Nantes | Hamburg | Helsinki

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D1.14 TECHNO-ECONOMIC ANALYSIS OF EACH INTERVENTION PER PILOT

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	D1.14 Techno-economic analysis of each intervention per pilot
Diss. Level	PU
Status	Working Verified by other WPs ■ Final version
Due date	31/10/2018
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 (Nantes, Hamburg, Helsinki) and follower cities (Bydgoszcz, Rijeka, Palencia) 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 sustainable energy action plan, 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. Esade 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
01/07/2018	0.3	Eneko Arrizabalaga (TEC) Carles Cervera Francesc Pardo (ESA) Aurélien Henon (NBK)	Advanced version with the general content of all the sections

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15/10/2018	0.4	Eneko Arrizabalaga (TEC) Carles Cervera Francesc Pardo (ESA) Aurélien Henon (NBK)	Advanced version sent to the reviewer
25/10/2018	0.5	Eneko Arrizabalaga (TEC) Carles Cervera Francesc Pardo (ESA) Aurélien Henon (NBK) and contributions from CAR and the reviewers (VWG, HMU)	Final version

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Table of Content

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

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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

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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 next approach:

Figure 1: Global vision of the mySMARTLife Project

This Innovative 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 D1.14 aims 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 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.

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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 in for the analysis.

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2. Introduction

2.1 Purpose and target group

This deliverable is allocated within Task 1.4, which is related to evaluating impacts in lighthouse (NAN, HAM, HEL) cities 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 includes 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 of 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.
- **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 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.

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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 first phase of the methodology proposed for the supply chain analysis of interventions which is focused on the selection of the interventions that will be evaluated. Here, an example is provided with the description of the cases of the three lighthouse cities.

Chapter 6: Describes more in detail the second phase of the methodology proposed for the supply chain analysis of interventions which is focused on the harmonization of the intervention categories. Here, an example is provided with the description of the cases of the three lighthouse cities.

Chapter 7: Describes more in detail the third phase of the methodology proposed for the supply chain analysis of interventions which is focused on the analysis of the socioeconomic and sectorial structure of each city/region. Here, an example is provided with the description of the cases of the three lighthouse cities.

Chapter 8: Describes more in detail the phase four of the methodology proposed for the supply chain analysis of interventions which is focused on the supply chain characterization of the interventions. Here, the main steps of the phase are described in detail including:

- Step I: Disaggregation of costs per intervention
- Step II: Assignment of each cost component with the corresponding subsector or commodity
- Step III: Evaluation of the capacities for the manufacturing and distribution of each cost component (commodity/subsector) in each city
- Step IV: Identification of the main stakeholder related to each cost component

Chapter 9: Includes a summary of the main output of the supply chain analysis of intervention and a discussion about this output can be used for evaluating the supply chain of scenarios

Chapter 10: Describes the main conclusions obtained from the work carried out in the subtask 1.4.3.

Chapter 11: Shows the references of the literature consulted to develop the work.

2.2 Contributions of partners

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

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Table 1: Contribution of partners

Participant short name	Contributions
TEC	Overall methodological development and redaction of all the sections 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.
ESA	Contribution with the development of the socioeconomic analysis of the three lighthouse cities in section 7.
NBK	Participation on the general strategy of the subtask. Contribution with the initial cost breakdown of interventions.
HEL	Contribution (data provision) to the section 5
HAM	Contribution (data provision) to the section 5
NAN	Contribution (data provision) to the section 5
VWG	Overall review of the deliverable
HMU	Overall review of the deliverable

2.3 Relation to other activities in the project

The following 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

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	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

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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.

Advanced Integrated Urban Planning approach of mySMARTLife project

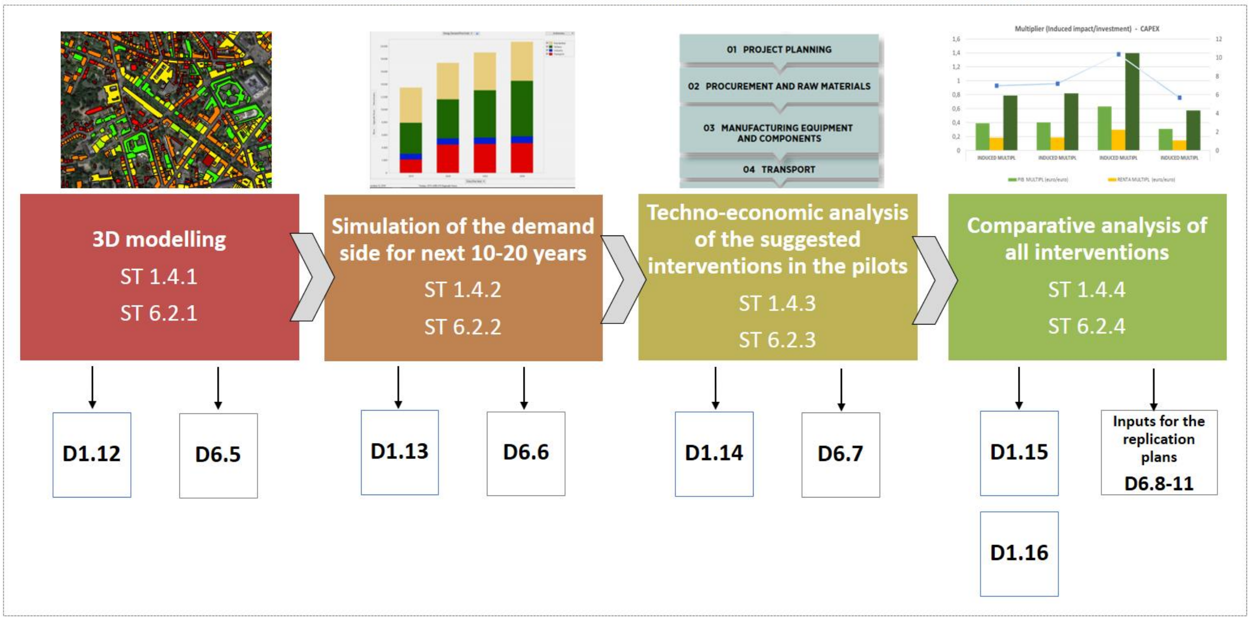

Figure 2: Methodological approach of the Advanced Integrated Urban Planning in mySMARTLife project.

The methodology is composed by four main phases that correspond with the main subtasks showed in the figure above. 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

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modelling provide the hourly energy demands (heating, cooling, domestic hot water) 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 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

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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 D1.6.

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).

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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 type 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 reveals supply chain relationships. It is necessary to mention also that the basic IO model 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].

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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. The figure below 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 power technology.

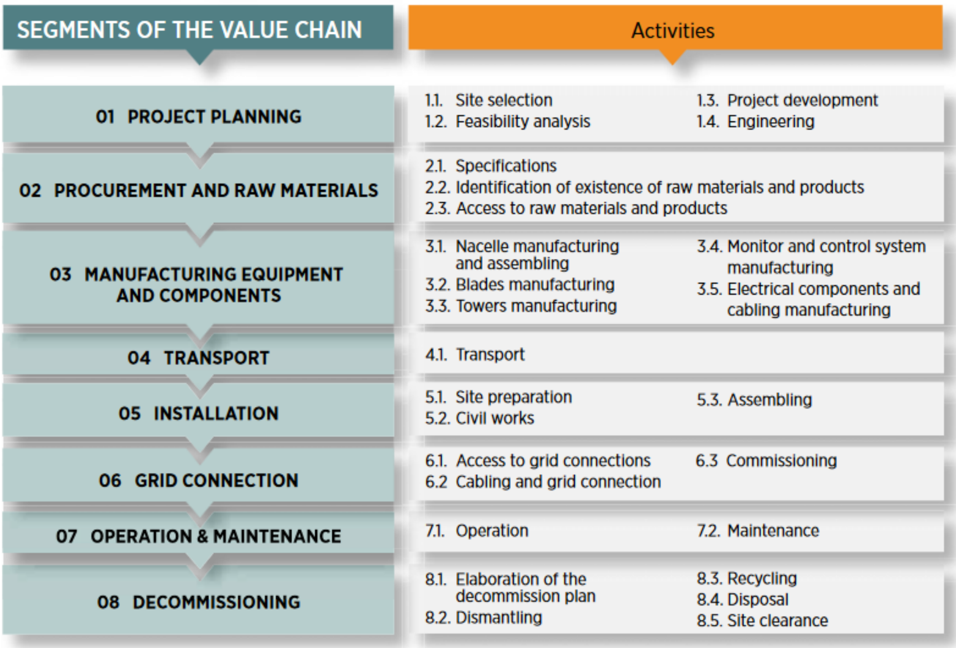

Figure 3: Segments of a wind power project value chain. [12]

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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 phases 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 phases of the method. Besides, the fourth phase is further described including the main sub-phases which are included in it.

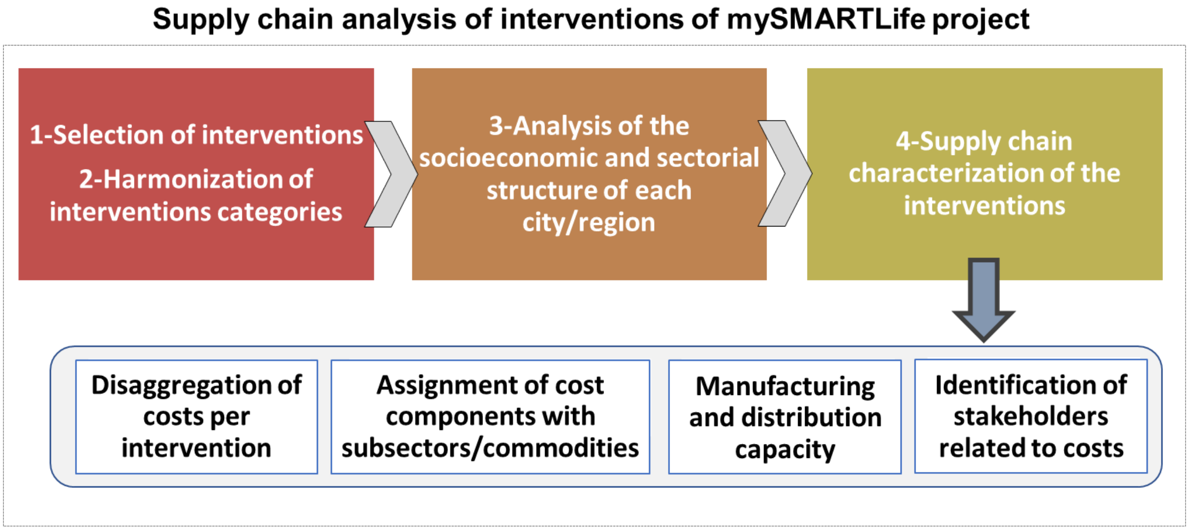

Figure 4: Methodological approach of the Advanced Integrated Urban Planning in mySMARTLife project.

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

Phase 1- Selection of interventions:

In this phase 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, 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 phase 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 phase is further described in the Subsection 6.

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

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This phase 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, 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 phase 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 sub-phase 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 row material, the manufacturing. Here, it is relevant to understand that depending 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 sub-phase is focused on finding a correspondence between each of the cost components of the supply chain analysis of each intervention with one of the subsectors or commodities of the IO table of the corresponding city/region.

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- **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 has 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.

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5. 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 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 associated a high 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.

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In order to provide an example of the selection of interventions, the following subsections describe in short the interventions selection for the three lighthouse cities according to the criteria mentioned above. It needs to be taken into account that this selection is representative by the time of developing this intermediate version of the deliverable but that can change soon depending on the data availability in each case.

5.1 Interventions selection in Helsinki

Based on the criteria defined above, the city of Helsinki has pre-selected the following interventions from all the interventions of the mySMARTLife project.

- Electric vehicles: Electric Bus Up-take
- Charging points: Electro-mobility charging node.
- Charging points: Smart personal EV charging-dynamic load balancing
- Retrofitting of Merihaka_Vilhonvuori; Building (12) and flat (1323) retrofitting and 167 with smart thermostats
- Smart public space (street) lighting
- Solar power plant (50-200 Kw) implementation for Korkeasaari Zoo
- Kalasatama, new buildins; 67 buildings, 4355 flats, smart home solutions (smart heat & electricity) controls, smart meters

5.2 Interventions selection in Hamburg

Based on the criteria defined above, the city of Hamburg has pre-selected as potentially interesting interventions for the analysis the following interventions of the mySMARTLife project.

- Electrical vehicles: Electrification of public vehicles fleet (25 e-cars, 35 e-bikes and 10 last mile people movers)
- Charging infrastructure for public e-vehicle fleet (25 for e-cars., 45 for e-micro mobility)
- Smart street lighting (30 lamps)
- On"Begedorf-Süd" area: Humble lamppost retrofitting of lamps (40)
- Large wind turbines (13 MW)

5.3 Interventions selection in Nantes

Based on the criteria defined above the city of Nantes has pre-selected the interventions that are listed here from all the interventions of the mySMARTLife project.

- Electric storage (620 Ah)

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- Electric buses
- Retrofitting - BELEM building: Insulation of facades and roof (12891 m2)
- Energy retrofitting in individual houses (1000 m2): Insulation of attics and walls
- Smart Lightning (action 18)
- PV solar plant (225 kWp)
- Retrofitting - BELEM buildings: Solar thermal (90MWh/yr)
- Retrofitting - BELEM buildings; Solar PV-Thermal hybrid (50 MWhe/yr + 20MWht/yr)
- MIN Solar Plant 30 000m2 PV, 5 MWc
- Collective self consumption (Malakoff)
- Hybrid solar power systems (30MWhe/yr + 43,86MWht/yr)
- Smart metering: based on the deployment of 8000 smart meters
- Retrofitting - BELEM buildings; Connection to the district heating (84% share RES)
- Digital boiler (action 7)

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6. 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.

Following with the same example of the lighthouse cities of the project, 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

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- **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 the table below.

Table 3: Categorization of interventions into intervention categories for the example described.

Intervention	Intervention category
Electric vehicles: Electric Bus Up-take	Mobility related interventions/ Electric vehicles
Charging points: Electro-mobility charging node.	Mobility related interventions/ Charging infrastructure
Charging points: Smart personal EV charging-dynamic load	Mobility related interventions/ Charging infrastructure
Retrofitting of Merihaka_Vilhonvuori; retrofitting and smart thermostats	Energy efficiency for buildings/ building envelope
Smart public space (street) lighting	Public lighting
Solar power plant (50-200 Kw) implementation	Renewable energy technologies/Solar
Kalasatama, new buildins; smart home solutions, smart meters	Energy efficiency for buildings/ Smart meters and control
Electrical vehicles: Electrification of public vehicles fleet	Mobility related interventions/ Electric vehicles
Charging infrast. For public e-vehicle fleet	Mobility related interventions/ Charging infrastructure
Smart street lighting (30 lamps)	Public lighting

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On"Begedorf-Süd" area: Humble lamppost retrofitting of lamps	Public lighting
Large wind turbines (13 MW)	Renewable energy technologies/Wind
Electric storage (620 Ah)	Renewable energy technologies
Electric buses	Mobility related interventions/ Electric vehicles
Retrofitting - BELEM building: Insulation of facades and roof	Energy efficiency for buildings/ building envelope
Energy retrofitting in individual houses	Energy efficiency for buildings/ building envelope
Smart Lighting (action 18)	Public lighting
PV solar plant (225 kWp)	Renewable energy technologies/Solar PV
Retrofitting - BELEM buildings: Solar thermal (90MWh/yr)	Renewable energy technologies/Solar Thermal
Retrofitting - BELEM buildings; Solar PV-Thermal hybrid	Renewable energy technologies/Solar PV
MIN Solar Plant 30 000m2 PV, 5 MWc	Renewable energy technologies/Solar PV
Hybrid solar power systems (30MWhe/yr + 43,86MWht/yr)	Renewable energy technologies
Smart metering: based on the deployment of 8000 smart meters	Energy efficiency for buildings/ Smart meters and control
Retrofitting - BELEM buildings; Connection to DH (84% RES)	Renewable energy technologies
Digital boiler (action 7)	Efficient energy generation technologies

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7. 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 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.

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

7.1 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 (IO) 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 is part the city 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.

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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.

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

Table 4: 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

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The parameters showed in the table 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

Following with the example the following paragraphs show a summary of the type of analysis that should be carried out applied to the three lighthouse cities.

- **Socioeconomic analysis of Helsinki**

In the case of the city of Helsinki, the analysis should include both the city and the region in which is located (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. 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 Uusimaa region[3], there is a total population of 1,620.261 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 64 for years. 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.

[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

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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. Regarding the non-EU countries, the most representative ones are Asia (60%) and Africa (26%). 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 region[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, 40497 (52%), followed by mother and children, 21.338 (28%). Regarding households, the average size of households is 1.9 persons with a total number of 321.328 dwellings households. 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%.

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 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].

- **Socioeconomic analysis of the city of Hamburg**

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

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

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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 914346 (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[6] and the crude death rate[7] for the city are 11,20 and 10,00 respectively.

For the Hamburg's region[8], there is a total population of 5.300.000 inhabitants. In terms of gender, the region has 49% for male and 51% for female. In terms of age structure[9] population, 12,42% of inhabitants are less than 15 years old, 59% are from 15 to 64 years old, and 15,33% are over 65 years old. The average age of the population is 42,1 years old [15]. 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 1525156 (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 increases up to 51,3% for inhabitants under 18 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. For 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**[10] 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,

[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 presented represents the metropolitan area.

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

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

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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% for male and 3,7% for female.

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

- **Socioeconomic analysis of the city of Nantes**

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 Loyre region). Therefore, all the analysis compares the main characteristics of both scales.

The city of Nantes has a total **population** of 619.240 inhabitants (0,95 % of total population in France). In terms of gender, Nantes has 296.500 (47,88%) male and 322.740 (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[11] and the crude death rate[12] for the city are 12,80 and 6,50 respectively.

For the Pays de la Loyre region[13], 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.

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. 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, there 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

[11] 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.
[12] 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.
[13] The data from the region follows the NUTS classification. In the case of Pays de la Loyre, the data used is from NUTS 2

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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**[14] 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. 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% for male and 13,30% for female. In the case of the region, the unemployment rate is 8,8% for male and 8,9% for female.

7.1.2 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 it is important to complete the analysis with the definition of the sectoral structure that will be 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 (IO) 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 specific table at regional level, it is recommended to use the public available IO tables of the World Input-Output Database (WIOD) [16].

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. It is downloadable at http://www.wiod.org/database/index.htm.

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

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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.

The following table shows the commodities classification used in the IO tables available in the WIOD database.

Table 5: Classification of commodities in WIOD [16] 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

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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
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, the following table shows the classification of sectors used in the IO tables available in the WIOD database.

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Table 6: 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
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

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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.

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.

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8. 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 sub-phases 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 sub-phases that are described more in detail in the following sub-sections.

8.1 Sub-phase I: Disaggregation of costs per intervention

The first sub-phase 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 us 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 sub-phase 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.

The figure below serves as an example of the initial cost breakdown of interventions. It is focused mainly in the disaggregation of the costs of the CAPEX (CAPital Expenditures) of the off-shore wind technology.

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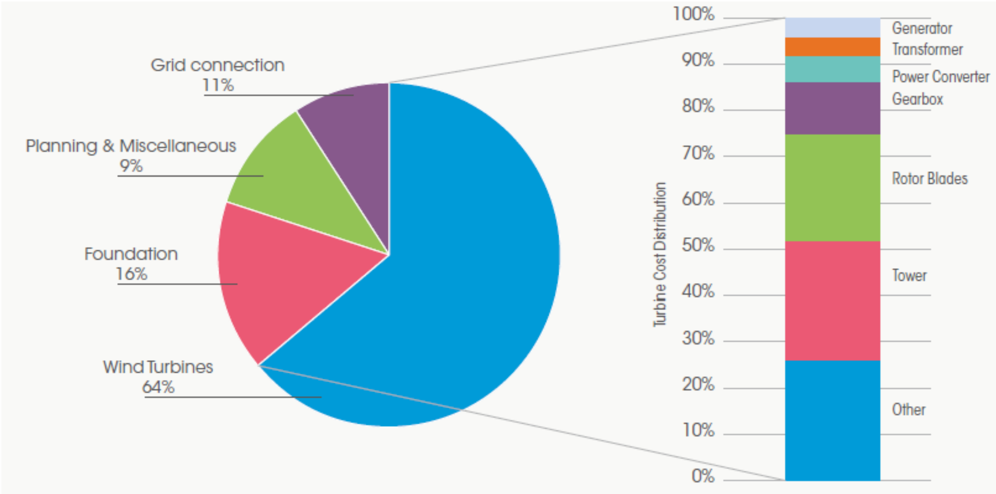

Figure 6: Capital costs breakdown example for the off-shore wind technology [17].

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 sub-phase, the investment plan and the economic viability studies should be used. The following table shows the treated data of the example which has been further disaggregated.

Table 7: 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%

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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.

The following data gathering template is provided in the project for gathering the required information in this sub-phase. It can be observed that not only CAPEX costs need to be considered. Here, the lifetime of the intervention, the OPEX (OPerating EXpense) 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 8: 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		€		

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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		
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.

8.2 Sub-phase II: Assignment of each cost component with the corresponding subsector or commodity

Once that the cost breakdown is completed, in the second sub-phase 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 sub-phases 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, the table below 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 [18]. 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 sub-phase.

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Table 9: 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	Machinery
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 equipment	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
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 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.

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8.3 Sub-phase III: Evaluation of the capacities for the manufacturing and distribution of each cost component (commodity/subsector) in each city

The third sub-phase 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 sub-phase 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 sub-phase 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.

The table below servers as the main data gathering template for the sub-phase 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 sub-phase, 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 10: 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)

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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)

8.4 Sub-phase IV: Identification of the main stakeholder related to each cost component

The sub-phase 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 sub-phase will evaluate origin of all the payments that take part in the deployment of each intervention. In this regard, three main types of actors 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,
- The percentage of the costs covered by public funding out of the region,
- The percentage of the costs 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 sub-phases 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 sub-phase the template provide in the figure below should be completed for each of the interventions evaluated.

Table 11**:** An example table (Wind Power) 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?

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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 costs)		€/year				
O&M Grid electricity base price (fixed costs)		€/year				
O&M cost (materials)		€/year				
O&M cost (labor)		€/year				
End of life costs		€				

This sub-phase 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 sub-phase is carried out to provide a higher level of detail of the shock that represents the intervention evaluated.

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9. Summary and output of the supply chain analysis of intervention

Following the methodology each municipality will obtain with the support of the analyst all the information necessary to generate the shock that will represent interventions and that will be the input for the socioeconomic modelling of the integrated urban planning process.

As a summary the information generated per each intervention of each city could be included in the template shown in the table below. Here, all the costs components are classified according to the commodity classification, the capacities of the city/region to provide the necessary components and the type of stakeholder who is participating.

Table 12: Template for the summary of the supply chain analysis of individual interventions.

Commodity /Sector	Local (city level)		Regional level		Who makes the payment?			
	local producer?	Local distribution?	local producer?	Local distribution?	% public funding (Out of the region)	% public (Regional) funding	% (citizens)	% private companies
Services auxiliary to financial services and insurance services								
Machinery and equipment n.e.c.								
Electrical equipment								
Fabricated metal products, except machinery and equipment								
Repair and installation services of machinery and equipment								
Electricity, gas, steam and air-conditioning								
Basic metals								

Therefore, in the case that one city evaluates more than one intervention, the same process needs to be replicated. This will allow obtaining the specific shock of each intervention and will also allow comparing their potential effects in the socioeconomic development of the city and region.

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The effect of the simultaneous implementation of interventions can be evaluated by summing by commodity (according to the classification defined) all the costs that are involved in all the interventions. This will allow obtaining specific shock that will represent in this case the entire scenario (which is composed by the simultaneous implementation of individual interventions).

Finally, in order to facilitate the following phases of the technoeconomic analysis, several data gathering templates have been created in the project in excel format and shared with the partners involved in the subtask. Each template includes the interventions that have been pre-selected by each city as potentially interesting for the analysis. Besides, a specific section has been included to gather all the information that is required in the proposed methodology.

	NANTES INTERVENTIONS TO BE INCLUDED IN THE TECHNOECONOMIC ANALYSIS
H1	Electric storage (620 Ah)
H2	Electric buses
H3	Retrofitting - BELEM building: Insulation of facades and roof (12891 m2)
H4	Energy retrofitting in individual houses (1000 m2): Insulation of attics and walls
H5	Smart Lightning (action 18)
H6	PV solar plant (225 kWp)
H7	Retrofitting - BELEM buildings: Solar thermal (90MWh/yr)
H8	Retrofitting - BELEM buildings; Solar PV-Thermal hybrid (50 MWhe/yr + 20MWht/yr)
H9	MIN Solar Plant 30 000m2 PV, 5 MWc
H10	Collective self consumption (Malakoff)
H11	Hybrid solar power systems (30MWhe/yr + 43,86MWht/yr)
H12	Smart metering: based on the deployment of 8000 smart meters
H13	Retrofitting - BELEM buildings; Connection to the district heating (84% share RES)
H14	Digital boiler (action 7)

H1 Electric storage (620 Ah)

Project / intervention lifetime

	Years

					Who pays?					
	Costs of the component	Unit (specify)	Specific lifetime of the component (years)	Total cost in the lifetime (including replacement)	% of cost paid with public funding (Out of the region)	% of cost paid with public (Regional) funding	% of cost paid by the individual (citizens)	% of cost paid by private companies	Total costs (needs to sum 100%)	local producer? (in the city) (YES/NO)
									0%	YES
									0%	YES
									0%	YES
									0%	YES
			-	-					0%	YES
			-	-					0%	YES
									0%	YES
									0%	YES
									0%	YES
									0%	YES
										YES
										YES

Figure 7: Data gathering templates generated and circulated to lighthouse cities and technical partners to complete the supply chain analysis of interventions (Example of the case of Nantes).

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10. 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, in this intermediate version the detailed methodological approach for the supply chain analysis of the interventions has been described in detail. 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 the lighthouse cities to obtain the same accuracy and level of detail of the "intermediate shock".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. From the work carried out in this subtask, it can be concluded that the relation between the analyst 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 project partners. This cost breakdown is then contrasted with the actual data of investments provided by municipalities.

Finally, it needs to be mentioned that in terms the socioeconomic analysis, the preparation of the information in the exact format in which it is needed for the following step of the process (which involves the use of the IO matrixes) is essential. This will be ensured following the methodology proposed.

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