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

SEMANCO Semantic Technologies for Carbon Reduction in Urban Planning

Deliverable 2.5
Final verification

Revision: 5
Due date: 2014-09-30 (m36)
Submission date: 2014-11-30
Lead contractor: CIMNE

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

Deliverable Administration & Summary						
No & name	**D2.5 Final verification**					
Status	Final	**Due**	m36	**Date**	2014-11-30	
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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. Deliverable 2.5 *Final Verification*. Final report on impact verification: strategies, results, impact and recommendations. 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 CO_2 emissions at the urban level.					
Comments						

Document history

V	Date	Author	Description
1	2014-11-07	Xavier Cipriano, Jose Santos, Gonzalo Gamboa (CIMNE)	First draft of the document
2	2014-11-20	Xavier Cipriano, Jose Santos, Gonzalo Gamboa (CIMNE)	Second draft of the document
3	2014-11-21	Tracey Crosbie, Martin Carpenter (UoT)	Revision of the content of Newcastle sections
4	2014-11-25	Leandro Madrazo (FUNITEC)	Revision of the overall content
5	2014-11-29	Tracey Crosbie (UoT), Leandro Madrazo (FUNITEC)	Edits to the executive summary introduction and conclusion and formatting of the document ready for submission to the commission.

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1 EXECUTIVE SUMMARY

This report presents the final impact verification of the SEMANCO integrated platform. The work presented applies the evaluation criteria established in Deliverable 2.4 *Updated impact verification* in the light of the final implementation of the demonstration scenarios reported in Deliverable 8.4 *Implementation effectiveness*.

Deliverable 2.4 identified the following criteria as the most appropriate to use when evaluating the SEMANCO integrated platform:

1. The functionalities of the platform in relation to the main challenges identified for each case study. This included: a) Urban energy systems operating at different levels, b) Multiple dimensions to represent urban energy systems, c) Energy transformations across scales and, d) Finding a balance between detailed and relevant information.
2. The ability of the platform to provide relevant information to support energy efficient urban planning. This includes: a) Creating alternative urban projects, b) integrating data from different sources, c) Simulating the energy performance of an urban area and d) Calculating performance indicators.
3. The relevance that the results produced by using the SEMANCO tools have for the users and stakeholders involved in energy efficient urban planning realm.

The results of the final phase of the demonstrations have been used to evaluate the platform against each of these criteria. A set of questions were formulated with the purpose of verifying the effectiveness of the platform in providing data which helps users and stakeholders to make decisions aimed at improving energy efficiency in urban areas. The results of this analysis showed that the SEMANCO platform provides added value to users enabling them to:

1. Address key issues concerning the planning of energy efficient cities and neighbourhoods;
2. Assess the validity of the calculations conducted in the light of the available data;
3. Improve their decision making process by providing qualified information;
4. Easily integrate data from multiple sources and different domains.

In summary, it was found that the platform is a useful tool for supplying valuable strategic information to support decision making in implementing energy efficiency improvements in a target urban area (existing or new area).

In addition, the graphic representations and tables within the platform were found to support users in performing a complementary analysis of different potential improvement scenarios. The platform additionally contributes to the decision making process by allowing the users to conduct a multi-criteria analysis of different scenarios.

We conclude that the main added-value of the SEMANCO integrated platform lies in its ability to allow users to handle the complexity underlying an urban energy system by providing them with an efficient integration between data, tools and performance indicators at different scale levels and domains.

2 INTRODUCTION

2.1 Purpose and target group

This document presents the final report on impact verification: strategies, results, impact and recommendations.

Deliverable 2.3 *Impact verification* (Gamboa et al., 2012) completed at the end of the first year of the project, focused on defining the key the challenges related to planning of energy efficient urban areas. According to Deliverable 2.3, the impact of the integrated platform depends upon its capacity to deal with the following theoretical and methodological challenges:

- Performing evaluations at different scales: accounting 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 Semantic Energy Information Framework (SEIF), such as the use of common categories of land uses.[1]
- The use of 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 building occupants and owners. Also, there are some specific requirements for the SEIF, such as the ability to calculate distributive indicators at larger scales (e.g. difference in access to final energy uses).
- Tracking energy transformations across scales: maintaining 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.
- Applying relevant energy simulation models to the scale of analysis: that is simplified models at urban scale and detailed models at dwelling and building scale.

As also highlighted in Deliverable 2.3 the impact of the integrated platform depends on its ability to meet the expectations of users, stakeholders and domain experts. To do so the platform must be capable of performing the following activities:

- Enabling users to create alternative urban plans.
- Integrating data from different sources (e.g. create input files for integrated and interfaced software).
- Calculating the energy performance and related performance indicators.
- Performing data analysis with advanced statistical techniques.
- Visualizing the results of energy performance calculations and data analysis.

In Deliverable 2.4 *Updated impact verification* (Gamboa et al., 2013) a review and update of the above mentioned issues was presented, and a set of inquiries to use to evaluate whether the current development of the integrated platform responds to these issues was defined.

[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 development of such functionality would require a project devoted to this specific task.

Those questions have been answered in the different tests carried out during the three demonstration rounds conducted in WP8.

Finally, this document includes the analysis of some of the comments gathered from users while they were participating in direct user testing. These have been analysed to identify whether the functionalities included in the platform are relevant for the work they do related to 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 UoT, NEA and FUNITEC. Detailed reviews of the deliverable were conducted by Ramboll and NEA. Finally, UoT and FUNITEC have undertaken the editing and proof-reading of the last version of this 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 Deliverable 2.3 and updated in Deliverable 2.4 are expected to be included in the integrated platform.

The work presented in this report is also related to WP6 *Enabling scenarios for stakeholders* and WP8 *Implementation*. In accordance with the work described in the DoW, there have been regular contacts with actors and between partners during the implementation (WP8) to capture users and stakeholders requirements (WP6) and to evaluate the integrated platform (WP2). This has ensured that users, stakeholders and domain experts evaluated the pertinence of the implemented functionalities in the context of each case study area.

3 CHALLENGES AND STRATEGIES FOR ENERGY EFFICIENT URBAN PLANNING

According to Deliverable 2.3 *Impact verification* (Gamboa et al., 2012) energy efficient urban planning presents several challenges deriving from the existence of multiple scales within the complex hierarchical system. For example, the need to consider multiple scales and dimensions in the analysis or to differentiate between energy related categories (i.e. primary energy sources, energy carriers and final energy uses).

The current section is devoted to analysing how well the final version of the SEMANCO integrated platform met each of these challenges. This is done for each of the case study areas within the SEMANCO project.

In Deliverable 2.4 *Updated impact verification* (Gamboa et al., 2013) several inquiries about the state of the platform were raised; most of them related to the functionalities of the platform in relation to the main challenges identified for each case study. In order to verify to which extent the final version of the platform, as implemented on the final demonstration scenarios, fulfils the goals set up in D2.4 four issues have been considered: a) Urban energy systems operating at different levels, b) Multiple dimensions to represent urban energy systems, c) Energy transformations across scales and, d) Finding a balance between detailed and relevant information

The verification of all of those groups of functionalities was performed by having the users and domain expert's attempt to use the SEMANCO platform to perform energy efficient urban planning, and by analysing the feedback gathered during this. Each of the following sections concerns one of the above mentioned groups of functionalities (subsections). The final section provides a summary of the overall results.

3.1 Urban energy systems operating at different levels

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.

Table 1. Specific inquiries

Item	Functionalities	Verification	Level of implementation
1	Are the urban space categories (e.g. building, neighbourhood, district, ward, and city) already included in the 3D models?	All the urban space categories are included in the 3D models	Already implemented
2	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)?	As showed in subsections 3.1.3, 3.2.3, and 3.3.3 the process of aggregation is up-scaled by the user only from building, to neighbourhood level.	Partially implemented

3	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?	As showed in subsection 3.4.4 all of these indicators can be calculated for the three cases, but not at city level.	Partially implemented
4	Is the integrated platform able to automatically change scale when zooming-in and -out?	In all cases the platform allows users to change scale when zooming	Already implemented

3.2 Multiple dimensions to represent urban energy systems

The following questions were 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 was assessed.

Table 2. Specific inquiries

Item	Functionalities	Verification	Level of implementation
1	Are the set of indicators listed in Table 1 already considered in the platform?	Already verified in section 3.4.4	See section 3.4.4
2	Is the social rating scheme included in the platform? Is it easy to use?	As showed in sections 3.14, 3.24, and 3.34, the social rating scheme was not included in the platform	Not implemented
3	Are indicators of social acceptance already included in the platform?	As showed in sections 3.14, 3.24, and 3.34, these kinds of indicators were not included in the platform. However t indicators of social acceptance can be manually added to the platform to include them in the multi-criteria analysis	Partially implemented

3.3 Energy transformation across scales

The following questions were 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.

Table 3. Specific inquiries

Item	Functionalities	Verification	Level of implementation
1	Is the system able to provide information on energy consumption differentiating between energy carriers and final energy uses?	In Manresa and Copenhagen differentiation between energy consumptions/demand and energy carriers has been implemented. In Newcastle it was not defined as a requirement.	Already implemented
2	Are the indicators related to GHG emissions differentiated according to energy carriers and final energy uses?	In Manresa and Copenhagen differentiation between energy consumptions/demand and energy carriers has been implemented. In Newcastle it was not defined as a requirement.	Already implemented

3.4 Finding a balance between detailed and relevant information

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

Table 4. Specific inquiries

Item	Functionalities	Verification	Level of implementation
1	Does the platform include calculation methods of energy performance for different urban scales (e.g. building, urban area)?	As showed before, only building and neighbourhood levels can be calculated	Partially implemented
2	Are the calculation methods for different scales available for all case studies?	As showed before, only building and neighbourhood levels can be calculated	Partially implemented
3	Would it be useful to integrate an additional calculation method dealing with specific urban scales?	Yes, an aggregation of results for the whole city is useful, especially if we want to integrate into SEAPs.	Not implemented
4	Is it possible to compare the results of the evaluation performed in different countries? If no, how can it be done?	Both URSOS and SAP integrated tools have been checked against the national energy labelling tools with good results. That means that the results in UK and in Spain can be compared since the national labelling tools in both countries follow the same framework for calculations (The EPBD. Although, we have to proceed very careful, since the calculations in the different EU countries were not be normalized to be able to compare, and some differences in input and outputs can be found.	Already implemented

5	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?	Yes, but not in an automated way, the final aggregation must be made out of the platform.	Not implemented
6	Are there solutions to overcome the limitations of these calculation models?	Is not necessary to improve the calculation models, since they allow users to get good results.	Already implemented

4 CHALLENGES EMERGING FROM IMPLEMENTATION

As mentioned in Deliverable 2.4 (see section 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.

The current chapter is aimed at checking if the platform provides relevant and qualified information to support energy efficient urban planning. To do this, the results obtained from the second and third round of demonstration scenarios have been analysed. In each of these scenarios a group of activities was performed in order to achieve the objectives defined for each location (see Deliverable 8.3 *Intermediate implemenation report* and Deliverable 8.4 *Implementation effectiveness*).

As the activities differ across the scenarios, the analysis has been done by grouping the activities as such: a) creating alternative urban projects, b) integrating data from different sources, c) simulating the energy performance of an urban area and, d) calculating performance indicators.

The strategies adopted in each scenario to deal with those group activities were outlined in the Deliverable 2.4 (see section 3). An adaptation of theses group of activities into steps of a working process have been done in each case study and a list of related functionalities of the platform has been identified. In the next subsections the level of implementation of these functionalities has been checked. Some of the activities and their related functionalities are specific of each case study and some of them are common to all countries.

4.1 Newcastle

4.1.1 Creating alternative urban projects

Table 5. Specific functionalities

Item	Functionalities	Verification	Level of implementation
1	To identify buildings with poor energy performance within a previously identified neighbourhood	By selecting an energy performance indicator, the user can visualize diverse colours corresponding to different level of boundaries	Already implemented
2	To calculate the potential benefits of energy efficiency interventions for a given dwelling by means of the SAP improvement tool.	Insulation and renewable electricity/heat generation are included as improvement options. The level of energy efficiency with SAP rate is illustrated on a scale from 1 to 100 (1 being lowest and 100 being the highest energy efficiency rating). An estimated installation cost is included. The user is able to filter potential improvement projects by costs or by energy performance.	Already implemented
3	To provide explanation of the plans and projects framework	Although the explanation between plans and projects is not provided, the user can distinguish the working frame within a two-option	Not implemented

		indicator tab to select plan/project	
4	An easy way to identify urban areas with high energy poverty based on mean value rates.	The user can visualize the information on fuel poverty at neighbourhood and city levels, including overlaying of this information with other indicators like income.	Already implemented

4.1.2 Integrating data from different sources

Table 6. Specific functionalities

Item	Functionalities	Verification	Level of implementation
1	To determine the geometry of the buildings as an input for the calculation method	Not currently implemented, information must be derived from studying photographic evidence. It was planned, but finally it was not tested with users.	Not implemented
2	Complementary data required to perform calculations can be accessed and manually edited by the user	All the complementary data is obtained throw existing databases, or available by studying online photography and can be edited by the user	Already implemented
3	Set of benchmarks and/or reference values in data required by the tool	Each parameter has a box filled with a predefined value and the user is able to edit it before performing calculations through the tool	Already implemented
4	Good user interaction, and useful information	After checking the responsiveness of platform, users conclude by saying that the platform is fast and easy to use. In general, the functionalities of the platform were perceived as very useful particularly being able to visualize the data in different forms, tabular and chart / info graphic	Already implemented
5	Good user interaction	After checking the responsiveness of platform, the conclusion is that the platform is fast and easy to use.	Already implemented
6	Clearly state the system requirements in the front page of the platform (JAVA version, speed of internet connection, operating system).	There is no information at home page. Only when you click on the 'Available area' a window is emerged from the internet browser asking for installing a Java plug-in with 1.5 or higher version.	Not implemented

4.1.3 Simulating energy performance of an urban energy system

Table 7. Specific functionalities

Item	Functionalities	Verification	Level of implementation
1	To obtain very fine results of SAP rate compared to an official SAP assessment, with only 3-6% of differences	The validation process of SAP tool integration was performed. Multiple users have raised concerns about the accuracy of the data contained in the integrated SAP tool, but we checked that the accuracy was acceptable	Already implemented
2	MCDA tool is provided and it allows summarizing the information generated by the SAP improvement tool and comparing the different alternative projects.	To use this tool, the user requires an explanation on the parameters of weights and thresholds to define adequate values. This tool has a great potential in supporting the decision making however the parameters are not easy to understand, and guidelines are needed.	Partially implemented. It will be included in the user manual to be delivered by Task 7.6
3	Strategic and valuable information to cover the need of decision making in implementing energy efficiency improvements in a target area.	The user may requires external data to fill the gaps in the SAP tool, however this data can be obtained by contacting peers who have information about the building stock	Already implemented
4	To perform a complementary analysis supported by graphic representations and tables.	These graphics and tables are available, but they are not very intuitive, and the user must change options to display the data in a useful format.	Already implemented
5	Integrate layers of urban space categories	Performance indicators work fine, but to aggregate and disaggregate indicators across scales is not implemented	Not implemented
6	Guide with reference values regarding energy efficient improvements	The user needs to have a previous expertise about the parameter values and its bandwidth	It will be included in the user manual to be delivered by Task 7.6
7	A quick guide explaining the integrated tools and the calculation procedures.	In the tests, several users had difficulties to understand some parameters, concepts and elements of the platform. The calculation methods as well as the validation process are not explained in the platform.	Not implemented. It will be included in the user manual to be delivered by Task 7.6
8	Integration of tools developed within T5.2 (Statistical treatment and analysis tools)	They are not integrated in automated way. It has been defined a procedure where the user ask for services related to statistical and	Partially implemented

		data mining treatments, and experts from the consortium can perform the analysis .	

4.1.4 Calculation of performance indicators

Table 8. Specific functionalities

Item	Functionalities	Verification	Level of implementation
1	Valid and useful indicators for urban planners	Indicators like SAP rate, CO_2 emissions and energy consumption are implemented to UK level. Additionally, more indicators can be added by the user when setting an improvement project	Already implemented
2	Users need to perform analysis on multiple dwellings at a time	The user can work with multiple buildings in various ways. He can rates a batch of them, do improvements and even get the aggregated results to compare in the MCDA tool. The user can also see the various energy ratings before/after improvement in the main graphical tool. The specific issue of aggregating SAP/CO_2 etc. up/down isn't done.	Partially implemented data
3	Differentiate between energy carriers and final energy uses when calculating indicator	There are no differences between energy uses and carriers.	Not implemented
4	Clear values and units without decimals in the indicators	Decimals are still appearing in the indicator values.	Not implemented
5	Other stakeholders apart of urban planners can deal with the platform thanks to the implementation of other relevant indicators	The indicators like land value, population, building density and building tenure, or other social indicators are not provided.	Not implemented

4.2 Copenhagen

4.2.1 Creating alternative urban projects

Table 9. Specific functionalities

Item	Functionalities	Verification	Level of implementation
1	To build an energy efficient city based on renewable energy supply with the lowest possible costs.	The platform allows the users to calculate the cost of implementing different projects and to identify which improvements tend to produce lower costs and better energy performance.	Already implemented

4.2.2 Integrating data from different sources

Table 10. Specific functionalities

Item	Functionalities	Verification	Level of implementation
1	Information about building properties and energy performance is available to the user through the 3D-model and pop-up windows.	The input data was compiled and provided by energy domain experts through excel sheets and afterwards, semantically modelled by the SEIF, followed by integration in the Urban Energy Performance (UEP-tool) to simulate improvements based on different building typologies.	Already implemented
2	Very intuitive platform to browse and change data by the user.	Within the platform the user is able to find hot spots of poor energy performance and propose energy efficient improvements. The improvements can be simulated by means of changing and editing the parameters (e.g. changing energy demand for different building typologies). Also, users were able to access and modify building parameters by means of specific forms.	Already implemented
3	Clearly state the system requirements in the front page of the platform (JAVA version, speed of internet connection, operating system).	There is no information at home page. Only when you click on the 'Available area' a window is emerged from the internet browser asking for installing a Java plug-in with 1.5 or higher version.	Not implemented
4	Good user interaction	After checking the responsiveness of platform, the conclusion is that the platform is fast and easy to use.	Already implemented

4.2.3 Simulating energy performance of an urban energy system

Table 11. Specific functionalities

Item	Functionalities	Verification	Level of implementation
1	UEP tool helps energy planners to analyse energy demand, CO_2 emissions and costs of choosing a specific energy supply when planning a new urban development area.	The user can model an energy efficient city stage based on demand side improvements with the lowest possible costs based on energy supplier.	Already implemented
2	MCDA tool provides information within a comparison of several improvement projects by including a multidimensional set of indicators.	To include a brief explanation of concepts behind the MCDA tool is very useful to understand the parameters used by the tool. For instance, in the demonstration, the users did not assign values to the preference thresholds and that importantly affected the outcomes of the MCDA tool, making the analysis and conclusions derived from the results misleading.	Not implemented
3	Integration of tools developed within T5.2	When data about building and energy use is missing, the definition of building typologies can be very useful to obtain benchmarks or reference values.	Not implemented
4	A quick guide explaining the integrated tools and the calculation procedures.	As several users had difficulties to understand some parameters, concepts and elements of the platform.	It will be included in the user manual to be delivered by Task 7.6
5	To provide explanation of the plans and projects framework	Although the explanation between plans and projects is not provided, the user can distinguish the working frame within a two-option indicator tab to select plan/project	Not implemented
6	Differentiate between energy carriers and final energy uses when calculating indicator	Different energy carriers can be used to perform different final energy uses. The platform only differentiates by final energy uses and exchangeability of energy carriers is not always possible	Partially implemented
7	Integrate layers of urban space categories	Performance indicators work fine, but to aggregate and disaggregate indicators across scales is not implemented	Not implemented

4.2.4 Calculation of performance indicators

Table 12. Specific functionalities

Item	Functionalities	Verification	Level of implementation
1	Intensive indicators to support energy efficient urban planning by differentiating energy suppliers.	There are implemented the indicators concerning supply technology in terms of energy demand, CO_2 emissions and energy cost. But, there are still missing some like internal rate of return (IRR) and energy saving indicators Users have also demanded a tool to evaluate the cost-effectiveness of different projects, which has not been implemented.	Partially implemented
2	Guide with reference values regarding energy efficient improvements	Users need to know how much the values can change when applies an improvement. Reference values are not included to compare results according to the building standards.	It will be included in the user manual to be delivered by Task 7.6
3	Set of benchmarks and/or reference values	To allow the comparison between results from evaluations	It will be included in the user manual to be delivered by Task 7.6
4	To provide explanation of the parameters of the MCDA tool.	User needs to be able to understand the results of the tool. When performing multi-criteria it is not so clear to the user what the results actually mean. Coefficients need to be explained.	Not implemented. It will be included in the user manual to be delivered by Task 7.6
5	Define procedures to up-scale indicators	Evaluations at multiple scales are required. What is good at one scale may not be good at a different scale	Not implemented
6	Clear values and units without decimals in the indicators	Decimals are still appearing in the indicator values.	Not implemented

4.3 Manresa

4.3.1 Creating alternative urban projects

Table 13. Specific functionalities

Item	Functionalities	Verification	Level of implementation
1	Relevant and useful support in decision making thanks to the data integration through 3D map representation and the filtering functionality.	Despite indicators are useful to show determinate energy performances, there is some visual confusion after deselecting target buildings due to the fact that these buildings appear in grey colour instead of white as initially.	Partially implemented
2	The process of aggregation is up-scaled by the user from building, neighbourhood to city level.	The user is able to aggregate from building to neighbourhood level. Aggregating from there to the level of blocks or other administrative boundaries represents is not implemented. There should be more levels allowing more detailed analysis	Partially implemented
3	In order allow the users to modify the existing urban structure, changes related to building structures are needed	Users cannot apply changes related to volumes (adding stories to a building, erasing stories, changing the shape or the orientation) to use these passive measures to improve energy performance.	Not implemented
4	To provide explanation of the plans and projects framework	Although the explanation between plans and projects is not provided, the user can distinguish the working frame within a two-option indicator tab to select plan/project	Not implemented

4.3.2 Integrating data from different sources

Table 14. Specific functionalities

Item	Functionalities	Verification	Level of implementation
1	Geometry editor allows the definition of new building in a plan or project.	The geometry editor is not integrated in the platform, and no new buildings can be included in a plan as a new development	Not implemented
2	Users are allowed to edit and change building parameters throw a USiT tool form.	Unfortunately, user is required to have expert knowledge to simulate efficient improvements. This could be solved including some reference values to guide the user in this functionality.	Partially implemented
3	Good user interaction	After checking the responsiveness of platform, the conclusion is that the platform is fast and easy to use.	Already implemented
4	Specify system requirements in the home page (JAVA version, speed of internet connection, operating system).	There is no information at home page. Only when you click on the 'Available area' a window asks for installing a Java plug-in with 1.5 or higher version.	Not implemented

4.3.3 Simulating energy performance of an urban energy system

Table 15. Specific functionalities

Item	Functionalities	Verification	Level of implementation
1	Integrate layers of urban space categories	Only neighbourhood scale indicators are integrated.	Partially implemented
2	A quick guide explaining the tools integrated in the platform and the calculation procedures.	Several users had difficulties to understand some parameters, concepts and elements of the platform.	Not implemented. It will be included in the user manual to be delivered by Task 7.6
3	Integration of tools developed within T5.2	When data about building and energy use is missing, the definition of building typologies can be very useful to obtain benchmarks or reference values.	Not implemented
4	MCDA tool provides a ranking list with the best efficient improvement as first option after defining the required coefficients.	The users have some difficulties to understand the parameters of the tool (i.e. weights and thresholds) and can be an obstacle to perform this analysis. An explanation is needed to understand this process.	Not implemented. It will be included in the user manual to be delivered by Task 7.6

4.3.4 Calculation of performance indicators

Table 16. Specific functionalities

Item	Functionalities	Verification	Level of implementation
1	In order to allow a multidimensional indicator comparison, the filtering function comprises two options: urban indicators and performance indicators at the same time.	Calculated indicators can be visualized by mixing other indicators. However, the non-energy related urban indicators like floor area, soil occupancy, green areas, constructed surface and population densities, are not provided.	Partially implemented
2	Set of benchmarks and/or reference values in data required by the tool	To enable comparisons between results from evaluations	Make available results of Spahousec study (http://www.idae.es/uploads/documentos/documentos_Informe_SPAHOUSEC_ACC_f68291a3.pdf)
3	Guide with reference values regarding energy efficient improvements	Users need to know how much the values can change when applies an improvement. Reference values are not included to compare results according to the building standards.	Not implemented. On-going in WP7 – make available tables of data and building parameters
4	To provide explanation of the parameters of the MCDA tool.	User needs to be able to interpret the results of the tool. When performing multi-criteria it is not so clear to the user what the results actually mean. Coefficients need to be explained.	Not implemented. It will be included in the user manual to be delivered by Task 7.6
6	Differentiate between energy carriers and final energy uses when calculating indicators	Different energy carriers can be used to perform different final energy uses. Exchangeability of energy carriers is not always possible	Partially implemented.
7	Clear values and units without decimals in the indicators	Decimals are still appearing in the indicator values.	Not implemented

4.4 Common inquiries

4.4.1 Creating alternative urban projects

The following set of questions was addressed to users and domain experts (see Deliverable 2.4, section 4) and is applicable to all of the three demonstration scenarios. 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.

Table 17. Specific inquiries

Item	Functionalities	Verification	Level of implementation
1	Is the framework of Urban Energy Model easy to understand and implement?	Several users had difficulties to understand some parameters, concepts and elements of the platform.	Not implemented. It will be included in the user manual to be delivered by Task 7.6
2	Is the framework of Urban Energy Model applicable to a wide range of energy efficient urban planning frameworks? Is this framework applicable across demonstration scenarios?	As showed in the three cases, the same framework of Urban Energy Model has been successfully applied.	Already implemented
3	Is it possible to develop alternative scenarios of urban planning (i.e. plans and projects) by means of the integrated platform?	As showed before, the platform allows users to develop alternative urban scenarios. Some limitations in the process of aggregation from building, neighbourhood to city level have been detected in Manresa and Newcastle	Partially implemented
4	How would you evaluate the platform in terms of user friendliness when developing and defining alternative plans and projects?	After checking the responsiveness of platform, the conclusion is that the platform is fast and easy to use. Concerning the use of simulation tools, MCDA tool, and other parameters, the need of complementary guidelines has been highlighted	Not implemented. It will be included in the user manual to be delivered by Task 7.6

4.4.2 Integrating data from different sources

The following set of questions was addressed to users and domain experts (see D2.4 section 4). 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.

Table 18. Specific inquiries

Item	Functionalities	Verification	Level of implementation
1	Are the input data of the applied calculation method correctly determined by SEIF?	As showed in subsections 3.1.2, 3.2.2, and 3.3.2 all inputs needed by the calculation tools have been correctly determined by SEIF in the case of Manresa and North Harbour. In Newcastle input data can be determined directly both throw the datasheet of SAP or by the SEIF	Already implemented
2	Is the SEIF able to generate the input file of integrated and interfaced tools?	As showed in subsections 3.1.3, 3.2.3, and 3.3.3 all input files needed by the calculation tools have been correctly integrated by SEIF in the case of Manresa and North Harbour. In Newcastle input data can be determined directly both throw the datasheet of SAP or by the SEIF	Already implemented
3	Is the system able to generate the input file of an external energy simulation model (e.g. an excel spread sheet)?	Not identified as a need. This functionality was only defined by the some experts, but not defined by the users, and the consortium of the project decided not to prioritise it.	Not implemented
4	Is the system able to classify buildings according to selected parameters?	In the three cases, all buildings are classified according to predefined classification, and all figures and tables of results follow this classification.	Already implemented
5	Is the system able to assign values to parameters based on statistical analysis?	Integration of national databases and expert knowledge based parameters has been carried out. Some of these databases are obtained from statistical treatment of national or regional data, and the user is allowed to edit them and include new values based on their knowledge or on statistical analysis. Integration of Rapid Miner tool has been performed, allowing the users to carry out new statistical treatments to obtain different values of parameters	Already implemented

4.4.3 Simulating energy performance of an urban energy system

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

Table 19. Specific inquiries

Item	Functionalities	Verification	Level of implementation
1	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?	Only one calculation method per each country has been developed; SAP in UK, URSOS in Spain, and UEP in Denmark. These calculation methods were selected as the most adequate to meet the defined requirements defined in each country (see D8.2, and D2.2), taking into account the existing data. In order to include new calculation methods, new UEM models or major modifications in the existing ones should be implemented.	Not implemented
2	Is the system able to provide sound/reliable outcomes? Does the system provide information on benchmark values?	As showed in subsections 3.1.4, 3.2.4, and 3.3.4 the users consider that outcomes obtained for each country are useful and reliable. Although, benchmark values and complementary guidelines are needed.	Medium implemented. It will be included in the user manual to be delivered by Task 7.6
3	Is there available a set of reference values for simulations using the SAP rating tool? Are they useful to make comparison across UEMs?	As showed in subsection 3.1.3, the need of a guide with reference values regarding energy efficient improvements was outlined by users. Regarding the usability of SAP across the other countries, it makes no sense since SAP is only used in the UK	Not implemented. It will be included in the user manual to be delivered by Task 7.6
4	Is there available a set of reference values for simulations using the URSOS calculation engine? Are they useful to make comparison across UEMs?	As showed in subsection 3.2.3, the need of a guide with reference values regarding energy efficient improvements was outlined by users. Regarding the usability of URSOS across the other countries, it is possible and could be useful since URSOS is designed to work all over Europe. Although, some adaptations in generation of the input file should be done according to the different existing information databases.	Not implemented. It will be included in the user manual to be delivered by Task 7.6
5	Is the system able to visualize shadows? Is this visualization useful for a preliminary urban planning?	Not identified as a need. This functionality was only defined by the some experts, but not defined by the users, and the consortium of	Not implemented

		the project decided not to prioritise it. This visualization could be useful for preliminary urban planning; however the URSOS integrated tool already includes shadows calculation when calculating the energy demand.	

4.4.4 Calculation of performance indicators

The integrated platform contains three types of tools: embedded, interfaced and external, each of them requiring different ways to calculate the defined performance indicators. In the final version of the integrated platform, some of the indicators presented in **¡Error! No se encuentra el origen de la referencia.**are directly calculated by the energy simulation tools (e.g. demand of energy carriers for heating and cooling).

In Deliverable 2.4 some issues related to the calculation of performance indicators were pointed out. The following set of questions was addressed to users and domain experts to evaluate if the integrated platform was able to represent the performance of the urban energy system by means of the set of performance indicators presented in Table 1 of Deliverable 2.4 (also in Table 16 in this document).

- Is the system able to calculate the indicators presented in Table 20?
- 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?

In order to check these questions, an analysis of the degree of implementation of the related functionalities has been performed, and results are showed in next table.

Table 20. Indicators to be calculated across scales

		Urban space category					
	Indicator	**Dwelling**	**Building**	**Neighbourhood**	**District**	**City**	**Status**
Manresa	Energy demand (from cooling, heating and electricity)		✓	✓ (A)			Already implemented
	CO_2 emissions (from cooling heating and electricity)		✓	✓ (A)			Already implemented
	Potential local PV energy generation		✓	✓ (A)			Not implemented
	Construction costs		✓				Not implemented as a calculation. User can add new indicators

							and include them in the multi-criteria analysis.
	Energy related operational costs (e.g. cost of bills)		✓	✓ (A)			Already implemented
	Internal rate of return		✓				Not implemented
Newcastle	Total predicted yearly energy demand (from cooling, heating and electricity)	✓	✓ (A)	✓ (A)			Already implemented
	Total predicted CO_2 emissions	✓	✓ (A)	✓ (A)			Already implemented
	Normalised CO_2 emissions	✓	✓ (A)	✓ (A)			Already implemented
	SAP rate	✓					Already implemented
	Upfront install cost of proposed improvements	✓	✓ (A)	✓ (A)			Not implemented
	Annual Savings on energy bill	✓	✓ (A)	✓ (A)			Not implemented
	Total predicted lifetime cost loss/gain balance	✓	✓ (A)	✓ (A)			Not implemented
	Index of multiple deprivation			✓ (DB)		✓ (DB)	Not implemented
	Percentage of households population with access to energy services			✓ (DB)			Not implemented
	Number and Percentage of Households in Fuel Poverty.			✓ (DB)			Already implemented
	Social acceptance		✓				Not implemented, but can be included as new indicator for the multi-criteria analysis
Copenhagen	Electricity consumption		✓		✓ (A)		Already implemented
	Heating demand		✓		✓ (A)		Already implemented
	Cooling demand		✓		✓ (A)		Already implemented

	CO_2 emissions (from electricity, heating and cooling)		✓		✓ (A)		Already implemented
	Cost of electricity		✓ (D)		✓		Already implemented
	Cost of heat supply		✓ (D)		✓		Already implemented
	Cost of cooling supply		✓ (D)		✓		Already implemented
	Internal rate of return				✓		Not implemented

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.

Table 21. Specific inquiries

Item	Functionalities	Verification	Level of implementation
1	Is the (advanced) user able to redefine the energy mix used to calculate CO_2 emissions?	This functionality was checked within the usability tests	Is not possible for users to modify the pre-defined parameters.
2	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?	This functionality was checked within the usability tests	Is not possible for users to modify the pre-defined parameters.
3	Is the user able to identify hot spots of energy performance based on visual inspection of results	This functionality was checked within the usability tests, as well as within the demonstration scenarios (See D8.4). In all of the three cases the scale of colours is defined according to the minimum and maximum value of the selected zone. Although, an improvement should be implemented by referring the scaling of colours to benchmark values. In North Harbour case, the identification of hot spots was not correctly performed, since it was done based on total energy demand, instead of based on CO_2 emissions. The calculation of energy demand in North Harbour is done taking fixed ratios of energy demand	Already implemented

		(kWh/m2) per each typology, so that, the total energy demand calculation is only influenced by the surface of buildings. Once the total demand calculation is done, the user selects the type of energy supply, which affects to the total CO_2 emissions. Therefore, we suggest selecting the hotpots according to CO_2 emissions, in order to take into account both the demand and the energy supply system.	

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 SEMANCO tools produce information relevant for users and stakeholders. The analysis presented in sections 4 and 3 illustrate that the functionalities provided by the platform are relevant for the work performed by potential users and stakeholders. The current section is concerned with the relevance of the calculation methods, data and indicators embedded in the SEMANCO integrated platform. To address this it answers the questions presented in section 5 of Deliverable 2.4 *Updated impact verification* (Gamboa et al., 2013).

5.1 Urban energy systems operating at different levels

The following questions deal with the relevance of multi-level evaluations in energy efficient urban planning.

Table 22. Specific inquiries

Item	Functionalities	Verification	Level of implementation
1	Are the urban space categories (i.e. building, neighbourhood, district/ward, and city) relevant for the analysis at different scales?	Already verified in section 3. The conclusion is that are relevant, but only two scales have been implemented	Partially implemented
2	Is it necessary to use a different land use classification than that based on administrative boundaries? Is this land use classification applicable to the analysed urban energy system?	Is not necessary to change the land use classification, since the existing one works fine in relation to the existing input data and the urban energy systems to be analysed	Already implemented
3	Are the calculated indicators relevant for the different urban scales? Which indicators are missing? Which indicators are not relevant and at which scale?	Yes they are, but only for the two implemented scales. Indicators related to social and economical issues are missing (see details in sections 3 and 4), but some can be included manually. The non relevant indicators were not included in the final development of the platform.	Partially implemented

5.2 Multiple dimensions to represent urban energy systems

The following questions deal with the relevance of using a multi-dimensional set of performance indicators in energy efficient urban planning.

Table 23. Specific inquiries

Item	Functionalities	Verification	Level of implementation
1	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?	Only differences between energy uses and carriers were not implemented. Some indicators related to internal return ratio or to social impact are missing	Not implemented
2	Which is the objective of the analysis performed during the second implementation round? Are the calculated indicators relevant for those objectives?	This question has been answered within D2.4, and D8.4.	Not applicable
3	Is it relevant to include indicators of social acceptance? How would include this issue in large projects?	Yes, if a participation process is performed. It can be included manually in the platform	
4	Are there available a set of benchmark values or external referents to verify the reliability of calculations?	As showed in subsection 3.4.3, users consider that outcomes obtained for each country are useful and reliable. Although, benchmark values and complementary guidelines are needed.	Partially implemented. It will be included in the user manual to be delivered by Task 7.6

5.3 Energy transformation across scales

The following questions deal with the relevance of differentiating between energy carriers and final energy uses when representing an urban energy model by means of the performance indicators.

Table 24. Specific inquiries

Item	Functionalities	Verification	Level of implementation
1	Is it useful and relevant to have information differentiating by energy sources, energy carriers and final energy uses	In Manresa and Copenhagen differentiation between energy consumptions/demand and energy carriers has been implemented. In Newcastle it was not defined as a requirement.	Already implemented
2	Which information is missing? Which information is not relevant?	None of the information related to the energy carriers is implemented.	Already implemented

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.

Table 25. Specific inquiries

Item	Functionalities	Verification	Level of implementation
1	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?	As showed in section 3 users consider that outputs are relevant for both energy analysis of an urban area and identification of hot spots of poor energy.	Already implemented

6 CONCLUSIONS

6.1 Contribution to overall picture

The main objective of Task 2.3 *Impact evaluation* is to provide strategies which enable the verification of the impact of the integrated tools and associated methodologies. These evaluation strategies set the basis for the constant evaluation and technological development of the project and have been applied in WP 8 in three yearly cycles.

The current report, presents the final update and validation of the requirements and usability of the platform. In doing this, final conclusions and final validation of the impact of platform have been identified. These are summarised using certain key questions.

What issues concerning the planning of energy efficient cities and neighbourhoods can be addressed with the help of the SEMANCO integrated platform?

In all of the cases, the platform enables users to:

1. design a new energy efficient area/city based on renewable energy sources (RES);
2. identify areas with low energy efficiency or high energy poverty based on mean or aggregated values (with URSOS, UEP, and SAP integrated tools);
3. determine the geometry of existing and new buildings and to add complementary data;
4. edit and change data and to calculate the potential benefits of energy efficient interventions (with UEP-tool, SAP improvement tool, and UIT tool).

In addition the process of aggregation from a single building to a city can be made when creating new areas, but not when calculating the current situation of an existing city, which is limited to the levels of single building and neighbourhoods.

Finally, we can affirm, that the platform is an useful tool for supplying strategic and valuable information to support decision making in implementing energy efficiency improvements in a target area (existing or new area), as well as to perform a complementary analysis supported by graphic representations and tables.

How to assure the validity of the outcomes of the platform, considering the available data?

Complementary guidelines and the platform itself provide a set of benchmarks and/or reference values in data required by the tool. Each parameter has a box filled with a predefined value and the user is able to edit it before performing calculations through the tool. This option allows the user to be assured that data is correct and relevant to the desired level of analysis.

Regarding the outcomes, the comparison of the results of the energy calculation tools against the official energy certification tools made in UK and Spain, assures that all the energy results are valid and useful for urban planning. In the case of UK the platform produces results very close to an official SAP assessment (only 3-6% difference on average,). In the case of Spain, the platform is supplied with a comparison between energy demand results from evaluations and results of Spahousec study[2].

[2] http://www.idae.es/uploads/documentos/documentos_Informe_SPAHOUSEC_ACC_f68291a3.pdf

How does the platform use qualified information to contribute to improving the decision making process?

One of the most important parts of the platform supporting this is the MCDA tool, which provides a ranking list with the best efficient improvement as first option after defining the required coefficients. When using this tool, the users had some difficulties in understanding the parameters of the tool (i.e. weights and thresholds). This was an obstacle to performing this analysis. An explanation and guidelines to support the user are in the process of being produced within WP7 *Dissemination and exploitation*, and these will be supplied together with the customer facing platform underdevelopment in Task 5.8 *Energy service platform web portal*.

In order to help planners in the decision making process, valid and useful indicators like the SAP rate (in UK), CO_2 emissions and energy consumption are implemented. Additionally, more indicators can be added by the user when setting an improvement project. Stakeholders other than planners can also work with the existing indicators like those concerning supply technology in terms of energy demand, CO_2 emissions and energy cost, and add complementary indicators. However some socio-economic indicators, such as population density, or internal rate of return (IRR) are not implemented directly within the platform.

What is the added value of the tools compared to other available tools?

The main added-value of the SEMANCO platform when compared to other tools is the way in which it provides a good integration between data, tools and performance indicators at different scale levels and different domains. The platform allows for working with both existing and new areas, and the evaluated indicators are identified by user requests or expert knowledge. The MCDA tool together with the 3D visualization and the filters of figures and tables included in the platform reflects an innovative way of supplying useful information to urban planners and promoters.

The semantic information framework (SEIF), together with the ontological editing framework within the platform, allows users to create and modify energy urban models in a user friendly manner. This development can be considered as a very innovative tool which represents a valuable contribution towards the research problem of understanding all of the variables and relationships that are involved in energy efficiency in urban areas.

6.2 Impact on other WPs and Tasks

The results of WP8 *Implementation* and WP6 *Enabling Scenarios for Stakeholders* have been collated and evaluated in the work presented in this deliverable to determine the usefulness of the platform in relation to the tasks defined by users.

Overall, Task 2.3 *Impact evaluation* provided valuable information used to inform the technological development of the platform. This deliverable presents the results of evaluating the functionalities of the latest version of the integrated platform developed in WP5 *Integrated tools*. At the same time, it summarises the results of the application of methods to evaluate the impact of the integrated tools during the implementation process (WP6 *Enabling scenarios for stakeholders* and WP8 *Implementation*).

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 work in the energy efficient urban planning realm. This has been demonstrated in the three rounds of demonstrations (WP8 *Implementation*). Then, the ability of users to perform those activities by means of the integrated platform, as well as the relevance of its functionalities have been also evaluated by means of direct contact with users and stakeholders (WP6 *Enabling scenarios for stakeholders*).

6.3 Contribution to demonstration

As mentioned in the DoW, the framework and tools developed by SEMANCO have been 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.

Table 26 lists the tasks which the SEMANCO integrated platform was expected to support as defined in Deliverable 2.3 *Impact evaluation* completed in month 12 of the project. It shows that while most of the tasks can be supported by the platform some became less relevant as the project developed and the understanding of stakeholders requirements became clearer.

Table 26. Contribution of D2.5 to the demonstration phases

Tasks in demonstration phases	Contribution of Deliverable 2.5	Status
The automated identification and classification of buildings for energy analysis within a geographic area	Not applicable	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’	Checked. Already implemented
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	Checked. Already implemented
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	Checked. Already implemented
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)	Checked. Already implemented
Predicting future demand following demographic and economic changes by identifying patterns of growth and sustainable urban developments which reduce energy consumption	Not applicable	Not applicable
The automated identification and classification of buildings for energy analysis within a geographic area	Not applicable	Not applicable

7 REFERENCES

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