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SEMANCO Semantic Tools for Carbon Reduction in Urban Planning

Deliverable 8.3
Intermediate implementation report

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

Deliverable Administration & Summary						
No & name	**D8.3 Intermediate implementation report**					
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Author(s)	Gonzalo Gamboa (CIMNE); Nadeem Niwaz (Ramboll); Joan Oliveras (FORUM); David Lynch (NEA).					
Editor	Gonzalo Gamboa (CIMNE)					
DoW	This task is aimed at performing an evaluation of the implementation process after the second iteration round. In order to do so, partners in charge of implementing demonstration scenarios will report the main drawbacks found in the implementation. A strategy for the third iteration to overcome the identified problems and obstacles will be developed. Partners in charge of demonstration scenarios will deliver data and the requirements (e.g. visualization requirements, calculation procedures or embedded tools) to the technological strand of the project (WP3, WP4 and WP5). Deliverable 8.3. Intermediate implementation report. Intermediate implementation report: Report of analysis and conclusions of the implementations, documenting the effectiveness of providing feedback on the work of WP2 and drawing conclusions on this iterative implementation process. The analysis will be on three levels: individual (per case study), comparative (between case studies), benchmarked (comparison to other projects and experiences) [month 25]					
Comments						

Document history

V	Date	Author	Description
1	2014/01/10	Nadeem Niwaz (Ramboll), David Lynch (NEA), Joan Oliveras (FORUM), Gonzalo Gamboa (CIMNE)	Preliminary description of demonstration scenarios
2	2014/3/10	Gonzalo Gamboa (CIMNE)	First version of the deliverable. It includes the description and evaluation of demonstration scenarios provided by Ramboll and NEA
3	2014/3/14	Nadeem Niwaz (Ramboll), David Lynch (NEA), Leandro Madrazo(FUNITEC), Gonzalo Gamboa (CIMNE)	Second version of the deliverable. It includes the description and evaluation of demonstration scenarios provided by Ramboll and NEA
4	2014/04/28	Nadeem Niwaz (Ramboll), David Lynch (NEA), Leandro Madrazo(FUNITEC), Gonzalo Gamboa (CIMNE)	Third version of the deliverable. It includes the results of the demonstration scenario performed by FORUM and addresses the comments made by Leandro Madrazo (FUNITEC). This version has been submitted for proof-reading, to be performed by Martin Carpenter (UoT)
5	2014/04/29	Nadeem Niwaz (Ramboll), David Lynch (NEA), Leandro Madrazo (FUNITEC), Gonzalo Gamboa (CIMNE)	Final version of the deliverable, to be submitted for internal review.

Disclaimer

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EXECUTIVE SUMMARY

The development of the SEMANCO integrated platform is following an iterative process consisting of three consecutive cycles of *implementation* and *demonstration* of the tools produced within the project. The goal of Task 8.3 *Intermediate report on implementation*, reported in this deliverable, was to carry out a second round of demonstrations in the three case study areas involved in the SEMANCO project: Newcastle, Copenhagen and Manresa. The goal of these demonstrations was to check whether the platform, in its current state, provides relevant and qualified information to support energy efficient urban planning. With this purpose the functionalities of the current platform were evaluated for each of the case study areas. In particular, the evaluation covered the following issues:

- **Access to data**: The users evaluated whether the data made available on the SEMANCO integrated platform is useful for making decisions in the planning of energy efficient urban areas and whether any items of data that they required to do this were missing from the platform.
- **Use of tools**: The users evaluated whether the tools available on the platform were adequate for supporting decision making regarding urban energy efficiency.
- **Performance indicators**: The users evaluated whether the set of indicators currently available on the SEMANCO platform are adequate for supporting their decision-making, or whether the platform should be extended to include additional indicators.

The process followed to carry out the demonstration scenarios can be summarized as follows:

1. A context specific problem scenario regarding carbon reduction in an urban setting was identified for each of the case study areas of Newcastle, Copenhagen and Manresa. The set of activities within each scenario was based upon the use cases described in D8.2 *Implementation Success Indicators* (specifically in sections 3.1, 4.1 and 5.1 of that deliverable) and adapted according to the current state of the platform.
2. Several potential users were contacted and asked to carry out the activities within each demonstration scenario. This involved using the SEMANCO platform to access information, create urban projects and to evaluate the energy performance of those projects.
3. Based on their experience of using the platform, the users were asked about their opinions of the capacity of the platform to provide the information they needed.
4. In parallel, the domain experts who set up the demonstration scenarios evaluated how well the platform enabled the end-users to meet the objectives of the demonstration.
5. Based on the evaluations of the users and domain experts, feedback was provided to indicate where the tools and the functionalities of the platform, needed to be updated. This included the ontology.

This process produced numerous items of feedback from the users, which will be used in the further development of the SEMANCO project. The following list contains the principal items of feedback produced:

- The users considered that the list of existing indicators was incomplete. The missing indicators related to several areas including urban issues (e.g. population densities, land values), energy performance (e.g. demand of energy carriers according to final energy uses and per square meter) and socio-economic indicators (e.g. internal rate of return or cost of supply technologies). While these extra indicators were felt to be required and will be included, the domain experts consider that there is no need to upgrade the ontology.
- The methods offered within the tools of the SEMANCO integrated whereby energy efficient improvements are simulated by changing the values of the building parameters were found to require that the user possesses considerable amounts of technical knowledge. Some users

suggested that certain reference values (e.g. U-values of different materials) which could help them in the creation of energy efficient projects should be included.

- Some users had difficulties understanding the parameters of the Multi Criteria Decision Aid (MCDA) tool, (i.e. weights and thresholds) and consequently in fully using it.

The users considered that all of the tools for simulating the energy performance of buildings were both relevant and useful for decision making. However, they required some explanations about both the calculation methods and the parameters of the tools.

1 INTRODUCTION

1.1 Purpose and target group

The development of the SEMANCO integrated platform is following an iterative process consisting of three cycles of *implementation*[1] and *demonstration*[2] of the tools being produced along the project. Demonstration takes place in the three case studies: Newcastle, Copenhagen and Manresa. The first implementation was carried out in Task 8.2 *Implementation* and was reported in Deliverable 8.2 *Implementation Success Indicators*. On that occasion, the integrated platform was still under development. The goal of Task 8.3 *Intermediate report on implementation* has been to carry out a second round of demonstrations in the three cases studies within the SEMANCO project. According to the requirements identified in the first implementation, the activities planned for the demonstration scenarios (presented in D8.2) and the current state of development of the platform, domain experts defined a sequence of tasks which were performed by the users in this second iteration of demonstrations.

The goal of the second round of demonstrations was to check whether the platform, in its current state, provided relevant and qualified information to support energy efficient urban planning. With this purpose, the end-users had to perform the following tasks on the platform:

- To frame a particular problem of CO_2 emissions reduction in the urban domain,
- To access the required information,
- To assess the energy performance of buildings and urban areas, and to compare alternative projects aimed at improving the energy performance of buildings.

In this first interaction with the platform, it was unavoidable that users made comments about its usability (visualization features, platform responsiveness and user-friendless). Despite the fact that in Task 5.6 a usability test of the final platform will be carried out, this document includes feedback from users regarding these issues.

Taking into account the results of this second demonstration cycle an enhanced version of the platform will be developed and then tested in the third and final demonstration.

1.2 Contribution of partners

The partners contributing to this task have been UoT, NEA, Ramboll, FORUM and CIMNE who were in charge of the implementation of the demonstration scenarios at each case study.

The editing of the document has been performed by CIMNE in collaboration with FUNITEC.

Internal reviews of the final deliverable have been conducted by Ilaria Ballarini (POLITO) and Martin Carpenter (UoT).

1.3 Relations to other activities of the project

The implementation and demonstration of the functionalities of the tools integrated in the SEMANCO platform are central to its technological development: the results of this demonstration informs the technological development according to what is expected from users and domain experts. In particular,

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[1] *Implementation* refers to the process of carrying out the sequence of activities considered in a use case either with external, prototype or integrated tools (depending on the state of project development). It encompasses gathering and integrating data, entering data to simulation models, calculating the performance indicators and visualize results.

[2] *Demonstration* refers to the validation of the SEMANCO decision support tools in terms of their cost effectiveness and capacity to support informed planning decisions that reduce CO_2 emissions in the built environment. Demonstration will take place mostly in the last implementation round, when the SEMANCO integrated platform is fully operative.

feedback about the relevance and usefulness of the current functionalities of the platform is provided to the technological development strand of the project. This includes the following issues:

- **Access to data**: Users evaluate whether the available data is useful to make decisions in the energy efficient urban planning domain. Also, users identify which relevant information is still missing. This will lead the domain experts to look for additional data to be semantically modelled and integrated into the platform (WP3 and WP4)
- **Use of tools**: Users evaluate whether the available tools are adequate and support decision making in the energy efficient urban planning domain. This will lead the domain experts and the technological strand of the project to improve the tools according to the feedback from users (WP5).
- **Performance indicators**: Users evaluate whether the current set of indicators are adequate and support decision making in the energy efficient urban planning domain. This will lead to the refinement of the list of indicators and/or the inclusion of new ones. Therefore, domain experts and the technological development will incorporate the calculation procedures of these new indicators to the available tools (WP5). If new indicators require additional data, this data has to be semantically modelled and integrated into the platform (WP3 and WP4).

The demonstration is part of the overall project methodology. This methodology started with the description of use cases that are relevant to the different case study areas. Use cases identify the most important strategic goals regarding carbon reduction in urban settings and the methods and tools required to achieve those goals. In this way, it is possible to create a shared vocabulary encompassing the data needed to perform energy assessments of urban areas and the tools to be used (See Figure 1). Then, semantically modelled data and tools identified in the use cases became accessible in the platform. The next stage in this process is to verify the extent to which end-users can effectively perform the tasks foreseen in the use cases working directly on the platform.

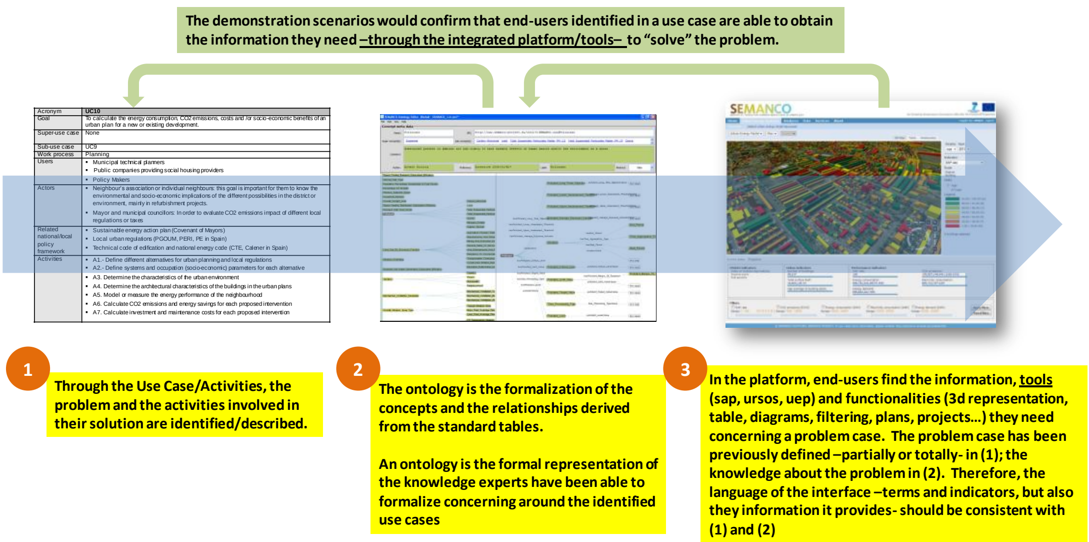

Figure 1. Relationship between use cases, ontology and tools and functionalities of the integrated platform

1.4 Structure of the report

The report is structured as follows. Chapter 2 presents the methodology followed to evaluate and report the demonstration scenarios. Then, chapters 3, 4 and 5 respectively deal with the demonstration scenarios of Newcastle, Copenhagen and Manresa. These chapters describe the objectives of the demonstrations and introduce the users that have performed them. Also, an evaluation of the performance of the platform from the point of view of users and domain experts is presented. In chapter 6, based on the results obtained in the demonstrations, feedback to technological development is presented. Finally, the conclusion of the report are presented in chapter 7.

2 METHODOLOGY

The outcomes and learned lessons of the first iteration of demonstrations were reported in Deliverable 8.2 *Implementation Success Indicators*. The first iteration of demonstrations was about deploying the methodology of use cases and activities in the real working scenarios. This was done during a stage in the development of SEMANCO in which the *SEMANCO integrated platform* was still under development and was not fully operative. Therefore, D8.2 was about presenting an assessment of how far the tools selected and being developed were able, at that time, to address the identified problems of carbon reduction.[3] In that context, the integration of data and tools was performed by domain experts: to gather and integrate data, to enter data to simulation models and to calculate the energy performance indicators. By doing so, the requirements of tools and of the technological platform were captured, and feedback to the technological development of the project was provided.

In Task 8.3 *Intermediate report on implementation* end-users worked for the first time with the SEMANCO platform in order to demonstrate and validate the relevance of the decision support tools integrated within the SEMANCO platform. The outcomes of the demonstration will be the basis of feedback regarding the technological development of the platform and offer the basis required in order to improve its functionalities. The platforms current state is an evolution of the prototype presented in *D5.4 Prototype of the Integrated Platform*.

As shown in Figure 2, the process started by defining general and specific problems of carbon reduction by means of the use case methodology. Then, demonstration scenarios specified how to solve those problems within the platform; that is, they specify the sequence of steps to be carried out during the demonstration, the set of tools and functionalities required and the necessary data. Finally, the outcomes of the demonstration serve to verify whether the proposed solutions enable the user to address the generic and specific problems.

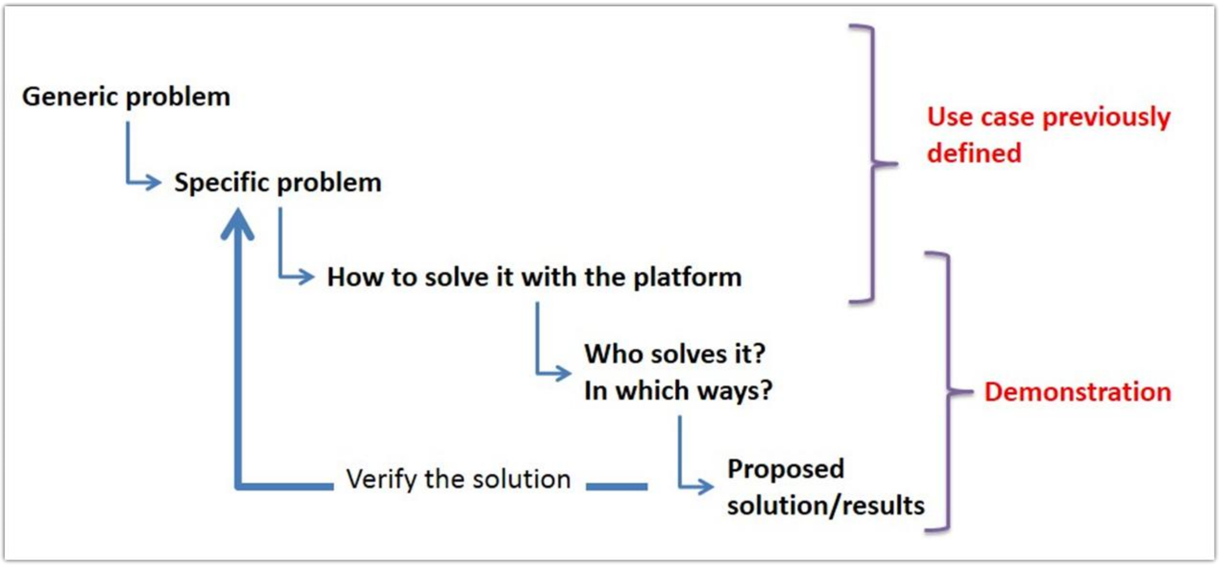

Figure 2. General scheme of the demonstration scenarios

The methodology followed to carry out the demonstration scenarios can be summarized as follows:

1. A problem of carbon reduction in an urban setting identified in the cases of Newcastle, Copenhagen and Manresa has been brought to the demonstration scenarios described in the

[3] The identification of problems is done by means of the use case methodology developed for the SEMANCO project (Madrazo et al, 2012). As the reader may already know, the use case methodology is used to identify a strategic goal regarding carbon reduction in urban settings and the methods and tools required to achieve that goal.

corresponding chapters. These sets of activities are based upon the use cases described in D8.2 *Implementation Success Indicators* (specifically in sections 3.1, 4.1 and 5.1 of that deliverable) and adapted according to the current state of the platform.

2. Several potential users have been contacted and asked to carry out the activities of each demonstration scenario. That is, to access information, to create urban projects and to apply some tools to evaluate their energy performance.
3. Based on their experience, users were asked to give their opinion about the current state of the platform. This was done in two ways. First, the opinions expressed by users during the demonstration itself were written down by the expert guiding the demonstration. Secondly, each user was asked a set of questions regarding the relevance of available data, of calculation methods and of performance indicators in supporting decision making.[4]
4. In parallel, a guide was provided to domain experts to evaluate the platform from a more technical perspective, to know whether the functionalities of the platform have enabled them to meet the objectives of the demonstration.
5. From the evaluations of users and domain experts, a feedback has been provided to upgrade the tools and the functionalities of the platform and, consequently, to upgrade the ontology. This feedback refers also to the usability of the platform.

[4] The corresponding evaluation questionnaire was developed prior the demonstration and is presented in Appendix B

3 DEMONSTRATION SCENARIO: NEWCASTLE

3.1 Objectives

In this case study, the particular problem of CO_2 emissions reduction in the urban domain can be described as follows: following the requirements of the domestic work stream outlined in Narec's Energy Master Plan, the Local Authority NCC (Newcastle City Council) wants to know how to target current initiatives and resources to reduce fuel poverty and CO_2 emissions from existing privately rented and owner occupied housing stock. As part of the aims to deliver the Energy Master Plan for the city, NCC wants to prioritize resources against the worst performing areas of the city in relation to energy efficiency.

In order to do so, the user has to identify urban areas and buildings of fuel poverty and/or high rates of CO_2 emissions. Once the target urban area and buildings have been identified, the user can propose energy efficient interventions in order to improve their energy performance. These energy efficient interventions are simulated and evaluated by means of the **SAP improvement tool,** which was developed within the integrated platform and explained in *D5.3 Energy simulation and trade-off visualisation tool*. In order to apply this tool, the user has to access and enter the following data, which is done automatically by the platform or manually by the user: property type, number of sides sheltered, fraction of windows in each direction, number of rooms, window area (i.e. quantity of windows in the dwelling concerned and amount of windows in a dwelling of that type), floors of dwelling (i.e. floor area, the overall height of the dwelling and the number of floors in the dwelling), roof orientation, exterior perimeter, exterior wall area, roof area, roof tilt, wall type, window glazing type, roof type, age of dwelling, roof window area, roof window glazing type, added wall insulation, added roof insulation, efficiency of main system, water heating boiler type, water storage insulation, main boiler type, ventilation.

Then, the user develops different energy efficient options (i.e. projects), for which the SAP improvement tool calculates the following indicators: SAP rate, CO_2 emissions and Energy consumption. These projects are then compared by applying the **MCDA tool**, which ranks these refit projects according to the scores of the mentioned indicators.

After the demonstrations, users are asked whether the platform is useful and relevant in supporting both energy efficient urban planning and to make informed decisions.

3.2 Users

The following users have taken part of the demonstration of the platform in the Newcastle case study.

Table 1. Users taking part of the Newcastle demonstration

User name	User profile	Institution/Organization	Objectives of the demo
Mr Michael Hamer	Technical Projects Manager	National Energy Action (NEA)	To run a simulation of the demonstration outlined in appendix A.
Professor Paul Jones	Director of Architecture Chair of Learning and Teaching in Architecture	Northumbria University Newcastle upon Tyne	To provide an overview of the SEMANCO visualization tool, its functions and features

Michael Hamer is Technical Development Manager at National Energy Action (NEA). Michael has worked with NEA for approximately five years. Michael and his team frequently conduct SAP assessments for existing buildings across the UK housing stock. Michael and his team use SAP software to estimate the baseline energy performance of dwellings. Once a baseline is identified, they use software to assess various scenarios to make improvements to the thermal performance of dwellings. Prior to this demonstration Michael had not used the SEMANCO visualisation tool. So the first task was to provide the user an illustration of the various functionalities of the SEMANCO visualisation tool.

Then, the user simulates how an Energy Officer working for Newcastle City Council would use the tool to feed into a report to identify fuel poor low energy efficient housing. The simulation helped Michael to understand how the tool may be applied to a real scenario.

Prof. Paul Jones studied at the Manchester Metropolitan University, gaining a first class degree, and a distinction in BArch at Manchester School of Architecture. Prior to teaching at Northumbria University, Paul taught in Studio at the Manchester School of Architecture, whilst also working in practice as an architect specialising in sustainable architecture. His expertise is in the teaching, design process and creativity. Paul has had success in international design competitions and has directed his students to numerous awards and commendations both at Northumbria and at his previous institution

The demonstration took place in Professor Jones's office located at Northumbria University Newcastle upon Tyne. Before commencing the demonstration some context was provided to Paul about the scope of the project and the purposes of the demonstration. Again the scenario described below was used to illustrate functionalities of the tool. In his feedback, the user provided a broader high level perspective as to how the model could feed into current policies related to energy, housing and the built environment.

3.3 Demonstration

As mentioned in Chapter 2 - *Methodology,* the demonstration scenarios are based upon the use cases described in D8.2 *Implementation Success Indicators* (specifically in section 3.1 of that deliverable) and adapted according to the current state of the platform.

The objectives of the use case can be summarized as follows:

- To identify low-income (Fuel Poor) households living in energy intensive dwellings with a poor SAP rate
- To propose and evaluate energy efficient improvements according to their SAP rate, CO_2 emissions and energy consumption
- To compare the energy efficient improvements projects using a set of multidimensional indicators

In 0, an analysis of the correspondence between the activities carried out during this second iteration and the activities of this use case planned in D8.2 is presented.

This use case is the formalization of a potential problem faced by a public officer. In this case, an Energy Officer working for NCC had recently visited a dissemination event of the SEMANCO tool in Newcastle and was impressed by its ability to provide a very quick synopsis of energy related indicators at the city, neighbourhood and building level. The Energy Officer believed the application of the SEMANCO visualization tool could be of some assistance in the development and planning of energy strategies. The Energy Officer consulted his/her manager about the benefits of the tool and both agreed to pay a one off discounted fee to trial the SEMANCO tool for a period of three months to see how it could be of assistance to them. As part of the trial subscription the Energy Officer also attended a 1 day training course in order to learn about the various functionalities of the SEMANCO visualization including the 'SAP' tool embedded within the project.

With access to the tool and training in place, the Energy Officer working for NCC has been asked by his/her manager to use the tool to produce a report indicating areas in Newcastle with high levels of fuel poverty and energy consumption. Once the Energy Officer had provided this report, the officer was asked by his/her manager to focus on one particular neighbourhood with one of the worst levels of fuel poverty and provide some data indicating which buildings were performing worst in relation to energy efficiency. The Energy Officer uses the SAP tool to assess one of the buildings which, as the SEMANCO visualization tool illustrates, is performing very poorly in relation to energy efficiency. The Energy Officer uses the SAP tool to simulate how the overall SAP rate of the dwelling could be improved using simple low cost energy efficiency measures such as cavity wall insulation, loft insulation and a high efficiency boiler. The various steps along this process from initially reviewing which neighbourhoods contained the highest levels of fuel poverty through to assessment of particular buildings to see how they could be improved is presented in the screen shots below.

3.3.1 Step 1. Identifying neighbourhood with high energy poverty rates

The Energy Officer gains accessed to the SEMANCO platform and selected fuel poverty using the indicator drop down list. Straight away the Officer noticed the map is changing colour indicating the levels of fuel poverty across various areas of the city (See Figure 3).

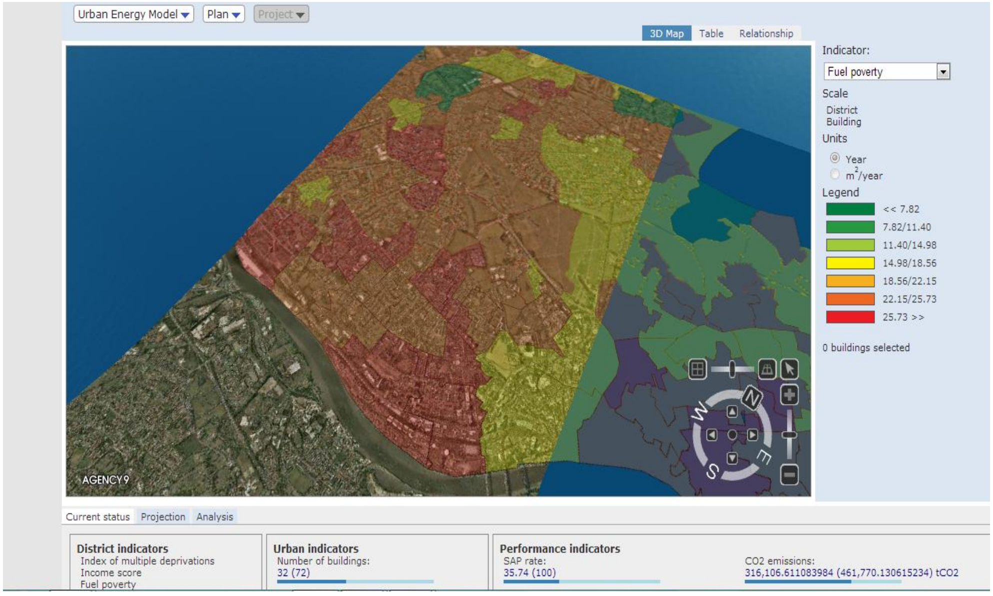

Figure 3. Looking for neighbourhoods with poor energy performance

The Officer used the image in his/her report to illustrate which areas across the city have high concentrations of fuel poverty.

3.3.2 Step 2. Approaching to building level

The Officer used the mouse functionalities of the tool and his/her prior training and zoomed into particular area demonstrating high levels of fuel poverty. The Officer noticed buildings begin to pop up illustrating the dynamics and footprint of an area. Due to prior local knowledge about the area in question, very quickly the Officer gained a feel as to the neighbourhoods he/she is focusing on.

3.3.3 Step 3. Selecting buildings with poor energy performance

Once the Officer was down to building level, for the second time, the indicator drop down menu was selected. This time, SAP was selected in order to illustrate SAP levels for each building in the neighbourhood. The Energy Officer could see the various SAP levels across the neighbourhood using the colour coding; green illustrating high SAP rating and red indicating low SAP. Very quickly, the Officer could identify which buildings have the lowest SAP rating and began to focus on these individual buildings.

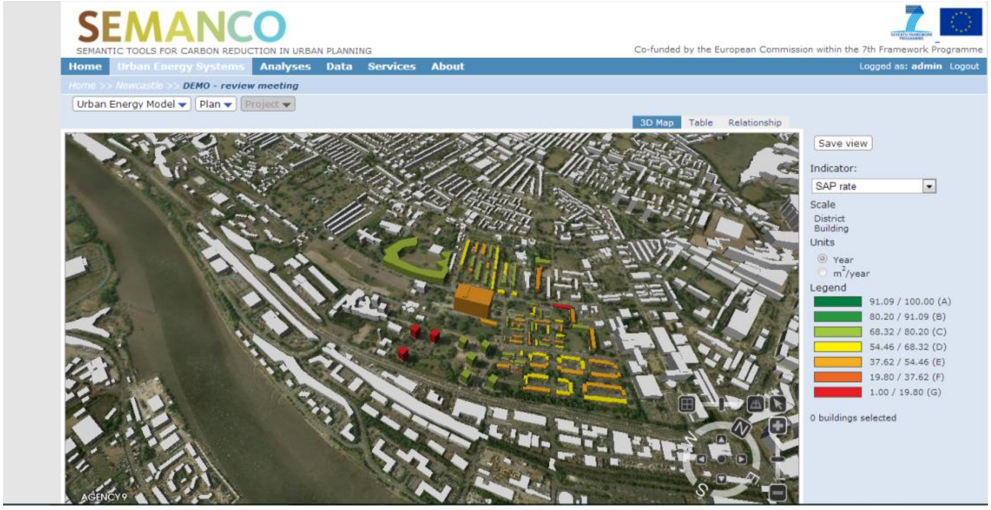

Figure 4. Selecting buildings with poor energy performance

3.3.4 Step 4. Introducing energy efficient improvements

The Officer used his/her mouse to zoom further into the model to focus on a particular building. This building was an orange shade illustrating it carries a low SAP rating. When the building was selected a pop up box appeared providing the user with a quick reference point for the building (See Figure 5). This pop us provided a quick reference point for the Officer, highlighting basic attributes of the building, SAP rating, surface height, number of floors, use and year of construction. Indicators were also illustrated concerning SAP rate, CO2 emissions (tCO2) and energy consumption (kWh).

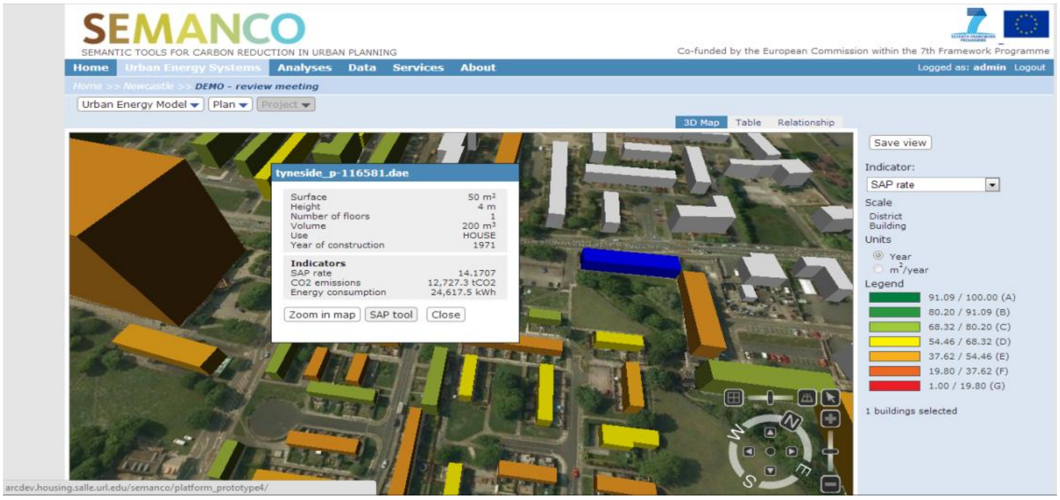

Figure 5. Building information in the 3D model

The Officer launched the SAP tool, immediately another sub window opened displaying further detail about the building in focus including House Data, Roof Data, Heating Data and Energy Efficiency Data (See Figure 6). To the right is a photograph of the building. Very quickly the user could verify the information displayed about the building based on the photograph and began to build up a mental picture of the types of measures needed to increase the energy efficiency of the dwelling. The Officer could see the cavity in the building has not been filled with insulation and proposed the addition of 150 mm of insulation.

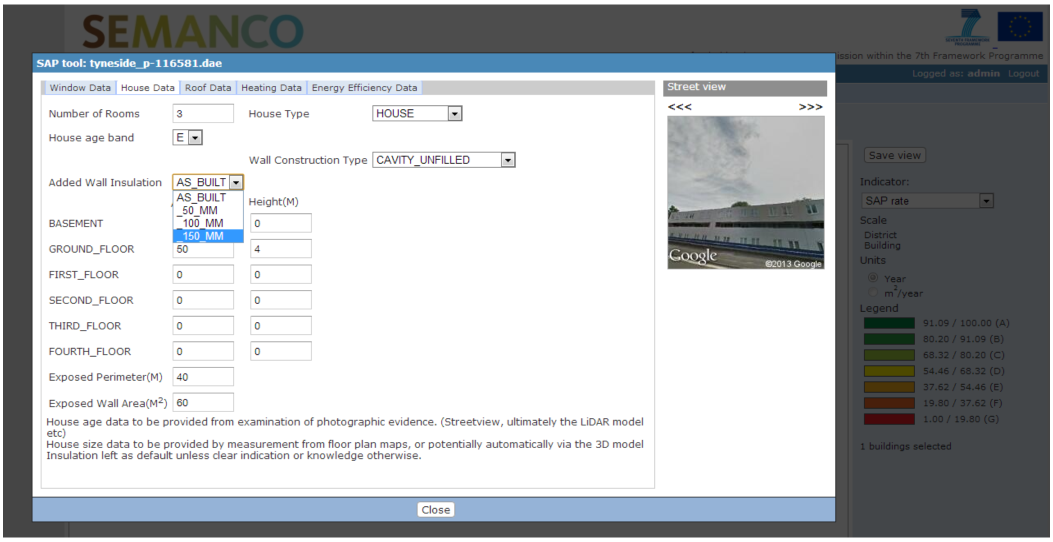

Figure 6. SAP tool – wall insulation improvement

The user began to use the SAP tool to simulate other potential energy efficiency improvements to the dwelling, in this example, the Officer could see there is limited insulation in the roof of the property and has prescribed filling the roof with 270 MM of loft insulation to increase energy efficiency hence thermal performance of the building (See Figure 7).

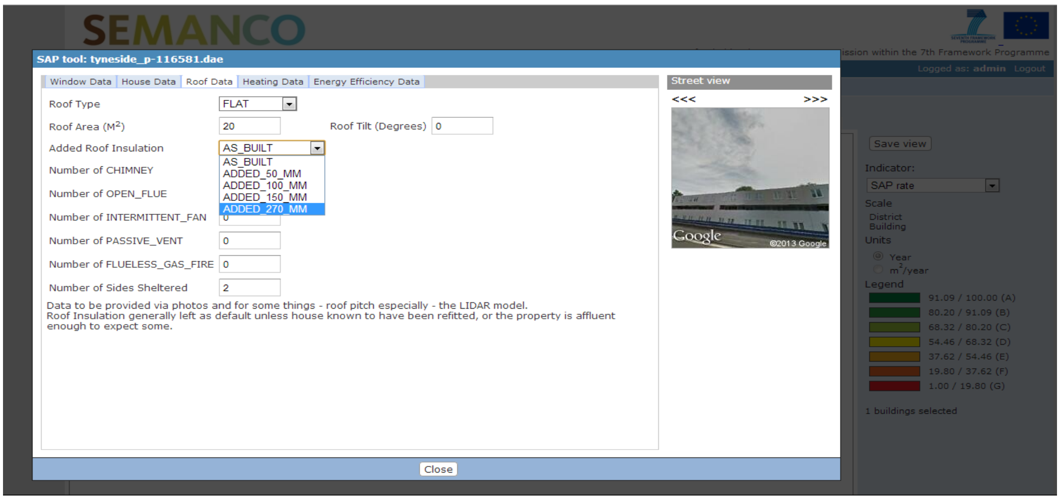

Figure 7. SAP tool – roof insulation improvement

The Officer moved along to the next tag in the SAP tool and could review the heating data aligned to the property. From this the officer could see there is an old electricity boiler running at low efficiency of just 65% (See Figure 8). The Officer proposed changing the boiler to a gas system to provide a more efficient low cost heating solution.

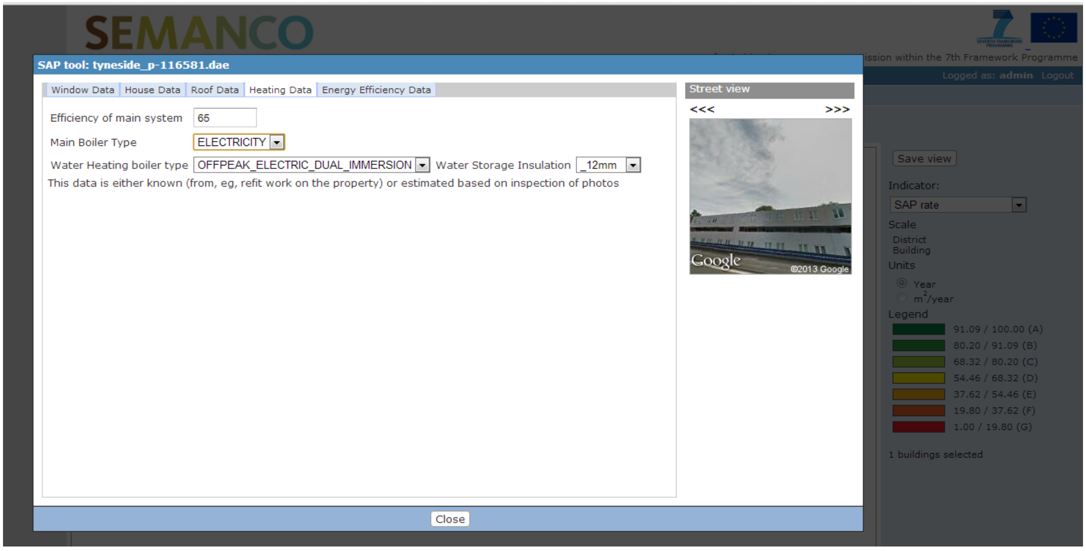

Figure 8. SAP tool – changing boiler technology

3.3.5 Step 5. Simulating energy efficient improvements

Based on the Energy Efficient improvements made to the property, the Officer used the SAP calculator to calculate and simulate a revised SAP for the property (See Figure 9). From this, the Officer can see the SAP rating has increased to 52.34 from an original SAP rating of just 14.

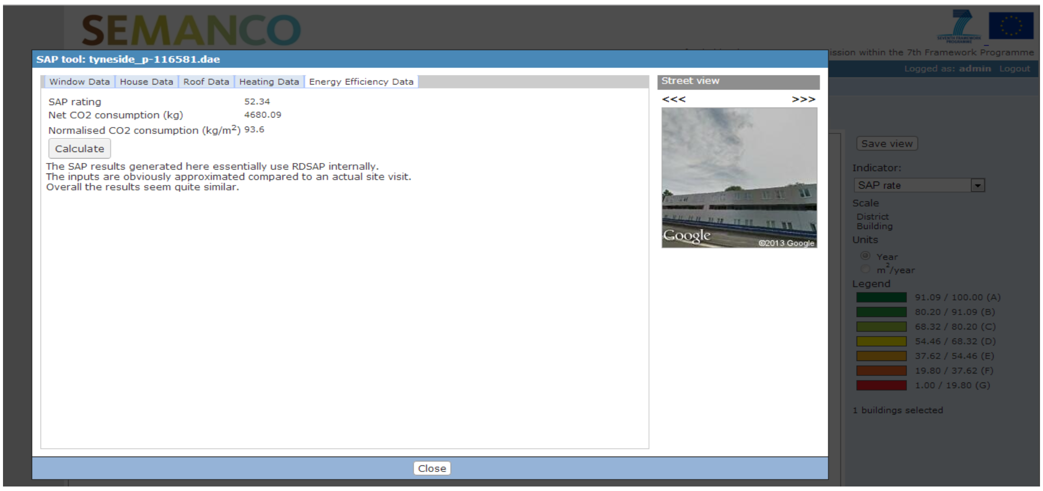

Figure 9. Outcomes of SAP rating tool

3.3.6 Step 6. Creation of alternative projects

To support the decisions making process, the Energy Officer was also asked to provide three alternative projects: one project based on insulation improvements, another project based on the implementation of renewables and a third project considering fabric refit in targeted buildings. Each project offered different energy efficiency improvements. The Energy Officer focused on improvements to the Kenilworth Road area of the neighbourhood.

3.3.7 Step 6. Multicriteria comparison of different projects

After defining the alternative projects, the user selected “Compare” from the “Plan” drop-down menu and open the MCDA tool. There, the user defined the weights and the thresholds of the indicators SAP ratings, CO2 emissions and Energy Consumption (kWh) (See Figure 10).

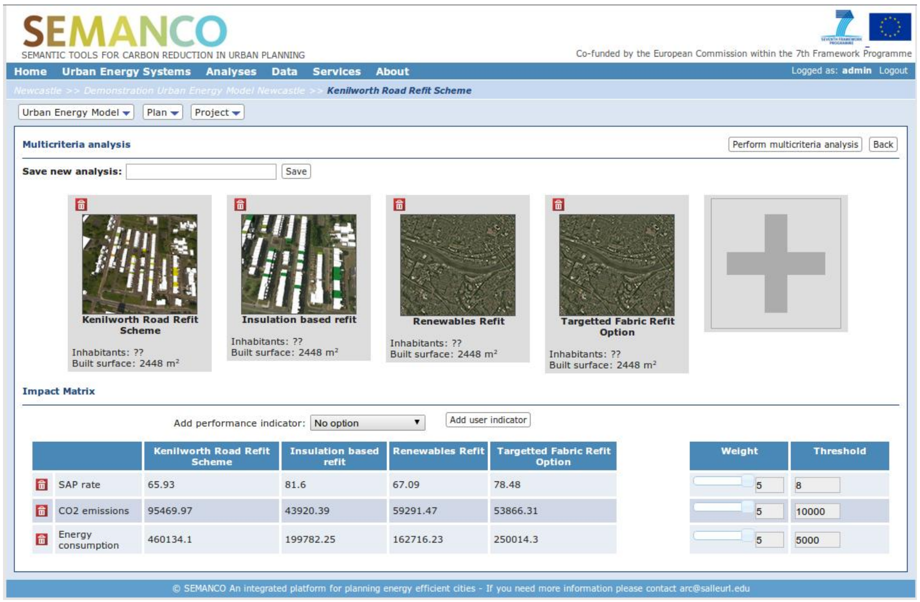

Figure 10. MCDA tool and definition of parameters

The Energy Officer utilized the output from the MCDA tool (See Figure 11) to produce a report and presentation to his manager. The manager would use the information to make a final decision on which measures to install, improving the energy efficiency standards of households in the Kenilworth Road area.

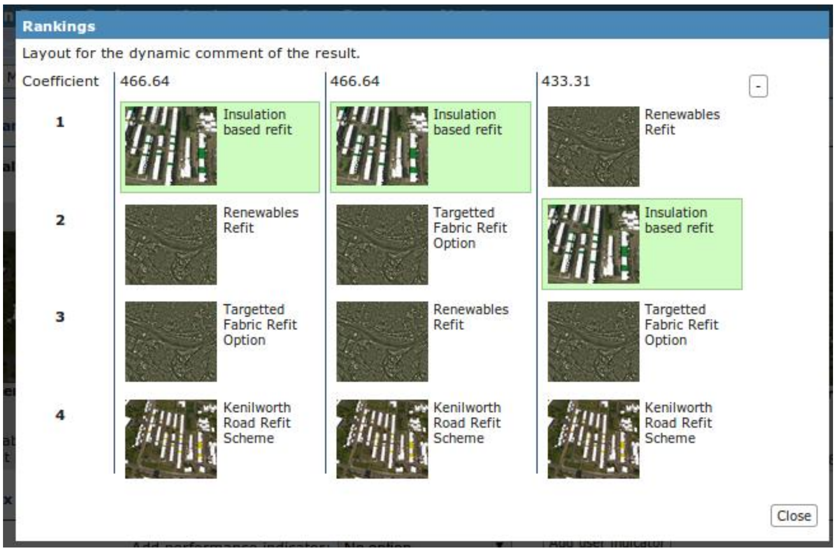

Figure 11. Results of multicriteria comparison

The platform presents the rankings supported by the larger number of indicators, which, in this case, is the Insulation based refit project.

3.3.8 Step 7. Complementary analysis

To assist with the presentation of his/her report, the Energy Officer used the relationship tag in the main SEMANCO tool to visualize the relationships between SAP rate and energy consumption in the fuel poor area (See Figure 12). The Officer could use the relationship tag to visually identify which buildings are performing poorly. By scrolling over the bubbles displayed on the screen, the Officer was presented with a pop up illustrating key attributes of the dwelling in focus including, year of construction energy consumption (kWh) and surface area (m^2). With multiple dwellings presented in this way the Energy Officer could identify and focus efforts on the buildings performing poorly. This evidence may be used to identify which buildings to prioritise when an energy efficiency program begins. The information presented (particularly the street view) also assisted the Energy Officer to identify the types of energy efficient measures required to improve the dwellings and to assess whether there are any issues related to access or planning/ conservation issues.

Figure 12. Complementary analysis by means of graphical representations

The Officer could also view the information displayed on the 3D model in tabular form. This provided another quick reference list illustrating building names, types, year of construction SAP rate, CO_2 emissions and energy consumption (See Figure 13).

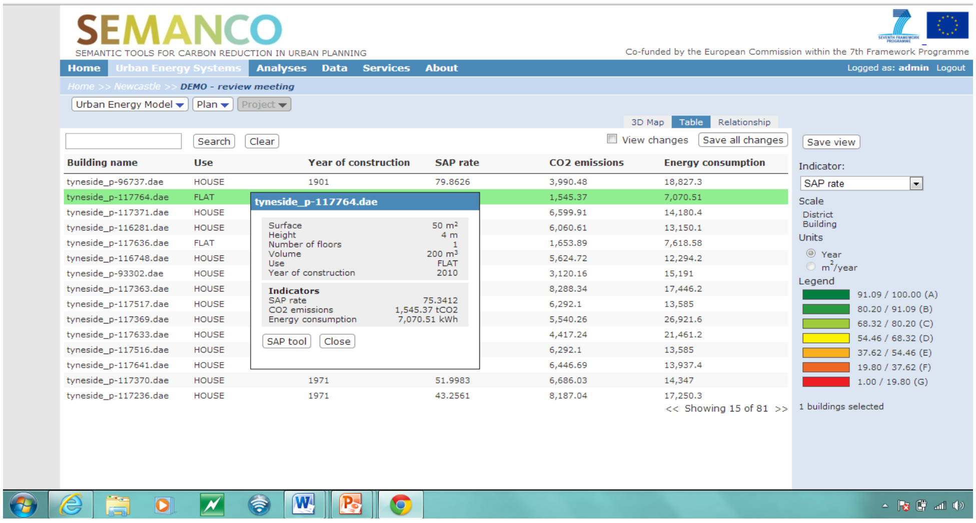

Figure 13. . Complementary analysis by means of tabular representations

Various screenshots were taken to illustrate the status and proposed energy efficiency improvements. Images are inserted into the Officers report and presented back to his/her manager. The manager would use the report to provide feedback to Narec as to which housing to prioritise as part of delivering the energy master plan for the city of Newcastle. Cost and procurement estimates were then produced to identify how much capital funding is required to make improvements to the housing stock

3.4 Evaluation of the platform

At the time of the demonstration the domain expert was present with the user. It has become apparent some tool functionalities are more intuitive than others and would not require guidance from a domain expert. However, for some, particularly the launch and application of the SAP tool, the user relied on the domain expert for support and guidance. It is clear from this demonstration training and support would be required as a pre-requisite to using the tool.

Significant improvements have been made to the tool since his last interaction with it. The user believes the tool is not a complete package, but has laid the foundations for a very useful and adaptable tool, to which further functionalities could be added. The user was able to follow the layers within the screens, he could observe the carbon emission performance of a neighbourhood using the drop down menu and he was impressed how quickly this could be done at as a desk based exercise. In this sense, the most significant attribute of the tool would be that it is time saving, in the sense that the tool would save significant time for those involved in urban planning, less site visits would be required as all the information is available on one screen.

The following sections present an evaluation of whether the platform provides relevant and qualified information to support energy efficient urban planning. The evaluation is done in terms of whether the tools and functionalities are useful to perform the planned activities and to meet the objectives stated in section 3.3.

The evaluation covers the following aspects: the access to data, the integrated tools and the information provided by the platform (e.g. indicators).

3.4.1 Access to data

The user was able to easily identify urban areas with high energy poverty rates. This is possible by means of visualizing the information on fuel poverty at neighbourhood and city levels. Additionally, users could overlay fuel poverty with IMD (Income) in 3D maps, providing additional and complementary information.

The user can also identify buildings with poor energy performance within previously identified neighborhood. It can be done by zooming in from neighborhood to building level, selecting an energy performance indicator to be visualized in the platform and obtaining basic information of a specific building through the pop-up window.

Before calculating the energy performance of dwellings and buildings, it is necessary to determine the geometry of the buildings as an input for the calculation method. This information is currently available in the platform (through 3D model) and is used as an input of the SAP rating tool. It is important to notice that the SAP tool does not require geometric information beyond that which the user can measure, therefore automatically providing this data to the calculation method simplifies the users' tasks.

The rest of data required to perform calculations was accessed manually by the user. This task and the calculation of the baseline SAP rates of targeted buildings have been performed previous to demonstration by domain experts. The aim was to have the baseline already available to carry out the demonstration and, in this way, users have been able to focus on simulating and comparing energy efficient improvements in the target buildings.

The users have been able to perform also a complementary analysis, supported by the graphic representations and tables. The configuration of the graphics is not intuitive. Users had to be shown how to negotiate the x, y options in order to display the graph in a useful format.

3.4.2 Integrated Tools

Currently, the user is able to calculate the potential benefits of energy efficiency interventions for a given dwelling by means of the SAP improvement tool. This includes both fabric improvements (insulation) and renewable electricity/heat generation such as solar PV panels or heat pumps. The energy efficiency rating of the dwelling (SAP rate) is illustrated on a scale of 1 to 100 (1 being lowest and 100 being the highest energy efficiency rating). In addition to the changes in the energy efficiency of the dwelling, the SAP improvement tool also provides an estimated installation cost for the improvements. The users considered this assessment tool very useful to perform a preliminary exploration of potential improvements in buildings. By using this tool, the user was able to filter potential projects, by disregarding those presenting very high costs or poor improvements in energy performance.

However, when it comes to decide between several improvement projects, the user required a tool that summarizes the information generated with the SAP improvement tool and compares the alternative projects. The MCDA tool provides these required functionalities. Nonetheless, when using this tool, the users required an explanation of the parameters of the tool – weights and thresholds – to be able to define adequate values. According to users, the tool has a great potential in supporting decision making, but its parameters are not easy to understand and can become an obstacle for its use.

On the other side, multiple users have raised concerns about the accuracy of the data contained in the SAP tool. In this regard, it is important to note the SAP rating tool was tested as part of Task 8.2 *Implementation Success Indicators*, in the first round of demonstrations. The results of that test illustrated the SAP tool embedded within the platform produced an error of about 3-6% in the SAP rate, compared to an official SAP assessment carried out by a registered SAP assessor. The results of this test are encouraging.

From time to time, users may require external data providers to fill in the gaps. Concerns were expressed by users in relation to this. Those with access to such data have become increasingly strategic as to what information they provide. Energy efficiency data in the UK context has become valuable information as it is used by private sector energy companies and other agencies to inform marketing strategies targeting areas in need of energy efficiency improvements. It is possible to use the SAP tool to calculate estimated SAP rates of buildings but this requires local knowledge or expertise in building energy efficiency. For example, simply by seeing a picture of a 'local' dwelling, the Energy Officer working for Newcastle City Council may be able to fill in many of the data fields in relation to wall, loft insulation and the energy efficiency of gas boilers installed; having carried out previous works in the area. Where the officer has difficulty recalling certain aspects, the information may be obtained by contacting peers who are likely to know details about the building stock.

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. The exportability of such information in this format was seen as very useful for the purposes of validation and justification when proposing or weighing up redevelopment proposals.

3.4.3 Performance indicators

The indicators present within the tool (i.e. SAP rate, CO_2 emissions and Energy consumption) were considered valid and useful for urban planners. At the moment a lot of the indicators are quantitative in nature and target driven. According to one user, the UK and arguably the EU is obsessed with reducing carbon or building carbon neutral buildings. In the UK 70% of architecture is redevelopment, where neighbourhoods are being developed the social indicators around defining an urban place / access to green spaces are becoming more important and increasingly used in tandem with quantitative assessments of carbon reduction. Due to this trend, the user believed other indicators could be added to SEMANCO – doing so would increase its appeal and relevance to those involved in urban planning[5].

At the time of writing this deliverable, functionality to allow the user to aggregate the net effects of the improvements to multiple dwellings is yet to be completed. However, this task will be considered during the next demonstration (round three).

At a policy planning level, architects are increasingly interested in how they can deal with 'people in a system'. In response, other indicators are coming into focus, connection to bio-diversity, green spaces, or happiness indicators. Other relevant indicators (not considered in D2.2 *Strategies and Indicators for Monitoring CO_2 Emissions*) are the following:

- Land values – it is important to measure land values for tax reasons.

[5] Currently, the platform allows the user to introduce an additional indicator manually, which is used in the multicriteria comparison of projects. The user is now able to define an indicator and introduce the scores of the different projects, and the corresponding thresholds and weights. The visualization of this data in the 3D maps is not possible, since the indicators are evaluated at project level and there is no information at building level.

- Density – If the tool could indicate how many dwellings are present per hectare this would be beneficial.
- Tenure – indicator highlighting owner occupier, social housing and mixed tenure.

4 DEMONSTRATION SCENARIO: NORTH HARBOUR

4.1 Objectives

The main objective of the stakeholders in the North Harbor project is to build an energy efficient city based on renewable energy supply with the lowest possible costs. The immediate goal for the stakeholders involved is to create a CO_2 friendly city from the beginning. Similar goals/targets have been set in other green field urban development projects in Denmark.

For another group of stakeholders at municipal or regional level (e.g. local Governments that have signed the Covenant of Mayors), the objective is to evaluate whether already decided and implemented energy efficiency and energy supply measures and new plans and projects, will contribute to meet a 20% carbon emission reduction by 2020, in the geographical area of the municipality.

The demonstration scenario documented below does not provide all the necessary answers to meet the objectives described above. Instead, it demonstrates how to map CO_2 emissions in a baseline situation and in alternative projects. The alternative projects focused on reducing the specific energy demand of buildings for the North Harbor urban development area. The evaluation and comparison of the baseline and the alternative projects was done in terms of energy demand, CO_2 emissions and energy costs (i.e. energy bill).

In order to map CO_2 emissions and other relevant indicators end-users applied the Urban Energy Planning (UEP) tool integrated in the platform, which requires access the following data accessed through the technological platform:

- Year of construction of buildings and building use. This information is used to define building typologies.
- Specific energy demand (in kWh/m^2) according to building typologies, obtained specific from data bases.
- Geometric building properties (e.g. number of complete floors, ground floor area, building gross floor area, conditioned space, unconditioned space), obtained from 3D maps.

Furthermore, the user had the option to choose energy supply levels (e.g. building based, local district heating and central district heating) and the relevant energy supply technologies (e.g. heat pumps, solar heating, boilers, PV-systems etc.).

Data was then processed by the **UEP tool** to calculate the following indicators for each building and for all buildings selected in a given urban area:

- Net energy demand (MWh/year) for heating, hot water, electricity and cooling
- Energy indicators (kWh/m2/year) for heating, hot water, electricity and cooling
- CO_2 indicators (tCO_2/year) for heating, hot water, electricity and cooling
- Cost indicators (EUR/year) for heating, hot water, electricity and cooling
- Total energy consumption, total CO2 emissions and total cost

4.2 Users

The following users have taken part of the demonstration of the platform in the North Harbour case study.

Table 2. Users taking part of the North Harbour demonstration

User name	User profile	Institution/Organization	Objectives of the demo
Helle Madsen	Energy Planner / Consultant	Ramboll	To provide an overview of the SEMANCO

Jane Moustgaard	Project manager	Ramboll	technological platform incl. 3D-model, tools, visualization options and other functions and features. Moreover, to demonstrate a use case by creating plans and projects using the platform and gain hands on experience for energy planners.
Martin Nilsson	Analyst	Ramboll	
Silas Petersen	Student Assistant	Ramboll	

4.3 Demonstration

As mentioned in Chapter 2 - *Methodology*, the demonstration scenarios are based upon the use cases described in D8.2 *Implementation Success Indicators* (specifically in section 4.1 of that deliverable) and adapted according to the current state of the platform.

The objective of the use case can be summarized as follows:

- To determine the energy demand and cost impacts of a range of different levels of building energy performance
- To compare different levels of building energy performance in terms of energy demand, CO_2 emissions and costs.

In 0, it is presented an analysis of the correspondence between the activities carried out during this second iteration and the activities of this use case planned in D8.2.

The users selected for the demonstration of the platform were all energy specialists and professionals working with energy planning. As part of the tests, the evaluation questionnaire was sent to the users prior to the demonstration meeting. The participants were asked to fill out the questionnaire during or after the demonstration.

The demonstration of the platform was conducted as an online meeting where the participants were first given a general presentation of the project. Then, it took place a presentation of the main tools and functionalities of the platform; e.g. its navigation features and the use of the tools.

Then, the participants were asked to perform the following sequence of tasks

- To import or create an urban energy model and a plan
- To create a project
- To conduct comparisons between projects.

To answer the following questions:

- What should be the energy performance of new buildings in the urban area? And
- What would be the impact on energy demand, CO_2 emissions and cost?

The participants were encouraged to browse the platform and look for features useful in their professional work, and to take notes during the process. The participants were also asked to take notes on possible changes or ideas to improve the interaction with the platform. The results of the demonstration cover a broad spectre of issues, from usability aspects to the relevance of the platform's functionalities to support decision making.

4.3.1 Step 1. Creation of an urban energy model and a plan

First, the urban energy model was created by naming and describing it, selecting the relevant tool to conduct the analysis, importing the data used in the baseline and adding users to the model. This sequence is shown in Figure 14, Figure 15 and Figure 16.

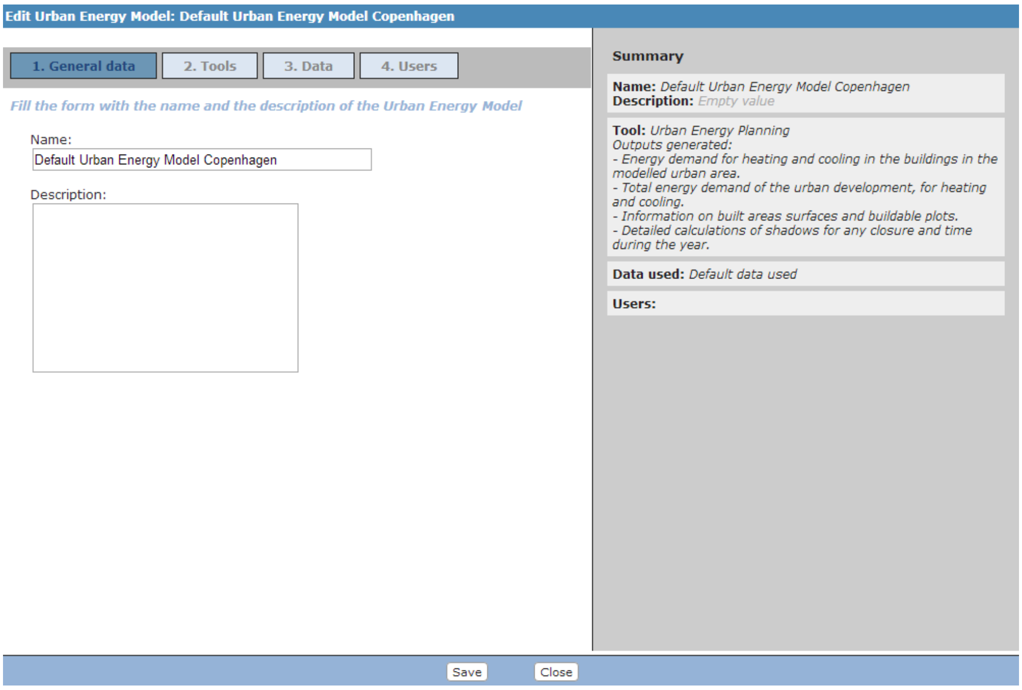

Figure 14. Creation of urban energy model of Copenhagen

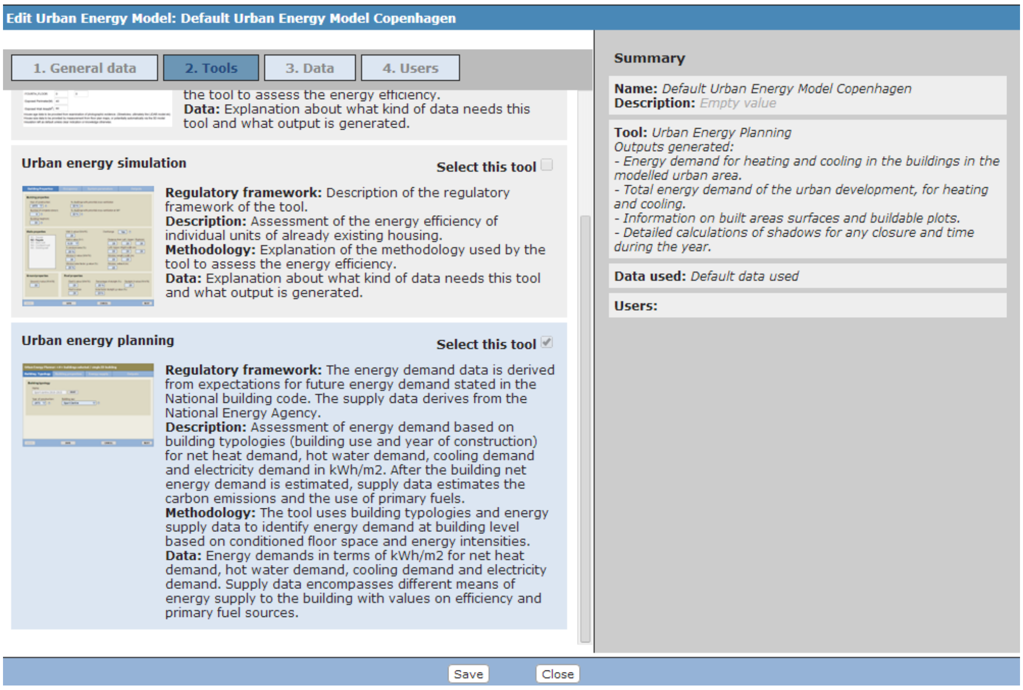

Figure 15. Choosing the tool to perform the demonstration

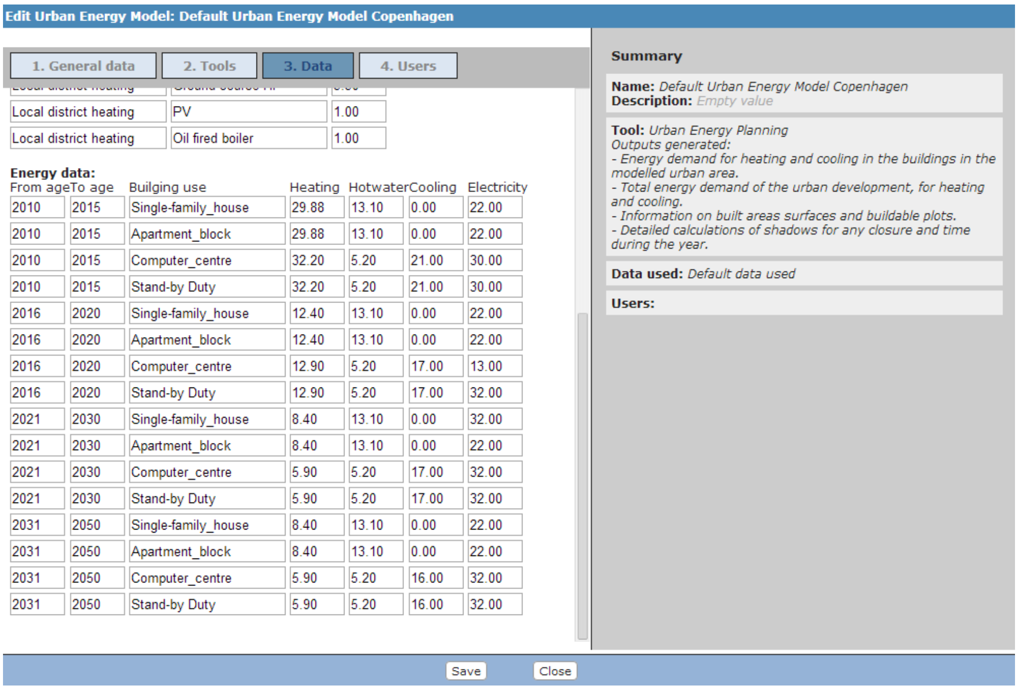

Figure 16. Defining the data required by the selected tool

Within the urban energy model, the user created a Plan describing its general properties and goals as shown in Figure 17.

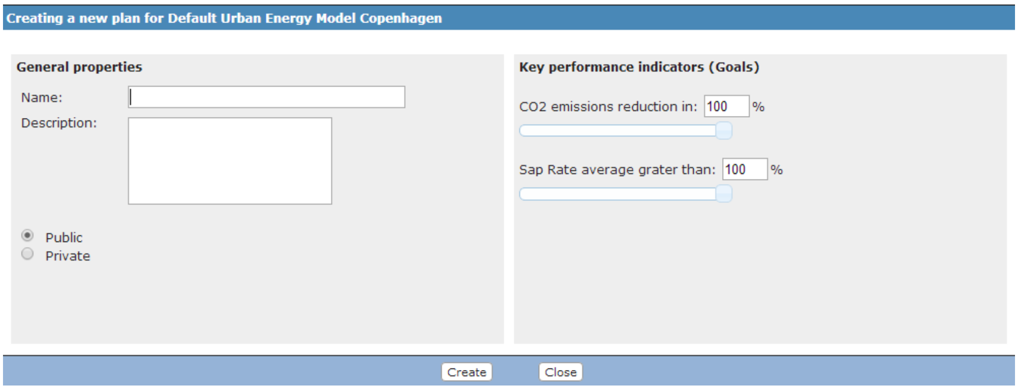

Figure 17. Creating an urban Plan

4.3.2 Step 2. Identifying buildings with high energy demand

After creating the urban Plan and entering to the 3D model, the user navigated to the target urban area and looked for buildings with high energy consumption. In order to do so, the user selects the indicator "energy demand for heating" from the drop-down list. The values presented in the platform correspond to a baseline situation, which has been calculated by assigning specific energy demands (expected demand of energy per unit of built surface area, in kWh/m^2) to buildings according to their use (e.g. residential, offices) and to the year of construction. Figure 18 presents a screenshot of the target urban area, in which buildings colored in yellow and red present medium and high energy demand for heating.

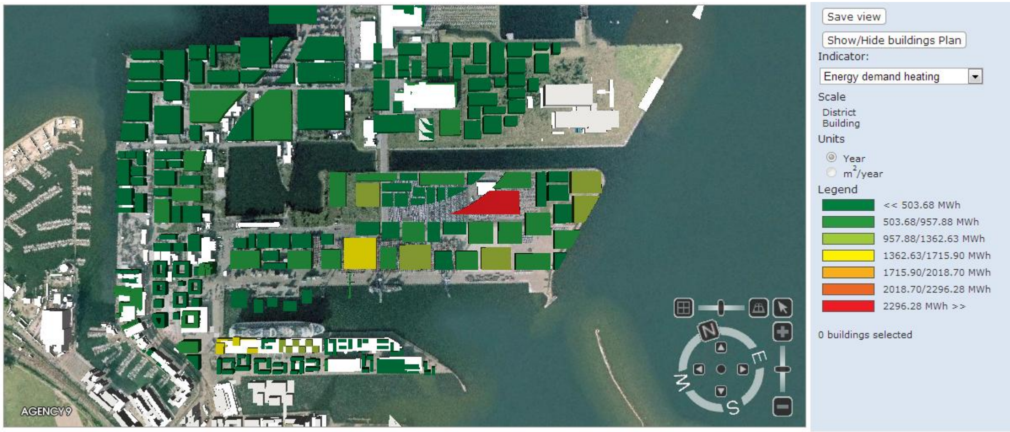

Figure 18. Target urban area presenting the energy performance of buildings.

The user chose the specific urban area for which the analysis will be conducted either by choosing one building at a time or by drawing a square with the mouse (See Figure 19). Then it was possible to show and hide the selection made by clicking "Show/Hide buildings plan" button.

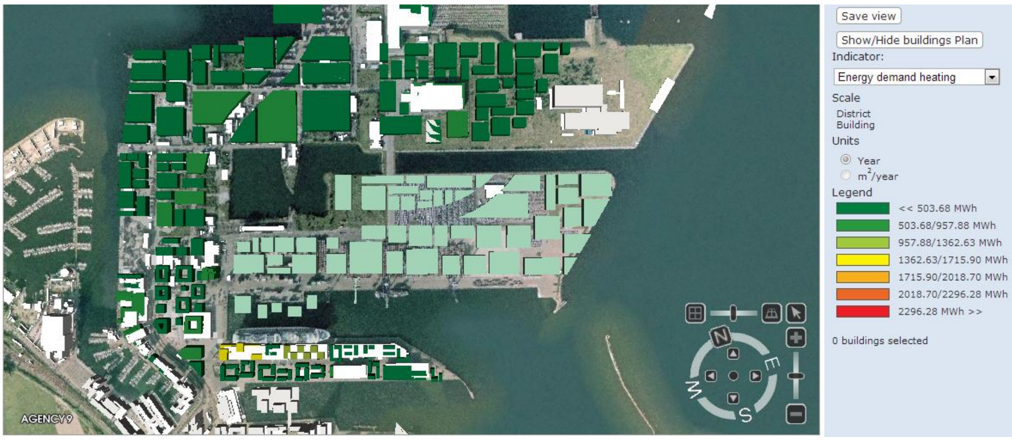

Figure 19. Selection of buildings in the urban area

4.3.3 Step 3. Creation of new urban project

The user then created a new project in the plan for the specific area of analysis selected above by first describing the project in the "General data" tab (See Figure 20). The description should indicate the purpose of the project. In this demonstration, the purpose was to improve the energy efficiency of the buildings constructed in the period 2010-2015 compared to the baseline.

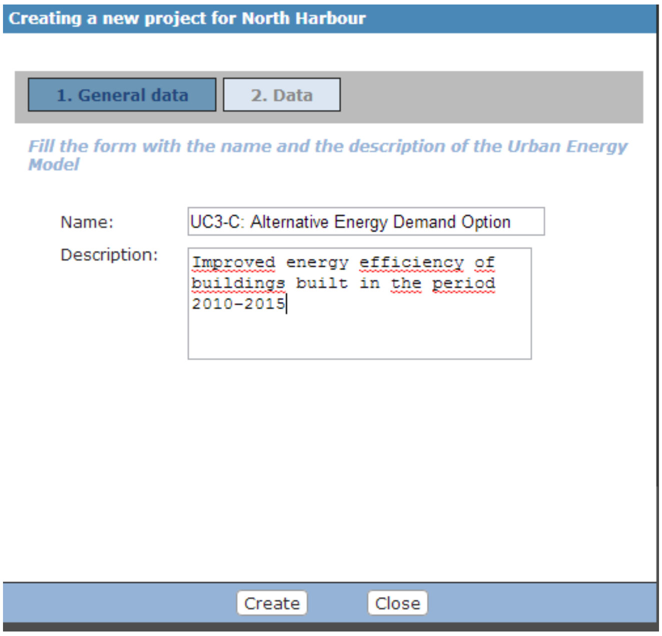

Figure 20. Creation of new urban project

Then, the specific energy consumption of buildings was improved by selecting the "Data" tab and by editing the data for building typologies built in the period 2010-2015 (see Figure 21). In this case, the energy intensities of different building typologies were improved, which means that the building constructed in the period 2010-2015 will consume less energy thanks to energy efficient improvements (e.g. improved insulation standard, energy efficient windows, energy efficient installations such as ventilation, lighting and appliances). After editing the values of specific energy consumption, the project was created by clicking the "Create" button

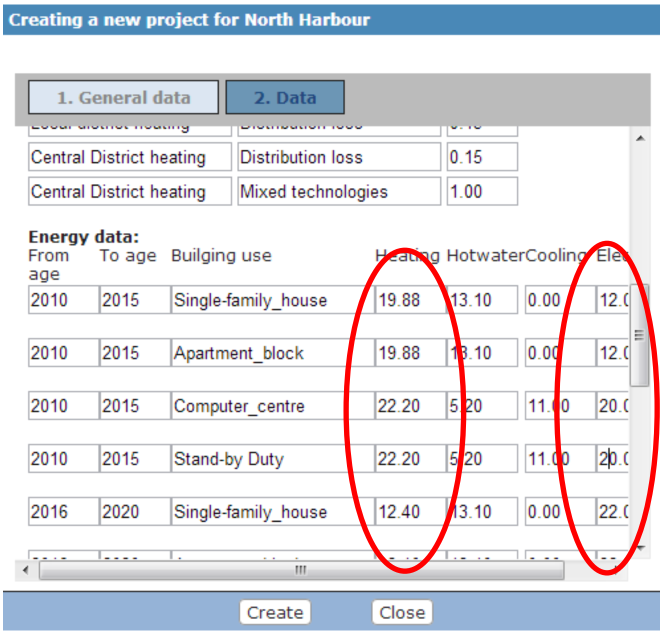

Figure 21.Changing specific energy consumption of buildings

4.3.4 Step 4. Simulating energy efficient improvements

In order to apply the Urban Energy Planning tool (UEP), the buildings in the project had to be selected again and then to click on the Urban Energy Planning button (see Figure 22).

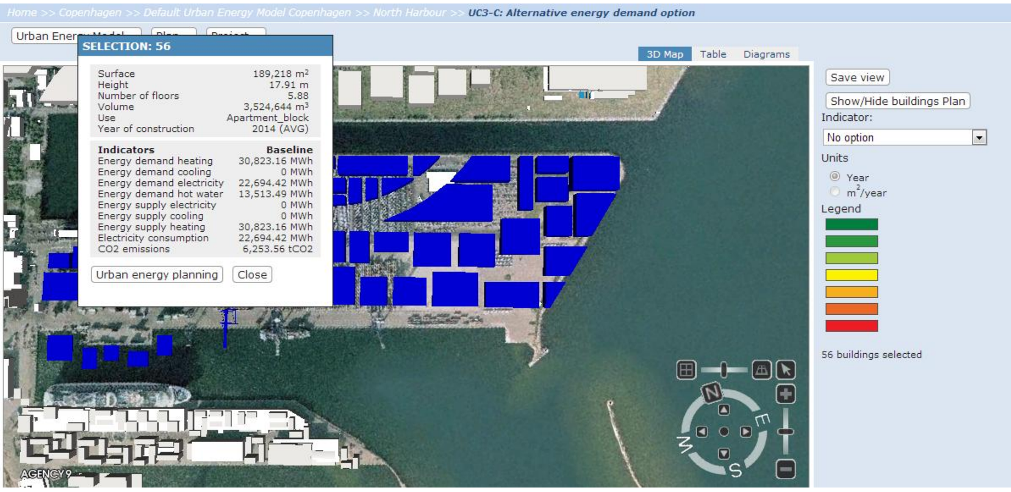

Figure 22. Launching the UEP tool

After performing the calculations, it was possible to see the results of improving the energy efficiency of buildings in a table view (see Figure 23).

Home >> Copenhagen >> Default Urban Energy Model Copenhagen >> North Harbour >> UC3-C: Alternative energy demand option

Urban Energy Model | Plan | Project — 3D Map | Table | Diagrams

Search | Clear

Building name	Use	Year of construction	Energy demand heating	Energy demand cooling	Energy demand electricity	Energy demand hot water	Energy : electrici
p641.kmz-547	Apartment_block	2014	256.227 **(170.475)**	0 **(0)**	188.654 **(102.902)**	112.335 **(112.335)**	0 **(0)**
p558.kmz-296	Apartment_block	2014	418.278 **(278.292)**	0 **(0)**	307.969 **(167.983)**	183.382 **(183.382)**	0 **(0)**
p643.kmz-496	Apartment_block	2014	123.434 **(82.1243)**	0 **(0)**	90.882 **(49.572)**	54.1161 **(54.1161)**	0 **(0)**
p649.kmz-543	Apartment_block	2014	33.7495 **(22.4545)**	0 **(0)**	24.849 **(13.554)**	14.7964 **(14.7964)**	0 **(0)**
p644.kmz-477	Apartment_block	2014	203.142 **(135.156)**	0 **(0)**	149.569 **(81.5832)**	89.0617 **(89.0617)**	0 **(0)**
p564.kmz-344	Apartment_block	2014	146.185 **(97.2609)**	0 **(0)**	107.633 **(58.7088)**	64.0904 **(64.0904)**	0 **(0)**
Kran.kmz-523	Apartment_block	2014	752.035 **(500.35)**	0 **(0)**	553.707 **(302.022)**	329.707 **(329.707)**	0 **(0)**
p645.kmz-517	Apartment_block	2014	70.2688 **(46.7518)**	0 **(0)**	51.7374 **(28.2204)**	30.8073 **(30.8073)**	0 **(0)**
p562.kmz-281	Apartment_block	2014	319.154 **(212.342)**	0 **(0)**	234.986 **(128.174)**	139.924 **(139.924)**	0 **(0)**
p640.kmz-500	Apartment_block	2014	414.352 **(275.68)**	0 **(0)**	305.078 **(166.406)**	181.66 **(181.66)**	0 **(0)**
p646.kmz-536	Apartment_block	2014	34.2066 **(22.7586)**	0 **(0)**	25.1856 **(13.7376)**	14.9969 **(14.9969)**	0 **(0)**
p567.kmz-253	Apartment_block	2014	353.684 **(235.316)**	0 **(0)**	260.41 **(142.042)**	155.062 **(155.062)**	0 **(0)**
p617.kmz-488	Apartment_block	2014	778.523 **(517.973)**	0 **(0)**	573.21 **(312.66)**	341.32 **(341.32)**	0 **(0)**
p560.kmz-240	Apartment_block	2014	278.978 **(185.612)**	0 **(0)**	205.405 **(112.039)**	122.309 **(122.309)**	0 **(0)**
p631.kmz-491	Apartment_block	2014	451.786 **(300.586)**	0 **(0)**	332.64 **(181.44)**	198.072 **(198.072)**	0 **(0)**
			30,823.16 (20,507.5122)	**0**	**22,694.42 (12,378.7756)**	**13,513.49 (13,513.49)**	**0**

<< Showing 15 of 56 >>

Figure 23. Outcomes of the UEP tool

The table indicates that the total energy demand for heating and electricity was reduced for the selected buildings (green numbers in brackets) giving a reduction in CO_2 emissions. The analysis has shown the effect of changing the specific energy demands for residential and office buildings in their energy demand and CO_2 emissions.

The above steps were repeated for different type of energy efficiency projects, where different measures were implemented.

4.3.5 Step 5. Multi-criteria comparison of projects

After defining a set of alternative energy efficient improvement projects, the user could compare them by applying the MCDA-tool embedded in the platform. A simple comparison between a baseline and two different energy efficiency projects has been performed. In order to open the MCDA tool, the users have chosen the option “Compare” from the “Plan” drop-down menu.

	Baseline	Energy efficiency project 1	Energy efficiency project 2	Weight	Threshold
Energy demand heating	3934.8	3698.388	3461.976	1	0
Energy demand electricity	12192.85	11956.438	11909.156	5	0
CO2 heating emissions	325.88	303.4209	280.9617	1	0
CO2 electricity emissions	2057.56	1922.221	1922.221	5	0
Heating cost	334457.64	314362.64	294267.64	1	0
Electricity cost	3413997.92	3347802.32	3334563.32	5	0
CO2 emissions	3298.2	3059.8128	3037.3536	5	0
Total Cost	4202734.66	4116444.66	4077081.66	5	0

Figure 24. MDCA tool

Figure 24 shows the multi-criteria matrix: the projects to be compared and the indicator scores for the three projects. The figure also shows the weights given to each indicator. In this demonstration, indicators related to energy demand for heating and electricity were chosen. Energy demand, CO_2 emissions and cost for heating were given the lowest weight of 1 and the remaining indicators the highest weights of 5.

After defining the alternative projects, the set of indicators, their weights and thresholds (i.e. the multicriteria structure), it was possible to run the MCDA tool, whose outcomes are shown in Figure 25 below.[6]

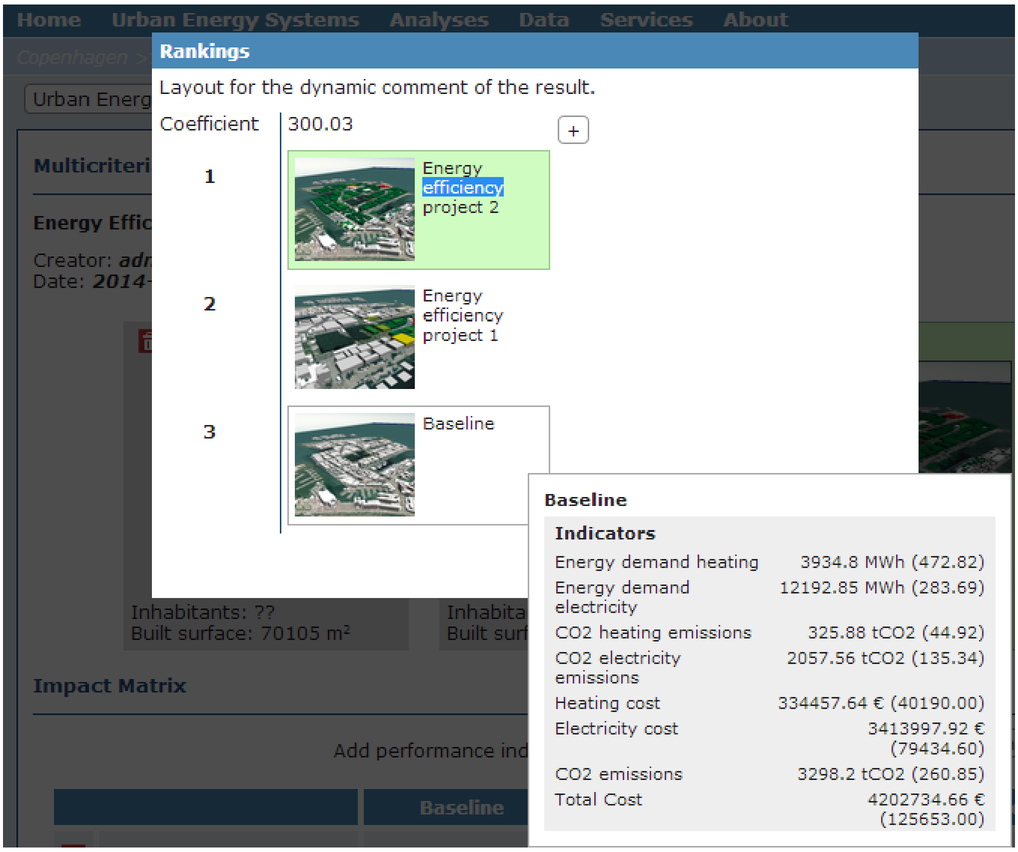

Figure 25. Results of multicriteria comparison

The platform provided the ranking with the higher coefficient (i.e. supported by the larger amount of indicators), in which Energy efficiency project 2 is ranked first, Energy efficient project 1 is ranked second and Baseline is ranked third. The user passed the mouse over an alternative and a window has pop-up and indicated the savings in energy demand, CO_2 emissions and cost for the project, and the difference with the best evaluated project (values in brackets).

[6] In this demonstration, users did not assign values to the preference thresholds. This may importantly affect the outcomes of the evaluation, misleading the analysis and conclusions derived from the results.

The user could expand the view (by pressing the "+" sing in the upper-right corner of the window) and observe other two rankings with high coefficient values (See Figure 26).

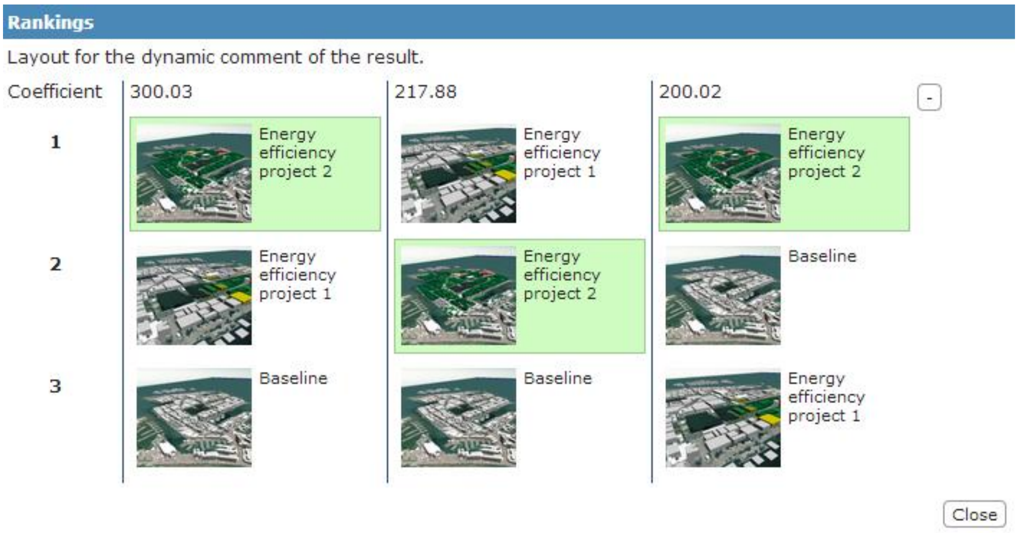

Figure 26. Pop-up window with information about the compared projects

4.4 Evaluation of the platform

The following sections present an evaluation of whether the platform provides relevant and qualified information to support energy efficient urban planning. The evaluation is done in terms of whether the tools and functionalities are useful to perform the planned activities and to meet the objectives stated in section 4.3.

The evaluation covers the following aspects: the access to data, the integrated tools and the information provided by the platform (e.g. indicators).

4.4.1 Access to data

Data about the year of construction and use of buildings, the corresponding specific energy demands, the geometric properties of the buildings and the energy supply technologies were uploaded to data repositories and semantically modelled by SEIF. The data was provided in an excel sheet by the energy domain experts (i.e. Ramboll) and imported by the developers of the technological platform (i.e. FUNITEC). These data can be accessed and changed by editing the urban energy model as illustrated in Figure 16 and Figure 21.

In general terms, to browse and change data have proved to be very intuitive for the user. The users were able to simulate different energy efficient measures by assigning different values to the specific energy demands. However, the users required technical knowledge to assign different values to the parameters according to the improvements being simulated.

Information about building properties and building energy performance was available to the user through the 3D-model and the pop-up boxes created for that purpose (See Figure 27).

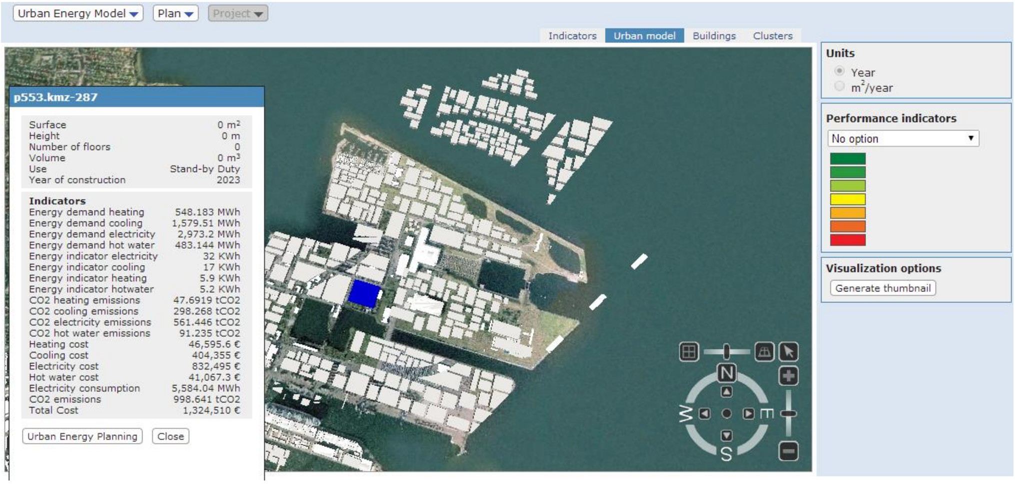

Figure 27. Pop-up window showing information about energy performance of selected building.

Also, users were able to access and modify building parameters by means of specific forms presented in Figure 28.

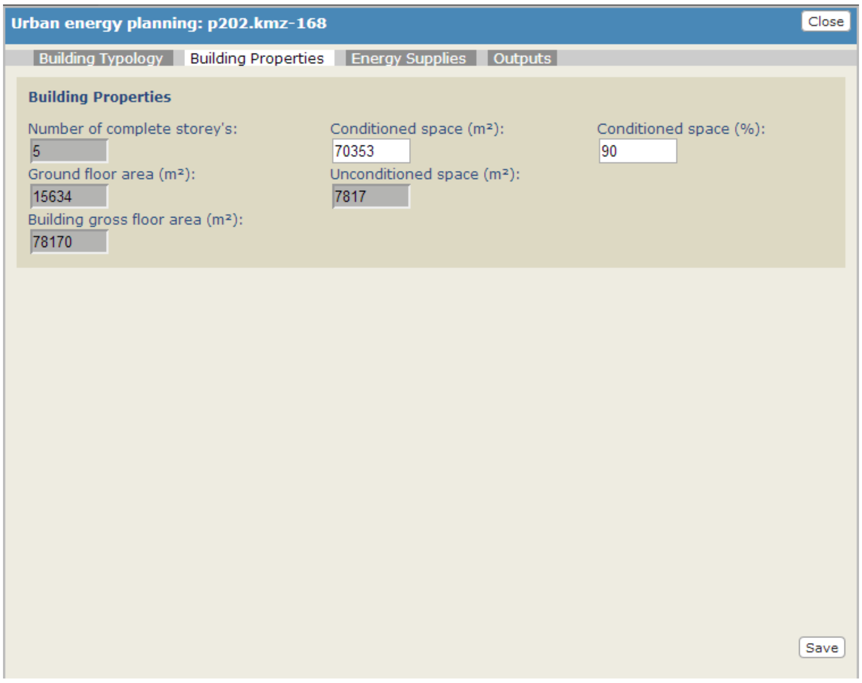

Figure 28. Form to change building parameters

As mentioned in section 4.3.4, the results of the calculations of energy performance have been accessed in tabular form. Also, users had the possibility to visualize information on the 3D model by repeating steps described in section 4.3.2. In this way, users were able to find hot spots of poor energy performance and propose energy efficient improvements. Improvements were simulated by means of changing and editing specific energy demands for different building typologies in the urban area.

4.4.2 Integrated tools

The UEP-tool has been developed in order to help energy planners to analyse the energy demand and energy supply when planning a new urban development area. One of the first questions from the project owner (e.g. urban developing company, municipality) and other stakeholders (e.g. architects, engineers, investors) is often related to the standards that the buildings should meet. The next question is often how the area should be supplied with sustainable energy. This decision is very often based on a cost-effectiveness analysis of different measures, both on the energy demand and energy supply sides.

The demonstration scenario described above shows how the UEP-tool can be applied to determine the energy demand, CO_2 emissions and cost related to the choice of a given energy standard for buildings. Therefore, at this stage of the project development, it can be said that the UEP tool supports the user in modelling an energy efficient city based on demand side improvements with the lower possible costs.

The tool will be further developed to include options on the energy supply side, and to identify the impacts on energy consumption and CO_2 emissions by choosing a specific energy supply technologies for new buildings in the urban area. In this way, users will be able to meet the objective of building an energy efficient city also based on renewable energy supply technologies at lowest possible costs.

In the current state of the platform, the MCDA tool provides information that goes beyond a cost-effectiveness analysis by including a multidimensional set of indicators in the evaluation and comparison of projects. However, users have also demanded a tool to evaluate the cost-effectiveness of different projects, which is being developed and is planned to be implemented in the third round of demonstrations.

According to users, the mathematics and calculations behind the MCDA tool, the output coefficients and ranking of projects are not easy to understand. To provide an online guide or to include brief explanations of the concepts of the MCDA tool would be very useful for users to understand the results. It is also important that the users correctly understand the parameters of the MCDA tool. For instance, in this demonstration users did not assign values to the preference thresholds. This may importantly affect the outcomes of the MCDA tool, making the analysis and conclusions derived from the results misleading.

The activities performed during this demonstration were steps forward in meeting the objectives and ultimate goals of the stakeholders in the North Harbour project: i.e. to build an energy efficient city based on renewable energy supply with the lowest possible costs. The platform has enabled the users to calculate the cost of implementing different projects and to identify which improvements tend to produce lower costs and good energy performances.

4.4.3 Performance indicators

Most of the users have found that the information provided by the platform is not enough to support energy efficient urban planning; information on intensive indicators (e.g. kWh/m^2, tCO_2/m^2) is missing. Also, benchmark or reference values to compare results are missing. This is strongly related to the issue of standards that building should meet mentioned above.

Most of the relevant indicators mentioned above are listed in *D2.2 "Strategies and Indicators for Monitoring CO_2 Emissions"*. However, users have identified the following missing indicators: internal rate of return (IRR) and energy savings indicators. These should be included in the indicator list.

5 DEMONSTRATION SCENARIO: MANRESA

5.1 Objectives

The goal of the demonstration in this case study was to compare a set of projects aimed at improving some buildings in a highly deteriorated neighbourhood. Buildings are owned by the social housing provider, which has a budget of 60.000 euros to upgrade the existing structures. As well, improvements will be aimed at decreasing the energy demand and the energy bill, which is an increasing problem for the dwellers in the target neighbourhood. The purpose of the demonstration was to know the best alternative project considering energy demand, CO_2 emissions and the cost of energy provision (i.e. the energy bill).

In order to meet the above mentioned objectives, the user had to identify the target buildings; that is, to identify which buildings had poor energy performance and were owned by the public social housing company. Also, the user had to prioritize the investment by filtering the buildings according to their age and surface material.

Then, when the target buildings were selected, the user simulated energy efficient improvements and calculated the upgraded energy performance. In order to do so, the users applied the **Urban Energy Simulation tool**, which requires to access to the following data:

- Age of construction from the cadastre.
- Building geometry (footprint and height, % of dwellings with cross ventilation) mainly from the 3D map.
- Characteristics of enclosures (U-values, glazing, solar factor, α-value) from tables relating the year of construction and these structural parameters.
- Occupation parameters (ground floor use, % of occupation of building, comfort temperatures, internal gains), calculated with data from census and tables relating income and comfort conditions.
- System parameters (Space and cooling systems and efficiencies, water heating system and efficiency, coverage of renewables) from tables relating household income with these system parameters.

Then, the platform provided the following indicators:

- Demand of energy carriers for heating and cooling in the target buildings.
- Direct and indirect CO_2 emissions.
- Cost of energy supply (i.e. energy bill).

With this set of indicators, and other indicators defined by the user, the projects can be compared using the **MCDA tool**. Finally, the user was required to produce a report, with clear figures, to support his/her analysis and provide advice to the final decision makers.

5.2 Users

The following users took part in the demonstration of the platform in the Manresa case study.

Table 3. Users taking part of the Manresa demonstration

User name	User profile	Institution/Organization	Objectives of the demo
Àlex Quintín	Architect / Urban Planner	Office of the POUM (Manresa Urban Master Plan)	To prepare the user with enough knowledge of the platform and, after that, to face him/her against the defined scenario. Evaluate the experience of the user and its degree of success.
Lara Rivero	Architect / Urban Planner	Urban Planning Department of the Manresa Municipality	
Ivan Ruiz	Technical Architect	Maintenance department at FORUM's office (housing company)	

Alex Quintin is a young architect who has been working as urban planner at the POUM office during the last one and a half year. Before joining the team in charge of reviewing the Urban Master Plan, he worked as an independent architect in the private sector during four years.

Lara Rivero is also a young architect working as urban planner at the Urban Planning Department of the Municipality. She works closely with Ricard Torres, the Head of this department. She has been actively analysing and reporting the situation of the different areas of the city during the last years, which included to review urban developments done by private parties.

Ivan Ruiz is the person in charge to carry out refurbishment projects proposed by the public housing company of Manresa. He has certified all residential buildings owned by the City Council according to the official energy efficient certification scheme.

5.3 Demonstration

As mentioned in Chapter 2 - *Methodology*, the demonstration scenarios are based upon the use cases described in D8.2 *Implementation Success Indicators* (specifically in section 5.1 of that deliverable) and adapted according to the current state of the platform.

The objective of the use case can be summarized as follows:

- To identify buildings with poor energy performance,
- To calculate the energy consumption and CO_2 emissions of an existing building and of the urban area,
- To compare alternative energy efficient projects between them and with the baseline situation.

In 0, an analysis of the correspondence between the activities carried out during this second round of demonstrations and the activities planned in D8.2 is presented.

Previous to the demonstration, users were provided with a brief introduction to the platform using a Power Point presentation. The main objective of this introduction was to make clear the objectives of the demonstration and to show the main functionalities of the platform. It was expected that users would then have enough information to perform the demonstration without additional support.

5.3.1 Step 1. Log-in and creating a new Plan

After logging in with a user and password, the user selected Manresa and accessed the 3D model of the city (See Figure 29).

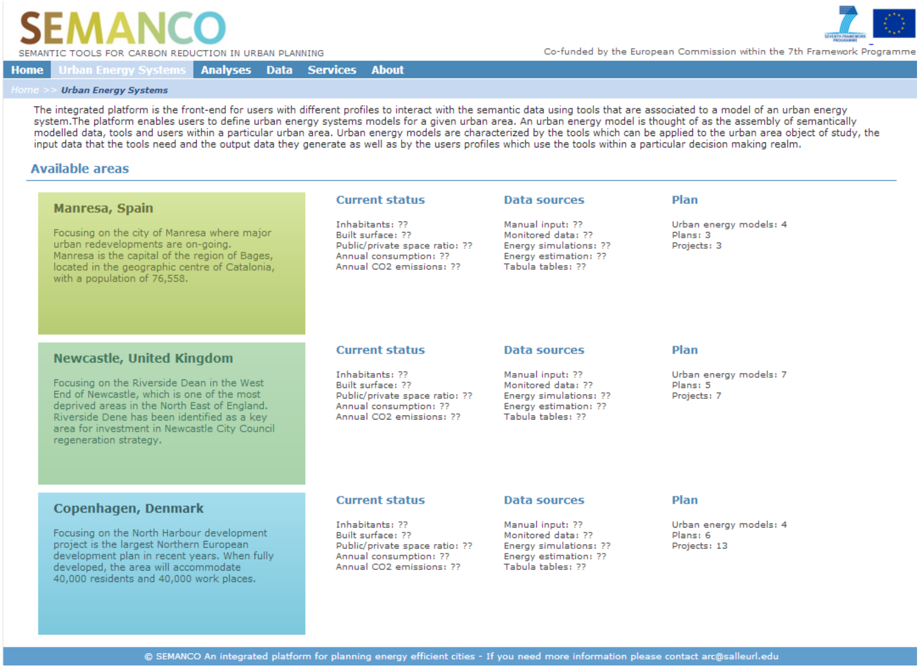

Figure 29. Front page of the platform

Then, the user created a Plan by clicking in the corresponding "New" button in the drop down menu "Plan". The user named the Plan with an appropriate name and wrote down a brief description (See Figure 30).

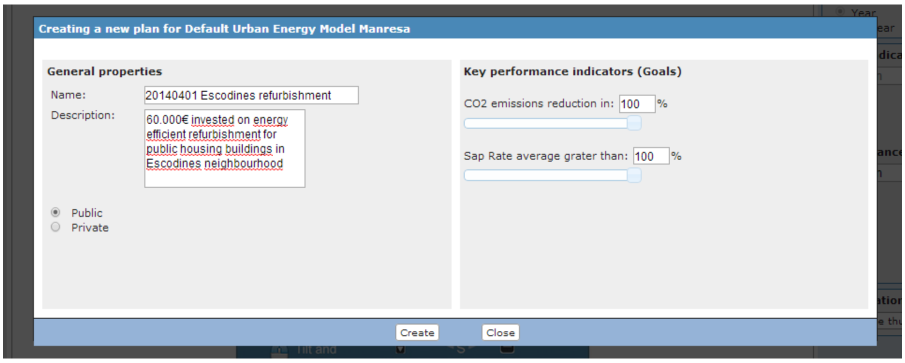

Figure 30. Naming and describing the Plan

5.3.2 Step 2. Selection of the target urban area

The user navigated through the 3D model by using the available navigation tools until an appropriate view of the target neighbourhood is obtained. Due to its technical profile, the user prefers a two dimensional view, with the north at the top of the screen (See Figure 31).

Figure 31. Orthogonal view of the urban area

Once the target urban area was located on the screen, the user selected the indicator "Energy Demand" from the drop-down menu list on the right side of the screen. After that, buildings were coloured according to their baseline Energy Demand. At this point, the user was able to identify the buildings with poor energy performance (coloured in red). Also, due to their experience in the city, the user knew that older buildings have more potential for implementing energy saving measures. Therefore, the next step was to apply a filter to show the buildings constructed prior to 1975 and with high energy need. Also, the user decided to exclude the largest buildings due to the limited available budget (See Figure 32).

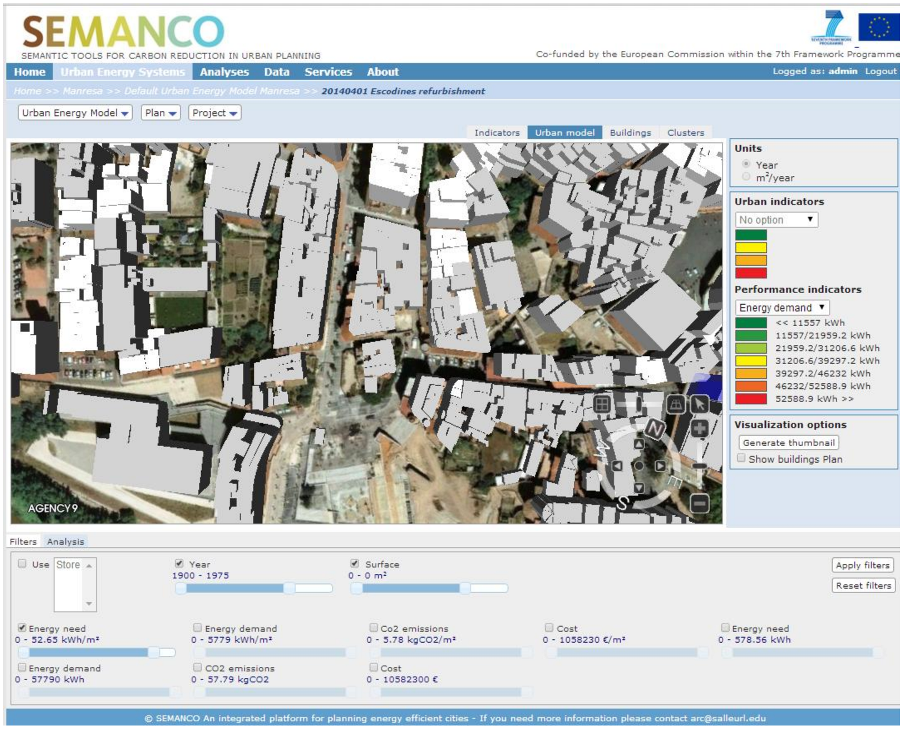

Figure 32. Filtering buildings according to year of construction, energy need and built surface

With these three filters activated, the user has chosen two buildings coloured in red (i.e. with the poorest range of energy demand) and another building which, despite being coloured in yellow, has structural problem in the roof that has to be repaired. The three buildings are owned by the public social housing company. The user then added these three buildings to the Plan by clicking on the corresponding button in the pop-up window (See Figure 33).

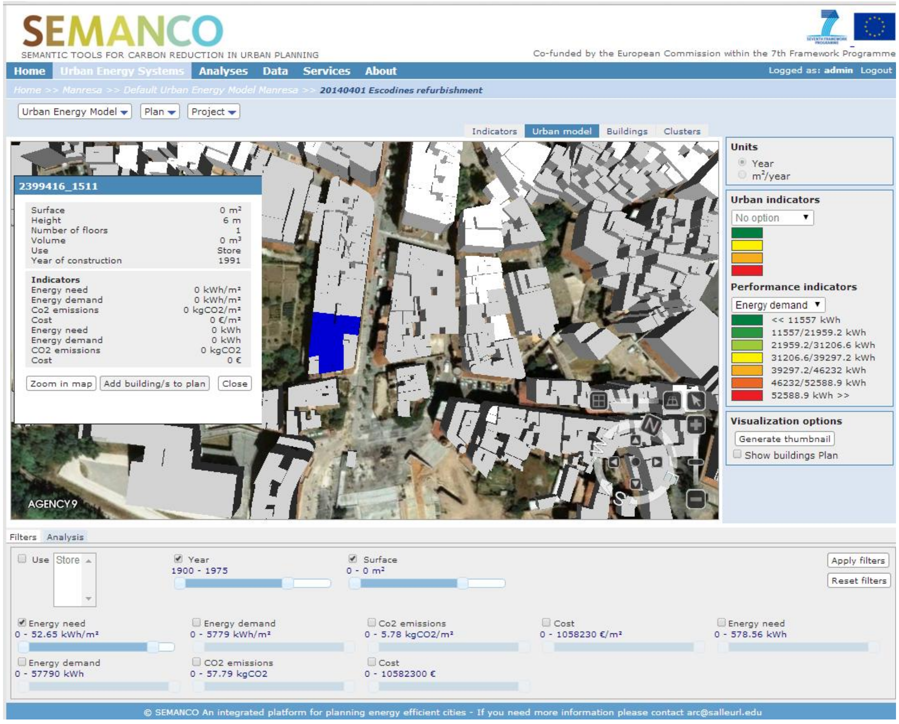

Figure 33. Adding buildings to the Plan

By checking the "show buildings plan" box, the user confirmed that the buildings have been added to the plan. At this point, the user decided to include another building. Despite the fact that this last building has not complied with the criteria to select buildings (i.e. it has not had a poor energy performance and was not very old), the people dwelling within it are willing to pay for a façade refurbishment (See Figure 34).

Figure 34. Selection of four buildings

5.3.3 Step 3. Creation of alternative projects

To create a project, the user clicked on "New" in the "Project" tab and filled in the project form with a name and description (See Figure 35). After that, the user had to define the improvements for each building in each project.

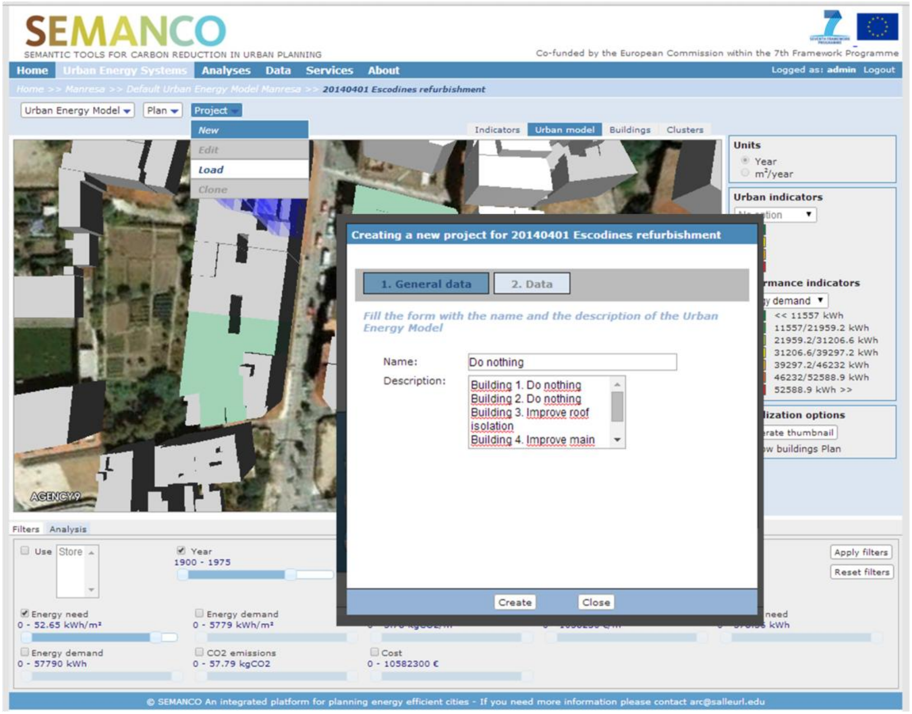

Figure 35. Creation of a new project

To simulate each energy efficient improvement the user had to change the correct parameter in the building form. In order to do so, the user selected the building and clicked "Edit parameters" in the pop-up window and edited the values in the form of the Urban Energy Simulation tool (See Figure 36). For instance, to improve the roof isolation the user has to change the value in the "Roof U value (W/m²K)" field, which is located in the "Building properties" tab of the form. A wooden pitched roof with 4 centimetres of EPS isolation has a U-value of about 0.81 W/m²K. If the user wants to improve windows facing north, s/he has to select walls oriented to North in the field "Walls properties" in the "Building properties" tab. Then, the user has to change the "Window U Value (W/m²K)" and "Window solar factor, g-value (%)" with values corresponding to new window, for example, to a window with double glazing and aluminium frame with thermal break has a U-value of 3.30 W/m²K and a solar factor of 75%.

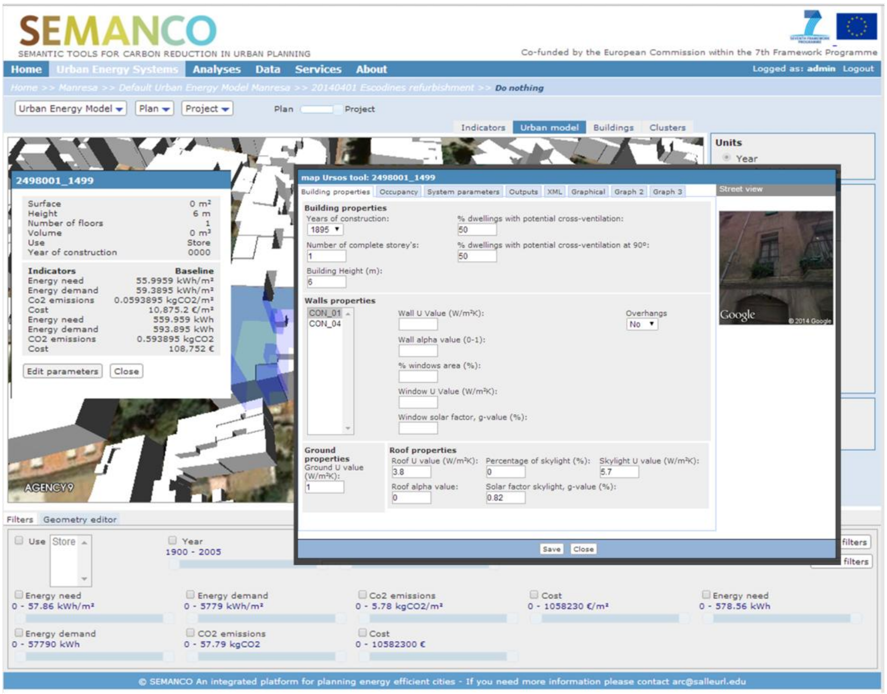

Figure 36. Editing building parameters in the form of the Urban Energy Simulation tool

By following the described procedure, the users have set up the following projects:

- **Project 1 name: Do nothing.** This project considered to carry out improvements in buildings requiring structural refurbishments.
  - Building 1. Do nothing
  - Building 2. Do nothing
  - Building 3. Improve roof isolation
  - Building 4. Improve main façade isolation

- **Project 2 name: Improve windows.** This project considered to change windows in buildings 1 and 2, repair the roof of building 3 and insulate the façade of building 4.
  - Building 1. Improve all windows
  - Building 2. Improve all windows
  - Building 3. Improve roof isolation
  - Building 4. Improve main façade isolation

- **Project 3 name: Boiler renewal.** This project considered to renew the boilers of buildings 1 and 2, repair the roof of building 3 and insulate the façade of building 4.
  - Building 1. Renew all boilers
  - Building 2. Renew all boilers
  - Building 3. Improve roof isolation
  - Building 4. Improve main façade isolation

- **Project 4 name: Budget spread.** This project considered to change windows of façades facing north in buildings 1 and 2. It also considered to allocate part of the budget in buildings 3 and 4, by repair the roof and increase the coverage of renewable energy for DHW supply in building 3, and to change some windows of building 4.
  - Building 1. Improve windows facing north
  - Building 2. Improve windows facing north
  - Building 3. Improve roof isolation + 60% coverage DHW with renewal resources
  - Building 4. Improve main façade isolation + improve main façade windows

- **Project 5 name: Full.** Finally, the user decided to create a project considering no budget limitations. Therefore, this project considered to implement all energy efficient improvements of the previous projects.
    - Building 1. Improve windows + Boiler renewal
    - Building 2. Improve windows + Boiler renewal
    - Building 3. Improve roof isolation + 60% coverage DHW with renewal resources
    - Building 4. Improve main façade isolation + improve main façade windows

After defining the 5 projects, the user checked that all of them are recorded within the Plan by clicking on the "Load" option of the "Project" drop-down menu (See Figure 37). After that, the user moved to the MCDA tool by clicking on the "Compare" option of the "Plan" drop-down menu.

Figure 37. List of projects within the Plan

5.3.4 Step 4. Multicriteria analysis

In the MCDA tool analysis, the user clicked on "New analysis" and saves it as "Analysis 1". As the tool only allows comparison between 5 projects, the user decided to remove the baseline situation, which in the platform is named with the name of the plan, and adds the missing project.

The user then moved to the list of indicators and decided to compare only absolute values. Therefore, he removed all the intensive indicators. Additionally, the user added a "user indicator" named "Investment cost". The values of this indicator were defined by the user according to his/her knowledge of the required investments in each option.

Then, the users defined the weights and thresholds of each indicator according to his/her preferences, and performed the multicriteria analysis by clicking on the corresponding button (See Figure 38).

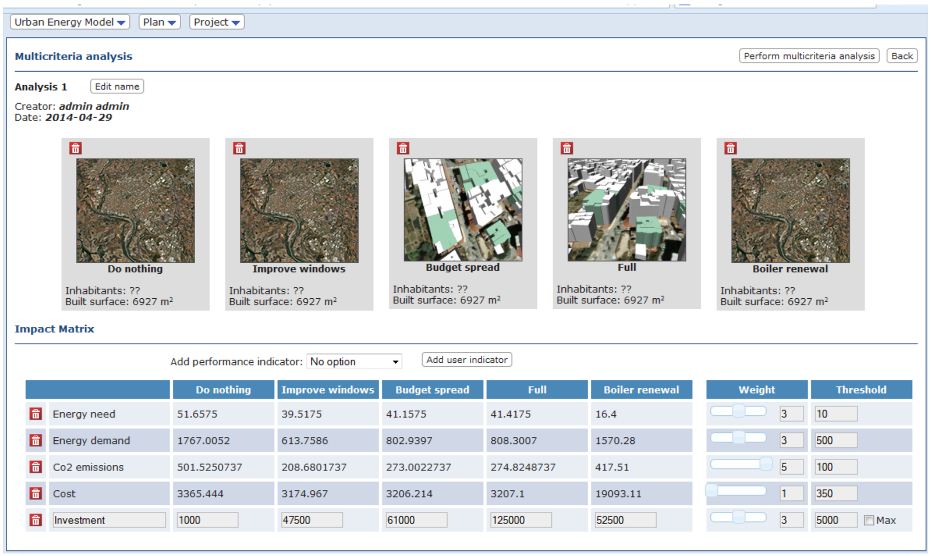

Figure 38. MCDA tool

The results of the MCDA tool are presented in Figure 39. From this analysis, the users was able to choose the project performing better according to the selected indicators. The platform provided the ranking with the higher coefficient (i.e. supported by the larger amount of indicators), in which : the Improve windows project is ranked first, Budget spread project is ranked second and the Full projects is ranked third, the Do nothing in the fourth position and the Boiler renewal project is ranked last. By passing the cursor over the projects in the ranking, a pop-up window present the energy need, energy demand, CO_2 emissions, energy related costs and investment costs of the project (See Figure 39).

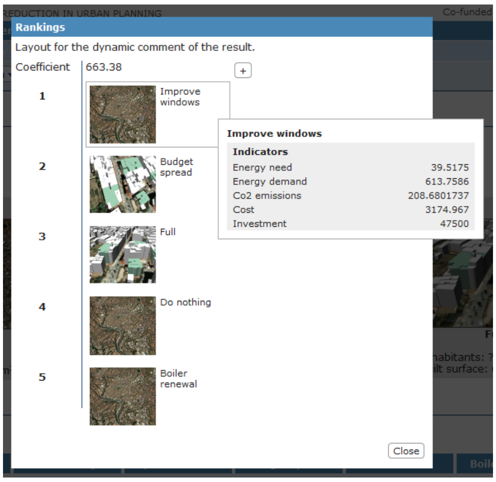

Figure 39. Outcomes of the MCDA tool: rankings of projects

The user could expand the view (by pressing the "+" sing in the upper-right corner of the window) and observe other two rankings with high coefficient values (See Figure 40), which confirms that the Improve windows projects is the best evaluated one.

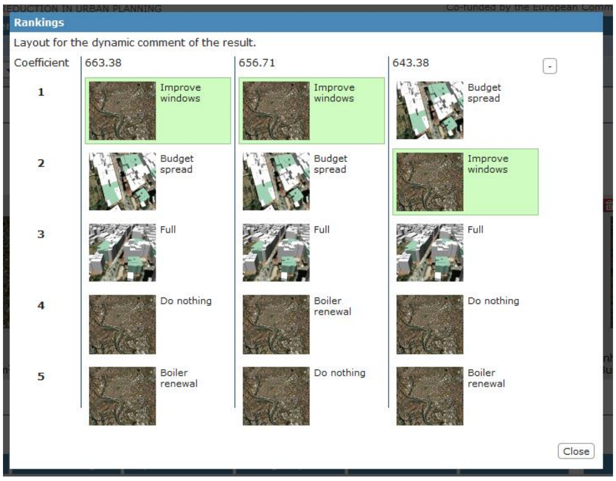

Figure 40. Outcomes of the MCDA tool. The best evaluated rankings

5.4 Evaluation of the platform

The following sections present an evaluation of whether the platform provides relevant and qualified information to support energy efficient urban planning. The evaluation is done in terms of whether the tools and functionalities are useful to perform the planned activities and to meet the objectives stated in section 5.3.

The evaluation covers the following aspects: the access to data, the integrated tools and the information provided by the platform (e.g. indicators).

5.4.1 Access to data

Users have been able to access data at building level by means of both the 3D map and the graphical representations, which were considered as relevant for supporting decision making.

Users found both the visualization of indicators in the 3D map and the filtering functionality very useful in finding buildings with poor energy performance. However, many buildings appear coloured in grey instead of white. This happens after applying a filter of an indicator or after unselecting a building. This issue confuses the user while trying to make a visual analysis.

Due to the professional profile, users asked to integrate urban indicators into the visualization environment. For instance, calculations might be, amongst others, based on ground floor area, soil occupancy, green areas, constructed surface and population densities.

5.4.2 Integrated tools

Users have been able to understand the process behind the calculation. They also found the form to enter or modify building parameters easy to use. However, to use the form requires technical expertise to know, for instance, how to simulate energy efficient improvements by changing the values of the parameters. Users proposed the inclusion of some reference values to guide the use of this functionality.

Regarding the MCDA tool, users considered the possibility to add additional indicators very useful. The MCDA tool has also been considered very useful. However, users had difficulties to understand the parameters of the tool (i.e. weights and thresholds), which is an obstacle for its use. The "Max" check-box and the coefficient of the rankings also need an explanation to facilitate the use of the tool.

5.4.3 Performance indicators

Because the users were not energy experts, they did not know whether the current set of indicators is relevant for energy efficient urban planning. Anyway, they are aware about the need to include urban and energy performance indicators aggregated at urban scales. Users considered that having access to real energy consumption data would be very useful for urban planning.

6 FEEDBACK TO TECHNOLOGICAL DEVELOPMENT

This section provides feedback to technological development by indicating the issues to be improved in the integrated platform according to the insights from users and domain experts. Feedback is organized around the following aspects:

- Required improvements to provide, though the platform, relevant and qualified information to support energy efficient urban planning.
- Required updates of the ontology, according to updates in tools and functionalities.
- Preliminary evaluation of the usability of the platform.

6.1 Improvements to provide relevant and qualified information

From the demonstration in the **Newcastle** case study, the following recommendation can be proposed:

- To include information or indicators regarding land value, population and building density, building tenure.
- To provide a brief explanation of the calculation method of the SAP rating tool, and also an explanation of the validation process performed during the first implementation round.
- To make more visible the possibility of introducing an additional indicator in the multicriteria comparison. Potentially, give two or three examples of indicators (e.g. social acceptance, cost).

From the demonstration in the **Copenhagen** case study, the following recommendation can be proposed:

- To include the calculation of intensive indicators (e.g. kWh/m^2, tCO_2/m^2) and other relevant indicators for the urban area. This would entail to calculate the average of energy demand per square meters considering all the buildings in the target urban area and their respective energy demands and built surface area.
- To include, at least, the following performance indicators: Internal rate of return (IRR), cost of supply technologies.
- Integrate the energy supply simulation.
- To calculate energy performance by differentiating energy carriers.

From the demonstration in the **Manresa** case study, the following recommendations can be proposed:

- Users have proposed to incorporate urban indicators into the visualization environment. For instance, building occupancy, green areas, built surface, population densities, among others.
- Since users have to have certain technical knowledge to simulate energy efficient improvements by changing the values of the parameters in the building form, a guide with some reference values would be useful to easy the use of the Urban Energy Simulation tool.
- Regarding the MCDA tool, users had difficulties to understand the parameters of the tool (i.e. weights and thresholds), which is an obstacle for its use. This issue call for incorporating an explanation of those concepts, as well as the meaning of the “max” check box, the ranking coefficient, among others.

6.2 Ontology

Evaluations of the tool to date indicate as far as the UK context is concerned, users are satisfied with the functionality of the indicators currently presented within the tool. No other indicators were identified but users have requested whether the visualisation tool could be applied to commercial or public buildings.

Currently, energy domain experts consider that there are already too many indicators displayed in the technological platform. The number of indicators displayed in the multi-criteria matrix by default will be reduced to the most relevant ones. Since no more indicators will be incorporated for the third demonstration round, there is no need to update the ontology at present.

In the case of Manresa, it is possible to include all indicators proposed by users with the current version of the ontology. Therefore, no updates are necessary yet.

6.3 Platform usability

The performance of the platform in terms of responsiveness and stability should be checked. Slow loading, erratic behavior of window panes and unexpected log off are some of the main issues highlighted by users.

Explanations of concepts and functionalities of the platform are required. A quick guide should be available online. This quick guide should include, for instance, an explanation the Urban energy model framework with plans and projects. Users found difficult to know where they are, i.e. which plan of project, when they work in the platform.

The online quick guide should also include an explanation of how to access different functionalities and tools of the platform. An explanation of the different parameters and coefficient of the tools should be included. This applies to the parameters of MCDA tool, which has been considered very useful to support decision making, but difficult to apply without knowing the meaning of its parameters.

An “export to Excel” function should be included, as well as the possibility of converting images to a jpeg file.

Then, there is a clear need to include intensive indicators such as energy demand, carbon emissions or cost per square meters (measured in $kWh/m^{2,}$ tCO_2/m^2 and $€/m^2$ respectively).

From the demonstrations, the following recommendations can be given to improve the platform:

- Clearly state the system requirements in the front page of the platform (JAVA version, speed of internet connection, operating system).
- To provide explanation of the plans and projects framework. Also, add an indication whether the user is working in the plans or in the project environment.
- A quick guide dealing with some basic instruction is needed. For instance, the use of the mouse, how to launch the SAP rating tool or how to configure the graphic representations.
- To provide explanation of calculation procedures. In the case of the Copenhagen case study, this can be done by making available for downloading the excel spreadsheet containing the calculation procedures.
- To provide explanation of the parameters of the MCDA tool. In one demonstration users did not assign values to the preference thresholds. This may importantly affects the outcomes of the evaluation, producing misleading the analysis and making the conclusions derived from the results unreliable.
- To review the size of window panes (sometimes small) and their responsiveness, and the login system and reasons of disconnection.
- To remove decimals from indicator scores.

Additional comments and recommendations can be found in Appendix C.

7 CONCLUSIONS

7.1 Contribution to overall picture

The purpose of the second round of demonstrations was to perform user testing to provide a preliminary verification of whether the identified problems in terms of carbon reduction can be addressed within the context of the current version of the SEMANCO integrated platform. The results of this have been presented in the current document. These results included both an overall evaluation of the current state of the platform and certain specific refinements that are required for the SEMANCO platform to reach its full potential. This information has been provided to the technological development in WP5 and will represent a highly valuable basis for improving the functionalities of the platform in the remainder of the project.

The report dealt with the following specific issues:

1. Design three demonstration scenarios as a sequence of activities, one for each case study area within the project. Each of these is based on the use cases described in D8.2 *Implementation Success Indicators* (specifically in sections 3.1, 4.1 and 5.1 of that deliverable) and was adapted according to the current state of the platform. These are described in sections 3.3, 4.3 and 5.3.
2. Having people representative of the intended end users of the SEMANCO platform interact with the platform and carry out the steps in demonstration scenarios.
3. Gathering concrete feedback from users regarding their experiences of using the platform within the scenarios. Three forms of feedback were gathered. Firstly, the end users comments made during the demonstration were written down by the domain expert guiding the demonstration. Secondly, the users were asked a specific set of questions concerning, amongst others, data integration, calculation, the relevance of indicators and visualization features. The results of this evaluation questionnaire are presented in Appendix B.
4. The status of the SEMANCO platform was also verified by the domain experts within the SEMANCO project. In particular these domain experts were asked to check whether the issues pending from Task 8.2 *Implementation* and Deliverable 8.2 *Implementation Success Indicators* had been solved within the current version of the platform.
5. Based on the results of these evaluations conducted by users and domain experts, some conclusions were drawn about the general performance of the platform and the user interface, the functionality of the tools and the access to data within the SEMANCO platform. These conclusions will be taken into account in the further development of the platform.

7.2 Impact on other WPs and Tasks

The main impact of Task 8.3 and Deliverable 8.3 is on WP5 *Integrated Tools*. The evaluations and comments about the performance of the platform have both yielded a highly valuable source of data for guiding the on-going refinement of the SEMANCO platform, and have highlighted certain specific problems which should be addressed.

In supporting the development of the SEMANCO platform, and in ensuring that its features are closely aligned with the requirements of eventual end users, it also contributes towards any future efforts exploiting the platform.

7.3 Contribution to demonstration

The current version of the SEMANCO platform allowed end users to identify and classify buildings for energy analysis within a geographic area. They were also able to visualize and identify hot spots of poor energy performance. These features support the effective targeting of urban energy efficiency and renewable energy interventions.

In addition, the users were able to assess the potential of different technical and social interventions and strategies to reduce CO_2 emissions at different geographic scales.

The MCDA tool and the SAP improvement tool enabled the end users to analyse the trade-offs between conflicting social, economic, political and environmental constraints within planning and design practice. These functionalities support the analyst in making decisions about energy efficient interventions.

The platform provides planning authorities (local, national and European) with appropriate indicators for monitoring and reporting future planning strategies. However, it is not yet possible to predict future demand following demographic and economic changes. Despite this, the platform allows its users to identify the patterns of growth and urban developments which reduce energy consumption.

In verifying which features of the platform can be happily used by end users in this way, the work in this deliverable considerably aids the successful design of future demonstrations of the SEMANCO platform. It thus forms a substantial contribution to the demonstration work within the SEMANCO project.

Appendix A. USE CASES AND DEMONSTRATION SCENARIOS

A.1. Newcastle demonstration scenario

Table A-1. Coherence between use cases defined in D8.2 and demonstration performed under Task 8.3

Activity	Description	Related activity performed in this demonstration
A.N1 – Definition of different alternatives of urban planning	In the Newcastle use case, each alternative corresponds to a separate model of the Newcastle case study area on which an end user is developing a proposed refit plan for a set of houses.	**Step 4**. Introducing energy efficient improvements
A.N2 – Determination of geometry of buildings and urban environment	Input data for the SAP calculations are automatically derived from the 3D model.	The determination of the geometry of buildings has not been specifically performed in this demonstration. Values for 65 single family dwellings in the case study area has been conducted using a prototype version of the SAP tool defined in excel, using data from maps freely available in the UK (Mhalas et al, 2012).
A.N3 – Determination of technical parameters of buildings	The basic method by which the SAP calculation drives the determination of the technical parameters of buildings is the manual inspection of open source street level photography. Certain additional details will be taken directly from the results of the LiDAR survey in order automate elements of this activity.	The determination of the technical parameters of buildings was not performed in this demonstration. Values has been manually determined for 65 single family dwellings in the case study area using a prototype version of the SAP tool defined in excel, using data from imagery and maps freely available in the UK (Mhalas et al, 2012). Values of technical parameters were already introduced in the platform.
A.N4 – Model the energy performance of individual buildings	Once all of the data above has been put in place, the SAP calculation tool calculates the energy performance, fuel costs, CO_2 emissions and other indicators for an individual dwelling.	SAP rates were not calculated in this demonstration. This activity has been conducted for 65 single family dwellings in the case study area using a prototype version of the SAP tool defined in excel. The geometrical and technical parameters of buildings from the earlier sections form the input for the various models constructed within the prototype (Mhalas et al, 2012). SAP rates were already introduced in the platform.
A.N5 – Calculation of operational costs (baseline)	This activity would be produced as part of the outputs of the SAP calculation tool and as such has been covered above.	Costs won't be included as an indicator. The SAP rating itself strongly relates to these costs but is normalised in relation to the amount of floor space within the dwelling and put onto a scale roughly between 0 and 100.

Activity	Description	Related activity performed in this demonstration
A.N6 – Calculation of the potential benefits of energy efficient interventions .	In this case a specific dwelling has been selected and the data resulting from its SAP evaluation produced. The tool then allows a full range of both fabric refits – e.g. improved insulation – and renewable electricity/heat interventions – such as solar PV – to be considered	**Step 4**. Introducing energy efficient improvements **Step 5**. Simulating energy efficient improvements
A.N7 – Decide on which energy efficiency interventions should be made .	By presenting both the energy savings likely to arise from any such refits and various items relating to the economic results of installing the improvements concerned the improvements tool allows users to select which set of refits they consider optimal for each given property. The economic data includes not only the differences made to individual fuel bills but also such items as government subsidies	This decision would be made after multicriteria comparison of projects
A.N8 – Calculation of energy savings and CO_2 emissions for each scenario .	Once the user has decided which set of refits should be applied to a given dwelling in this specific improvement scenario they can choose to store this data. The SAP calculation tool is then run again and the new results are stored.	**Step 5**. Simulating energy efficient improvements
A.N9 – Multi criteria comparison of different scenarios	In this case each scenario is taken to be the fitting of one particular sort of improvement to a single dwelling. Different improvement alternatives will be compared using a multi criteria tool, which provides decision support to allow the user to consider qualitative aspects when deciding which improvement should be made. This activity has not been implemented yet since the tool requires an improvement of its user interface to be fully operative.	**Step 6**. Multi-criteria comparison
A.N10.- Total energy demand and demand distribution	Looking forwards to the third implementation round it is anticipated that one major area of work will be the aggregation of the results of refits applied to single buildings at higher levels, and methods for comparing such results	Planned for the third iteration
A.N11.- Determine CO_2 emissions and energy savings in each alternative or measure	By means of the SAP rating tool and the SAP improvement tool the user is able to calculate the CO_2 emissions of the different projects.	**Step 5**. Simulating energy efficient improvements
A.N12 – Visualization of socio-economic and energy related characteristics of the urban environment .	Databases containing LLSOA boundary data have been delivered, and they can be visualized through the integrated platform (3D map). This information is useful to identify levels of fuel poverty at the neighbourhood level. Also, it is possible to visualize outputs of SAP calculations in terms of properties with high, mid and low range SAP values	**Step 1**. Identifying neighbourhood with high energy poverty rates (by means of visualizing the corresponding indicators in the 3D map) **Step 2**. Approaching to building level **Step 3**. Selecting buildings with poor energy performance **Step 7**. Complementary analysis

A.2. North Harbour demonstration scenario

Table A-2. Coherence between use cases defined in D8.2 and demonstration performed under Task 8.3

Activity	**Description**	**Related activity performed in this demonstration**
A.NH1 – Energy performance alternatives definition	The first activity is to define some energy performance standards for building typologies. The total energy demand of the buildings in the baseline is based on the expected specific energy demands (kWh/m2) for new buildings Energy performance alternatives can be evaluated by changing the specific energy demand for building typologies.	**Step 1**. Identifying buildings with high expected energy demand **Step 2**. Creation of new urban project to change specific energy demand for building typologies.
A.NH2 – Determination of geometric characteristics	The geometric characteristics for the North Harbour demonstration scenario are extracted from 3D Maps based on the architectural 3D model of the urban area. The data is crucial for determination of the gross floor area.	Automatic determination of geometric characteristics of buildings
A.NH3 – Determination of characteristics of urban environment .	Ortho photos and related GIS data of the North Harbour area and its surroundings have been delivered and implemented in 3D Maps	Automatic determination of characteristics of the urban environment
A.NH6 – Definition and classification of building typologies	The building typologies used in the demonstration scenario are based on the standard tables developed in *D.3.3 Guidelines forstructuring contextual data* with an added temporal scale for the baseline energy performance.	Four building typologies covering dwellings and offices are used to specify the planned final layout of the urban area. Energy intensities of different building typologies are integrated in the platform. Changes in those energy intensities are carried out in **Step 2** when creating a new urban project
A.NH5 – Model the energy performance of the EP alternatives (baseline and advanced)	The simulation of the energy performance of buildings divided into four age classes have been carried out for the baseline. The energy performance standards are based on existing and future expected requirements in the national building codes.	**Step 4**. Simulating energy efficient improvements
A.NH7 – Calculation of operational and maintenance costs (baseline and advanced)	The calculation of energy costs is performed by the UEP tool. Instead of calculating operational and maintenance costs on the energy supply side it has been chosen to calculate energy costs on the energy demand side (consumer side) instead.	**Step 4**. Simulating energy efficient improvements

Activity	Description	Related activity performed in this demonstration
A.NH8.- Definition of supply alternatives	A comprehensive energy supply technology catalogue covering the 3 levels (building based supply, local district heating, central district heating) has already been identified in the Excel-tool. This catalogue with different supply technologies has partially been implemented in the technological platform to describe the heating supply in a baseline situation.	The energy supply side is currently not being simulated at the desired level and detail in the technological platform (e.g. electricity supply in the baseline situation and the possibility of simulating other energy supply options in a new project is missing).
A.NH9.- Energy supply calculation for each scenario	To apply the energy supply catalogue (incl. data) in the calculation of different plans and projects and visualized in the technological platform.	The energy supply side is currently not being simulated at the desired level and detail in the technological platform (e.g. electricity supply in the baseline situation and the possibility of simulating other energy supply options in a new project is missing).
A.NH10.- Ranking comparison EP and supply technologies alternatives	To calculate different energy performance standards of buildings and energy supply technologies alternatives in different plans and projects and rank these according to cost-effectiveness. Visualization of plans and projects in the technological platform.	A first version of an optimization tool in Excel to visualize cost effectiveness of energy performance and energy supply measures has been created. It is yet to be integrated and demonstrated through the technological platform
A.NH11.- Total energy demand and demand distribution	To calculate the total energy demand and energy demand for heating, hot water, electricity and cooling for individual buildings in the 3D-model.	**Step 4**. Simulating energy efficient improvements

A.3. Manresa demonstration scenario

Table A-3. Coherence between use cases defined in D8.2 and demonstration performed under Task 8.3

Activity	Description	Related activity performed in this demonstration
A.M1 – Definition of different alternatives of urban projects	Definition of energy efficient interventions aimed at improving the energy performance of buildings.	**Step 3.** Creation of alternative projects
A.M2 – Definition of system and occupation parameters	Occupancy parameters can be divided in three categories: **internal gains** (the degree of occupancy of the building, the electric appliances and the number of inhabitants), **building systems** (energy carriers and efficiencies of heating, cooling and domestic hot water systems) and **living conditions** (comfort temperatures in winter and summer and ventilation rates).	**Step 3.** Creation of alternative projects. System and occupation parameters are automatically assigned values according to their construction year (cadastre) and occupancy (census). The users change these parameters in order to simulate energy efficient improvements.
A.M3 – Determination of geometry of buildings and urban environment	These data were retrieved from Manresa GIS files and the 3D map	Geometry of the buildings and of the urban environment is automatically defined by the platform; retrieving information from the 3D map.

Activity	**Description**	**Related activity performed in this demonstration**
A.M4 – Determination of technical parameters of buildings	Technical parameters of buildings encompass U-values of enclosures and windows, percentage of windows in each enclosure, transmittances, solar absorption factor, among other. These values are assigned according to the age of the building, which is retrieved from the land registry.	**Step 3.** Creation of alternative projects. Building parameters are assigned default values according to their construction year and occupancy. The users change these parameters in order to simulate energy efficient improvements.
A.M8 – Determination of environmental characteristics of the urban environment	This category of data encompasses climatic and solar irradiance data, which are obtained from the Manresa weather station of the Catalan government	Environmental data is automatically assigned by the platform according to the location of the buildings.
A.M5 – Calculate the energy performance of buildings and urban area	To calculate the energy performance of the buildings (heating, cooling and DHW) by means of the Urban energy simulation tool	**Step 3.** Creation of alternative projects. The Urban energy simulation tool automatically calculates the energy performance of buildings after the user update the occupation, system, geometric and technical parameters.
A.M6 – Calculation of CO_2 emissions of buildings and urban area	To calculate the CO_2 emissions of the buildings and the urban area according to final energy uses. Energy demand of heating and cooling is obtained from the Urban energy simulation tool. Then, CO_2 emissions are calculated according to the energy carrier used and to the Spanish energy mix.	**Step 3.** Creation of alternative projects. The Urban energy simulation tool automatically calculates the energy performance of buildings after the user update the occupation, system, geometric and technical parameters.
A.M7 – Calculation of operational and maintenance costs	Based on the energy efficient improvements, the operational and maintenance costs are calculated	These cost have not been calculated. Instead, the Urban energy simulation tool calculates the cost related to energy uses (i.e. energy bill). Also, in this demonstration, the users added the indicator “investment cost” and value it according to their knowledge on the issue.

Appendix B. EVALUATION QUESTIONNAIRE FOR USERS

B.1. Questionnaire for users

1. Is the framework of Urban Energy Model easy to understand and implement?

   ☐ yes

   ☐ no, why not?

2. Which problems and/or obstacles did you find in the demonstration when defining UEM, Plans and Projects?
3. Do you find information provided by the platform relevant for energy efficient urban planning?

   ☐ yes

   ☐ no, Which information is missing?

4. Have you used (or tried to use) the module of data mining in the platform?

   ☐ Yes

   a. Which analysis did you perform? did you find it useful?
   b. Which data is missing?

   ☐ no

5. When you performed calculations of energy performance through the platform, have you found benchmarks or reference values against to which contrast the results?

   ☐ yes

   ☐ no, is this feature necessary?

6. Is the system able to visualize shadows? Is this visualization useful for a preliminary urban planning?
7. Are all relevant indicators included in the platform? (see the following table)

   ☐ yes

   ☐ no, which are missing? At which scales?

Dem. scenario	Indicator	Urban space category				
		Dwelling	Building	Neighbourhood	District	City
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				✓	
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		✓			

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.

8. Is it useful and relevant to have information differentiating by energy sources, energy carriers and final energy uses?

   ☐ yes

   ☐ no, why not?

9. Is it relevant to include indicators of social acceptance?

   ☐ Yes

   ☐ no, why not?

10. How would you include indicators of social acceptance in large projects?
11. Are the urban space categories included in the platform relevant for the analysis at different scales? (refer to question 1.1)

    ☐ yes

    ☐ no, which are missing?

12. Is it necessary to use a different land use classification than that based on administrative boundaries?

    ☐ Yes, which ones?

    ☐ no,

13. Have been you able to identify hot spots of energy performance based on visual inspection of results?

    ☐ yes

    ☐ no, why not?

14. Have been you able to identify hot spots of energy performance by means of browsing table of indicators?

☐ yes

☐ no, why not?

Appendix C. ADDITIONAL COMMENTS FROM USERS

C.1. Newcastle upon Tyne

C.1.1. General system performance and user interface

Speed of platform and user-friendly

- The requirement of Java as a pre requirement is frustrating, particularly if users don't have administrative permission rights over their computers. This is likely in local authorities, universities where IT permissions are restricted and controlled by a team of IT specialists.
- Some of the window panes are frustratingly small and the resolution makes the titles difficult to see. The SAP tool icon also needs a title as do some of the other pop up boxes.
- Window panes do not close properly.
- The tool logs the user off all of a sudden with no apparent reason. The same happens when shifting through panes.
- The performance indicators are useful but the 'scale' function is not intuitive. Some labelling of the scales would help improve this.

Plans and projects:

- It's very hard to identify where exactly you are when you're running the programme.
- When trying to compare different projects it is very easy to get lost between projects, especially when introducing editing and trying to show the final result.
- Has difficulty creating projects when I'm in the plan and also difficulties creating new plans.

C.1.2. Using tools, data and analysis

- Energy consumption and CO_2 emissions, remove the decimal places they aren't necessary. The ranges need to be round numbers, this would make the scales easier to understand.
- Some of the filters at the bottom of the page don't always work. The clear filters function doesn't work either.
- It is not clear what the units box does. At the moment it is not possible to switch between year and m^2/year.
- The user has found the information box that appears when clicking over a building very useful due to the detailed information displayed.
- Building use and hot water is misspelled. Energy data is missing units.

C.1.3. Suggestions for improvements

- It should be made possible to save and compare different projects and see the different effects on the same plan.
- An "export to Excel" function should be included, as well as the possibility of converting images to a jpeg file.

C.2. North Harbour

In general terms, the users consider that the performance of the platform is pretty slow and subject to sometimes freezing. Some of them experienced problems such as unexpected log-off with the consequence of losing all the work done so far. The zooming feature seems not to be working well and window panes don't close properly.

Regarding the structure of plans and projects, it has not been understood properly by users. For instance, some consider that it is difficult to "identify where exactly you are when you're running the programme".

It seems that users neither understand how the information on energy supply is used in the model nor the aggregation procedures. In fact, one of the users asks why the whole plan changes after changing the parameters of one building.

Regarding tools, users get confused about why to select tools before creating plans. This seems to reflect the fact that users don't understand well the approach of urban energy systems (i.e. Urban energy system, plans and projects).

In general terms, the users have answered that they have found easy to understand the Urban Energy Model framework. However, as mentioned in the previous section, there are some problems in differentiating plans and projects.

C.2.1. General system performance and user interface

Speed of platform and user-friendliness

- In general the loading times of the programme are unacceptably long, even with a broadband connection of 20 Mbit+.
- The window pane is very small and there doesn't seem to be any way of enlarging it. In the windows close/cancel is different. When zooming both the window and the page moves which is very frustrating.
- The zoom function seems to be confused and cannot tell if I zoom in the map or in the window despite keeping the cursor over the map all the time.
- When navigating between panes, I often get logged off, or I lose the work I'm working on. Is the programme supposed to work this way?
- Window panes do not close properly.
- Logs off all of a sudden with no apparent reason. The same happens when shifting through panes.
- It freezed several times.
- To suddenly have inactive buttons such as important ones like Plan and Project.
- When trying to compare different plans it shows a window where it is possible to choose a "new analysis", however when pressing it nothing happens and the program freezes.
- The performance indicators, at the bottom, are very "confusing".
- In windows and tools there is usually only a close and/or cancel button, the significance for the user is very different. I was thinking, am I opening something to view it or am I trying to change some of the content here? There is no way to be sure about this.

Plans and projects

- As I understand it, the Plan, is the baseline? And the project would be what we normally refer to as a plan/project. The definition of these and the name giving is not easily understood, if you're going to use terms that are not naturally used this way, it would be very beneficial to have a small definition of what is defined as a plan, and a project.
- It's very hard to identify where exactly you are when you're running the programme. An example would be an indication of whether you're in the planning or in the project phase. There is no visualization of it, perhaps it would help to have some sort of visual indicator.
- When trying to compare different projects it is very easy to get lost between projects, especially when introducing editing and trying to show the final result.
- Has difficulty creating projects when I'm in the plan and also difficulties creating new plans.

Calculations

- It is unclear how the energy supply should be used in the model, is every production and consumption produced on local building level, and then added up?
- When editing in a single building one would expect the changes to be for that building only in order to compare the intervention to the plan or, the selected project itself. It does not however seem to change the buildings energy production and consumption, etc. but it's changing the entire project. This won't work for planning specific projects.

C.2.2. Using tools, data and analysis

Summary of the evaluations relating to the use of tools, data and experiences with the analysis process in SEMANCO.

- Under tools there seems to be a category regarding regulatory framework? What is this? And should it refer to the local regulations, national law or what is the point of this. It's rather confusing.
- Names and methodology for the tools are very hard to comprehend. Is it always necessary to select the tools first before you create the plan? And is it the same for the projects, it would make more sense to load in your data and then get to play around with several tools, in order to find solutions, and identify projects.
- The building types such as Single-family_house seems to be used wrongly. I suggest a revision of the categories.
- Year of construction should be in intervals such as 1971 – 1975; 1976 – 1980
- The tables have too many characters. It is not necessary to have decimals. This is estimated, future consumptions and not exact number. The decimals are not useful but confusing.
- Urban Energy Model → Edit → reading the descriptions:
  "Estimated SAP" – what is that? Explanation, please.
- Additional issues
  - Energy data is missing units.
  - Building use is misspelled.
  - "Hotwater" is two words.
  - Some places the second word is with a capital letter, some places not: "Supply Technology" vs. "From age".
  - Indicator disappears in 3D view after recalculating.

C.2.3. Suggestions for improvements

- Out of curiosity, it would be very interesting to know how the data models for buildings can be loaded into the projects plans, and how this will function. When developing new areas hopefully there will be integration with other systems, such as excel, ACCESS or other database tools?
- It should be made possible to save and compare different projects and see the different effects on the same plan.
- An "export to Excel" function should be included.
- It would be useful to be able to see things like cost/m^2 for the different energy supplies.
- Consider if there should be an indicator in order to see which pane you're currently working in, since it's hard to navigate.
- It would be very beneficial if it was possible just to change the single buildings consumption (demand) and production and then update the project instead of having to upgrade the entire project.

- The supply side should be incorporated.

C.3. Manresa

C.3.1. General system performance and user interface

Speed of platform and user-friendly

- Sometimes users lose admin features without being logged out from the system, and have to log in again.
- Windows cannot be dragged across the screen.

C.3.2. Using tools, data and analysis

- Regarding multiple selection of buildings, users stated that it should be more user friendly. It should allow multiple selection not only by a cross-window.
- URSOS form. A reference is needed when dealing with wall parameters. The form is extremely technical. An urban planner is not an energy expert. There should be incorporated some help to define each value (explanations, reference values, etc.).
- When “save” the project, it remains the doubt whether the calculation is done?
- In the MCDa tool, when adding a new indicator, the “Max” box needs more explanation.
- When adding a user indicator, if you don’t click on “Add”, all values disappear when clicking elsewhere.
- The results of the MCDA tool are also confusing (the ranking coefficient, etc.) and a large discussion emerged from the results.

C.3.3. Suggestions for improvements

- Users requires the possibility to export the results of the evaluations and of the comparison (pdf report, excel, etc).