SEMANCO

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Updated impact verification

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DoW	Task 2.3 *Impact evaluation*. This task is in charge to provide strategies which will enable to verify the impact of the integrated tools and associated methodologies, which will be then applied in WP 8 in three yearly cycles. Specifically, this report updates the impact verification strategy and the recommendations to continue with the development of the integrated platform functionalities whose purpose is to help to reduce CO2 emissions at the urban level.				
Comments					

Document history

V	Date	Author	Description
1	2013-9-18	Gonzalo Gamboa, Xavier Cipriano, Stoyan Danov	First draft of the document
2	2013-10-3	Gonzalo Gamboa, Xavier Cipriano	This version addresses most of the comments done by Leandro Madrazo
3	2013-10-6	Gonzalo Gamboa, Xavier Cipriano	This version addresses comments by Leandro Madrazo, Ilaria Ballarini and David Lynch
4	2013-10-25	Leandro Madrazo	Review and editing.
5	2013-10-29	Gonzalo Gamboa	This version addresses comments by Leandro Madrazo. It is submitted for internal review
6	2013-10-29	Martin Carpenter	Proof-reading
7	2013-10-30	Gonzalo Gamboa	This final version addresses comments raised in the internal review.
8	2013-10-30	Martin Carpenter	Final proof-reading

Table of Contents

1 EXECUTIVE SUMMARY

The present document is an update of D2.3 *Impact verification*, in the sense that the assumptions and results of that deliverable are reviewed and updated according to the current state of the integrated platform. The aim is then to update the strategy to verify the impact of the integrated platform, which depends on the following issues:

1. The ability of the platform to deal with the challenges emerging from the existence of elements of the urban energy system operating simultaneously at different scales. That is, to integrate the functionalities to perform evaluation of the energy performance at different scales, to use a set of multidimensional indicators, to differentiate the energy related categories (i.e. primary energy sources, energy carriers and final energy uses) in the calculation of energy performance and indicators, and to use an adequate energy calculation method with respect to the objectives of the analysis. (i.e. find a balance between detailed and relevant information)
2. The ability of users to perform a set of activities planned for implementation by means of the integrated platform; i.e. by means of a set of required and expected functionalities. As the activities differ across the scenarios, the analysis has been done by grouping the activities in the following way: creating alternative urban projects, integrating data from different sources, simulating the energy performance of an urban area and calculating performance indicators.
3. The relevance, for users and stakeholders, of the outcomes of the SEMANCO tools. That is, the relevance of methods, data and indicators included in the integrated platform for the daily work of different actors involved in energy efficient urban planning realm.

For each of the above mentioned issues, a review and update of challenges and strategies is carried out. Then, a set of questions in each case is defined in order to evaluate the impact of the integrated platform. Due to the nature of those issues, questions are addressed to different type of actors. Questions related to point 1 are addressed to domain experts. Questions related to point 2 are addressed to users and domain experts, who implement the functionalities in real scenarios. Questions related to point 3 are addressed to users and stakeholders, who are the people that will make use of the final version of the SEMANCO integrated platform.

Finally, the document presents a list of tasks to be performed by partners in charge of implementation and of technological development. These tasks are aimed at assuring that the set of required and relevant functionalities are/will be included in the platform.

2 INTRODUCTION

2.1 Purpose and target group

During the first year of the project, WP2 produced three deliverables. In D2.1 *Report of the case studies and analysis* the context in which the semantic-based energy information framework and the suite of tools to support energy efficient urban planning would be developed was presented. That deliverable also identified the data and the data sources to be semantically modeled and accessed through the SEMANCO integrated platform.

In D2.2 *Strategies and indicators for monitoring CO_2 emissions* a list of relevant indicators to monitor CO_2 emissions and energy consumption in the context of energy efficient urban planning were compiled. This provided a clear understanding of the data requirements for the development of strategies, methods and tools for energy efficient urban planning. It also helped to consider the needs of different actors involved within the scope of the case studies.

Finally, as of the end of the first year of the project, D2.3 *Impact verification* was delivered, which focused on the challenges to be faced when implementing urban planning at multiple scales. According to D2.3, the impact of the integrated platform would depend on:

- The ability of the integrated platform to deal with the theoretical challenges identified and methodological strategies defined in D2.3. That is,
  - The ability to perform evaluations at different scales: to account for the flows of energy carriers and CO_2 emissions through the components of the urban system acting at different scales. This entails some specific requirements for the SEIF, such as the use of common categories of land uses.[1]
  - The ability to use non-equivalent descriptive domains: to evaluate the performance by means of a set of multidimensional indicators. Following the feedback obtained during the first year review, this includes considering key social indicators, such as the acceptance of projects by dwellers and/or building owners. Also, there are some specific requirements for the SEIF, such as the ability to calculate distributive indicators at higher scales (e.g. difference in access to final energy uses).
  - The ability to keep track of energy transformations across scales: it entails to keep the distinction between different energy related categories (i.e. primary energy sources, energy carriers and final energy uses) when accounting for energy related flows and calculating indicators.
  - The ability to use adequate energy simulation models suitable to the scale of analysis: simplified models at urban scale and detailed models at dwelling and building scale.
- The ability of the integrated platform to meet expectations of users, stakeholders and domain experts in terms of whether it is possible to perform the activities planned for implementation by means of the platform. This means:
  - To enable the user to create alternative urban plans.
  - To integrate data from different sources (e.g. create input files for integrated and interfaced software).
  - To calculate the energy performance and related performance indicators.
  - To perform data analysis with advanced statistical techniques.
  - To visualize results of energy performance calculations and data analysis.

[1] According to D2.3, the ability to assess the feasibility of future plans or projects is also a specific requirement for the SEIF. However, the task of fully developing such functionality would require a project devoted specifically to that and so lies outside the feasible scope of SEMANCO.

In this document, a review and update of the above mentioned issues is presented. With this purpose, a set of inquiries to evaluate whether the current development of the integrated platform responds to these issues have been defined. Those questions will need be answered by domain experts and users once the platform is operative and the second implementation round has been carried out.

Finally, this document includes a list of questions for users and stakeholders to know whether the functionalities included in the platform are relevant for the work they do concerning planning of energy efficient cities.

2.2 Contribution of partners

This report has been written by CIMNE as leader of Task 2.3 *Impact evaluation*. The editing of the document has been performed by CIMNE in collaboration with FUNITEC and NEA. Detailed reviews of the deliverable were conducted by FUNITEC, NEA and POLITO. Finally, UoT has undertaken the proof reading of the final document.

2.3 Relations to other activities in the project

Firstly, this deliverable is closely related to the work done in WP5 *Integrated tools* since most of the requirements that were defined in D2.3 and updated here are expected to be included in the integrated platform. For instance, those requirements concerning the assessment and visualization of energy performance at different scales by means of a multidimensional set of indicators.

The work presented in D2.4 is also related to WP6 and WP8. According to the DoW, there will be regular contact with actors and between partners during implementation (WP8) to capture users and stakeholders requirements (WP6) and evaluate the impact of the integrated platform (WP2). This conveys to ask users, stakeholders and domain experts to evaluate the pertinence of the implemented functionalities. Since each demonstration scenario has its specificities, the questions presented in this document should be tailored to each case. This entails the need of close collaboration between leaders of WPs 2, 6 and 8, and partners in charge of implementation.

3 CHALLENGES AND STRATEGIES FOR ENERGY EFFICIENT URBAN PLANNING

According to D2.3 *Impact verification*, energy efficient urban planning presents several challenges deriving from the existence of multiple scales within the complex hierarchical system; such as the need to consider multiple scales and dimensions in the analysis, or to differentiate the energy related categories i.e. primary energy sources, energy carriers and final energy uses. These challenges need to be taken into consideration in order to have a successful development and implementation of the suit of integrated tools. This section is aimed at reviewing and updating the strategies for impact verification defined in D2.3, as a result of the insights derived from the first implementation round (D8.2 *Implementation success indicators*) and from the interaction with stakeholders (D6.1 *Enabling scenarios for stakeholders*).

Each of the following subsections is structured as follows:

1. Summary of the challenges identified in D2.3
2. Summary of the strategies defined in D2.3
3. Inquiries about the functionalities that should be integrated in the platform

In summary, the content of the following sections is the basis to verify the impact of the integrated platform, in terms of whether the integrated functionalities deal with the theoretical challenges and methodological strategies for energy efficient urban planning. The evaluation will be performed by asking the set of questions provided in this section to domain experts after the second implementation round.

3.1 Urban energy systems operating at different levels

3.1.1 Challenges

An urban energy system can be seen as a complex network of relations between elements operating simultaneously at different levels. The elements of the urban energy system are very interrelated and there are high degrees of interdependence between them. For example, an urban intervention at building level may have (positive and/or negative) effects at a higher and lower urban levels, and vice-versa. Likewise, increasing the height of a building may help to increase the solar radiation over the building, hence, improving its energy performance by reducing the energy requirements for heating. But, a taller building may cast more shadows over other buildings, worsening the energy performance of the urban area, by increasing the overall energy requirements for heating.

3.1.2 Strategies

To evaluate the energy performance of urban areas at different scales (i.e. micro, meso and macro) it is necessary to use an adequate accounting framework to up- and down-scale indicators across levels.

The main strategy to do so consists in defining a set of nested urban space[2] categories. For instance, dwellings make up a building, buildings make up a neighbourhood, neighbourhoods make up a district and districts make up a city. These urban space categories (e.g. building, neighbourhood, district/ward, city) should be indicated in the city's GIS and its corresponding 3D model. In this way, it is possible to map the flows of energy carriers (e.g. electricity, gasoil, natural gas) and matter (e.g. CO_2 emissions) in the residential sector across administrative boundaries.

[2] As it was stated in D2.1, "the notion of "area" is understood under two distinct approaches: "one considers space as a set of relations and the second considers space as a container. The former might be determined by the interactions between the elements of the system and present flexible boundaries (*e.g.* the area covered by a district heating system). Space as a container is presented as an established boundary determined by administrative authority (e.g. districts/wards, cities, municipalities, provinces)" (Gamboa et al., 2012; p. 5). In this case, we are dealing with the space as a container.

Then, the process of up-scaling intensive indicators is performed in the following way:

a) Aggregating the flows of energy carriers and CO_2 emissions (and other relevant flows) that pass through urban system elements operating at certain scale (e.g. buildings), to obtain the flows passing through a higher level element of the urban system (e.g. neighbourhood). For instance, aggregate flows of electricity passing through the buildings belonging to a certain neighbourhood, in order to obtain the electricity consumption at neighbourhood level.

b) Aggregating the surface of the lower level compartments through which the flows of energy carriers and CO_2 emissions (and other relevant flows) pass by. For instance, aggregate the built surfaces of the buildings belonging to a certain neighbourhood. The flows of electricity accounted in the previous step are passing through the built surface calculated in this step.

c) Dividing the aggregated flow (e.g. of electricity) by the aggregated surface, in order to obtain the flow per square meter of land at a higher level (e.g. neighbourhood).

In this way it would be possible to represent the energy performance of the building level (i.e. the building considered individually) and of the upper level components of the urban energy system (e.g. neighbourhood, district, city). This way, a user of the integrated platform would be able to check whether the impacts of an urban project are good (or bad) across scales.

It should be noticed here that different urban space categories can be used to up- and down-scale indicators. For instance, we could use land use categories related to the activities instead of administrative boundaries. In this case, the nested urban space categories would be the following: housing buildings make the residential sector; office buildings and commercial centers make the commercial sector; public services, schools and hospitals make the public sector, among others. However, the simulation software included in the integrated platform (i.e. URSOS) is aimed to calculate the energy demand of housing, not other building uses. Then, the space categories based on administrative boundaries seem more appropriate than using those based on activities. The land use classification based on activities can be used when data is available for a wider range of building uses (e.g. when visualizing real data from monitoring).

3.1.3 Inquiries about the current state of the platform

The following questions are aimed at capturing the opinion of domain experts regarding the ability to carry out multi-scale evaluations of the performance of urban energy systems by means of the integrated platform.

- Are the urban space categories (e.g. building, neighbourhood, district, ward, city) already included in the 3D models?
- Is the integrated platform able to calculate and visualize extensive indicators at different levels? Is the system able to aggregate indicators on building energy performance to provide information on the energy performance of an urban area (e.g. neighbourhood or city)?
- Is the system able to calculate and visualize intensive indicators across levels? Is the system able to calculate energy demand (kWh/m^2) or CO_2 emissions (Ton/m^2) per square meter from the building to the level of an urban area?
- Is the integrated platform able to automatically change scale when zooming-in and -out?

3.2 Multiple dimensions to represent urban energy systems

3.2.1 Challenges

On the one side, multiple scales also imply the existence of multiple identities of the same system across scales. A building can be described by focusing on its physical characteristics such as the type of enclosures (opaque walls and windows) and its technical building systems. But it can also be described in terms of the socio-economic and demographic characteristics of its inhabitants. This entails that the perception and representation of an urban energy system should be done using multiple dimensions of analysis in order to embrace different points of view about its energy related performance.

The preliminary set of indicators defined in D2.2 encompassed socio-economic and biophysical indicators: e.g. investment and operational costs, and flows of energy carriers and CO_2 emissions. However, it is becoming increasingly important in urban planning to consider the implications for residents and local citizens. Following feedback during the first year review, social acceptance indicators will be included in the set of performance indicators. This is an important issue, since the successful implementation of an energy efficient urban project requires the acceptance of inhabitants, building owners, or even a wider range of social actors going beyond the target urban area.

On the other side, as it has been noticed in D2.3, the existence of multiple scales entails that a system might have some properties that the elements that make the system lack, and vice versa. That is, when changing the scale of analysis, emergent attributes become relevant to represent the urban energy system. For instance, the inequality in access to energy services (e.g. energy consumption for heating) is a relevant indicator to compare between households, buildings or neighbourhoods. But the same indicator may be irrelevant at dwelling level.

In practical terms, the existence of emergent properties across scales implies that, when calculating indicators, one has to decide whether to aggregate or disaggregate them and up to which level is relevant to do so. For instance, the internal rate of return of investing in a new boiler in one building may be irrelevant at neighbourhood scale.

3.2.2 Strategies

The main strategy to deal with the issue of multiple identities at multiple scales is to use a set of multidimensional indicators to assess and represent the performance of the urban energy systems. This set of indicators was defined in D2.2 *Strategies and indicators for monitoring CO_2 emissions* and is updated here by including strategies to measure social acceptance of urban projects.

Table 1 provides a list of the indicators to be calculated in the second implementation round of the demonstration scenarios. Each indicator has been denoted as relating to one or more urban space categories by the domain experts. It remains to define, within the integrated platform, how and who defines which indicators are to be aggregated and up to which scale.

Table 1. Indicators to be calculated across scales

Dem. scenario	Indicator	Urban space category				
		Dwelling	Building	Neighbourhood	District	City
Manresa	Energy demand (from cooling, heating and electricity)		✓	✓ (A)		
	CO_2 emissions (from cooling heating and electricity)		✓	✓ (A)		
	Potential local PV energy generation		✓	✓ (A)		
	Construction costs		✓			
	Energy related operational costs (e.g. cost of bills)		✓	✓ (A)		
	Internal rate of return		✓			
Newcastle	Total predicted yearly energy demand (from cooling, heating and electricity)	✓	✓ (A)	✓ (A)		
	Total predicted CO_2 emissions	✓	✓ (A)	✓ (A)		
	Normalised CO_2 emissions	✓	✓ (A)	✓ (A)		
	SAP rate	✓				
	Upfront install cost of proposed improvements	✓	✓ (A)	✓ (A)		
	Annual Savings on energy bill	✓	✓ (A)	✓ (A)		
	Total predicted lifetime cost loss/gain balance	✓	✓ (A)	✓ (A)		
	Index of multiple deprivation			✓ (DB)		✓ (DB)
	Percentage of households population with access to energy services			✓ (DB)		
	Number and Percentage of Households in Fuel Poverty.			✓ (DB)		
	Social acceptance		✓			
North Harbour	Electricity consumption		✓		✓ (A)	
	Heating demand		✓		✓ (A)	
	Cooling demand		✓		✓ (A)	
	CO_2 emissions (from electricity, heating and cooling)		✓		✓ (A)	
	Cost of electricity		✓ (D)		✓	
	Cost of heat supply		✓ (D)		✓	
	Cost of cooling supply		✓ (D)		✓	
	Internal rate of return				✓	

Obs: The following nomenclature is used in the table:
✓: indicators calculated by means of the tool used in the demonstration scenario;
✓ (A): indicators calculated by aggregating the figures of lower level urban system elements;
✓ (D): indicators calculated by disaggregating the figures of higher level urban system elements;
✓ (DB): indicators obtained from data bases, which are available for certain scales.

On the other side, and in general terms, it is quite expensive and time consuming to assess an indicator of social acceptance. To evaluate it in a representative manner it is necessary to run a survey to know people's perception. The cost of doing such an evaluation would increase according to the amount of consulted people. For this project, it would be possible to conduct surveys in the case of individual building refurbishment, where the amount of affected and consulted people is limited to dwellers and building owners, as in the Newcastle demonstration scenario.

However, when dealing with energy efficient urban interventions at higher scales, the application of public opinion surveys falls beyond the scope of this project[3]. In those cases, it can be implemented a social rating scheme, as the "Like" scheme in the social networks, to evaluate people's perception of different projects. In that case, the different type of users will be able to rate each project from one to five stars, and the average rating would be an indication of the popularity of the project. In this way, the integrated platform would provide information on the technical performance of a project (i.e. indicators) and the social acceptance (i.e. social rating) in parallel. It should be noticed however, that some typologies of people do not have access to ICT schemes, which may bias the results of the social rating.

3.2.3 Inquiries about the current state of the platform

The following questions are aimed to obtain the evaluation of domain experts regarding the adequacy and relevance of the set of indicators included in the platform. Also, the suitability of the social rating scheme is assessed.

- Are the set of indicators listed in Table 1 already considered in the platform?
- Is the social rating scheme included in the platform? Is it easy to use?
- Are indicators of social acceptance already included in the platform?

3.3 Energy transformations across scales

3.3.1 Challenges

It can be argued that the range of final energy uses depends on the ability of the energy sector to deliver the required energy carriers, which are produced from the available mix of primary energy sources. For example, the energy carriers produced from one kW of coal are different than the energy carriers produced from one kW of oil. Therefore, the possibilities of performing some final energy uses are also different (e.g. one cannot produce gasoil from coal to fuel cars). In other words, the availability to perform certain final energy uses depends on the mix of primary energy sources that are transformed into some energy carriers.

When urban or energy planners propose to change energy carriers to reach a final energy use in the urban environment, they need be aware that this entails non-linear changes in the energy transformation chain and, in particular, in the demand of primary energy sources. For instance, if people change the energy carrier used in the heating system from electricity to natural gas, it is expected to increase the consumption of natural gas and to reduce the consumption of primary energy sources and of the energy carriers used to produce electricity (e.g. gasoil, coal, and also natural gas). Besides, the consequences of the release of GHG emissions will be different depending on both the energy carrier and the final energy use targets for intervention.

3.3.2 Strategies

The above mentioned issues call for keeping the distinction between different energy related categories (i.e. primary energy sources, energy carriers and final energy uses) when calculating indicators. In this way, it would be possible to keep track of the series of energy transformations across scales. For instance, when calculating the CO_2 emissions, results will be provided according to

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[3] This does not mean that public opinion surveys at neighbourhood, district or city scale cannot be implemented in real applications of the integrated platform. This is certainly an issue to be decided by the local administration or by the promoters of the intervention, for instance.

final energy use (e.g. CO_2 emissions from heating and cooling) and energy carrier (CO_2 emissions from the use of natural gas and electricity). In this way, it would be possible to compare and to find interventions with higher contributions to the reduction of GHG emissions. In order to disaggregate indicators , the technical standard EN15603 *Energy performance of buildings - Overall energy use and definition of energy ratings* (European Committee of Standardization, 2012)[4] will be followed. This standard provides a procedure to express energy performance indicators by energy service (heating, DHW etc.) or by energy carrier (natural gas, oil, electricity etc.). It presents also the way for calculating and reporting primary energy.

3.3.3 Inquiries about the current state of the platform

The following questions are aimed to obtain the evaluation of domain experts regarding the ability of the integrated platform to differentiate indicators according to energy carriers and final energy uses:

- Is the system able to provide information on energy consumption differentiating between energy carriers and final energy uses?
- Are the indicators related to GHG emissions differentiated according to energy carriers and final energy uses?

3.4 Finding a balance between detailed and relevant information

3.4.1 Challenges

As stated by the Zadeh's Incompatibility Principle (Zadeh, 1973), our ability to make precise and yet relevant statements about a system diminishes as the complexity of the system increases. This principle applies to the use of different energy modeling methods at different urban scales. Roughly speaking, we can classify energy simulation methods in simplified and detailed methods: they require different levels of details in the input data and the outputs they provide also differ in the level of detail.

3.4.2 Strategies

At the outset, a simplified model would be more suitable to optimize energy demand of a group of buildings (i.e. to find the configuration of the urban area with less energy consumption in relation with other evaluated alternatives). On the other side, a detailed model is more suitable to develop a building project which requires detailed information about the building (e.g. structure, materials, internal distribution of dwellings and their occupation). Each method has very different requirements of data and processing time.

It is interesting to notice that data standards and simulation methods are mostly developed for dwellings and buildings. Moreover, each country uses their calculation method in order to evaluate if buildings conform to national regulations (e.g. energy certification schemes). This makes it necessary to relate a particular tool with the regulatory framework (e.g. the local, national or European regulations) for which the outcomes of the tool might be relevant. This link between tools and application cases needs to be considered in the integrated platform.

In its current version, the integrated platform encompasses more or less simplified methods, which can be applied to single dwelling or urban scales. The SAP rating tool, implemented in the Newcastle demonstration scenario, is a simplified method for individual dwellings. It is the national calculation method fulfilling legal requirements of UK, which limits its usability in countries different than the UK. Then, increasing in the level of simplification, the URSOS calculation engine and the Urban Planning Tool are suitable to evaluate the energy performance of urban areas. These tools can be applied to any location if the required data is available.

[4] This standard (also mentioned in Del. 3.2) provides a procedure to express the energy performance indicators, to express final energy by energy service (heating, DHW etc.), or by energy carrier (natural gas, oil, electricity etc.). It presents also the way for calculating and reporting primary energy.

3.4.3 Inquiries about the current state of the platform

The following questions are aimed to obtain the evaluation of domain experts regarding the integration of calculation methods with different degrees of simplification in the platform.

- Does the platform include calculation methods of energy performance for different urban scales (e.g. building, urban area)?
- Are the calculation methods for different scales available for all case studies?
- Would it be useful to integrate an additional calculation method dealing with specific urban scales?
- Is it possible to compare the results of the evaluation performed in different countries? If no, how can it be done?
- If a calculation method for the energy assessment of urban areas as a whole is not available, can the calculation models based on the building scale be applied to building stocks? Which are the implications/limitations?
- Are there solutions to overcome the limitations of these calculation models?

4 CHALLENGES EMERGING FROM IMPLEMENTATION

As mentioned in D2.3, the impact of the integrated platform depends on what is expected from users, stakeholders and domain experts and whether they can improve their decision making through the functionalities provided by the platform.

This section provides an overview of the strategies adopted in the development of integrated platform to enable users to perform the activities to be implemented in the demonstration scenarios. As the activities differ across the scenarios, the analysis has been done by grouping the activities as such: creating alternative urban projects, integrating data from different sources, simulating the energy performance of an urban area and calculating performance indicators.

In the following subsections, the strategies adopted to deal with each of the above mentioned group of activities are outlined. Some of these strategies are specific of each demonstration scenario and some of them are common to all countries.

4.1 Creating alternative urban projects

4.1.1 Strategy

In its current version, the integrated platform includes the concepts of Urban Energy Model (UEM), Plans and Projects. A UEM is made up by data, tools and users. Plans refer to different urban plans addressing an urban problem within a target urban area, and Projects refer to the different energy efficient interventions or urban plans within a Plan, which will be compared against each other and against the baseline. This framework is intended to encompass a wide range of problems related with energy efficient urban planning, from the assessment of interventions at the dwelling level (e.g. Newcastle) to urban plans (e.g. Manresa), or even to proposing energy supply systems which suit the energy demand of an urban area (North Harbour, Copenhagen).

This framework also conveys a process by which the tools and data needed for the analysis of an Urban Energy model are selected and configured. The process starts with the selection of tools and data, which are used to calculate the baseline of the energy performance of the target urban area. After those steps, the user will have the necessary information to define different plans within the target urban area, and to develop different projects to be compared.

The process of defining Plans and Projects is common to all UEMs. The functionalities to create alternative urban projects are also the same across Urban Energy Models. That is, disregarding the UEM, the platform will enable the user to change both building and urban geometries (e.g. to demolish, to build), occupation parameters (e.g. comfort temperatures, occupation), structural characteristics (e.g. U-values and solar absorption factors of enclosures) and system features (e.g. type of energy carriers, energy supply systems).

4.1.2 Inquiries

The following set of questions is addressed to users and domain experts. The aim of these questions is to evaluate the easiness of use of the platform and the ability of users to create alternative urban projects:

- Is the framework of Urban Energy Model easy to understand and implement?
- Is the framework of Urban Energy Model applicable to a wide range of energy efficient urban planning frameworks? For instance, is this framework applicable across demonstration scenarios?
- Is it possible to develop alternative scenarios of urban planning (i.e. plans and projects) by means of the integrated platform?
- How would you evaluate the platform in terms of user friendliness when developing and defining alternative plans and projects?

4.2 Integrating data from different sources

4.2.1 Strategies

The integrated platform contains three types of tools: embedded, interfaced and external, each of them requiring different ways to input data. Data is retrieved from different sources by SEIF, which produces an input file for the selected tool. As mentioned in Corrado et al (2013, p. 8) "the main goal of the SEIF is to ensure the principle of data access interoperability: tools or users should be able to formulate data queries without knowing technical details concerning access methods supported by single sources, sources' content, data schemas or specific semantics employed by each source".

In the current version of the platform, the URSOS calculation engine as well as the Urban Planning Tool use semantically modeled data coming from different sources; either outcomes from previous calculations or directly from data bases. In the case of the URSOS calculation engine, an interfaced tool, building geometries are obtained from the city's GIS while occupation parameters are calculated from the census, technical parameters of buildings from tables relating the year of construction of the building with its structural characteristics, and the year of construction of the building from the cadaster.

In order to implement the principle of data access interoperability, an URSOS form to enter calculation parameters has been created. This input form is automatically filled in by SEIF with information from data bases or default values. Then, the user has the possibility to change some parameters without the need to know the technical details of data integration. Another important issue related to data integration is the one of assigning values to parameters that are not contained in databases but are calculated by the platform tools. For instance, it would be useful to determine the percentage of windows in a façade according to both the year of construction of the building and the orientation of the wall. In the same line, it would be useful to determine the expected electricity consumption of a building according to socio-economic factors of its inhabitants. This is an issue very much related to T5.2, within which the tools for statistical analysis are developed.

4.2.2 Inquiries

The following set of questions is addressed to users and domain experts. The aim of these inquiries is to evaluate the ability of SEIF to integrate data from different sources and provide the information required by the different calculation methods:

- Are the input data of the applied calculation method correctly determined by SEIF?
- Is SEIF able to generate the input file of integrated and interfaced tools?
- Is the system able to generate the input file of an external energy simulation model (e.g. an excel spread sheet)?
- Is the system able to classify buildings according to selected parameters?
- Is the system able to assign values to parameters based on statistical analysis?

4.3 Simulating the energy performance of an urban energy system

4.3.1 Strategies

As mentioned in section 3.2, each demonstration scenario uses a different calculation method to obtain the energy demand of the urban areas. Also, each case has developed some calculation procedures, to be implemented through specific tools, to calculate the performance indicators (see Table 1).

In its current version, the integrated platform encompasses three methods to calculate the energy performance of urban energy systems, with different degrees of simplification, for different urban scales and hence for different purposes. The SAP rating tool, specific for the UK, is aimed to calculate the energy performance of dwellings. The URSOS calculation engine, which can be used in different locations, is aimed at calculating the energy demand for cooling and heating of buildings considering their urban environment. The Urban Energy Planning (UEP) tool, also available for any location, is aimed at estimating the overall energy requirements of a newly planned urban area in order to calculate the energy supply systems. In this sense, the second and third implementation round would provide insights about challenges and opportunities offered by the application of different sort of methods.

Regarding the outcomes of these calculation methods, a certain level of reliability is expected. In fact, in order to effectively support decision making the calculations should produce results that are close to reality. To assure a minimum level of reliability, the following strategies have been applied in the demonstration scenarios:

- In the case of the Newcastle case study, the calculations with the SAP rating tool have been validated against evaluations carried out manually by sites visits. Those manual calculations were conducted by visits to properties by the social housing provider in the Newcastle case study area- Your Homes Newcastle.
- In the case of North Harbour, values of energy intensities have been derived from expert knowledge. However, it might happen that those energy intensities do not correspond to the real values when the new urban area is constructed and inhabited. In any case, these values are used to design energy supply options, which have to meet peak values of energy demand. In other words, the analysis performed in this case is a preliminary approximation of potential energy demand to be covered by a combination of energy supply options.
- In the case of Manresa, the outcomes obtained from the application of URSOS software have been compared with typical values of energy intensities in the residential sector. The result of this comparison is that this software provides reliable results if the data used for the calculation is of good quality.

Finally, it has to be recalled that the focus of the SEMANCO project is on applying semantic data modeling techniques in the field of energy efficient urban planning. This entails that the evaluation of the energy performance of urban energy systems should consider the interaction between urban elements; specifically, the effects of shadows. Since the only tool able to deal with the effect of shadows is the URSOS calculation engine, it becomes a must to provide information on this regard when applying calculation models that do not consider the effects of shadows in the evaluation of energy performance of buildings. The main strategy in this regard will be the ability of the 3D maps to show how buildings and other urban elements cast shadows over each other. This would help for a preliminary exploration of the effects of an urban project alternative in terms of increasing or decreasing shadowing over the surrounding buildings (and decreasing or increasing received solar radiation respectively).

4.3.2 Inquiries

The following set of questions is addressed to users and domain experts. The aim of these inquiries is to evaluate whether the different calculation methods can be applied across demonstration scenarios or whether there is the need of integrating additional tool.

- Are the users able to apply different calculation methods to the urban energy system under analysis? If not, which are the main obstacles to do so? How difficult is to collect and provide the required data to implement a different calculation method?
- Is the system able to provide sound/reliable outcomes? Does the system provide information on benchmark values?
- Is there available a set of reference values for simulations using the SAP rating tool? Are they useful to make comparison across UEMs?
- Is there available a set of reference values for simulations using the URSOS calculation engine? Are they useful to make comparison across UEMs?
- Is the system able to visualize shadows? Is this visualization useful for a preliminary urban planning?

4.4 Calculating performance indicators

4.4.1 Strategies

In the current version of the integrated platform, some of the indicators presented in Table 1 are directly calculated by the energy simulation methods presented in the previous section: e.g. demand of energy carriers for heating and cooling. In fact, the SAP rating tool is aimed at calculating all the indicators presented in Table 1 for the Newcastle demonstration scenario, but the social acceptance one, which will be assessed by means of direct consultation to dwellers and building owners.

In the Manresa demonstration scenario, on the one side, the outcomes of the URSOS calculation engine include the energy demand for heating and cooling, and the solar radiation over the enclosures of the building, at building and neighbourhood levels. With this and some additional information it is possible to calculate the rest indicators presented in Table 1. These calculations are to be performed by means of different calculation procedures integrated into the platform as embedded tools. On the other side, the evaluation of social acceptance of alternative urban projects through social rating scheme will be tested. In the North Harbour demonstration scenario, the Urban Planning Tool is used to calculate all the energy performance indicators presented in Table 1. As in the case of Manresa, the measurement of social acceptance will be tested by means of implementing a social rate scheme.

Some indicators, such as the one to calculate CO_2 emissions or the internal rate of return, could be calculated for any location. The calculation of indicators that are common across countries would follow the same procedure, but retrieve data from different sources. For instance, the calculation of CO_2 emissions is done, in all cases, by multiplying the demand of an energy carrier by the emission factor of that energy carrier, and the emission factors are specific to the energy mix of each country. However, in the process of developing the calculation procedures these tools were created for each location independently. In these cases, there is no need to develop specific tools for each case, therefore these tools have to be standardized to be applied in all cases and make them available when defining the Urban Energy Model.

4.4.2 Inquiries

The following set of questions is addressed to users and domain experts. Questions are aimed at evaluating whether the integrated platform is able to represent the performance of the urban energy system by means of the set of performance indicators presented in Table 1.

- Is the system able to calculate the indicators presented in Table 1?
- Is the (advanced) user able to redefine the energy mix used to calculate CO_2 emissions?
- Is the (advanced) able to change the cost of energy carriers and other related parameters used to calculate energy related costs of the alternative urban projects?
- Is the user able to identify hot spots of energy performance based on visual inspection of results? And by means of browsing table of indicators?

5 IMPACT VERIFICATION ACCORDING TO THE RELEVANCE FOR USERS AND STAKEHOLDERS

As already mentioned in the introduction, the impact of the implementation process and of the integrated platform depends on whether the outcomes of the SEMANCO tools are relevant for users and stakeholders. From the analysis carried out in sections 3 and 4, one can identify a set of functionalities to be implemented in the platform, which have to be relevant for the work performed by potential users and stakeholders. Therefore, this section is aimed at outlining a set of questions for users and stakeholders in order to evaluate the relevance of methods, data and indicators included in the integrated platform.

5.1 Urban energy systems operating at different levels

The following questions, addressed to users and stakeholders, deal with the relevance of multi-level evaluations in energy efficient urban planning:

- Are the urban space categories (i.e. building, neighbourhood, district/ward, city) relevant for the analysis at different scales?
- Is it necessary to use a different land use classification than that based on administrative boundaries? Is this land use classification applicable to the analyzed urban energy system?
- Are the calculated indicators relevant for the different urban scales? Which indicators are missing? Which indicators are not relevant and at which scale?

5.2 Multiple dimensions to represent urban energy systems

The following questions dealing with the relevance of using a multi-dimensional set of performance indicators in energy efficient urban planning are addressed to users and stakeholders:

- Are the relevant dimensions (i.e. flows) considered within the set of indicators? Is any relevant indicator missing? If so, which ones? At which scales?
- Which is the objective of the analysis performed during the second implementation round? Are the calculated indicators relevant for those objectives?
- Is it relevant to include indicators of social acceptance? How would include this issue in large projects?
- Are there available a set of benchmark values or external referents to verify the reliability of calculations?

5.3 Energy transformation across scales

The following questions dealing with the relevance of differentiating between energy carriers and final energy uses when representing an urban energy model by means of the performance indicators. These questions are addressed to users and stakeholders:

- Is it useful and relevant to have information differentiating by energy sources, energy carriers and final energy uses?
- Which information is missing? Which information is not relevant?

5.4 Finding a balance between detailed and relevant information

The following questions deal with the relevance of using detailed and/or simplified energy simulation models at different scales are addressed to users and stakeholders:

- Do the calculation methods at building level provide useful information, for instance, to know the energy performance of the building for certification or to identify hot spots of poor energy performance? Is this relevant for the energy analysis of an urban area?
- Do the calculation methods at urban level provide useful information in order to optimize the energy performance of an urban area, to observe trends of energy consumption or to identify hot spots of poor energy consumption? Is this relevant for the energy analysis of an urban area?

6 FORTHCOMING TASKS

From the analysis performed in the previous sections, one can identify a set of functionalities and data required to perform the relevant activities planned for implementation. The impact of the integrated platform depends on the proper implementation of those functionalities. Therefore, this section summarizes the issues to be checked and updated once the integrated platform is operative. This checking should be done jointly between partners in charge of the technological development and partners in charge of implementation.

Table 2. Issues of the integrated platform to be checked by partners responsible of technological development and implementation

Issues to be checked	Project strand	Partners
Define of nested urban space categories, and their incorporation in 3D maps	Implementation	UoT, NEA, Ramboll, FORUM, CIMNE
Define procedures to up-scale intensive indicators	Implementation	UoT, NEA, Ramboll, FORUM, CIMNE
	Technological development	FUNITEC
Check whether the relevant set of indicators is already included	Implementation	UoT, NEA, Ramboll, FORUM, CIMNE
Integrate social rating scheme to evaluate social acceptance of projects	Technological development	FUNITEC
Indicators have to differentiate between energy carriers and final energy uses	Implementation	UoT, NEA, Ramboll, FORUM, CIMNE
	Technological development	FUNITEC
Ursos and UEP tool are available for all UEM	Technological development	FUNITEC
Create of SAP input file	Implementation	UoT, NEA
	Technological development	FUNITEC
Create of URSOS input file	Implementation	FORUM, CIMNE
	Technological development	FUNITEC
Create of input files for external software (e.g. LEAP)	Implementation	Ramboll
	Technological development	FUNITEC
Integration of tools of T5.2 to define parameters of buildings	Implementation	UoT, NEA, Ramboll, FORUM, CIMNE
	Technological development	FUNITEC, HAS
Check whether embedded tools available for all locations are not duplicated in the platform	Implementation	UoT, NEA, Ramboll, FORUM, CIMNE
	Technological development	FUNITEC
Availability of external referents or benchmark values	Implementation	UoT, NEA, Ramboll, FORUM, CIMNE

7 CONCLUSIONS

7.1 Contribution to overall picture

The aim of this deliverable has been to update the strategies to verify the impact of the SEMANCO integrated platform. In order to do so, the main theoretical challenges and methodological strategies defined in D2.3 *Impact verification* have been reviewed and updated according to the advances in the project development. This entails to clearly identify a set of functionalities required to assure a positive impact of the the integrated tools and associated methodologies. In particular the work has conveyed:

1. Updating of the requirements of the integrated platform according to the current state of the project development (i.e. from the theoretical and methodological considerations done in D2.3 as well as from the implementation process). This includes the identification of the data required to perform the planned activities.
2. Identifying the partners responsible for checking whether the identified functionalities and required data are already integrated in the platform and update them necessary.
3. Defining the framework (i.e. set of questions) to evaluate the relevance of the platform functionalities: i.e. the ability of the integrated platform to support the daily work of urban planners, decision makers, among other actors within the energy efficient urban planning realm.

In other words, D2.4 has contributed to update the underlying methodological base which supports the technological development of the project

7.2 Impact on other WPs and Tasks

Overall, Task 2.3 *Impact evaluation* provides valuable information to continue with the planned activities in other WPs. It provides insights to continue with the development of the integrated platform (WP5) and helps to the application of methods to evaluate the impact of the integrated tools during the implementation process (WP6 and WP8).

In practical terms, the proposed strategies require to check whether certain functionalities are already integrated into platform, such as the ability to evaluate the energy performance of urban areas at different levels, to use a set of multidimensional indicators, to clearly differentiate between energy carriers and final energy uses in the evaluation of energy performance and to use adequate energy simulation tools according to the scale of analysis. This has direct implications on the technological development (WP5). Also, it has implications on the identification and integration of missing data required to implement those functionalities (WP3 and WP4).

The set of required functionalities identified in this report will enable the users to perform a set of activities that are relevant for their daily-life work in the energy efficient urban planning realm. This will be demonstrated in the remaining implementation rounds (WP8). Then, the ability of users to perform those activities by means of the integrated platform, as well as the relevance of its functionalities will be evaluated by means of direct contact with users and stakeholders (WP6).

7.3 Contribution to demonstration

As mentioned in the DoW, the framework and tools developed by SEMANCO will be used within each case study to demonstrate quantifiable and significant reductions in energy consumption and CO_2 emissions, achieved by means of the application of the ICTs developed by SEMANCO.

Within the demonstration and validation process, the integrated platform is expected to support the tasks listed in Table 3.

Table 3. Contribution of D2.4 to the demonstration phases.

Tasks in the demonstration phases	***Contribution of Deliverable 2.4***
The automated identification and classification of buildings for energy analysis within a geographic area	Not applicable
The identification and visualisation of 'energy use hot spots' to support the effective targeting of urban energy efficiency and renewable energy interventions	It updates information about the accounting framework able to track the different forms of energy flows and to calculate adequate performance indicators in order to identify 'energy use hot spots'
Assessment of the potential of different technical and social interventions and strategies to reduce CO_2 emissions at different geographic scales;	Update the strategy to evaluate the ability of the platform to perform energy performance evaluations at different scales
Optimisation or trade-offs between conflicting social, economic, political and environmental constraints within planning and design practice to support stakeholder decision making;	Update the strategy to evaluate the ability of the platform to perform energy performance evaluations at different scales. Also, the indicators to be calculated at different scales is listed in order to check their application
Extracting guidelines to apply to other areas and projects, providing planning authorities (local, national and European) with appropriate indicators for monitoring and reporting that can be used to establish future planning strategies;	Proposes to create a data base with external referents and/or benchmarks according to the tool used for the calculations (e.g. SAP, URSOS)
Predicting future demand following demographic and economic changes by identifying patterns of growth and sustainable urban developments which reduce energy consumption	Not applicable

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