	0 %	0 %	60 %
Charging station network management software cost	280.200,00	€	40 %	0 %	0 %	60 %
Construction/Foundation works	2.500.000,00	€	20 %	0 %	0 %	80 %
Grid electricity price	0,18	€/kWh	0 %	0 %	0 %	0 %
Operation & Maintenance cost (materials + labour)	6.350,00	€/year	0 %	0 %	0 %	0 %
End of life costs	64.000,00	€	0 %	0 %	0 %	0 %

- **<u>Intervention 3: "Smart street lighting (30 lamps)"</u>**

Table 91: Analysis of the main stakeholder related to each cost component (commodity/subsector) for the intervention 3

			Who makes the payment?			
Cost breakdown	Costs	Unit	% paid with public funding (Out of the region)	% paid with public (Regional) funding	% paid by the individual (citizens)	% paid by private companies
Lamp pole cost (5m)	250,00	€/lamp	100 %	0 %	0 %	0 %
Luminaire cost (including LED cost)	220,00	€/luminaire	100 %	0 %	0 %	0 %
Sensor for cyclist and pedestrian detection cost	170,00	€/sensor	100 %	0 %	0 %	0 %
Cyclist counting point (with sensor) cost	8.000,00	€/point	100 %	0 %	0 %	0 %
Control units to manage the adaptative lighting cost	200,00	€/unit	100 %	0 %	0 %	0 %

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

Control units to manage WIFI cost	-		0 %	0 %	0 %	100 %
Installation works (first erection of the lamp pole)	180,00	€/pole	0 %	0 %	0 %	0 %
Grid electricity price	14,19	€ lamp /year	100 %	0 %	0 %	0 %
Scrap value of the lamp cost (materials)	18,75	€/lamp	100 %	0 %	0 %	0 %

- **Intervention 4: "On "Bergedorf-Süd" area: Humble lamppost retrofitting of lamps (40)"**

Table 92: Analysis of the main stakeholder related to each cost component (commodity/subsector) for the intervention 4

			Who makes the payment?			
Cost breakdown	Costs	Unit	% paid with public funding (Out of the region)	% paid with public (Regional) funding	% paid by the individual (citizens)	% paid by private companies
Lamp post cost (without the LED cost)	200,80	€/lamp	100 %	0 %	0 %	0 %
LED cost	19,00	€/lamp	100 %	0 %	0 %	0 %
Lamp driver cost	25,00	€/lamp	100 %	0 %	0 %	0 %
Installation works	150,00	€/lamp	100 %	0 %	0 %	0 %
Grid electricity price	14,19	€ lamp /year	100 %	0 %	0 %	0 %
Scrap value of the lamp cost (materials)	18,75	€	100 %	0 %	0 %	0 %

- **Intervention 5: "Large wind turbines (13 MW)"**

Table 93: Analysis of the main stakeholder related to each cost component (commodity/subsector) for the intervention 5

			Who makes the payment?			
Cost breakdown	Costs	Unit	% paid with public funding (Out of the region)	% paid with public (Regional) funding	% paid by the individual (citizens)	% paid by private companies
WEA (wind energy turbine) cost	3.500.000,00	€	0 %	0 %	0 %	100 %
Battery cost	1.200.000,00	€	40 %	0 %	0 %	60 %
Grid connection works / Civil engineering cost	530.000,00	€	0 %	0 %	0 %	0 %
Planning and project management cost	1.130.000,00	€	0 %	0 %	0 %	0 %
Construction/Foundation works	1.140.000,00	€	0 %	0 %	0 %	0 %
Operation & Maintenance (battery) cost (founding period)	100.000,00	€/year	40 %	0 %	0 %	60 %
Operation & Maintenance cost (materials + labour)	250.000,00	€/year	0 %	0 %	0 %	0 %

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

End of life costs	0,00	€	0 %	0 %	0 %	0 %

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

7. Conclusions

This deliverable includes a description of the work carried out in mySMARTLife project related to the technoeconomic analysis of the interventions. Due to the novelty and complexity of the socioeconomic impact approach of the project, in this deliverable the detailed methodological approach used in mySMARTLife project for the supply chain analysis of the interventions has been described in detail in the initial sections. This step is relevant for the entire socioeconomic impact analysis since the accuracy obtained in the supply chain characterization of each intervention will directly affect the type of results that can be obtained in the following steps (socioeconomic impact assessment and the development of the prioritization matrix).

The results obtained in the Subtask 1.4.3 (described in this deliverable) have contributed to define a simplified methodology which will allow a homogenized approach of different cities to the supply chain characterization. Following in detail the four phases of the methodology will allow cities to obtain the same accuracy and level of detail of the "intermediate shock" which will represent each of the interventions evaluated. All these shocks will have the same format so that the socioeconomic modelling process is simplified. This is a critical aspect also for the replication of the process in WP6, where follower cities will evaluate the potential impact associated to the replication of the interventions implemented by lighthouse cities in the context of the project.

From the work carried out in this subtask, it can be concluded that the relation between the analysist that will do the modelling and the information providers (in this case municipalities) is the most relevant aspect. The methodology proposed has been developed trying to reduce as much as possible the data required. Therefore, in the first phases of the method an initial disaggregation of the costs of interventions is proposed to be done by the technical partners that are involved in the project. This cost breakdown is then contrasted with the actual data of investments provided by municipalities.

It needs to be mentioned that in terms of the total socioeconomic analysis, the most important part of the step of the supply chain analysis of interventions is to prepare the information in the exact format that is needed in the following step of the process which involves the use of the IO matrixes.

In a second step, the methodology developed has been proven in this subtask through its application in the three lighthouse cities of the project. Each city supported by a RTO of the project has been able to evaluate and collect the most important part of the data required in the different steps of the method. Among the data gathering related to the cost disaggregation of interventions, each city was able to relate this data with the corresponding commodity according to the commodity classification of their country in WIOD. This is a relevant aspect to foster the harmonization of the analysis between the three cities and will also facilitate the replication not only in the follower cities of the project but also in other cities out of the scope of the project. Besides, a complete analysis has been carried out regarding the capabilities of the local manufacturing and distribution of components in each city per each intervention included in the pilots, as well as an analysis of the origin of the investments.

As a general conclusion it can be said that the methodology is very data demanding and in some cases time consuming but also very flexible to be adapted to each city. Besides, the information and the analysis provided by this method will allow a deep socioeconomic impact assessment which will be specific by each city and that will be able to compare the expected impact associated to each of the interventions. This is a valuable information the cities can use if necessary to redirect the direction of their strategy in terms of the deployment of interventions oriented to the reduction of the environmental impacts while trying to maximize the impact generated in their socioeconomic development.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

8. References

[1] D. Ürge-Vorsatz, A. Kelemen, S. Tirado-Herrero, S. Thomas, J. Thema, N. Mzavanadze, D. Hauptstock, F. Suerkemper, J. Teubler, M. Gupta, and S. Chatterjee, “Measuring multiple impacts of low-carbon energy options in a green economy context,” *Appl. Energy*, vol. 179, pp. 1409–1426, 2016.

[2] E. Igos, B. Rugani, S. Rege, E. Benetto, L. Drouet, and D. S. Zachary, “Combination of equilibrium models and hybrid life cycle-input-output analysis to predict the environmental impacts of energy policy scenarios,” *Appl. Energy*, vol. 145, pp. 234–245, 2015.

[3] A. Mirakyan and R. De Guio, “Integrated energy planning in cities and territories: A review of methods and tools,” *Renew. Sustain. Energy Rev.*, vol. 22, pp. 289–297, 2013.

[4] B. Mattoni, F. Gugliermetti, and F. Bisegna, “A multilevel method to assess and design the renovation and integration of Smart Cities,” *Sustain. Cities Soc.*, vol. 15, pp. 105–119, 2015.

[5] M. F. Lawrence, D. Wei, A. Rose, S. Williamson, and D. Cartwright-Smith, “Macroeconomic impacts of proposed climate change mitigation strategies for transportation in Southern California,” *Res. Transp. Econ.*, vol. 307, 2016.

[6] A. Rose and W. Miernyk, “Input–Output Analysis: The First Fifty Years,” *Econ. Syst. Res.*, vol. 1, no. 2, 1989.

[7] M. D. Partridge and D. S. Rickman, “Computable General Equilibrium (CGE) Modelling for Regional Economic Development Analysis,” *Reg. Stud.*, vol. 44, no. 10, 2010.

[8] W. Leontief, “The Structure of the American Economy, 1919e1939,” *Oxford Univ. Press. Oxford, UK.*, 1941.

[9] B. Wicke, E. Smeets, A. Tabeau, J. Hilbert, and A. Faaij, “Macroeconomic impacts of bioenergy production on surplus agricultural land-A case study of Argentina,” *Renew. Sustain. Energy Rev.*, vol. 13, no. 9, pp. 2463–2473, 2009.

[10] K. Kratena, “Un Modelo Input-Output para la Cuantificación del Impacto Macroeconómico (MIOCIM),” 2015.

[11] IRENA, “‘Renewable Energy Benefits: Measuring The Economics’. IRENA, Abu Dhabi.,” 2016.

[12] E. Arrizabalaga, “Multi-criteria methodology for the prioritisation of alternative energy transition scenarios of cities,” University of the Basque Country, 2017.

[13] Eurostat, 2016. Regions and cities. City statistics. https://ec.europa.eu/eurostat/statistics-explained/index.php/Urban_Europe_%E2%80%94_statistics_on_cities,_towns_and_suburbs.

[14] Statistics Finland, 2016, income and consumptionhttps://www.stat.fi/til/tul_en.html.

[15] The World Input-Output Database (WIOD): Contents, Sources and Methods. Marcel Timmer (University of Groningen), 2012.

[16] IRENA. RENEWABLE ENERGY TECHNOLOGIES: COST ANALYSIS SERIES. Volume 1: Power Sector. Wind Power, 2012.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

[17] European Commission, CPA Statistical Classification of Products by Activity https://ec.europa.eu/eurostat/web/cpa-2008.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.