OptEEmAL

OPTIMISED ENERGY EFFICIENT DESIGN PLATFORM FOR REFURBISHMENT AT DISTRICT LEVEL

Optimised Energy Efficient Design Platform for Refurbishment at District Level
H2020-WORK PROGRAMME 2014-2015 – 5. Leadership in enabling and industrial technologies
H2020-EeB-05-2015: Innovative design tools for refurbishment at building and district level

D1.6: Output definition: information and documentation resulting from the design

WP1, Task 1.5

August 2017 (m24)

Deliverable version: D1.6, v1.0

Dissemination level: Public

Author(s): Maxime Pousse[1], Michele Garraffa[2], El Hassan Ridouane[2], Xabat Oregi[3], Gema Hernández Moral[4], Miguel García-Fuentes[4], Patricio Moreno Montero[5]

([1]NBK, [2]UTRC-I, [3]TEC, [4]CAR, [5]ACC)

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No 680676

Document History

Project Acronym	OptEEmAL		
Project Title	Optimised Energy Efficient Design Platform for Refurbishment at District Level		
Project Coordinator	Miguel Á. GARCÍA-FUENTES (miggar@cartif.es) Fundación CARTIF		
Project Duration	1st September 2015 – 28th February 2019 (42 Months)		
Deliverable No.	D1.6. Outputs definition: information and documentation resulting from the design		
Dissemination Level	PU		
Status		Working	
		Verified by other WPs	
		Final version	
Due date	31/08/2017		
Work Package	WP1 – Stakeholders' involvement through IPD design strategy and input data process		
Lead beneficiary	ACC		
Contributing beneficiary(ies)	ACC, CAR, TEC, NBK, FUNITEC, TUC, UTRC-I		
DoA	Task 1.5 – Definition of user interfaces: requirements definition and specification		

Date	Version	Author	Comment
19/09/2016	0.1	Patricio Moreno Montero (ACC)	Index and responsibilities division proposal
09/05/2017	0.2	Maxime Pousse (NBK)	Section 3
11/05/2017	0.3	El Hassan Ridouane (UTRC -I)	Section 5
01/06/2017	0.4	Patricio Moreno Montero (ACC)	Outputs extraction from survey
07/07/2017	0.5	All	Feedback to the list
10/07/2017	0.6	Xabat Oregi (TEC)	Section 4.2
18/07/2017	0.7	Gema Hernández Moral (CAR)	Section 6
10/08/2017	0.8	Patricio Moreno Montero (ACC)	Sections 1, 2, 7
21/08/2017	0.9	Maxime Pousse (NBK), Gema Hernández, Miguel García (CAR)	Review of contents and modifications
28/08/2017	1.0	Gema Hernández (CAR), El Hassan Ridouane (UTRC-I), Michele Garraffa (UTRC-I), Patricio Moreno (ACC)	Sections 4 and 5 update Formal parts of the document

29/08/2017	1.0	Patricio Moreno (ACC)	Final version for submission

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Abbreviations and Acronyms

Acronym	Description
OptEEmAL	Optimised Energy Efficient Design Platform for Refurbishment at District Level.
BIM	Building Information Modeling
CityGML	City Geography Markup Language: Open standardised data model and exchange format to store digital 3D models of cities and landscapes
DPI	District Performance Indicator
ECM	Energy Conservation Measure
GUI	Graphical User Interface
IPD	Integrated Project Delivery
UC	Use Case

Executive Summary

The OptEEmAL project will provide a platform for optimised energy efficient design of refurbishment projects at district level. Within the definition of the platform, a very important aspect is the definition of its outputs in the different stages. That is, to define what information is provided to the user in each case in order for them to understand the problem, interact with the platform and be able to make informed decisions based on the offered contrasted information.

At the end of the process the final goal of the platform is to have the material needed to start the implementation design and planning. This goal is the subject of the study made in this document, the output of the platform. Defining these outputs with an adequate level of detail will be the key for having the outcome the users will need to start the next stage, the design of the implementation.

To define these outputs, the followed is based on a survey to the stakeholders in which they expressed their concerns and interests. Then the information to elaborate a list of requirements that the output of the platform shall comply with was extracted. This information was completed by project partners with more detail, based on the possible outcomes that the platform can provide, having at the end of the process each of the outputs associated to the use case in which it is expected to be offered.

This document explicitly specifies the output the platform will provide, not only the results expected at the end, but also the outputs the user will need to use the platform in a meaningful manner. The document has been divided into five different parts; the high level description of the use of the platform and the methodology that has been followed, the stakeholders vision that will be the primal origin of information of this study, the IPD considerations for the output, the diagnosis of the current conditions, the study of the EE retrofitting scenarios and the final outcomes the platform will provide.

The result of the study is a list of requirements that the output should have along with a detailed description of the outputs the platform will deliver for starting the implementation phase of the project, the final goal of the platform.

1 Introduction

1.1 Purpose and target group

The main purpose of this document is to define the outputs that will be delivered by the OptEEmAL platform. These outputs will serve for developing the implementation design of the project so that they cover just the design of the solutions along with information on the benefits that could be obtained using the solutions that will be proposed. In order to make this design project, the user will have information at his hand coming not only from the automatic calculations performed in the platform, but also comments from the rest of the members of the team. This information will serve for having all possible information on the current situation of the district and also of the different alternatives the platform will propose to improve the energy efficiency of the district. These data will include information on energy performance, environmental performance, economic data, information on how the problem has been defined, list of best scenarios and particularities of each Energy Conservation Measure involved (name, short description, advantages, disadvantages…). Using this detailed information, the users can select the preferred scenario to have all the specifics of the design that will serve them for starting the implementation design of the solution. Since the platform will follow the Integrated Project Delivery paradigm, all the outputs of the platform shall be accessible to every stakeholder.

1.2 Contributions of partners

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

Table 1: Contribution of partners

Participant short name	Contributions
CAR	Overall and specific content to sections 4, 6
NBK	Overall and specific content to section 3
TEC	Specific content to section 4.2
UTRC-I	Overall and specific content to section 4, 5
ACC	Overall and specific content to sections 1, 2, 7

1.3 Relation to other activities in the project

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

Table 2: Relation to other activities in the project

Deliverable Number	Contributions
D1.5	Requirements and specification of Graphical User Interfaces (that will deliver the outputs).

D1.2	Requirements and specification of input data process to evaluate users objectives and current conditions.

2 High level platform use description and definition methodology

The OptEEmAL platform aims to provide a solution for technical users (architects, engineers, technical offices…) by offering software for the design of district retrofitting solutions, simulating and evaluating the different scenarios generated by the combination of Energy Conservation Measures (ECMs) in the district. The platform will follow three main steps, which cover the data insertion and diagnosis of current conditions, the generation and evaluation of retrofitting scenarios, and the exportation of the final outcomes. For these stages specific outcomes are to be provided to the platform users.

The definition of these outputs from the platform has been supported by the utilisation of use cases which served to set up, among other components, the graphical users interface (D1.5). The specification of those use cases not only included a brief description of the expected output, but also a diagram for each of them in which it is explicitly stated when outputs are provided.

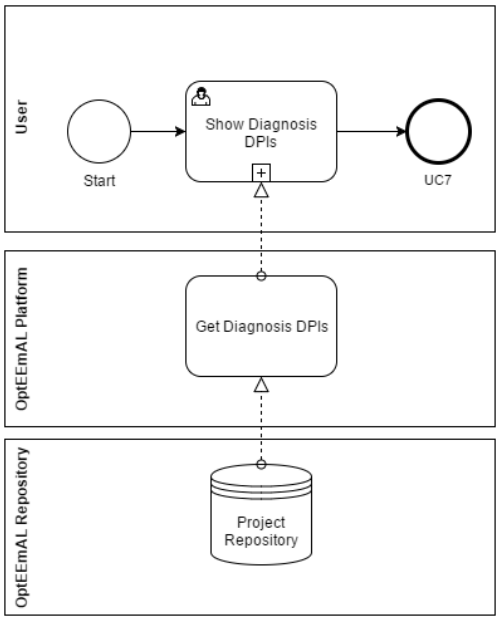

Figure 1: BPMN diagram example that illustrates a use case

As can be seen in the Figure 1, the outputs are represented with arrows that come from the row marked as “OptEEmAL platform” to the one marked as “User”. Taking this into account, the methodology that has been followed is depicted in Figure 2.

The process started with the interpretation of the survey summarized in section 3 focusing on the outcomes that the OptEEmAL users expect from the platform and also on the use cases description that was given in T1.4 (Definition of user interfaces: requirements definition and specification) that depicts the use that the platform will have. Once those inputs were established, the process is the following:

1. A list of specific outputs was made using the answers to the survey.
2. The UCs that could use the outputs defined in the previous step were identified.
3. Only for the final stage, the outputs were detailed, providing the values that will be included in each output (DPIs, guidelines, ECM data, etc.).

The final result of this process is a list with all the outputs whose relation with the use cases defines where the output will be used. In the most important subset of the outputs, the final output (section 6.2), the list is detailed by explicitly enumerating the values that will be included in the reports such as DPIs, guidelines, graphs, etc.

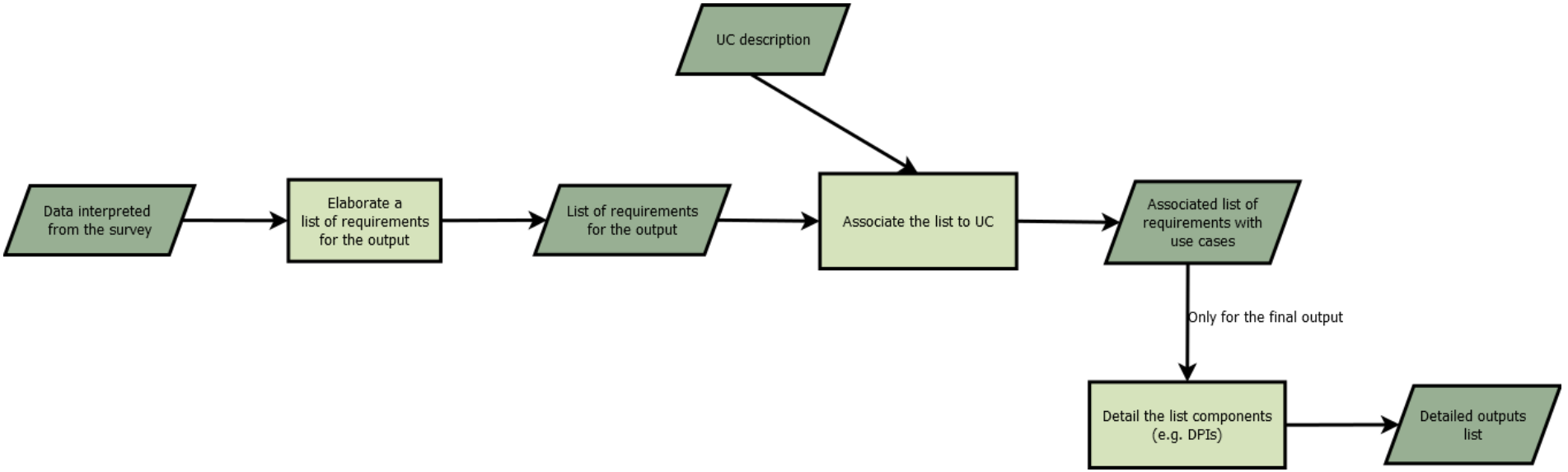

Figure 2: Flow diagram of the methodology for the output specification

3 Stakeholders' consideration in the process

As a first step in the definition of the OptEEmAL platform's outputs, the end-users of the platform were asked to identify the different outputs they would like to have after using the platform. This section describes the methodology implemented to gather their feedbacks as well as the results obtained from this exercise.

As a preamble, it shall be reminded that the work presented in this section is a complement to the already gathered feedbacks regarding the platform's outputs which were collected during a first round of questionnaire survey. This survey was performed in order to gather end users points of view regarding the general platform design. The main outcomes, in terms of platform's outputs, were:

- A BIM model is considered an adequate output
- Outputs of the platform in terms of financial aspects shall be precisely defined
    - A business plan indicating the cash flows and savings (including incentives, cost of energy services, payback time, etc.) year by year is usually used in the evaluation process of a retrofitting project.
    - The financial information shall be coupled to the energy information (also important in the evaluation process of a retrofitting project).

Also, it shall be noted that this work aims at defining in more details the outputs considering their previous definitions which were:

- A BIM model[1] containing the Energy Conservation Measures[2] (ECMs) that have been implemented at building level.
- A CityGML model[3] containing the ECMs that have been implemented at district level.
- A PDF report including the description of the project as inserted by the user, a complete list of selected ECMs with relative information and other complementary information.
- An XLS file containing the results, the District Performance Indicators[4] (DPI) calculation and a ranking of the best scenarios (highlighting the one selected by the user).

3.1 Methodology

In order to collect the feedbacks from the end-users, it was decided to set up a questionnaire survey. The questionnaire was elaborated by the OptEEmAL consortium members and then sent to the "targets" (the template of the final questionnaire is available in annex, see Annex 2: Detailed feedbacks). In this case, it was decided to target the potential future users of the platform in the three demo cases that will be used for validation activities. The questionnaire was elaborated in English and sent to the different contact points (members of the OptEEmAL consortium) for the different demo cases. Then, the questionnaire were sent to the targets by the contact points (when needed, a translation in national languages was performed). A 3 weeks period was let to the targeted persons in order to fulfil the questionnaire. After this period, questionnaires were collected by contact points and analysed. The analysis was done per profile of respondents (in agreement with the IPD profiles): Owner, Architects and Prime Designer.

[1] A BIM (Building Information Modelling) model is a digital representation of physical and functional characteristics of a building and a share knowledge resource for information about this building.

[2] Energy Conservation Measures (ECMs) are all measures that could be applied during the retrofitting of a building/district in order to reduce its energy consumption.

[3] A CityGML (City Geography Markup Language: Open standardised data model and exchange format to store digital 3D models of cities and landscapes) model is basically the equivalence of a BIM model at the urban scale.

[4] District Performance Indicators are the indicators that will be calculated by OptEEmAL (e.g. fossil energy consumption, GHG emissions, etc.)

Feedbacks and results obtained from this questionnaire survey are described in the next sub-section.

3.2 Results

Results of the questionnaire survey are presented in this section. First, details about the respondent profiles are provided in order to understand their feedbacks. Then, a synthesis of their feedbacks is provided (detailed results are provided in annex, see Annex 2: Detailed feedbacks).

3.2.1 Profile of the respondents

In total, the questionnaire was sent to 10 persons and all of them provide an answer. The role of the respondent in their organisation is described in the Figure 3 below. As mentioned in this figure, the distribution between the different roles is quite homogeneous. However, unfortunately, no prime constructor has been involved in this process, probably because the demo cases are in too early phases of implementation. As a consequence, their opinion is missing in this document and this shall be taken into account into the subsequent steps for the definition of the platform's outputs.

It shall be noted that more than the three roles mentioned in the first figure below have been faced in the raw answers provided by respondents. In order to ease the analysis, groupings have been made between different roles. This grouping can be consulted in annex (see Annex 2: Detailed feedbacks).

The country of the different respondents is mentioned in Figure 4 as it can also have an influence on the provided feedbacks.

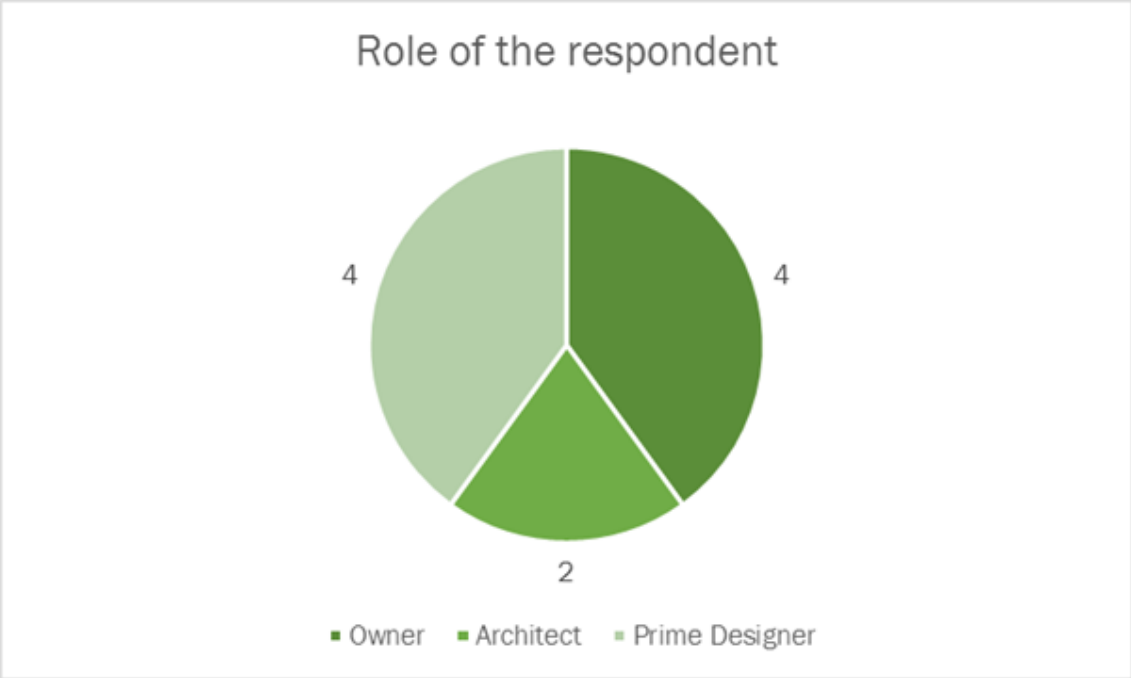

Figure 3: Distribution of the respondents according to their role

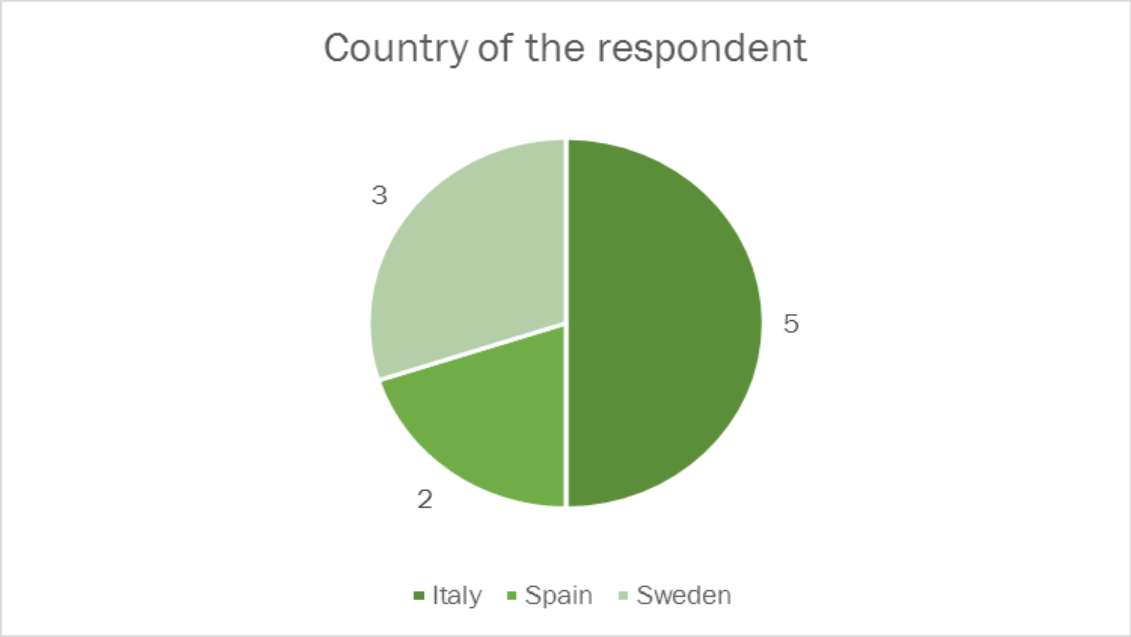

Figure 4: Distribution of the respondents according to their country of origin

3.2.2 Synthesis of feedbacks and recommendations

The questionnaire sent to responding organisations was divided into several sections (general questions, BIM and CityGML related questions, etc.). These sections are used in this document to present a synthesis of the feedbacks gathered. After each main feedback, a summary is provided.

3.2.2.1 General questions

Table 3: Summary of survey: Mandatory information as output of the design stage

Mandatory information as output of the design stage	
Synthesis of the feedback OWNER	Respondents highlight the importance of having a clear picture of the economic and energy aspects associated with the current baseline and the different envisaged scenarios. This is crucial to take informed decisions. To a lesser extent, user comfort and CO_2 emission reduction are also mentioned.
Synthesis of the feedback ARCHITECT	For architects, the platform should provide detailed information about the energy performance of the different scenarios (and the baseline). Metric estimate, Technical report appliances, Energy report are among the listed needed technical documents.
Synthesis of the feedback PRIME DESIGNER	Prime designers highlight their needs to have the energy savings and associated investments quantified and provided as outcomes of the platform. Other elements such as GWP reduction are also mentioned.
Summary	*Overall, it has been mentioned that the platform should provide (as mandatory information) the balance between energy reduction and investments. Other aspects have been mentioned (such as CO_2 emission reduction or user comfort) but this is of lower importance. Also, some technical information such as metric estimate, technical appliances report, etc. have been mentioned as a mandatory output of the design stage. Finally, the ability to see the difference between the current status and the different envisaged scenarios has been mentioned has important.*

Table 4: Summary of survey: Information lacking to have a fully informed decision making

Information lacking to have a fully informed decision making	
Synthesis of the feedback OWNER	Owners mention that they usually lack information about user comfort improvement and energy demand (performance and reduction) to have a fully informed decision making process.
Synthesis of the feedback ARCHITECT	Architects indicate that they lack an adequate technical report which allows understanding the calculations and associated results. In terms of outputs to the process, they often lack detailed technical information such as the one that can be provided into a BIM file.
Synthesis of the feedback PRIME DESIGNER	Prime designers mention that they usually lack the justification for a given option (in particular technical justification)
Summary	*It is difficult to summarise feedbacks to this question because the question has been understood in a different way by the participants. Overall, it seems that the information missing to take a fully informed decision regarding a given retrofitting option is user comfort improvement and energy demand reduction. The needed level of details is variable depending on the user (owners require less detailed information than architects of prime designers).*

Table 5: Summary of survey: Important data to compare different scenario possibilities

Important data to compare different scenario possibilities	
Synthesis of the feedback OWNER	Owners are mostly interested by the comparison between energy savings and economic investments (e.g. payback time). As a complement, owners mention users comfort or “easily to operate” systems as important aspects.
Synthesis of the feedback ARCHITECT	Architects also mention economic information as the most critical information (which should be provided together with the expected energy savings). Other aspects mentioned are: benefits from a comfort perspective, benefits in acknowledged certification systems (LEED, BREEAM…) and some complementary financial aspects such as capital gain.
Synthesis of the feedback PRIME DESIGNER	Prime designers mention time, cost, easiness of implementation and expected benefits as the most important data to compare different options. Limitations of the different strategies are also highlighted as an important data.
Summary	*Once again, it appears that the comparison between the expected energy savings and economic investments for a given option is the most important information to be provided. As a complement, other aspects are mentioned such as user comfort, ease of operation/implementation, limitations, etc.*

Table 6: Summary of survey: Use of the outputs (which occasion? what for?)

Use of the outputs (which occasion? what for?)	
Synthesis of the feedback OWNER	Owners indicate that outputs of the platform will be used in the decision making process to choose between different options in the design stage.
Synthesis of the feedback ARCHITECT	Architects mention that they will use the outputs of the platform to elaborate the “program document” in order to have a future integrated design.

Synthesis of the feedback PRIME DESIGNER	Prime designers will use the outputs to prioritize different retrofitting options and to plan a redevelopment integrating variable scales from building to district.
Summary	*Outputs of the platform will be used as support to the decision making process in the design stage of a retrofitting plan. They might also be included as supporting information to justify the choice for a given option in the "program document" of the retrofitting plan.*

3.2.2.2 BIM and CityGML related outputs

Table 7: Summary of survey: BIM and CityGML related outputs

Envisaged use of the BIM and CityGML files	
Synthesis of the feedback OWNER	Overall, owners are not familiar with BIM and CityGML files. They acknowledge that the updated BIM and CityGML files could be used to investigate other strategies but do not necessarily know how this could be done in practice. Other possible uses of the BIM/CityGML files include extraordinary maintenance planning and facility management optimisation.
Synthesis of the feedback ARCHITECT	Architects mention that the BIM and CityGML files will be used for two main purposes: 1) see what the area looks like in reality and adjust plan accordingly and 2) optimise the facility management (minimising maintenance cost and energy supply).
Synthesis of the feedback PRIME DESIGNER	Prime designers indicate that the files could be used to improve the accuracy of the evaluation and assess other strategies (for instance at district level).
Summary	*BIM and CityGML files are envisaged to be used in order to improve facility management (reduce maintenance and energy supply costs) but also to investigate other strategies that are not necessarily investigated in OptEEmAL. The ability to use these files is heterogeneous between respondents (especially owners are not familiar with these files).*

Table 8: Summary of survey: Compliances of BIM and CityGML files with existing software

Compliances of BIM and CityGML files with existing software	
Synthesis of the feedback OWNER	Owners do not consider the compliance mandatory because they do not precisely know what these files contained/can be used for and/or they are not using it. Only one owner (out of 4) indicates that this compliance is needed.
Synthesis of the feedback ARCHITECT	Architects do not agree on this point. One says this is not mandatory while the other mentions that this is mandatory (with REVIT).
Synthesis of the feedback PRIME DESIGNER	3 prime designers out of 4 mention the importance to have the BIM and CityGML files compliant with other existing software. This is especially important to use the information in existing Facility Management systems. Mentioned software are: Revit, Allplan, Termus, Primus (BIM) and Infraworks 360 or Civil 3d (CityGML). One prime designer mentions that this compliance is not mandatory.
Summary	*The compliance of the enhanced BIM and CityGML file appears necessary. Several existing software are mentioned as used in current practices.*

Table 9: Summary of survey: Ability to implement changes in a BIM model following some technical descriptions

Ability to implement changes in a BIM model following some technical descriptions	
Synthesis of the feedback OWNER	Owners mention that they are not able to implement changes in a BIM model because they do not use this type of files.
Synthesis of the feedback ARCHITECT	Architects indicate that they should be able to implement changes in a BIM model if the explanations are sufficiently detailed.
Synthesis of the feedback PRIME DESIGNER	Prime designers mention that they should be able to implement changes in a BIM model after a proper training.
Summary	*Users will be able to implement changes in a BIM model but the instructions shall be clear and training might be needed.*

Table 10: Summary of survey: Inclusion of energy systems and building materials in BIM and CityGML files

Inclusion of energy systems and building materials in BIM and CityGML files	
Synthesis of the feedback OWNER	Owners are not experts in BIM / CityGML files but consider the inclusion of energy systems and building materials important for more detailed models.
Synthesis of the feedback ARCHITECT	Architects mention that the inclusion of energy systems is mandatory in the BIM and CityGML files. The level of detail of this inclusion can be discussed.
Synthesis of the feedback PRIME DESIGNER	Overall, prime designers indicate that this information shall be included in the BIM and CityGML file. One of them also mentioned that this is not currently done in usual practices but this could represent a significant improvement to account for cost and maintenance.
Summary	*The inclusion of energy systems and building materials in the BIM and CityGML models appears necessary.*

3.2.2.3 Pdf and xls related outputs

Table 11: Summary of survey: Pdf and xls related outputs

Adequate scale of the information (building or district)	
Synthesis of the feedback OWNER	Both scales are interesting according to the aim of the retrofitting project. In any case, it seems important to provide information at the building scale.
Synthesis of the feedback ARCHITECT	Both scales are interesting according to the implemented strategy(ies). In any case, it seems important to provide information at the building scale.
Synthesis of the feedback PRIME DESIGNER	Very heterogeneous feedback has been provided by the prime designers on this question. No synthesis is provided (detailed answers can be consulted in annex).
Summary	*Both scales (district and building) are interesting from an end user perspective. In addition, the inclusion of information at building level is considered necessary.*

Table 12: Summary of survey: Presentation of the information / Presence of graphs

Presentation of the information / Presence of graphs	
Synthesis of the feedback OWNER	Owners mention that the information shall be presented in the most easily understandable way and that graphs could be helpful in this way (but they are not mandatory). Results of the calculations shall be presented in xls and drawing suggestions could be made in pdf.
Synthesis of the feedback ARCHITECT	Architects have different point of view regarding this point. One mention that graphs are easy to read and interesting to discuss with other stakeholders. The other one indicates that all the information shall be provided in Revit.
Synthesis of the feedback PRIME DESIGNER	Prime designers consider the presence of graphs mandatory as they can give an immediate and easy to read of the information. Detailed information could be provided in tables (or other means).
Summary	*It appears the necessity to have both clear and easy to read information but also access to, if needed, detailed information in the pdf and xls files. In this way, graphs and charts are considered interesting but detailed information (for instance in tables) is considered necessary.*

Table 13: Summary of survey: Most important criteria in the decision making process

Most important criteria in the decision making process	
Synthesis of the feedback OWNER	Owners highlight the economic criteria as the most important. Energy and environmental aspects are also mentioned as important.
Synthesis of the feedback ARCHITECT	Architects mention the economic and environmental criteria as the most important.
Synthesis of the feedback PRIME DESIGNER	Prime designers indicate the economic, energy and social criteria as the most important.
Summary	*As previously mentioned, economic and energy aspects shall be presented in details while more synthetic information could be provided for other criteria (environmental, social, urban, etc.). In terms of scope, it is highlighted that assessment shall take into account the whole life cycle of the intervention.*

Table 14: Summary of survey: Timescale of the information (annual or monthly average, hourly time series)

Timescale of the information (annual or monthly average, hourly time series)	
Synthesis of the feedback OWNER	The timescale of the information is dependent on the information itself. For energy aspects, monthly (or even hourly) information is considered adequate while economic information can be provided on a yearly basis.
Synthesis of the feedback ARCHITECT	Architects indicate that the assessment shall include hourly variations. However, for the presentation, monthly information for energy and yearly information for economy is considered adequate.
Synthesis of the feedback PRIME DESIGNER	Prime designers are interested in having annual or monthly results provided as outputs of the platform.

Summary	*Overall, it appears that results of the assessment shall be presented with different timescales. Energy related results shall be presented with a monthly perspective while other criteria (economic, environmental, etc.) can be provided at the yearly scale.*

Table 15: Summary of survey: Possibility to customise the pdf or xls files

Possibility to customise the pdf or xls files	
Synthesis of the feedback OWNER	Owners consider this possibility as important.
Synthesis of the feedback ARCHITECT	Architect considers this possibility as important/mandatory.
Synthesis of the feedback PRIME DESIGNER	Prime designers consider this possibility as important.
Summary	*The possibility to customise the pdf or xls files is an important feature for the respondents.*

Table 16: Summary of survey: Focus on define targets and boundaries or general information

Focus on define targets and boundaries or general information	
Synthesis of the feedback OWNER	Owners think that the information provided shall be primarily provided regarding their targets and boundaries but that general information is also interesting.
Synthesis of the feedback ARCHITECT	Overall, architects provide the same feedback than owners.
Synthesis of the feedback PRIME DESIGNER	Prime designers mention that both targets-related and general information shall be provided.
Summary	*Overall, it seems that targets and boundaries related information shall be provided first but general information shall also be made available.*

Table 17: Summary of survey: Content of the pdf file

Content of the pdf file	
Synthesis of the feedback OWNER	Owners indicate that both inputs and outputs shall be provided in the pdf file. They also considered the possibility to choose between a detailed report and a summarised report an interesting option.
Synthesis of the feedback ARCHITECT	Architects indicate that both inputs and outputs shall be provided. They also considered that all information shall be presented.
Synthesis of the feedback PRIME DESIGNER	In majority, prime designers consider that both inputs and outputs shall be provided in a detailed way.

Summary	*Overall, it seems that both inputs and outputs shall be provided in the pdf file in a detailed way. An interesting option mentioned here could be to choose between a detailed and a summarised report.*

Table 18: Summary of survey: content of the xls file

Content of the xls file	
Synthesis of the feedback OWNER	Owners indicate that both inputs and outputs shall be provided in the xls file. They also considered the possibility to choose between a detailed report and a summarised report an interesting option.
Synthesis of the feedback ARCHITECT	Architects mention that both inputs and outputs shall be provided. They also considered that all information shall be presented.
Synthesis of the feedback PRIME DESIGNER	Prime designers consider that both inputs and outputs shall be provided in the xls file in a detailed way.
Summary	*Overall, it seems that both inputs and outputs shall be provided in the pdf file in a detailed way. An interesting option mentioned here could be to choose between a detailed and a summarised report.*

3.3 Conclusions

Collected feedbacks have highlighted several aspects for the definition of the OptEEmAL platform outputs. These aspects are summarised below per section of the questionnaire.

For the **general aspects**, respondents highlight the importance to have a detailed justification of the selected option for the outputs to be useful in the decision making process. They also mention that in their current practices, they usually lack information about user comfort improvement and energy demand reduction for a given option. Those two points are expected to be solved by OptEEmAL. Other interesting information that they need and which are not necessarily available in their current practices is: ease of implementation of a given measure, CO_2 reduction for a given option, time to have the measure implemented, etc. For these elements, some of them are expected to be treated by OptEEmAL but others (e.g. time to have the measure implemented) are not expected to be treated. This is, from our perspective, of lower importance as it is considered as secondary aspects by the respondents. Overall, the outputs of the platform will be used in the decision making process and will be used as the basis for the elaboration of the "program" of the retrofitting plan. Thus, they shall contain easy to understand information (based on detailed information) easily usable in such documents.

Regarding the **BIM and CityGML files**, they are expected to be used to validate the overall design, to investigate other options which are not necessarily treated in OptEEmAL and also to make the link with Facility Management tools. As a consequence, their compliance with existing software appears highly necessary and several existing software have been mentioned as used in current practices. Another important aspect for the BIM and CityGML (mostly the BIM file) is the inclusion of energy systems and building materials which appears as mandatory according to the respondents. As already mentioned, this could be of particular interest to make the link with Facility Management tools. Regarding this inclusion, in the case the automatic inclusion of these elements in the BIM file is not possible in the platform; end users (at least the more technical of them) are capable of including it even though it might require a proper training and an easy access to all the necessary information.

Regarding the **pdf and xls files**, it has been indicated that the focus shall be primarily done on the economic and energy aspects as they are the ones of critical importance for the respondents. Gathered feedbacks also indicate that different level of details shall be provided in the outputs. First, global results shall be provided in order to give the main information about the envisaged retrofitting scenario and how it performs in comparison to the baseline. For this purpose, graphs are preferred as they are easier to understand. Then, detailed information is also expected in order to fully understand a given option. This detailed information is particularly expected from more technical users (architects & prime designers). It shall also be noted that this difference between technical and other users can be handled through the different profiles that will be used in the OptEEmAL platform. Also, it has been mentioned that global information at the district scale is expected as a first step but that building level information is also expected. In practice, one option to fulfil all these requirements could be to have on one side a global report at the district level including graphs with the main results and on another side a detailed technical report with all the data included in tables. According to the profile of the user in the platform, those reports can be made available or not. In all cases, end users expect both inputs and outputs to be provided in the pdf and xls files.

Finally, in terms of methodology, it shall be mentioned that the establishment of physical working sessions with the respondents could be of particular interest in order to clarify the questions to the respondents. This would allow the collection of more precise and relevant feedbacks.

3.4 IPD considerations in each output phase

In an IPD approach it is intended to put the highest amount of effort in the design phases with the goal in mind of reducing the need for modifications in the implementation phase (when it is more expensive). This concept also applies to the implementation documentation. The effort of elaborating the implementation documentation has to be less than in a traditional approach due to the participation of the constructor from the beginning in the design process.

The figure below shows the comparison of the traditional design process versus an integrated design process, which shows when each stakeholder is included within the stages.

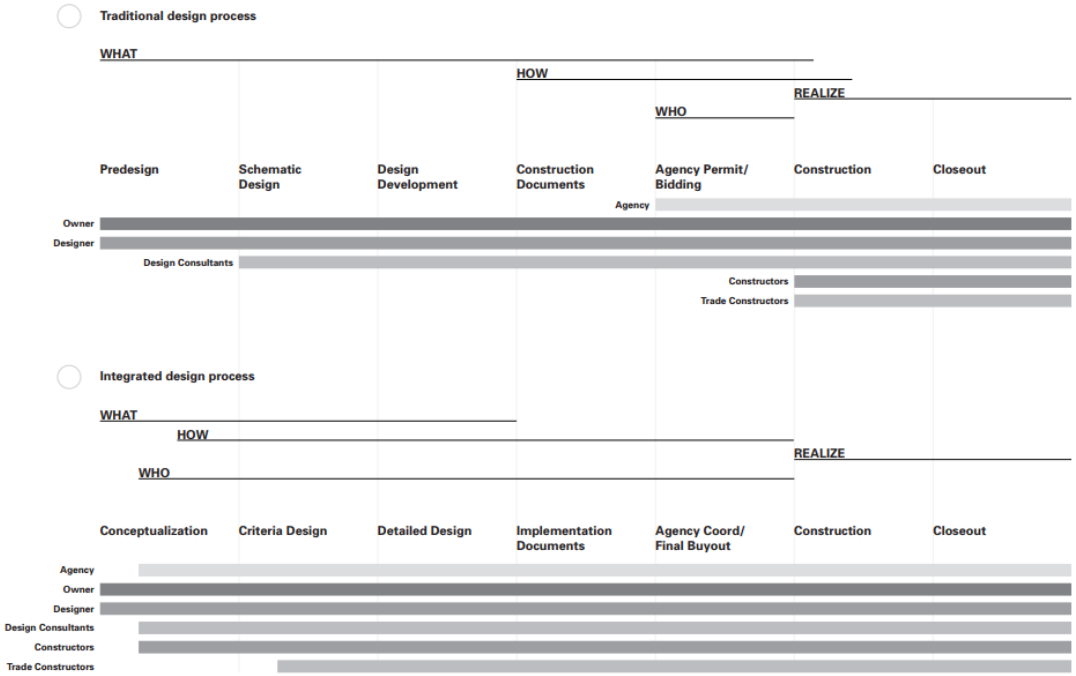

Figure 5: *Different* stages in a construction project using a traditional or an IPD approach (IPD Guide by AIA)

An "Integrated Project Delivery" approach has been followed in order to design the OptEEmAL platform and, therefore, to define its outcomes. In order to ensure the implementation of this IPD approach, it has to be ensured that it follows an "Integrated" process, not "differentiated". This concept is not only related to the outcome but also to the method that has to be followed for putting together all the information, it has to be provided in a holistic manner for being integrated. In a traditional approach, the outcome is well differentiated among the different roles but in an "integrated" one, such as the "Integrated Project Delivery" the information has to be reachable for every stakeholder in order to guarantee that:

"[…] *Integrated practice is a holistic approach to building in which all project stakeholders and participants work in highly collaborative relationships throughout the complete facility life cycle to achieve effective and efficient buildings. […]*" ([02]).

It is possible to compare how the information has to be distributed using a traditional or an IPD approach as it is done in Figure 6.

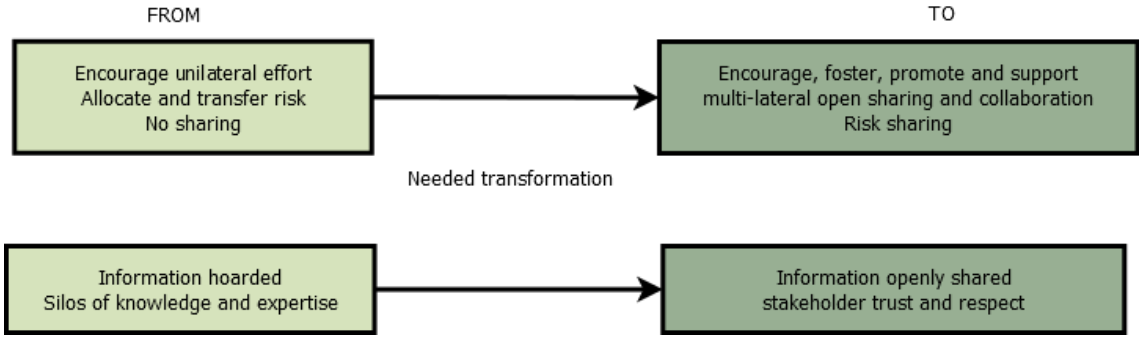

Figure 6: Comparison between the traditional and the IPD approach outcome.

How the information is shared in the traditional approach is determined by the allocation and transference of risk between the stakeholders. The attitude in a traditional approach tends to be the "hunkering down" one ([01]). This is clearly opposed to what it is needed for making a successful IPD approach. In this approach, the risks are shared and thus, it is in the interest of everyone to be sure that everyone is having the same vision of the project.

For having the information related to a building centralized and accessible to everyone, the logical method is the use of BIM (Building Information modelling). Specifically, in the specification of the IPD approach ([01]) it is said that:

"[…]Because BIM can combine, among other things, the design fabrication information , erection instructions, and project management logistics in one database, it provides a platform for collaboration throughout the project's design and construction.[…] BIM is a tool, not a project delivery method, but IPD process methods work hand in hand with BIM and leverage the tool's capabilities[…]".

It is therefore desirable that all the information that could be included into a BIM structure does so.

It is a common practice to have different models for different purposes developed by each expert stakeholder. This practice is due to the fact that nowadays the BIM technology is an evolving technology that is not being used consistently in the industry. For having an integrated outcome the platform might use one single model for everyone which will foster the integration of all the information as well as it will simplify the decision making processes that involve different aspects of the design project.

The following subsections describe the considerations that have been followed within the different stages to ensure the Integrated Project Delivery approach within the stakeholders' interaction with the OptEEmAL platform.

3.4.1 Diagnosis of current conditions

The diagnosis of current conditions phase aims at analysing the current conditions of the district based on evaluating a set of indicators and on defining the boundary conditions affecting the design of the retrofitting process.

In a traditional approach, the diagnosis is performed when the project is being predesigned. It is not expected any participation more than the willingness of the owner for defining the problem that is going to be tackled and the designer ability for anticipating and understanding the requirements coming from the owner desires. But in the IPD approach:

"[…] the Owner is required to participate in establishing project metrics at an earlier stage than is typical in a traditional project. […]" ([01]).

From the previous statement it can be derived that the role the owner has to play is much more intense than in the traditional approach, not only in defining with accuracy what he wants but also because the process must integrate the insights of the designer and the constructor that could advice the owner about the feasibility of the goals the owner wants from the platform. The owner will have to understand what the constructor and the designer are advising him and that fact will increase the effort required from the owner. In the diagnosis of the current conditions, the IPD team has to encourage the precise description of the district, not only regarding their personal field of expertise but also considering every aspect that could affect to the diagnosis of the district.

3.4.2 EE district retrofitting scenarios

With the previous statement in mind, one logical conclusion is that the owner will have to decide the kind of project that will be implemented, but the IPD approach encourages taking into account every perspective in the decisions:

To be able to make the best possible decision following the IPD approach, the users shall have the same amount of information so that every stakeholder would have not only to consider the aspects that are customary to their role but also those that are associated to the other roles. This would make the definition of the outputs needed for selecting the best option more difficult but it will provide a holistic perspective that would reduce costs and time. Everyone must have voice in the decision process but having in mind the goal of reaching a consensus which is more easily obtained if:

"[…] However, decisions need to be made on a micro, as well as a macro, level. For that reason, the project protocols determine areas of responsibility for decision making. For example, structural integrity remains the structural engineer's province and while other parties may recommend, the structural engineer decides whether a proposed modification is acceptable. Collaboration needs flexibility, but it also needs structure.[…]" ([01]).

It is possible to deduce from the previous cite that it is needed a protocol for making the decisions and that protocol has to be flexible enough to take into account every perspective. The output for being able to understand the problem has to cover as many aspects of the problem and the solution as possible in order to have every perspective into account as well as for helping everyone to participate actively in the decision making process. As it was stated in the GUI definition, the decision making process is designed for taking into account every perspective. The ideal situation is to reach a consensus for deciding the best solution. In case this consensus cannot be reached, the ultimate decision will correspond to the owner as it is explicitly stated in the IPD Guide [01]:

"[…] Although the team may present alternatives and counsel the owner, goals remain the owner's province. The owner determines its program and what it wants to achieve. However, standards based upon goals and used to judge project success and compensation are jointly agreed upon. It's necessary for all parties to be comfortable with the agreed-upon anticipated outcomes, as they may affect potential bonus and compensation structures. […]" [01]

3.4.3 Final scenario

In the final stage of the use of the platform, the documents and models needed for starting the implementation stage are delivered to the users.

It should be taken into account that the delivery has to be “integrated” (Integrated Project Delivery) which means that every aspect should be present in the models and reports following a holistic perspective. This means not dividing the information into silos of expertise but to promote to openly share all the information in order to make an integrated design using central repositories of information. The trend of the technology is to foster this centralized way of working like can be seen in the current BIM software.

It is mandatory to make possible to every user of the platform to get all the information that the platform is capable to provide. The desirable holistic nature of the outcome of the platform will be fostered this way, but also by integrating all the information into a single model when possible.

4 Diagnosis of current conditions

4.1 Specific considerations for the output

As it has been explained in section 2, the Diagnosis of current conditions corresponds to the first stage of the platform, which is described in the image below.

First of all, the input data phase is performed by the user: data related to the project, identification of the team, buildings, district, energy systems, contextual data, etc., which should be checked and stored into the corresponding repository (City, BIM, Context or Project repository).

Once all those data are introduced it is possible to launch the generation of simulation models and perform the assessment of the baseline scenario through a set of 42 District Performance Indicators (DPIs) in the Simulation Module, which will be the most important output of this phase and will be stored in the Project Repository for further usage. These will be shown to the user to be deployed as a reference when configuring the problem to be solved in the platform. To do so, they will be asked as series of questions and introduction of values to define targets, boundaries and barriers, both related to District Performance Indicators and Energy Conservation Measures (ECMs), as well as Prioritisation Criteria, which will set the weights of the DPIs in the optimisation process.

In the image below the first phase of the platform is explained, which covers from the first point of data introduction into the platform to the storage of baseline DPIs in the Project Repository.

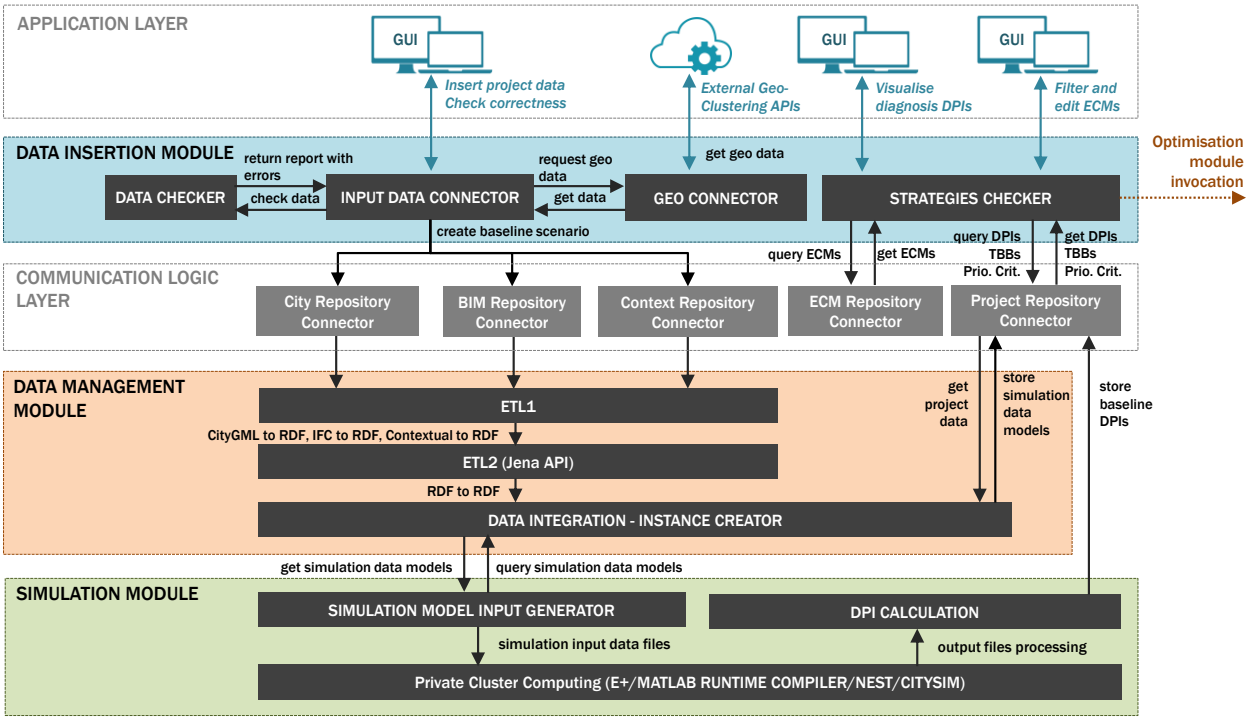

Figure 7: Diagnosis of current conditions process

Therefore, as a user, the main output to be obtained at this stage will be presented at two stages, as it is shown in the image below, which depicts the problem definition in the OptEEmAL platform and the use cases associated with it.

In the preliminary phase (1) represented by UC6 “Show DPIs”, the calculations have already been launched and the results of the DPIs shown to the user. The main objective is to provide the user with enough information to precisely depict the performance of the current conditions of the district, since they will have to base their criteria on these results to define the problem in the platform, that is, on the one side defining barriers related to ECMs and checking the strategies (process 1) and on the other side, defining boundaries and prioritisation criteria (process 2). At this phase they will be

also enabled to select the DPIs of interest to them, which will be used in process 2 shown in the figure below.

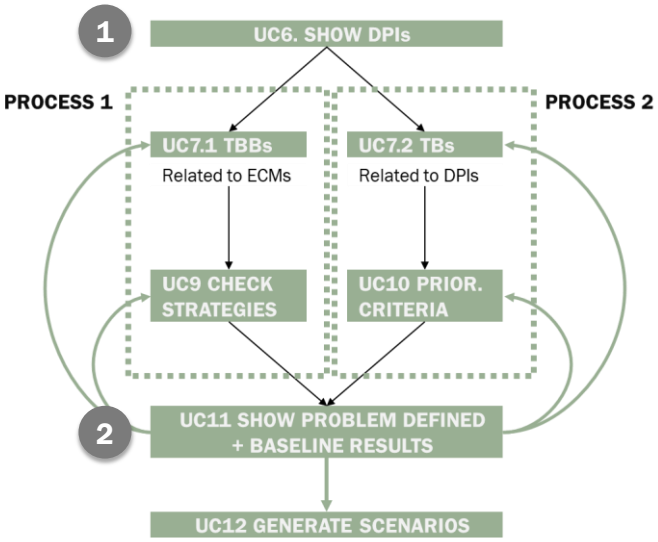

Figure 8: Problem definition process in Diagnosis of Current Conditions Phase

Afterwards, the user will follow both processes 1 and 2 and will define the problem inside the platform. Then, the tool will provide all users with a summary of the information introduced in the latter phase (2) that corresponds to UC11 “Show problem defined and baseline results”. In this phase, in addition to the results of the assessment provided by the simulation module, the user will also be able to see how he has defined the problem both in terms of the optimisation and the application of possible Energy Conservation Measures. If some part of this configuration does not comply with the expectations of a user, it will be possible to comment and edit the data introduced (see arrows in above image).

Therefore, the information to be presented to the user in the Diagnosis of Current Conditions will be:

- Baseline scenario results – represented by DPIs
- Problem definition data – configuration of the problem performed by the user

The expectation from the user is then to analyse the output in the two sub-phases mentioned above and, depending on their role specified in the IPD agreement/guide be (1) informed about the current conditions (in case of UC6) or (2) comment and make suggestions (in the case of UC11) on the configuration data introduced into the platform. This decision varies, as follows, from one IPD actor to another, as it can be seen below:

- The **Owner**: this actor will have a very relevant role in this step, since they will be able to establish together with the other stakeholders the main objectives to be achieved after the analysis of the current conditions, where they will be advised by the other stakeholders with a more technical background, who can better evaluate the performance of the current scenarios.
- The **Prime Designer**: their main contribution to this phase is analysing the results of the current scenario and providing comments and suggestions both to the prime constructor and to the owner in order to adequately set the objectives to be achieved.
- The **Prime Constructor**: this actor will provide his technical knowledge on possible technologies to be included and will aid the prime designer and the owner mainly in checking the strategies to be applied in the district.

4.2 Contents of diagnosis output

In this section it will be specified the requirements the output will have for the user to have the most accurate model of the district possible, including its indicators but also the geometrical disposition of the elements, the functionality of the buildings and all the information the rest of the users have introduced into the system for describing the district and its behaviour.

As in the rest of the stages considered, the methodology has started from the results of the survey made to the stakeholders, it was followed by an extraction of the information from the responses that is related to the diagnosis of the district and then it was formalized as a list of requirements that the output should comply with in the diagnosis phase.

The information has been organized as follows:

- A column called "Stakeholder requirement" that synthetizes the stakeholder desire expressed in the survey.
- A column named "Object to comply with the requirement" that describes an example of an object that could be used to satisfy the requirement.
- Other called "Stakeholder origin of the requirement" which expresses the role of the source of the requirement.
- Use Cases. In this column it will be specified the use cases in which the output could be given by the platform.

The table in which all this information is gathered is the following:

Table 19: Requirements for output specification in the Diagnosis Output

Stakeholder requirement (from survey)	Object to comply with the requirement	Stakeholder origin of the requirement	Use Cases
Presentation of the result at least with monthly variations for the energy and yearly variations for the economic information are adequate.	Report that includes all the DPIs related to energy with a monthly segmentation and those economic with a yearly segmentation	OWNER PRIME DESIGNER PRIME CONSTRUCTOR	UC6, UC11
3D Graphic representation of the current state of the district based on the values obtained in the consumption, CO_2 emissions, etc.	This graphic representation could be coded according to a colour scale which will make easy to distinguish among the best and worst performing buildings in the district. The value to be coded according to the scale could be selected by the user (energy consumption, CO2 emissions, etc.)	OWNER PRIME DESIGNER PRIME CONSTRUCTOR	UC11
Detailed information about the energy performance of the baseline.	Detailed information about the energy performance of the baseline.	PRIME DESIGNER	UC6, UC11
Clear information about the legal boundaries of the scenario	Report that includes the boundaries related to the legislation.	PRIME CONSTRUCTOR	UC11
It is needed a clear picture of the following parameters of the	The platform has to provide, related to the baseline: the DPIs related to economic and	OWNER	UC6, UC11

baseline scenario: economic and energy indicators CO2 emissions User comfort	energy aspects the CO2 emissions of the components indicators that express the user comfort in a quantifiable manner		
All the information has to be written in some way in the pdfs and excel files, both of them have to be customizable	Reports have to be able to contain all the information (DPIs, targets, boundaries…) and they have to be customizable too.	OWNER PRIME DESIGNER PRIME CONSTRUCTOR	UC11
The possibility of choosing between a detailed and a summarized report should be available to the user.	The platform has to give the chance for having a summarized report or a complete one	OWNER PRIME DESIGNER PRIME CONSTRUCTOR	UC11
Configuration of the problem	The user should be presented with the criteria they have introduced into the platform that has led to the results obtained in the optimisation process.	OWNER PRIME DESIGNER PRIME CONSTRUCTOR	UC16, UC20, UC11

In the following sub-sections the different outputs reflected in the table are defined in more detail. The classification deployed corresponds to what can be provided by the platform at this stage, namely:

- Problem definition data: every configuration made by the user which will affect the final result obtained in the platform
- Baseline scenario results: which measure the performance of the current scenario

4.2.1 Problem definition data

Before running the optimisation phase, the user has to define the problem to be solved in the platform by setting some prioritization criteria, targets and boundaries in order to guide the optimizer towards the most suitable scenarios with respect to the general objectives of the design.

This problem definition data is related, as explained in section 4.1 to Energy Conservation Measures (described in UC7.1 (insertTBBsECM) and UC9 (CheckStrategy)) and to District Performance Indicators (described in UC7.2 (insertTBBsDPIs) and UC10 (insertCriteria)) (see D1.5 for more information). Both categories are explained in more detail in the following subsections.

4.2.1.1 Problem definition data related to ECMs

In the OptEEmAL platform the user will be able to define their problem based on Energy Conservation Measures, by filtering the ones that can be applied (UC7.1 insertTBBsECM) or directly discarding the ones that are not in line with their objectives (UC7.2 insertTBBsDPIs).

To do so, the user will go through two stages in the platform. The first one corresponds to UC7.1 (insert TBBsECM), where they will have to answer certain questions that are linked to the application of certain ECMs. By answering these questions the user will be filtering the complete list of Energy Conservation Measures to finally obtain the applicable matrix of ECMs (1) which reflects the ones that can be applied. Some examples of the type of questions the user will have to answer are the following:

- Do you / can you modify your façades?
    - Can they be refurbished internally?

- Can they be refurbished externally?
- Can you apply external roof insulation?
- Do you want to consider the implementation of renewable sources?

After having completed this step the user will be presented with the list of filtered Energy Conservation Measures and will be enabled to check more information on each ECM (technical data, energy data, environmental data, economic data etc) in order to decide if they want to discard specific Energy Conservation Measures or consider them in the optimisation process. At the end of this process the applicable matrix (1) obtained in the previous process will be refined and the applicable matrix (2) will be configured. This last one represents the ECMs that are applicable in the district and, thus, are going to be considered in the optimisation process, and that have been revised by the user. Both of them will be presented to the user at each of the steps.

For more information on these two processes please refer to deliverable D4.2.

4.2.1.2 Problem definition data related to DPIs

In order to complete the problem definition data the user will have to define their preferences with respect to District Performance Indicators. The problem setting in this case and to this regard is also divided into two different sections: described in UC7.2 (insertTBBsDPIs), where the user will be asked to introduce some values to some questions (boundaries), and UC10 (insertCriteria), where they will be able to define prioritisation criteria, which will be explained later in this section.

In UC7.2 insertTBBsDPIs the user will be presented with the possibility to answer some questions related to District Performance Indicators, namely:

- What are the maximum values you want to consider for these topics?:
  Here three values should be mandatorily provided by the user, which can be seen in the figure below:

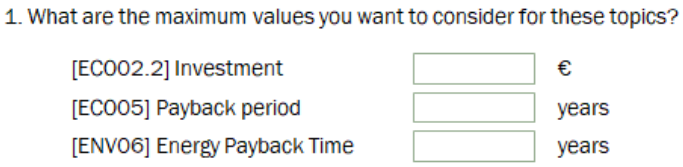

Figure 9: Boundaries definition: step 1

- Are there values that you would not like to surpass?:
  Under this question the user can decide if they want to introduce a maximum and a minimum value for each District Performance Indicator. An example can be seen in the figure below:

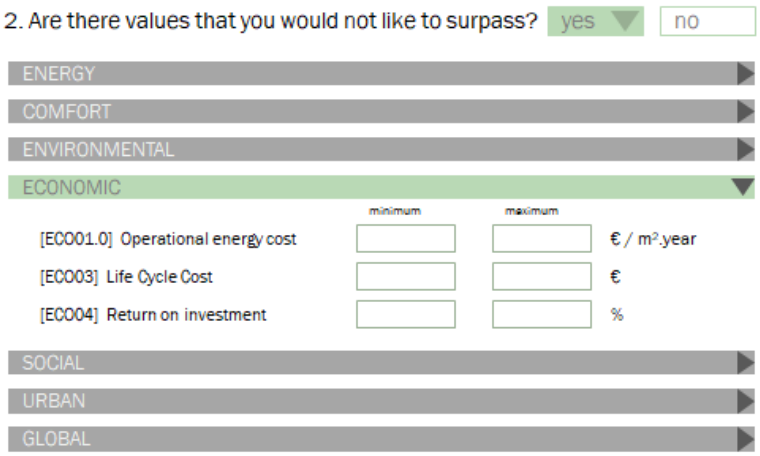

Figure 10: Boundaries definition: step 2

- Are there targets that you would like to achieve?:
  Similarly to the previous question, the user will be able to define targets, that is, values to be achieved of each DPI of interest in the platform, as it can be seen in the figure below:

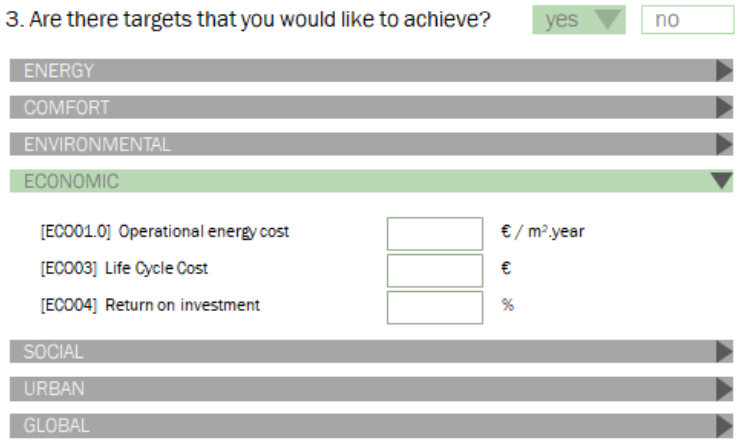

Figure 11: Boundaries definition: step 3

The following example is related to the defined boundaries and targets applied to ENE01, COM02, ENV01 and ECO04. The idea is to show the structure of the data presented to the user in this context (see Table 20).

Table 20: Example of boundaries and targets related to DPIs

DPI Name	DPI description	Boundaries	Targets
ENE01: Energy Demand	Total energy required in order to maintain predefined conditions to all of the conditioned building spaces	Maximum: <null> Minimum: <null>	70 kWh/m_2
COM02: Local Temperature Deviation from Set-Point	Quantifies the thermal comfort calculating the average deviation between the desired temperature and the measured value	Maximum: 30% Minimum: 10%	20%
ENV01: Global Warming Potential (GWP)	Estimation of the total CO_2 equivalent emissions due to energy consumption	Maximum: 50 kg CO2eq /M2 · year Minimum: <null>	63 kg CO_2 eq/m_2/year
ECO04: Return on investment	Clear gain in monetary units associated with a particular refurbishment scenario	Maximum: <null> Minimum: <null>	35%

In UC10 insertCriteria prioritization criteria will be defined. These are weights assigned to a list of 18 selected District Performance Indicators, which will be used in the optimisation process with the aim to find the most suitable scenarios according to different types of expectations.

The DPI categories used for the definition of the prioritization criteria are described in D4.2. They define all the important aspects for the scenario comparison. The following table enumerates all these categories and includes the number of DPIs under each category.

Table 21: DPIs taxonomy

Category name	Number of DPIs	DPIs code
Energy	19	ENE01, … , ENE19

Comfort	5	COM01, … , COM05
Environmental	6	ENV01, … , ENV06
Economic	6	ECO01, … , ECO06
Social	1	SOC01
Urban	4	URB01, … , URB04
Global	2	GLO01, GLO02

The definition of the prioritization criteria can satisfy the user need to see the trade-off between conflicting objectives, which fully describes the different weak and strong points of each scenario. Furthermore, they allow showing some general information for the analysis of each case, which are quite unrelated with other aspects.

Some predefined prioritization criteria can be immediately selected by the user. They try to satisfy the most common user expectations on the platform: the pre-defined weighing schemes. Here follows two examples, where two predefined prioritization criteria are described. Each case is described by a set of DPIs, identified by their code, name, and a weight coefficient between 0 and 1, representing the DPI importance in the global objective. In Table 3, a predefined prioritization criterion formed by the 18 DPIs is shown. It is divided into three sections, which correspond to the three different matrixes deployed in the evaluator component (refer to D4.2 for more information). In the table below an example of pre-defined weighting scheme is presented, which corresponds to Scheme 1: Priority to achieve a nearly Zero Energy District, which focuses on the main indicators that define what a nearly Zero Energy District is: have a very high energy performance, the energy required should be covered to a significant extend by energy from renewables, importance of considering primary energy consumption and primary energy use.

Table 22: Example of a predefined weighting scheme: Scheme 1 – Priority to achieve a nearly Zero Energy District

DPI code	DPI name	Weight
ENV01	Global warming potential	0.1592
ENV04	Primary energy consumption	0.6064
ENV06	Energy payback time	0.0586
ECO02	Investments	0.0586
ECO03	Life cycle cost	0.0586
ECO05	Payback period	0.0586
DPI code	**DPI name**	**Weight**
ENE01	Energy demand	0.1979
ENE02	Final energy consumption	0.3452
ENE06	Net fossil energy consumed	0.1979

ENE09	Energy demand covered by renewable resources	0.1979
ENE13	Energy use from district heating	0.0305
COM01	Local thermal comfort	0.0305
DPI code	**DPI name**	**Weight**
ENE14	Energy use from Biomass	0.1667
ENE15	Energy use from PV	0.1667
ENE16	Energy use from Solar Thermal	0.1667
ENE17	Energy use from Hydraulic	0.1667
ENE18	Energy use from Mini-Eolic	0.1667
ENE19	Energy use from Geothermal	0.1667

Apart from enabling the user to select a pre-defined weighting scheme, the platform will provide the possibility to define them by performing a pairwise comparison among all of the DPIs of each of the three sections defined above. For instance: how important is “Energy demand” in comparison to the “Net fossil energy consumed”. Or how important is “Life cycle cost” in comparison to the “Energy payback time”.

Either way, the user will be presented in the end with the list of the 18 DPIs defined above with their corresponding weight to be used in the optimisation process, together with the description of what each DPI mean.

5 EE district retrofitting scenarios

The optimization module uses the diagnosis of current conditions as a baseline for generation and evaluation of alternative retrofit scenarios. Each scenario is a combination of selected ECMs that are applicable for the district under study. This section is introduced to guide the user's interactions with the OptEEmAL platform following the optimization process. Sub-section 5.1 briefly explains the optimization process and how the platform arrives at the EE district retrofit scenarios then sets the expectations from the user when interacting with the platform to select the best scenario from a short list of best scenarios. Sub-section 5.2 defines the content to be shown to user to guide the selection process. Each scenario will be presented to the user in terms of DPIs and their scores as well as details of ECMs that make the scenario. This information will be presented in a format that helps the user to choose the optimal scenario to be exported as final output of the platform.

5.1 Specific considerations for the description of the retrofitting scenarios

Following the optimization process, the OptEEmAL platform will provide the user with a set of best retrofit scenarios referred to as "EE district retrofit scenarios", which are compliant with the user objectives. The EE retrofit scenarios are the outcome of the evaluation/optimization stage, which considers all applicable scenarios that satisfy project targets, barriers and boundaries. Each of the applicable scenarios is modelled and evaluated using a set of District Performance Indicators (DPIs). UC16 (selectOptimalScenario) describes the workflow and UI processes for the platform interaction with the user (see D1.5 for more details). This sub-section describes **how the platform arrives** to EE district retrofit scenarios and the **expectations** from the users.

The platform process for retrofit scenario generation and evaluation is illustrated in Figure 12. Scenarios are generated within the optimisation module as combinations of applicable ECMs then modelled and simulated within the simulation module. The output of the simulations is used to calculate DPIs for the scenarios, which are communicated to the evaluator within the optimisation module. This process is repeated for all possible scenarios and the optimisation module decides on the best scenarios using rankings performed by the evaluator.

The optimisation module takes as input targets, diagnosis DPIs, boundaries and barriers, applicable ECMs, and prioritization criteria. The Simulation module is in charge of generating the corresponding input data files of the simulation tools and to supervise the calculation processes. This module integrates existing simulation tools as well as simplified calculation methodologies to calculate all needed indicators to perform a consistent evaluation of retrofitting scenarios. The output of the optimisation module is communicated to the user and contains all the necessary information required for selection of the optimal scenario. The user will be presented by:

- **Problem definition** data:
  - List of prioritization criteria, targets and boundaries
- Results of **optimization process**:
  - List of best scenarios ordered following the prioritization criteria
  - Scenario details related to DPIs: and their diagnosis DPIs scores for comparison and easy visualization of improvements. Scenario details will also have information about the ECMs included in the scenario such as name, short description, advantages and disadvantages
  - Scenario details related to ECMs: and how they are applied to each building typology and to the district in case of district level ECMs. This matrix will also show Level 5 for each ECM (e.g. boiler replacement with a 49kW condensing fuel type: natural gas boiler)

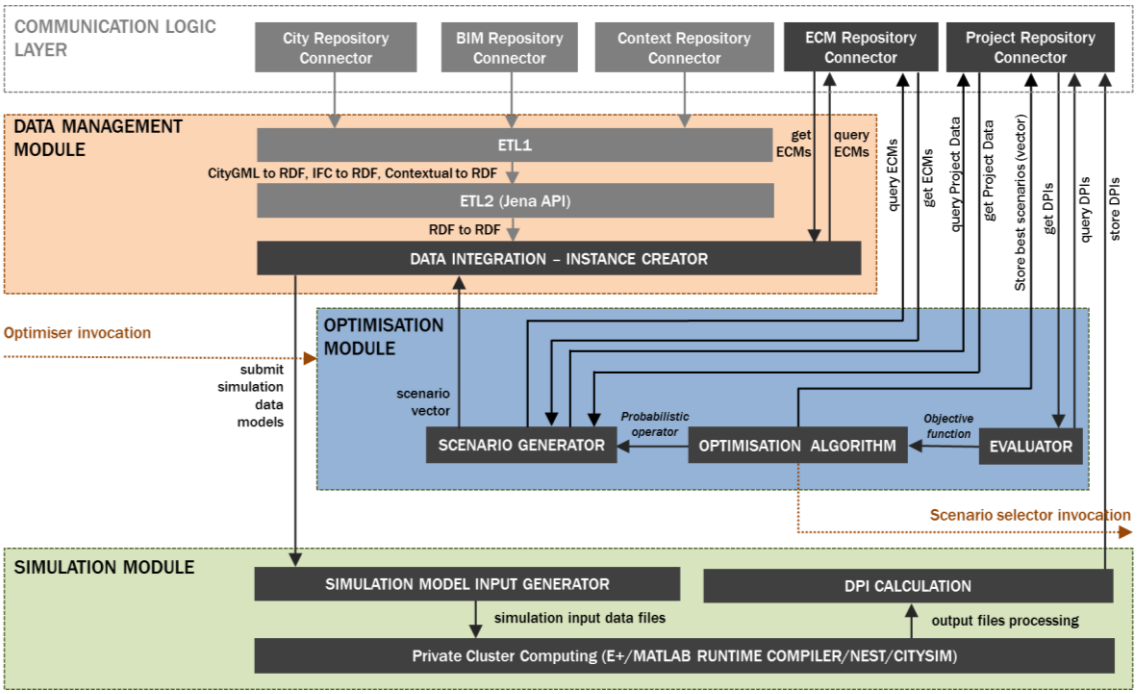

Figure 12: Scenario generation and optimisation process

Sub-section 5.2 will provide the details of these four elements to be shown to the user focussing on the "WHAT" to show to the use under each of these elements. The main objective is to provide precise quantifiable information in the right format to make it easy to understand, interpret and compare.

The expectation from the user is then to analyse the optimisation output listed above and, depending on their role specified in the IPD agreement/guide, take the decision on the best scenario. This decision varies, as follows, from one IPD actor to another:

- The **Owner** has substantially greater and more active role in deciding the best scenario. In fact, the owner is expected to (a) analyse the platform output for each of the best scenarios, (b) request input and recommendations from the other IPD team members based on their analysis of the scenarios, and (c) evaluate the input from the IPD team and take a decision and select the optimal scenario to be implemented.
- When requested by the Owner, the **Prime Designer** is required to analyse the platform output for the best scenarios and, from the design standpoint, provide comments and recommendations for the optimal scenario.
- Similar to the Prime Designer, and when requested by the Owner, the **Prime Constructor** is required to analyse the platform output for the best scenarios and, from the construction standpoint, provide comments and recommendations for the optimal scenario.

In order to better support the Owners decision, it is recommended that the comments and recommendations form the Prime Designer and Prime Constructor to be precise and justified.

5.2 Contents of EE district retrofitting scenarios output

In this section, the content of the EE district retrofitting scenarios output and the corresponding interaction with the user are described. The main goal is for the user to perform an informed selection of the best scenario during the decision making process. This is based on consensus between stakeholders and supported by platform data. It is done by comparing the proposed scenarios such that differences, weak and strong points of each alternative are presented and highlighted via a proper graphical user interface.

The criteria on which this comparison is performed, is set prior to the optimisation stage and is based on user objectives and preferences. It varies relatively depending on the user, who might have different expectations from the retrofit project as depicted in Table 23. The table is a result of the process depicted in Figure 2 that provides a list of requirements for the output and a set of outcomes that will be needed at this stage of the platform use. These requirements are gathered as survey results conducted with different stakeholders and shows diversity of interest from one stakeholder to another. For more information on the Use Cases, please refer to Deliverable 5.2 "Functional architecture specification, interfaces definition and overall platform design".

The following tables are the result of the process depicted in Figure 2 that provides a list of requirements for the output and a set of outcomes that will be needed in this stage of the platform use.

Table 23: Requirements for output specification in the EE retrofitting scenarios

Stakeholder requirement (from survey)	Object to comply with the requirement	Stakeholder origin of the requirement	Use Cases
All the information has to be written in some way in the pdfs and excel files, both of them have to be customizable	Reports have to be able to contain all the information (DPIs, targets, boundaries…) and they have to be customizable too.	OWNER PRIME DESIGNER PRIME CONSTRUCTOR	UC16, UC20, UC11
There must be the possibility of choosing between a detailed and a summarized report.	The platform has to give the chance for having a summarized report or a complete one	OWNER PRIME DESIGNER PRIME CONSTRUCTOR	UC20
Adequate technical report to understand the calculations and associated results.	Adequate technical report to understand the calculations and associated results.	PRIME DESIGNER	UC16, UC20, UC11
Information about: The benefits in comfort The capital gain A comparison between energy savings and economic investments (payback time).	A report that includes: The 5 comfort DPIs ECO04 'Return of investment' ENV06 'Energy payback time'	PRIME DESIGNER OWNER	Uc16, UC20
Information about cost.	The platform has to provide the cost of the technologies involved.	PRIME DESIGNER	UC16, UC20
Detailed information about the energy performance of the different scenarios.	The platform has to provide detailed information about the energy consumption of each scenario	PRIME DESIGNER	UC16, UC20, UC11
Economic costs of the implementation of each one of the alternatives (including materials and needed personnel).	The platform has to provide the costs of each one of the technologies proposed and that cost has to include every cost associated to that technology including materials and installation cost. The specific DPI is	PRIME CONSTRUCTOR	UC6, UC16

	ECO02.		
Energy and environmental aspects.	Economic information together with the expected energy savings.	OWNER PRIME DESIGNER	UC16
Energy demand along with its performance and reduction.	The platform has to provide an indicator about the energy demand along with the expected reduction.	PRIME DESIGNER	UC16
Information about the roles of the personnel to install each one of the technologies.	The platform will provide some information of the qualifications needed to implement an ECM if they are too specific to be considered.	PRIME CONSTRUCTOR	UC16
Justification for a given option.	Information about the roles of the personnel to install each one of the technologies.	PRIME DESIGNER	UC16
Limitations of the different strategies.	The platform has to provide information about the limitations of the different alternatives, boundaries and barriers.	PRIME DESIGNER	UC16, UC11
Sociological	The platform has to provide the sociological indicators of each one of the scenarios, specifically SOC01	PRIME DESIGNER	UC16, UC11
Technical report appliances.	The platform has to provide the technical report of each one of the appliances installed in each one of the alternatives, the variables that are associated to each specific ECM.	PRIME DESIGNER	UC16, UC11
User comfort comparison	The platform has to provide the means to enable the comparison of the comfort DPIs of each one of the scenarios.	OWNER	UC16, UC11
All the information has to be written in some way in the pdfs and excel files, both of them have to be customizable	Reports have to be able to contain all the information (DPIs, targets, boundaries…) and they have to be customizable too.	OWNER PRIME DESIGNER PRIME CONSTRUCTOR	UC16, UC11
Configuration of the problem	The user should be presented with the criteria they have introduced into the platform that has led to the results obtained in the optimisation process.	ALL	UC16, UC20, UC11

The content of the user graphical interface related to the output of the optimization phase will be described below. For the user, the whole optimization process is seen as a black box. When the optimization phase is concluded, one or more of the most efficient scenarios, chosen according to the user preferences, are presented. At this point, the user is able to see the information about the prioritization criteria, targets and boundaries (see details in section 4.2) and the computed scenarios. Decision to select the best scenario is required at this stage (for more details about the UI, see UC16, 'Select Optimal Scenario', in Section 5.14 of D1.5).

In the following sub-sections the different outputs reflected in Table 26 are defined in more detail. The classification deployed in the next sections corresponds to the ones that can be provided by the platform at this stage, namely:

- Problem definition data: all the configuration data necessary to define the problem.
- Scenarios information: all the necessary information to support the user in selecting the best scenario among the optimal ones. The scenarios information can be subdivided as follows:
  - list of best scenarios
  - scenario details related to DPIs and ECMs
  - scenario matrix showing how ECMs are applied to buildings

5.2.1 Problem definition data: prioritisation criteria, targets and barriers

An important step of the design process that requires users input is the definition of the problem to be solved by the platform. This should have been performed previously, as explained in section 4.1 and involves the setting the prioritisation criteria, targets and barriers to assist the platform to properly define the problem. For further details about problem definition, the reader is referred to sub-section 4.2.2. At this point, the aim of the platform is to recall the definitions given previously, in order to better understand the results in terms of selected scenarios.

5.2.2 Scenarios information: List of best scenarios ordered following the prioritization criteria

Now that the user is reminded with the problem definition data defined for their project, this is the moment when he/she is presented with the list of best scenarios according to their previously defined objectives. They are ranked according to the results obtained from the optimisation from the highest score to the lowest score. The user accesses the information related to each of these scenarios via a proper form. This form basically presents the output of the optimization phase, and it is shown in the following figure. In general, the owner can view the scenarios prior to receiving comments from the technical users.

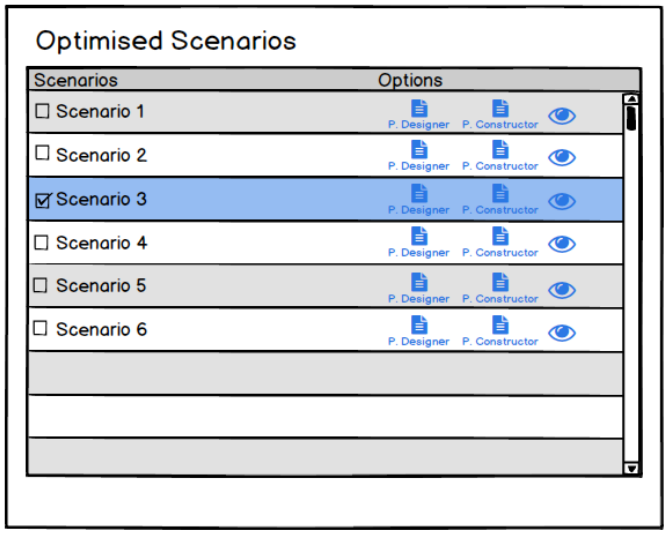

Figure 13: Show optimised scenarios and request for comments in UC16

The owner can access all the information about the computed scenarios, as many times as necessary. However, the owner needs to wait for the technical users comments before taking the decision and selecting the optimal scenarios. Before going into detailed analysis of each scenario, the user will be presented with the scenario scores showing the brief summary of scenario rankings relative to baseline as shown in Table 24. This information can also be completed with the percentage of improvement of the benefit and cost functions according to the stakeholders priorities used for the weighting of the DPIs that build these indexes.

Table 24: Scores of best scenarios relative to baseline scenario

Scenario	Score	% benefit improvement	% cost improvement
Baseline scenario	7.1	-	-
Scenario 1	10	41%	25%
Scenario 2	9.5	34%	22%
Scenario 3	8.9	25%	22%
Scenario 4	8.7	23%	18%
Scenario 5	8.5	20%	17%
Scenario 6	7.9	11%	18%

When the prime designer and prime constructor release comments about the selected scenario, they can be viewed by the other users. These comments are an evaluation of the scenario proposed by the platform. They can be positive or negative and they can highlight aspects related to design and construction. An example of user comments is given in Table 25. These comments need to be considered by the owner in the selection of the best scenario, since they can emphasize aspects that are critical for the design and construction later on.

Table 25: IPD user group comments about EE retrofit scenarios

User	Comment
Prime Designer	This scenario is straight forward from design perspective. I recommend it for implementation
Prime Constructor	Because of ECM1, this scenario is challenging from construction perspective. I do not recommend it for implementation

Furthermore, other information about each scenario is directly presented to the user as an output. They are related to DPIs evaluation and the selection of ECMs that make the scenario. The following sub-section addresses these details, which will be shown by the platform for each of the best scenarios.

5.2.3 Scenarios information: Scenario details related to DPIs and ECMs

The information related to DPIs and ECMs is the core of the output shown for each scenario. On the one hand, DPIs values establish how good the selected scenario is according to the various criteria used during the optimization phase. On the other hand, ECMs represent the structure of the retrofitting scenario, reporting which measures should be implemented in order to achieve the result indicated in terms of DPIs value.

Here the information related to the specific scenario is presented. For each DPI, the user will be presented by the name and the code of the DPI, in order to univocally identify it among the ones used in OptEEmAL. Moreover, the user can see the value of the DPI for the current conditions (Value of baseline scenario) and the results of the DPIs for the EE scenarios as well as the relative difference between each of the DPI results shown as the percentage of improvement. It could be negative in the case where adopting the scenario considered degrades the performance of the district with respect to this DPI. Basically, it happens when a specific measure improves the performance relatively to a DPI but it worsens the value associated to another DPI. Finally, a

qualitative evaluation of the value obtained by adopting the current scenario for this specific DPI is shown. Table 29 shows some examples about the values that are shown when presenting the DPIs of a specific scenario.

Table 29: Example of scenario details - DPIs

DPI Name and code	Value of baseline scenario	Value of Scenario	% Improvement	General Evaluation
ENE01: Energy Demand	80 kWh/m^2	78 kWh/m^2	2.5%	Below target
COM02: Local Temperature Deviation from Set-Point	1.6 Δ °C	1.5 Δ °C	6.25%	On target
ENV01: Global Warming Potential (GWP)	73 kg CO_2 eq/m_2/year	56 kg CO_2 eq/m_2/year	23%	Above target
ECO04: Return on investment	35%	40%	14%	Above target

The list of ECMs represents all the measures proposed by the current scenario. They are energy conservation measures that can be installed at buildings and/or district level, improving the overall performances in terms of energy, comfort, economic and other criteria presented by DPIs. An example of ECMs information related to the scenario selected is shown in Table 30. It consists of ECM name, description, application, advantages and disadvantages, boundaries and barriers, and technical report of the ECM.

Table 30: Example of scenario details – ECMs

ECM Name	Action	Application	Advantages	Disadvantages	Where to act	Barriers	Technical report
Passive Façade External insulation Ventilated - Mineral wool 100	Install	Where external walls are poorly insulated. • Where external walls are deteriorating or are insufficiently weather-tight, causing damp, draughts and heat loss…	Energy saving: Low heat losses in cold periods and low heat gains in hot months. Healthier environment, Comfort: No thermal bridges, and avoid the humidity…	Time: Application is larger than in other façades systems. Costs: Costs are high. Complication: Two types of structure and various materials. Colocation Not applied in protected areas.	Install on south Façade of buildings A and B	Maximum value façades can grow externally.	Ventilated façade is fastened to an auxiliary metal structure fixed to the external walls of the building. The insulation layer…
Passive Roof Internal Insulation - Default - Mineral wool 60	Install	Where external roof insulation is not possible or to costly • Where external roof is protected and cannot be modified • Installing external insulation would adversely affect the appearance of the building…	• Energy saving: Low heat losses in cold periods and low heat gains in hot months. • Healthier environment, Comfort: No thermal bridges, and avoid the humidity…	Thermal bridges may appear if the layer is not continuous Difficult to ensure entire water tightness and zero moisture because of the conditions of the roof.	Install in Building B	Maximum value roofs can grow internally.	It consists in an insulation layer in the internal face of the roof, in this case to make habitable normally the upper space in pitched roofs or as a protection for the house.
Condensing natural gas boiler – Default – 208 kW	Replace	Generation of heat to use for space heating and domestic hot water.	Increase efficiency and reduce operational energy cost with respect to other generation heating systems.	Higher initial investment compared to regular boilers.	Replace existing boiler of the centralised heating system with this new boiler	Access to natural gas Functional space to implement DH boilers.	Condensing natural gas boilers are water heaters fuelled by gas or oil. They achieve high efficiency by condensing water…

Load Following Plant Control – Default – Heating CT1	Install	The measure is applicable in several cases of refurbishment and system upgrades and enables to utilize the cheapest HVAC up to its maximum capacity.	More than one supply equipment can be used to fulfil the building demand.	Utilisation of the HVAC supplying to peak demand may be limited.	Install this control ECM on the BEMS or similar platform that operates the heating system	This control ECM implementation requires hardware and measurement system.	This control ECM enables to coordinate two HVAC supply components such that…

The output provided for the DPIs and ECMs associated to each scenario, allows detecting the improvement that the scenario has brought to the baseline scenario and underlines the measure connected to the improvements. The user can access to all of the specific data about DPIs and ECMs and get a quick understanding of the scenario structure and how the user objectives are pursued.

5.2.4 Scenario matrix showing how ECMs are applied to buildings

Each retrofitting scenario determines a scenario matrix, indicating the association between ECMs and buildings in the district. Furthermore, the information related to the ECMs should include also the definition of some parameters relative to the specific implementation of the ECM, such as size. The columns of the scenario matrix are associated to the selected ECMs, while the buildings and the district represented are represented by the rows.

The content of the matrix has to be presented to the user in order to provide a specific description of the modifications brought to the baseline scenario. Table 31 shows all the ECMs with a brief description and the parameters value associated to them. They are connected with the building where they should be applied according to the current scenario, or to the district in the case where they are district level ECMs.

Rows in Table 31 show different building typologies and whether or not an ECM is applied to that specific typology. In a row, all applied ECMs are marked with a “Yes”, otherwise with a “No”. The last row is dedicated to the district level ECMs, which are the ones whose impact reflects on the entire district.

Table 31: Representation of the scenario matrix

Building Typology	ECM 1: Passive Façade External insulation Ventilated - Mineral wool 100	ECM 2: Passive Roof Internal Insulation - Default - Mineral wool 60	ECM 3: Condensing natural gas boiler –Default – 208 kW	ECM 4: Load Following Plant Control – Default – Heating CT1
Building Typology 1	Yes	Yes	No	No
Building Typology 2	No	No	No	No
Building Typology 3	No	Yes	No	No
Building Typology 4	Yes	Yes	No	No
District	No	No	Yes	Yes

6 Final scenario: information and documentation resulting in the final output design

6.1 Specific considerations for the output

The last stage carried out in the platform is the data exportation process, where the main objective is to process the information generated in the previous stages in order to generate exportable information that is relevant for the user to execute their retrofitting project, and therefore providing the outcomes of the design process.

The process followed in the platform in this last stage is depicted in the following figure:

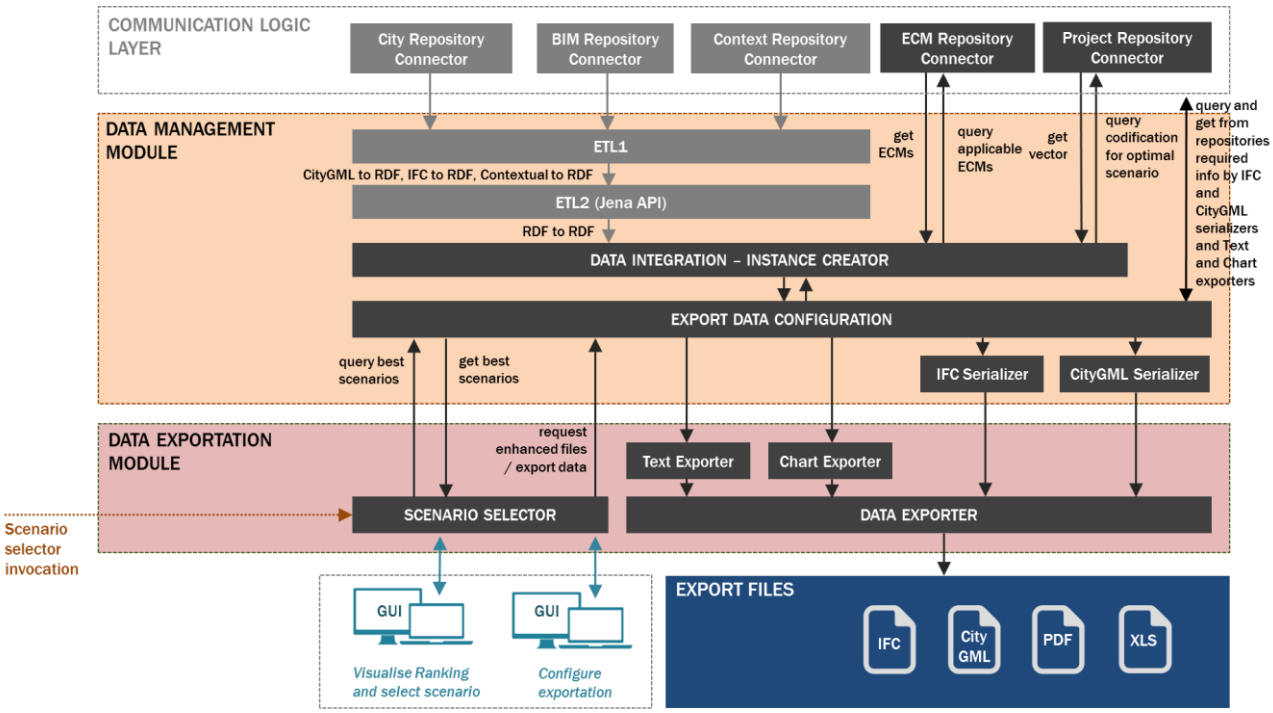

Figure 14: Data exportation process

After the selection of the optimal scenario by the user (see D5.2 and D1.5 for further information), the export data configurator is launched, and the subsequent processes enable the user to export the files with the information: IFC, CityGML, PDF and XLS.

As described within section 3.4.3 the delivery of the outcome, it should be taken into account that the delivery has to be “integrated” (Integrated Project Delivery) which means that every aspect should be present in the models and reports in a holistic manner. This consideration will mean that there will not be different models for different characteristics of the project. All the models have to be integrated, containing all the information and relating the different characteristics if needed. The same consideration will be taken for the reports.

6.2 Contents of final scenario output

The contents of the final scenario output are presented in this section. As it has been previously explained, the main aim of this phase is to be able to retrieve all the possible information once the best scenario has been selected. Data about the process followed in the platform, baseline information, models deployed, information related to the final scenario selected and also the guidelines offered to the user will be provided in different formats to the users.

Following the methodology deployed, a list of outputs was defined according to different stakeholders' expectations, displayed below. Each desired final scenario output (FS.#) is related to the stakeholder demanding such information (stakeholder origin of the requirement), classified according to the type of output within the OptEEmAL platform (type of output and the section where it is explained in more detail) and with the Use Case(s) where this output will be needed. For more information on the Use Cases, please refer to Deliverable 5.2 "Functional architecture specification, interfaces definition and overall platform design" annex 2 of this document, where a summarised and updated version is to be found.

Table 26: Contents of final scenario output related to stakeholders' requirements

#	Stakeholder requirement (from survey)	Object to comply with the requirement	Stakeholder origin of the requirement	Type of output (and section)	Related UC
FS1	List of ECMs applied	A list of the ECMs considered in each scenario should be provided to the user, with the possibility to extend the information if necessary.	OWNER PRIME DESIGNER PRIME CONSTRUCTOR	Final scenario information – related to ECMs (6.2.3.3)	UC17, UC19, UC21
FS2	Results of DPIs selected by the users	The results of the complete list of DPIs of the ones selected by the users of the discarded scenarios have to be downloadable	OWNER PRIME DESIGNER PRIME CONSTRUCTOR	Final scenario information – general data (6.2.3.1)	UC17, UC19, UC20, UC21
FS3	Comparison graphs among scenarios	The results of the DPIs of the optimal scenarios presented by the platform (or a selection thereof performed by the user) should be able to be compared	OWNER PRIME DESIGNER PRIME CONSTRUCTOR	Final scenario information – general data (6.2.3.1)	UC17, UC19, UC20, UC21
FS4	Results of the DPIs selected by the users in the selected scenario	If wanted by the users the results of the complete list of DPIs of the ones selected by the users of the discarded scenarios could be downloaded. The results should be provided through graphs and/or tables in the most understandable way, in order to be discussed with other stakeholders. Moreover, when possible, the data should include hourly, monthly (energy demand) and yearly (economic) variations.	PRIME DESIGNER	Final scenario information – related to DPIs (6.2.3.2)	UC17, UC19, UC20, UC21
FS5	Economic costs of the implementation of each one of the alternatives (including materials and needed personnel)	The platform has to include a report that will include the economic costs of the implementation of each one of the alternatives (including materials and needed personnel).	PRIME CONSTRUCTOR	Final scenario information – related to ECMs (6.2.3.3)	UC17, UC19, UC21
FS6	Information about the roles of the personnel to install each one of the technologies	The report has to include information about the qualifications needed for install each one of the technologies involved	PRIME CONSTRUCTOR	*This output will not be provided in the OptEEmAL platform*	-

FS7	Models of the two scales, building and district	The platform has to provide reports and models of the two scales; building and district.	PRIME CONSTRUCTOR PRIME DESIGNER	Downloadable models (6.2.4)	UC18, UC21
FS8	An idea of how the area will look like in reality and adjust plan accordingly	The platform has to provide a visualization of the district.	PRIME CONSTRUCTOR PRIME DESIGNER	Downloadable models (6.2.4)	UC18, UC21
FS9	The BIM/CityGML models have to comply with other existing software (Revist, Allplan, Termus, Primus, Infraworks, civil3D)	Files that will comply with existing software (Revit, Allplan, Termus), such as those in the IFC format.	PRIME DESIGNER	Downloadable models (6.2.4)	UC18, UC21
FS10	Maintenance information in the BIM/cityGML	The BIM/cityGML models have to include maintenance information.	OWNER	Downloadable models (6.2.4)	UC18, UC21
FS11	Guides for the user	OptEEmAL functioning guide.	OWNER PRIME DESIGNER PRIME CONSTRUCTOR	Guides for the user (6.2.5)	UC20, UC21
FS12	IPD guide deployed during the platform functioning	Guide to implement IPD inside OptEEmAL, which has been deployed during the whole platform functioning. It will include recommendations for the next steps outside the platform.	OWNER PRIME CONSTRUCTOR PRIME DESIGNER	Guides for the user – general process and IPD approach (6.2.5.1)	UC20, UC21
FS13	BIM modelling guidelines	Guidelines provided to the users in the first stage of the platform in order to guide the users on the best practices to model BIM files, which also comply with OptEEmAL requirements.	PRIME DESIGNER	Guides for the user – BIM modelling guidelines (6.2.5.2)	UC20, UC21
FS14	A proper training method for implementing changes in the BIM model and gathering the information contained in the BIM/CityGML models.	A report with guidelines about how to gather information from the BIM/CityGML files generated by the platform.	PRIME DESIGNER	*This output will not be provided in the OptEEmAL platform*	-

In the following sub-sections the different outputs reflected in the table are defined in more detail. The classification deployed in the next sections complements the one shown in the fourth column of the table (type of output) with possible outputs, which have not specifically been named by the stakeholders but can be provided by the platform, namely:

- Baseline scenario results: which measure the performance of the current scenario
- Problem definition data: every configuration made by the user which will affect the final result obtained in the platform
- Final scenario information: performance results and information of the final scenario in terms of Energy Conservation Measures applied, among others.
- Downloadable models: in IFC, according to the Energy Conservation Measures applied in the final scenario
- Guides for the user: documents that will aid the user when using the platform and implementing the Integrated Project Delivery paradigm.

Finally, in section 6.3 a detailed list of final outputs of the platform is presented, which is subject to modification during the development of the project.

6.2.1 Baseline scenario results

The information related to the current status of the district was highlighted by the stakeholders, as it has been explained in section 4 related to the Diagnosis of current conditions. Specifically, stakeholders remarked their interest on energy, economic and environmental aspects to be shown in a monthly or yearly basis. Baseline results are shown to the user on several occasions during the platform functioning, and will consist primarily on visualising the list of District Performance Indicators of Diagnosis, that is, the ones that only concern the baseline scenario. Even though they have been shown to the user in the “Diagnosis of current conditions” phase, at this final stage all the results will be available for download in the form of a report or charts, according to what the user configures and the capabilities to be provided by the platform.

The main information to be provided in the baseline results, which the OptEEmAL platform is also capable of offering, is information on the following topics:

- Energy performance of the current scenario
- Comfort performance of the current scenario
- Environmental performance of the current scenario
- Economic performance of the current scenario
- Social indicator of the current scenario
- Urban performance of the current scenario

They will be shown to the user in the form of District Performance Indicators (please refer to

Table 30 for a detailed list of the expected outputs to this regard) and will be offered both at building and at district level in this case of the baseline scenario.

For a clearer understanding of these values, they will be complemented by an explanation of what each District Performance Indicator means, their unit and also which building ID they refer to in each case. The DPIs will be ordered showing in the first place the ones selected by the user as important (in UC6 – Show DPIs). The possibility to express the values in graphs or through diagrams will be explored for a better understanding of the user, as well as the configuration capabilities of the platform.

6.2.2 Problem definition

As it can be observed in section 3 stakeholders have not mentioned in the survey performed interest for problem definition data, that is, every type of configuration made in the platform that will affect the results to be obtained with it. It is important for the users to be aware of what they have configured in order to evaluate the results that they have obtained.

Problem definition data is also shown in the Diagnosis of current conditions phase, however, similarly to what happens to the baseline scenario results, now these data will be available for the user to download in the form of tables or text, according to the configuration possibilities of the platform.

With regards to the content of these data it is the same as the one provided in the Diagnosis of current conditions: targets, boundaries, barriers and prioritisation criteria, among others. The information to be provided by the user is the following:

- Identification of the project
- Identification of the IPD team
- List of boundaries related to DPIs (both mandatory and optional)
- List of targets related to DPIs
- List of barriers related to ECMs
- List of discarded ECMs in strategies checker step
- Applicable matrix
- Weather data
- Contextual data related to systems (energy systems, control and schedules associated to zones)

Depending on the type of data they will be shown in form of tables or lists of items. For a more detailed description of what will be provided under these topics please refer to Table 28.

6.2.3 Final scenario information

One of the most important outputs is the final scenario information, since obtaining the optimal scenario is the main objective of the platform. As expected, this fact was highlighted by all stakeholders who declared their interests on the Energy Conservation Measures applied, the results of the performance of the scenario, which should be comparable to the previous scenarios obtained and also the economic costs of the alternatives.

In this section they have been subdivided into three main outputs:

1. **General data**: provides general information on the final scenario, such as the comparison of this scenario to the others provided by the platform in terms of performance, ECMs applied etc.
2. **Related to DPIs**: data related to the performance of this particular scenario, which will be depicted with the use of District Performance Indicators.
3. **Related to ECMs**: data related to the different Energy Conservation Measures applied in the scenario.

In the next sections these outputs are defined in more detail.

6.2.3.1 General data

General data related to the final scenario is meant to contextualise the results obtained, by providing the user with comparisons with the previous scenarios. This necessity was highlighted by stakeholders who wanted comparison graphs among scenarios. The contents of general data will be related with the following topics:

- Comparison of this scenario in terms of their performance, which will be reflected with the use of District Performance Indicators of interest selected by the user:
  - With the baseline scenario
  - With other scenarios, which should also show their improvement in terms of performance to the current scenario
- Comparison of the final scenario to previous ones in terms of the ECMs applied

6.2.3.2 Related to DPIs

The definition of the performance of the final scenario is of the utmost importance to the stakeholders, since by observing the results of these indicators the performance of them can be judged and compared objectively. Moreover, it is crucial for users to understand the meaning of them to be able to arrive at a decision. Therefore, the possibility to select the most relevant indicators to the user will be granted in the platform.

The main data to be provided in the final results will be versed on the following topics:

- Energy performance of the final scenario
- Comfort performance of the final scenario
- Environmental performance of the final scenario
- Economic performance of the final scenario
- Social indicator of the final scenario
- Urban performance of the final scenario

They will be shown to the user in the form of District Performance Indicators (please refer to Table 30 for a detailed list of the expected outputs to this regard) and will be offered in the case of the final scenario only at district level.

For a clearer understanding of these values, they will be complemented by an explanation of what each District Performance Indicator means, their unit and also which building ID they refer to in each case. The DPIs will be ordered showing in the first place the ones selected by the user as important (in UC6 – Show DPIs). The possibility to express the values in graphs or through diagrams will be explored for a better understanding of the user, as well as the configuration capabilities of the platform.

6.2.3.3 Related to ECMs

The survey revealed that apart from the results of the performance of the final scenario in comparison to the other scenarios and the baseline scenario, it is highly relevant for stakeholders to know which technologies have been applied in the final scenario.

For this reason, first of all a comparison in terms of ECMs applied among scenarios will be provided to the users (please refer to section 6.2.3.1 General data), in order for them to have an overall view. Then, they will be offered as well a list of ECMs applied in the selected scenario with some basic characterisation to describe each of the ECMs.

Afterwards, a more detailed report on the ECMs applied in the scenario will be available for download. In it, all relevant attributes to adequately describe the technologies will be included. Moreover, the information to be provided related to the ECMs will be associated always to where

they are applied, be it a building or the whole district. The information to be offered to the user related to ECMs applied in the final scenario will be on the following fields:

- Passive ECMs
- Active ECMs
- Renewable ECMs
- Control ECMs

For more information on the attributes to be included in the report, please refer to Table 31. Please note that parameters included in this table are a summary and the complete list will be provided in D3.3.

6.2.4 Downloadable models

Even though the survey performed to stakeholders revealed that some of them are not familiarised with BIM or with GIS, others showed their interest in having all of the information contained in these models. The final output to this regard will be several IFC models with enhanced information and partial mappings of ECMs data will be performed when this is technically viable. Enhanced IFC snippets of the measures, containing all needed property sets to fully characterise the measure, will be provided to the user separately. The final list of attributes to be provided in the IFC will be defined in the exportation phase.

6.2.5 Guides for the user

Stakeholders reflected in the survey their need to be provided with guides in order to operate the OptEEmAL platform, as well as information on Integrated Project Delivery processes, and even a training method in order to implement those pieces of information not automatically integrated into the BIM / CityGML files obtained as output from the platform.

In general terms, all these claims will be addressed in OptEEmAL except for the latter (training method in order to implement changes in the models), since the users are expected to be familiarised with this type of files, as they have to provide them as an input in the very first phase of the platform process. It should be reminded that for creating and inserting the required inputs, they will be supported by the IPD guideline developed by the project (as reported within D1.1).

The contents of the guides to be offered to the user in the OptEEmAL platform are described in the two following subsections. Both will be part of a unique guide; however, since the objectives of each of them are so different from one another are described separately.

6.2.5.1 General process and IPD approach

The section of the guidelines devoted to the general process and the IPD approach will provide the user with information on how to work with the platform, how to insert the information, how to adequately define the problem in order to obtain the best results, what each of the elements deployed in the platform is (Energy Conservation Measures, District Performance Indicators, scenarios… etc.)

Below the sections to be covered in the guidelines are provided. These should be considered as a tentative approach to what the final version of the guidelines will be and the final version will be reported in Deliverable 1.1 "E-guide on stakeholders' involvement and IPD implementation for the design and execution".

The sections that are so far included in this document cover the following aspects:

- Information on the platform and IPD
  - Introduction
  - Integrated Project Delivery concept
  - IPD in the platform, scope
- Considerations to take into account before using the platform

    - IPD team building
    - Roles, responsibilities and scopes of services
    - Defining and measuring project outcomes
    - Legal considerations and contracts
- How to use the platform to follow the IPD paradigm
    - Stage 1
    - Stage 2
    - Stage n

For more information related to each of the sections listed above, please refer to

Table 33 and to the final version of the document D1.1.

6.2.5.2 BIM modelling guidelines

BIM modelling guidelines will be indispensable for the user to be able to insert adequate IFC data to be deployed within the OptEEmAL platform. Therefore, guidance should be provided to them before initiating the whole process; however, the BIM guidelines will also be provided at the last stage for future reference and they will tackle the following aspects:

- Installation requirements
- Data requirements
    - Static Data
        - building geometry
        - material thermal properties
        - rooms, spaces and HVAC zones
        - HVAC Systems
    - Dynamic Data
        - Internal gains & operation schedules
- Exportation setup

For more information on what each of the section contains please refer to Table 34.

6.3 Contents of Final scenario output: compilation tables

In the following tables the contents of the final scenario outputs are listed with a higher level of detail. Parameters related to each type of outputs are shown (“parameter” column) and specified (“level of detail”).

Also, below the title it is possible to see how this outputs are related to which Use Cases, in order to be able to establish a direct relationship between them and the GUIs defined in D1.5 “Requirements and specification of Graphical User Interfaces”.

Table 27: 1. Baseline results (Final scenario output)

1. BASELINE RESULTS (Final scenario output)		
Use cases where this information is deployed:		UC17, UC19, UC20, UC21
Information provided	**Parameter**	**Level of detail**
Energy performance of the current scenario	The following DPIs: • "ENE01" - Energy demand (kWh/m²) • "ENE02"- Final Energy consumption (kWh/m²) • "ENE03"- Peak load and profile of electricity demand (kW) • "ENE04"- Peak load and profile of thermal energy demand (kW) • "ENE05"- Degree of energetic self-supply (kWh/kWh) • "ENE06"- Net fossil energy consumed (kWh/m²) • "ENE07"- Total energy use per capita (kWh/hab·year) • "ENE08"- Total residential electrical energy use per capita (kWh/hab·year) • "ENE09"- Energy demand covered by renewable sources (%) • "ENE10"- Total residential natural gas energy use per capita (kWh/hab·year) • "ENE11"- Total residential butane gas energy use per capita (kWh/hab·year) • ENE12"- Energy consumption of public buildings per year (kWh/year·m²) • "ENE13"- Energy use from District Heating (kWh/year·m²) • "ENE14"- Energy use from Biomass (kWh/year·m²) • "ENE15"- Energy use from PV (kWh/year·m²) • "ENE16"- Energy use from Solar Thermal (kWh/year·m²) • "ENE17"- Energy use from Hydraulic (kWh/year·m²) • "ENE18"- Energy use from Mini-Eolic (kWh/year·m²) • "ENE19"- Energy use from Geothermal (kWh/year·m²)	• To be provided at building and district level • Complemented with an explanation of their meaning • Showed in order according to users' interests • Possibility of expressing values through graphs or charts to be explored.
Comfort performance of the current scenario	The following DPIs: • "COM01"- Local thermal comfort (Level) • "COM02"- Local Temperature Deviation from Set-Point (Δ ºC)	• To be provided at building and district level • Complemented with an explanation of their meaning • Showed in order according to users' interests

	• "COM03"- Percentage outside range (%) • "COM04"- Indoor air quality (n.a) • "COM05"- Visual comfort (lux)	• Possibility of expressing values through graphs or charts to be explored.
Environmental performance of the current scenario	The following DPIs: • "ENV01"- Global Warming Potential – GWP (kg CO_2 eq/m^2/year) • "ENV04"- Primary energy consumption(MJ/m^2/year)	• To be provided at building and district level • Complemented with an explanation of their meaning • Showed in order according to users' interests • Possibility of expressing values through graphs or charts to be explored.
Economic performance of the current scenario	The following DPI: • "ECO01"- Operational energy cost (€/year/m^2)	• To be provided at building and district level • Complemented with an explanation of its meaning • Possibility of expressing values through graphs or charts to be explored.
Social indicator of the current scenario	The following DPI: • "SOC01"- Energy poverty measured as % of inhabitants that use more than 10% of their incomes to pay energy bills (%)	• To be provided at building and district level • Complemented with an explanation of its meaning • Possibility of expressing values through graphs or charts to be explored.
Urban performance of the current scenario	The following DPIs: • "URB01"- Percentage of buildings with an A rating in the Energy Performance Certificate (EPC) (%) • "URB02"- Percentage of buildings compliant with Passiv House standards (%) • "URB03"- Percentage of buildings compliant with EnerPhit standards (%) • "URB04"- Percentage of buildings compliant with nZEB standards (%)	• To be provided at building and district level • Complemented with an explanation of its meaning • Possibility of expressing values through graphs or charts to be explored.

Table 28: 2. Problem definition data (Final scenario output)

2. PROBLEM DEFINITION DATA (Final scenario output)		
Use cases where this information is deployed:		UC17, UC19, UC21
Information provided	**Parameter**	**Level of detail**

Identification of the project	- Information of the project:
	  - Project name
	  - Short project description
	  - Project location
	- Information of the owner
	  - Contact person name
	  - Email address
	  - Phone number
	  - Address
		This information will be the one that the owner introduced in the platform in the first step of the process and that will serve for identification purposes.

Identification of the IPD team	- Identification of the IPD team members related to the project:
	  - Contact person name
	  - Email address
	  - IPD role
		This information will be the one introduced by the different stakeholders of the project, reflecting their IPD roles.
		Either one member of each primary role is identified (Owner, Prime Designer and Prime Constructor), or a substitute (Integrated Project Coordinator) should be assigned.

List of boundaries related to DPIs	- Three mandatory values to be inserted by the user:
	  - "ECO02.2" Investment (€)
	  - "ECO05" Payback period (years)
	  - "ENV06" Energy payback time (years)
	- Optional values to be inserted by the user (minimum and maximum value):
	  - On energy performance:
	  ▪ "ENE 01"- Energy demand (kWh/m^2· year)
	  ▪ "ENE 02.0"- Final energy consumption (kWh/m^2· year)
	  ▪ "ENE 05"-Degree of energetic self-supply (kWh/kWh)
		The output will be the values introduced by the user, the three first are mandatory while the rest are optional.
		These values are defined in general terms for the complete district, not specifically for each building.
		These values will always be accompanied by the name of the DPI and their unit. They can also be complemented with the description of each DPI.

	▪ "ENE 06"- Net fossil energy consumed (kWh/m2. year) ▪ "ENE 09"- Energy demand covered by renewable sources (%) ▪ "ENE 12"- Energy consumption of public buildings per year (kWh/m2. year) ▪ "ENE 13" - Energy use from District Heating (kWh/m2. year) ▪ "ENE 14" - Energy use from Biomass (kWh/m2. year) ▪ "ENE 15"- Energy use from PV (kWh/m2. year) ▪ "ENE 16" - Energy use from Solar Thermal (kWh/m2. year) ▪ "ENE 17"- Energy use from hydraulic (kWh/m2. year) ▪ "ENE 18" - Energy use from mini-eolic (kWh/m2. year) ▪ "ENE 19" - Energy use from geothermal (kWh/m2. year) - On comfort performance: ▪ "COM01"- Local thermal comfort (Level) - On environmental performance: ▪ "ENV01"- Global Warming Potential – GWP (kg CO_2 eq/m2/year) ▪ "ENV02"- GWP investment (kg CO_2 eq/m2) ▪ "ENV03"- GWP reduction ▪ "ENV04"- Primary energy consumption(MJ/m2/year) ▪ "ENV05"- Embodied energy of refurbishment scenarios ▪ "ENV06"- Energy payback time - On economic performance: ▪ "ECO01"- Operational energy cost (€/year/m2) ▪ "ECO02"- Investments (€, €/m2) ▪ "ECO03"- Life cycle cost (€) ▪ "ECO05"- Payback Period (years) - On social performance: ▪ "SOC01"- Energy poverty measured as % of inhabitants that use more than 10% of their incomes to pay energy bills (%) - On urban performance: ▪ "URB01"- Percentage of buildings with an A rating in the Energy Performance Certificate (EPC) (%) ▪ "URB02"- Percentage of buildings compliant with Passiv House standards (%) ▪ "URB03"- Percentage of buildings compliant with EnerPhit standards (%) ▪ "URB04"- Percentage of buildings compliant with nZEB standards (%)	

List of targets related to DPIs	- Optional values to be inserted by the user (only one target value per DPI):
	  - On energy performance:
	  ▪ "ENE 01"- Energy demand (kWh/m2. year)
	  ▪ "ENE 02.0"- Final energy consumption (kWh/m2. year)
	  ▪ "ENE 05"-Degree of energetic self-supply (kWh/kWh)
	  ▪ "ENE 06"- Net fossil energy consumed (kWh/m2. year)
	  ▪ "ENE 09"- Energy demand covered by renewable sources (%)
	  ▪ "ENE 13" - Energy use from District Heating (kWh/m2. year)
	  ▪ "ENE 14" - Energy use from Biomass (kWh/m2. year)
	  ▪ "ENE 15"- Energy use from PV (kWh/m2. year)
	  ▪ "ENE 16" - Energy use from Solar Thermal (kWh/m2. year)
	  ▪ "ENE 17"- Energy use from hydraulic (kWh/m2. year)
	  ▪ "ENE 18" - Energy use from mini-eolic (kWh/m2. year)
	  ▪ "ENE 19" - Energy use from geothermal (kWh/m2. year)
	  - On comfort performance:
	  ▪ "COM01"- Local thermal comfort (Level)
	  - On environmental performance:
	  ▪ "ENV01"- Global Warming Potential – GWP (kg CO_2 eq/m2/year)
	  ▪ "ENV03"- GWP reduction
	  ▪ "ENV04"- Primary energy consumption(MJ/m2/year)
	  ▪ "ENV06"- Energy payback time
	  - On economic performance:
	  ▪ "ECO02.2"- Investments (€)
	  ▪ "ECO05"- Payback Period (years)
	  - On social performance:
	  ▪ "SOC01"- Energy poverty measured as % of inhabitants that use more than 10% of their incomes to pay energy bills (%)
	  - On urban performance:
	  ▪ "URB01"- Percentage of buildings with an A rating in the Energy Performance Certificate (EPC) (%)
	  ▪ "URB02"- Percentage of buildings compliant with Passiv House standards (%)
	  ▪ "URB03"- Percentage of buildings compliant with EnerPhit standards (%)
	  ▪ "URB04"- Percentage of buildings compliant with nZEB standards (%)
		The output will be the values introduced by the user, if done so, since the introduction of these values is optional.

List of barriers related to ECMs	- List of questions where the user has replied with “no” and therefore has discarded some measures. Each question will be related to:
	  - The building / district to which it refers
	  - The measure that has been discarded as a consequence to that answer
		-

Applicable matrix 2	The applicable matrix will reflect the following aspects: - Type of applicable ECM and identification code - ID of building / district where it is of application	The final form of the applicable matrix and how this information will be presented to the user is yet to be detailed.

Contextual data related to systems	Information defined by the user on energy systems and renewables both at district and building level will be available to be consulted:
	- Energy systems at building level
	  - ID and name of energy system and basic characterisation
	  - Related to the building ID where they are applied
	  - Related to the energy need they cover
	  - Related to the zone that they supply
	  - Related to the schedules of the zones they supply
	- Energy systems at district level
	  - ID and name of energy system at district level and basic characterisation
	  - Related to the building IDs they supply
	  - Related to the energy need they cover
	- Renewable systems at building and district level:
	  - ID and name of renewable system and basic characterisation
	  - Related to the building ID(s) where they are applied
	  - Related to the building ID(s) that they supply
	  - Related to the energy need they cover
		The final list of parameter related to contextual data on energy systems and renewables and how this information will be presented to the user is yet to be detailed.

Table 29: 3.1. Final scenario – general data (Final scenario output)

3.1. FINAL SCENARIO – GENERAL DATA (Final scenario output)		
Use cases where this information is deployed:		UC17, UC19, UC21
Information provided	**Parameter**	**Level of detail**

Comparison in terms of performance (with baseline scenario)	- Improvement in performance in the following fields (expressed with DPIs):
	  - Energy
	  - Economic
	  - Comfort
	  - Environmental
	  - Social
	  - Urban
	  - Global
		Only the increase in performance of the DPIs selected by the user will be displayed.
		(The complete list of DPIs related to the baseline and where comparisons can be drawn can be found in Table 27 Baseline Results (final scenario output).
		The comparison could be reflected to the user in graphs according to the configuration capabilities of the platform.

Comparison in terms of performance (with other scenarios)	- Difference in performance in the following fields (expressed with DPIs):
	  - Energy
	  - Economic
	  - Comfort
	  - Environmental
	  - Social
	  - Urban
	  - Global
		Only the increase in performance of the DIPs selected by the user will be displayed.
		(The complete list of DPIs related to the baseline and where comparisons can be drawn can be found in
		Table 30 Final scenario – related to DPIs).
		The comparison could be reflected to the user in graphs according to the configuration capabilities of the platform.

Comparison in terms of ECMs applied (with other scenarios)	- ECMs applied in each scenario and classified according to:
	  - Type of ECM
	  - Where it is applied
	  - Basic characteristics
		(More information on the complete list of ECMs applicable in each scenario can be found in table Table 31).

Table 30: 3.2. Final scenario – related to DPIs (Final scenario output)

3.2. FINAL SCENARIO – RELATED TO DPIs		
Use cases where this information is deployed:		UC17, UC19, UC20, UC21
Information provided	**Parameter**	**Level of detail**
Energy performance of the final scenario	The following DPIs: • "ENE01" - Energy demand (kWh/m²) • "ENE02"- Final Energy consumption (kWh/m²) • "ENE03"- Peak load and profile of electricity demand (kW) • "ENE04"- Peak load and profile of thermal energy demand (kW) • "ENE05"- Degree of energetic self-supply (kWh/kWh) • "ENE06"- Net fossil energy consumed (kWh/m²) • "ENE07"- Total energy use per capita (kWh/hab·year) • "ENE08"- Total residential electrical energy use per capita (kWh/hab·year) • "ENE09"- Energy demand covered by renewable sources (%) • "ENE10"- Total residential natural gas energy use per capita (kWh/hab·year) • "ENE11"- Total residential butane gas energy use per capita (kWh/hab·year) • ENE12"- Energy consumption of public buildings per year (kWh/year·m²) • "ENE13"- Energy use from District Heating (kWh/year·m²) • "ENE14"- Energy use from Biomass (kWh/year·m²) • "ENE15"- Energy use from PV (kWh/year·m²) • "ENE16"- Energy use from Solar Thermal (kWh/year·m²) • "ENE17"- Energy use from Hydraulic (kWh/year·m²) • "ENE18"- Energy use from Mini-Eolica (kWh/year·m²) • "ENE19"- Energy use from Geothermal (kWh/year·m²)	• To be provided at district level • Complemented with an explanation of their meaning • Showed in order according to users' interests • Possibility of expressing values through graphs or charts to be explored.
Comfort performance of the final scenario	The following DPIs: • "COM01"- Local thermal comfort (Level) • "COM02"- Local Temperature Deviation from Set-Point (Δ °C)	• To be provided at district level • Complemented with an explanation of their meaning • Showed in order according to users' interests

	• "COM03"- Percentage outside range (%) • "COM04"- Indoor air quality (n.a) • "COM05"- Visual comfort (lux)	• Possibility of expressing values through graphs or charts to be explored.
Environmental performance of the final scenario	The following DPIs: • "ENV01"- Global Warming Potential – GWP (kg CO_2 eq/m^2/year) • "ENV02"- GWP investment (kg CO_2 eq/m^2) • "ENV03"- GWP reduction • "ENV04"- Primary energy consumption(MJ/m^2/year) • "ENV05"- Embodied energy of refurbishment scenarios • "ENV06"- Energy payback time	• To be provided at district level • Complemented with an explanation of their meaning • Showed in order according to users' interests • Possibility of expressing values through graphs or charts to be explored.
Economic performance of the final scenario	The following DPIs: • "ECO01"- Operational energy cost (€/year/m2) • "ECO02"- Investments (€, €/m^2) • "ECO03"- Life cycle cost (€) • "ECO04"- Return of investment (%) • "ECO05"- Payback Period (years)	• To be provided at district level • Complemented with an explanation of its meaning • Possibility of expressing values through graphs or charts to be explored.
Social indicator of the final scenario	The following DPI: • "SOC01"- Energy poverty measured as % of inhabitants that use more than 10% of their incomes to pay energy bills (%)	• To be provided at building and district level • Complemented with an explanation of its meaning • Possibility of expressing values through graphs or charts to be explored.
Urban performance of the final scenario	The following DPIs: • "URB01"- Percentage of buildings with an A rating in the Energy Performance Certificate (EPC) (%) • "URB02"- Percentage of buildings compliant with Passiv House standards (%) • "URB03"- Percentage of buildings compliant with EnerPhit standards (%) • "URB04"- Percentage of buildings compliant with nZEB standards (%)	• To be provided at building and district level • Complemented with an explanation of its meaning • Possibility of expressing values through graphs or charts to be explored.

Table 31: 3.2. Final scenario – related to ECMs (Final scenario output)

3.2 FINAL SCENARIO –RELATED TO ECMs		
Use cases where this information is deployed:		UC17, UC19, UC21
Information provided	**Parameter**	**Level of detail**

List of ECMs applied	- Scenario vector where the applied ECMs can be seen and has the following information:
	  - Type of ECM and code
	  - Where the ECM is applied (building ID / district)
	  - Basic characterisation of the ECM
		This list will serve as a reference and will be further detailed in each section of ECMs (passive, active, renewable, control).

Passive Energy Conservation Measures data	Of applied passive ECMs:
	- Group of measure applied
	- Location
	- Category
	- Measure Type
	- Measure properties
	  - Generic data
	  - Characteristics
	  - Environmental data
	  - Thermal data
	  - Economic data
		All of the parameters included in the XML in the Energy Conservation Measures Catalogue will be available to the user. For more information please refer to D3.3.

Active Energy Conservation Measures data	Of applied passive ECMs: - Group of measure applied - Location - Category - Measure Type - Measure properties - Generic data	All of the parameters included in the XML in the Energy Conservation Measures Catalogue will be available to the user. For more information please refer to D3.3.

	- Characteristics - Environmental data - Thermal data - Economic data	

Renewable Energy Conservation Measures data	Of applied passive ECMs:
	- Group of measure applied
	- Location
	- Category
	- Measure Type
	- Measure properties
	  - Generic data
	  - Characteristics
	  - Environmental data
	  - Thermal data
	  - Economic data
		All of the parameters included in the XML in the Energy Conservation Measures Catalogue will be available to the user. For more information please refer to D3.3.

Control Energy Conservation Measures data	Of applied passive ECMs:
	- Group of measure applied
	- Location
	- Category
	- Measure Type
	- Measure properties
	  - Generic data
	  - Characteristics
	  - Environmental data
	  - Thermal data
	  - Economic data
		All of the parameters included in the XML in the Energy Conservation Measures Catalogue will be available to the user. For more information please refer to D3.3.

* Asked users have reflected their interest in specific parameters of the measure properties. Since not all the parameters are reflected in this tables, but in D3.3, “ALL” have been reflected as interested in this set of data.

Table 32: 4. Downloadable models (Final scenario output)

4. DOWNLOADABLE MODELS		
Use cases where this information is deployed:		UC18, UC21
Information provided	Parameter	Level of detail

IFC model of buildings in final scenario	- The models will have the following characteristics:
	  - Enhanced: second level space boundaries and building external shading surfaces required for simulation purposes will be included
	  - ECMs of passive measures will be added – including all relevant attributes to describe them.
		In the case of the active, renewable and control, measures will be provided to the user separately in the form of IFC snippets containing relevant attributes that describe their characteristics.
		
		3D characterisation will be possible to be visualised in IFC viewers.

Table 33: 5.1.Guides for the user – general process and IPD approach (Final scenario output)

5.1 GUIDES FOR THE USER – GENERAL PROCESS AND IPD APPROACH		
Use cases where this information is deployed:		UC20, UC21
Information provided	Parameter	Level of detail
Information on the platform and IPD	- Introduction - Integrated Project Delivery concept - IPD in the platform, scope	In these sections the users will be informed on general concepts of the IPD process and how they are considered in the platform.
Considerations to take into account before using the	- IPD team building - Roles, responsibilities and scopes of services - Defining and measuring project outcomes	In these sections the users can learn about how to build an IPD team and other general aspects that should be established before starting with the platform process.

platform	- Legal considerations and contracts	
How to use the platform to follow the IPD paradigm	- Different stages of the platform and how the IPD process is integrated within them	The subsections to be contained here will focus on the different stages on the platform and will specify in more detail how the IPD paradigm is introduced and the general functioning process of the platform.

Table 34: 5.2.Guides for the user – BIM modelling guidelines (Final scenario output)

5.2 GUIDES FOR THE USER – BIM MODELLING GUIDELINES		
Use cases where this information is deployed:		UC20, UC21
Information provided	**Parameter**	**Level of detail**
Installation requirements	Information about the exportation process to obtain IFC (text and exporter)	At least two IFC exporters will be available for download (IFC4 exporter for REVIT 2017 and IFC4 exporter for REVIT 2018)
Data requirements	Static data (building geometry)	Describes how to model the building geometry including aspects as: ground boundary condition, conditioned spaces or architectural element clashes and duplicated elements
	Static data (material thermal properties)	Information on how to define opaque building layers and glazing
	Static data (rooms, spaces and HVAC zones)	Information on the adequate definition of spaces to be used in the simulation process.
	Static data (HVAC systems)	Explanation on how information on HVAC systems can be provided within REVIT.

	Dynamic data – Internal gains & operation schedules	Information on how to define schedules in REVIT.
Exportation setup	-	Explanation on how to export all the data to IFC which has been introduced into the BIM file and is required for the building simulation.

7 Conclusions

The definition of the output has been made using a methodology which has originated from the stakeholders' view of the platform potential. When the survey was analysed, it could be seen that the stakeholders not only defined their requirements in terms of expected outcomes, but also in terms of visualisation or exportation format. Following that directive the information about the content of the different outputs they expect was extracted, focusing on the final outcome the platform shall provide.

To make the document understandable it has been divided into five different parts; the impact that the Integrated Project Delivery methodology has in the outputs specifications, the survey that serves as the starting point of the process, the diagnosis of the conditions of the district before any retrofit, how the selection of the best candidate is made using outputs of the platform, and finally the final outcome the users want.

From the survey it can be deducted for the general aspects that it is important for the stakeholders to have well justified each one of the alternatives, since, for instance, they usually do not have information about the user comfort improvement nor the energy demand reduction. It is also desired to give information of other parameters as can be de CO_2 emissions reduction, time to implement a measure, ease of implementation, etc. Some of them have been considered, while others have been excluded from the evaluation, for instance, the time to implement a measure is determined by the expertise of the installer and this parameter is out of the scope of the platform, the ease of implementation will depend not only in the installer expertise but also on conditions of the scenario that cannot be taken into account in the platform (geometrical issues, lack of providers, etc.)

The shape of the reports and models the platform will provide is out of the scope of this document, but the specific content that should have the reports and models are specified in a precise, but flexible way. This flexibility is necessary because one of the points the survey respondents emphasized was the ability to customize the reports.

Other important aspect of the definition of the outputs that has given more impact that the expected is the fact that the delivery has to be integrated, that is, not differentiated for each role in the project. The traditional approach tends to give the information segmented by interests which is the opposite that the Integrated Project Delivery approach intends, that is, the integration of all interests into a single project as it is explained in the specific section associated of the IPD approach.

The suitability of the final outcome of the platform has been secured by defining with high level of detail this ultimate material that has to serve as basis for the next stage of the project, the implementation phase. This has been reached thanks to detailing; the information the output will have to include, the name of the parameter, and the level of detail.

It is important to notice that the outcomes as reported within this document may suffer some minor adaptations and adjustments as result of the demonstration activities of the platform according to the feedback received from the OptEEmAL users.

8 References

[01] INTEGRATED PROJECT DELIVERY: A GUIDE. American Institute of Architects. (2007).

[02] INTEGRATED PRACTICE IN ARCHITECTURE: MASTERING DESIGN-BUILD, FAST-TRACK, AND BUILDING INFORMATION MODELLING. George Elvin.

9 Annex 1: Complete Use Case List

Table 35: Complete use case list

	TOPIC	#UC	Use case	Description	Interaction with user
A. DIAGNOSIS OF CURRENT CONDITIONS	1. BASIC SETTINGS	**UC1**	createNewProject()	Creation of a new project and information gathering related to the project.	YES
		UC2	createNewIPDgroup()	Creation of a new IPD group set. Gathering information about all IPD users and their role, as well as registering them into the platform.	YES
	2. DATA INSERTION	**UC3.1**	insertCityGML()	Insertion of CityGML model. These data will be checked.	YES
		UC3.2	insertBIMs()	Insertion of BIM model(s). These data will be checked.	YES
		UC3.3	matchCityGMLBIM()	Matching of buildings into the district through the IFC and the CityGML files.	YES
		UC3.4	insertContextualData()	Insertion of contextual data. These data will refer to location, the specification of energy systems in the district, etc.	YES
		UC3.5	queryGeoData()	Data related to climate, energy prices, etc. that varies depending on the location will be consulted, retrieved and stored in the context repository. Unstructured data will be also queried and conclusions from this search from the users stored in the platform repository.	NO
	3. BASELINE SIMULATION	**UC4**	generateSimulationDataModels()	Obtaining the simulation data models from the BIM and CityGML models provided by the user. These models are created through the data integration process described in D2.3.	NO
		UC5.1	calculateDiagnosisDPIs()	Based on the simulation data models obtained calculation of diagnosis DPIs with external tools.	NO

	4. PROBLEM DEFINITION	**UC6**	showDPIs()	Showing the results of the diagnosis DPIs to the user to have a clear understanding of the district performance and be able to select the ones of their preference.	YES
		UC7.1	insertTBBsECMs()	Insertion of targets, boundaries and barriers related to ECMs. These data will be checked and stored into the project repository.	YES
		UC7.2	insertTBBsDPIs()	Insertion of targets and boundaries related to DPIs. These data will be checked and stored into the project repository.	YES
		UC9	checkStrategy()	Showing strategies to all IPD roles to verify and, if needed, delete those ECMs that cannot be used in the district.	YES
		UC8.1	queryCatalogueCheck Strategies	Obtaining from the catalogue all the ECMs of possible application and the necessary information from them to present to the user in order to be able to reject measures.	NO
		UC10	insertCriteria()	Insertion of prioritisation criteria. These data will be checked and stored into the project repository.	YES
		UC11	showDefinedProblem()	Show the user the problem defined in the platform and allow them to go back to the uses cases where these aspects have been defined.	YES
B. EE DISTRICT RETROFITTING SCENARIOS	5. OPTIMISATION PROCESS	**UC8.2**	queryCatalogueOptimi sation()	Obtaining from the catalogue all the ECMs of possible application and the necessary information from them to be applied in the simulation models and evaluated in the optimisation process.	NO
		UC12	generateScenarios()	Generation of scenarios by combining one or several Energy Conservation Measures.	NO
		UC13	modifySimulationData Models()	Modifying the simulation data models with the measures indicated in the scenario vector	NO
		UC5.2	calculateEvaluationDP Is()	Based on the simulation data models obtained, calculation of	NO

				evaluation DPIs through external tools.	
		UC14	Calculateobjfunction()	Assessing the results of the evaluation DPIs and providing a unique value for the scenario taking into account the prioritization criteria, and following a process of normalisation and scaling.	NO
		UC15	optimiseScenario()	Optimisation of scenarios based on the conditions established by the user (prioritisation criteria, targets and boundaries) and the diagnosis DPIs. The optimisation algorithm will assess the set of scenarios and will provide the user with the set of the best scenarios.	NO
		UC8.3	queryCatalogueSelectScenario ()	Obtaining from the catalogue all the ECMs of possible application and the necessary information from them to enable the user to select the optimal scenario.	NO
		UC16	selectOptimalScenario ()	Selection by the user (all IPD roles) of the optimal scenario from the set of best scenarios provided.	YES
C. FINAL SCENARIO: INFORMATION AND DOCUMENTATION RESULTING IN THE FINAL OUTPUT DESIGN	**6. EXPORTATION PROCESS**	**UC17**	configureExportData()	Configuration of the information to be exported in the last step of the process. The user will decide the information needed from the platform.	YES
		UC8.4	queryCatalogueExport ()	Obtaining from the catalogue all the ECMs of possible application and the necessary information from them to export.	NO
		UC18	mapIFC()	Generation of a serialized IFC containing the measures to be applied, integration in the same IFC model.	NO
		UC19	exportText()	Generation of a PDF file containing the description of the project inserted by the user. A list of selected ECMs and detailed information as included in the ECMs catalogue, recommendations about the implementation of the ECMs and operation after the	YES

				implementation (e.g. maintenance), and complete calculation of DPIs and detailed information about the expected savings, costs, etc.	
		UC20	exportCharts()	Generation of a XLS document with important information. Among other data the document will provide information of the DPIs calculation, a comparison of the ranking of best scenarios highlighting the selected scenario by the user	YES
		UC21	exportFiles()	Exportation of the necessary information to implement the energy retrofit in the district: IFC, list of recommendations, reasoned report of the scenarios considered and simulation models of the selected scenario	YES

10 Annex 2: Detailed feedbacks

Table 36: Detailed feedback from respondents 1-5

		1	2	3	4	5
Information about the respondent						
	Last name	Martinez Gonzalez	Oregi Isasi	Hansson	Persson	Sundström
	First name	Iker	Xabat	Gunilla	Oscar	Lotta
	Email	iker_martinez@donostia.eus	xabat.oregi@tecnalia.com	gunilla.hansson3@lund.se	oscar.persson@lund.se	lotta@wigot.se
	Organisation	Fomento de San Sebastian	TECNALIA	Lund municipality	Lund municipality	Wigot Arkitekter
	Role	Other (Validator)	Other (Technical office)	Owner	Other (BIM coordinator)	Architect
	Role for graphs	Owner	Prime Designer	Owner	Prime Designer	Architect
General questions						
	1. According to your profile, what information is mandatory for you as an output of the design stage of a retrofitting process?	1 - Economic investment 2 - Users comfort (technical solution) 3 - CO2 emission reduction 4 - Energy demand reduction	a. Energy demand reduction. b. Primary energy reduction c. GWP reduction d. Economic investment e. Payback of the investment	The status of the building as of today. Particularly concerning its status when it comes to energy. This is important because we can then make better decisions about where to spend our limited resources.	-	To be able to see larger parts of a building in a lucid way. For example: to be able to see the effects if you add a certain amount of insulation or what effects a certain u-value in the windows would give.
	2. What information are you usually lacking in your retrofitting projects to have a fully informed decision making process?	1 - Users comfort improvement (technical solution) 2 - Energy demand reduction	a. Primary energy reduction b. GWP reduction c. BIM model d. Renewable energy strategies potential	In some cases drawings/blue prints are missing. In that case we don't know how the house is built. In most cases we lack detailed energy statistics, for example down to the specific building part or system. We also lack information about user behaviour.	-	The architect comes into the process in an early stage, before the technical consultants. Therefore the architect is often missing technical information in this early stage. It would be good to get this earlier so that the architect can make good choices early in the process.

	3. What data would you consider important to compare different scenario possibilities? Is some specific data mandatory for you to choice between different two different possibilities?	1 - Economic investment 2 - Users comfort (technical solution) 3 - CO2 emission reduction 4 - Energy demand reduction	a. Limitations (mechanical, architectural, etc.) of each strategies b. Economic investment c. Advantage and disadvantages of each technology	Economic data, possible savings. So that we can decide if a measure is worth doing or not. Safety of operation is also important. It is very important to us to not have too complicated systems. The have to work in our day to day work and also be suitable for the users.	-	Economic data would be good, over the life cycle of a measure. This is lacking today.
	4. How are you planning to use the outputs of the platform? In which occasion? What for?	To compare different retrofitting solutions at the design stage and before deciding the final intervention, in order to evaluate the most interesting solution for each case.	In order to prioritize between different refurbishment strategies (especially in design stage of the project)	Planning and decision making. Drawings would be useful in the planning/layout design phase.	-	A bit tricky to answer when we have not seen the platform, but it could act as support in the decision making process when you develop the program document (do not know the English word for this, but it is a document that is developed early in the process to describe the project).
BIM and CityGML related outputs						
	1. What would you use this updated BIM/CityGML files for?	We do not use BIM/CityGML models.	a. To improve the accuracy of the evaluation (BIM model) b. To assess other strategies at district level (CityGML model)	We could experiment with different u-values or insulation for example, to see what results it could give. Concerning CityGML we are not really sure since we are not familiar with it. Possibly it could be used for decision making when it comes to	-	To be able to see what the area looks like in reality so that you can adjust your plans for the building to the surrounding area. Today we often have to send someone out to measure and the results are not always correct. It would be good to

				PV:s (if it could tell us about shading for example).		be able to see heights and levels. .
	2. Do you consider mandatory the compliance of the BIM and CityGML files with existing software you are using? If yes, please provide the name of the software.	I do not consider mandatory the use of BIM/CityGML models from my point of view.	No.	Cannot answer this question, but our BIM-coordinator is answering it.	This is strongly preferred, as it will enable us to use the information in other Facility Management systems (today we primarily use Incit Xpand as our FM-system). The software we are using are primarily Autodesk-based. Revit for BIM. CityGML aren't used by us today, but we could possibly use it with Infraworks 360 or Civil 3d.	YES. Revit.
	3. Would you be able to implement changes in a BIM model following some technical descriptions?	We do not use BIM/CityGML models.	Depending on the complexity of the changes. We are limited to implement only changes related to materials or constructive solutions of the building modeled by BIM.	Yes	Yes, we can change BIM-model if needed.	We use BIM (Revit) today and we should be able to do it if the instructions are good. The architect and the designer/constructor create the BIM model and the other disciplines add their information.
	4. Do you consider mandatory the inclusion of energy systems and building materials in the BIM and CityGML files which will be generated from the platform?	We do not use BIM/CityGML models, but I think the inclusion of energy systems and building materials in the BIM and CityGML files would be interesting to have better analisys.	The energy system should be mandatory in both models, BIM and CityGML. However, in both cases it could be semantic information aggregated to the model. According to building materials, it could be only mandatory in the BIM model.	We don't understand the question.	Energy system today and in the foreseeable future isn't necessary to document in the BIM-model. Building materials would be interesting to get into the BIM-model based on the systems suggestion. We could potentially leverage this information in a later stage to calculate cost and maintenance. We don't do this today, but our Facility management system has some functions for this.	YES.

					CityGML aren't used in our Facilty management system, and therefore not that interesting today.	
	5. If so, what type of details would you like to be included for energy systems?	N/A	Its energy source and its seasonal energy performance	See above.	-	Everything that take up space and thereby affect the architect and the other disciplines.
Pdf and xls related outputs						
	1. Which aspects are mandatory to understand a given retrofitting option?	1 - Economic investment 2 - Users comfort (technical solution) 3 - CO2 emission reduction 4 - Energy demand reduction	a. Measurements of each strategy b. Definition of technical (energy, economic and environmental) data of each strategy	We don´t understand the question.	-	Don't understand the question.
	2. What is the level of details you consider adequate (building or district)?	Both are interesting depending the aim of the retrofitting project.	According to the strategy. For example, a ventilated façade could be defined at building scale. However, other strategies such as district heating should be considered at district level.	Building	-	Building.
	3. How would you like the information to be presented? Do you consider the presence of graphs mandatory?	As simple as possible, easy to understand. I think that Graphs could be helpful to facilitate the comparison.	The presentation by graphs is very helpful to take the final decisions and to discuss with other stakeholders.	Calculations, saving etc. should be in Excel. Graphs are not mandatory. Drawing suggestions in pdf.	-	No, not for us. We would like to have results in Revit.
	4. Among the following categories, which one you would consider the most important in your decision making process? (and thus should be particularly detailed in the outputs)	Economic	Energy	Economic	-	Environment / Economic

	For this specific category, which information are you needed to take decisions?	-	Energy demand reduction; energy consumption reduction, primary energy reduction, energy generated by renewable strategies	An LCC would be appreciated.	-	Economy: life cycle. Environment: the holistic picture. Life cycle.
	5. In which format would you like to see this information presented (annual or monthly average, hourly time series)?	Annual and monthly to see the evolution during the year.	According to each strategy, the presentation of the information should be different. However, we think that monthly average could be enough.	We are not sure that we understand what kind of information you mean. Monthly data would be good for energy. Yearly for economic data..	-	Yearly or monthly.
	6. Would you consider the possibility to customise the content in the pdf or xls file (according to your needs or interests) an interesting feature?	Different profiles in the platform can give different outputs, and so we can have defined and fixed outputs profiles as a standard of the platform. The possibility to customise the content can be also interesting for those who need to evaluate specific topics.	We think that the xls should be editable, making possible the integration of new criteria	Not necessary but interesting.	-	Yes. Specific for the building in question.
	7. In the OptEEmAL platform, you will be able to define the targets and constraints you have for your retrofitting projects. Do you think the pdf and xls outputs have to focus on these targets and constraints or provide only general information (or both)?	I think that it would be more interesting to focus on the targets but also giving general information.	Both.	Yes, it has to focus on our targets and constraints.	-	Yes, focus on targets and constraints.
	8. Generally speaking, the PDF file shall contain:	b. Inputs and outputs	b. Inputs and outputs	b. Inputs and outputs	-	b. Inputs and outputs
	9. Similarly, the PDF file shall contain:	a. Only a summary of the information (e.g. name of the district, total number of buildings, etc.) - I will give the possibility to choose between a detailed report and a summarised report.	b. All information (detailed inputs and outputs)	b. All information (detailed inputs and outputs)	-	a. Only a summary of the information (e.g. name of the district, total number of buildings, etc.) - I will give the possibility to choose between a detailed report and a summarised report. b. All information (detailed

						inputs and outputs)
	10. Generally speaking, the XLS file shall contain:	b. Inputs and outputs	b. Inputs and outputs	b. Inputs and outputs	-	b. Inputs and outputs
	11. Similarly, the XLS file shall contain:	b. All information (detailed inputs and outputs)	b. All information (detailed inputs and outputs)	b. All information (detailed inputs and outputs)	-	a. Only a summary of the information (e.g. name of the district, total number of buildings, etc.) - I will give the possibility to choose between a detailed report and a summarised report. b. All information (detailed inputs and outputs)

Table 37: Detailed feedback from respondents 6-10

		6	7	8	9	10
Information about the respondent						
	Last name	Carabalona	Sebben	Tomasi	Segalla	Voltolini
	First name	Andrea	Matteo	Andrea	Roberto	Gianni
	Email	andrea.carabalona@dttn.it	matteo.sebben@ststrentino.it	andrea.tomasi@ststrentino.it	segalla@cla.tn.it	Gianni.voltolini@operauni.tn.it
	Organisation	Habitech - Distretto Tecnologico Trentino S.c.a.r.l.	STS Trentino Engineering	STS Trentino Engineering	Consorzio Lavaro Ambiente Soc. Coop.	Opera Universitaria di Trento
	Role	IPC (Architect)	Prime Designer	Prime Designer	Owner of a part of the property	Owner of a part of the property
	Role for graphs	Architect	Prime Designer	Prime Designer	Owner	Owner
General questions						
	1. According to your profile, what information is mandatory for you as an output of the design stage of a retrofitting process?	Metric estimate, Technical Report Appliances, Energy Report, Technical documents, Processed Charts	Data on energy savings.	The quantification of the expected benefit and the planned investment for obtaining it.	To have information about savings and improvements in energy and environment fields.	Energy report and metric estimate.
	2. What information are you usually lacking in your retrofitting projects to have a fully informed decision making process?	An adequate technical report which allows to trace the calculations starting from the input data. Capital gain of the property when the actions have been implemented.	N/A	To clarify what are the main variables to the analysis carried out and the motivations of their setting.	Reliable data on performance improvement and on how to use the facilities.	A complete audit on the energetic state of the building

	3. What data would you consider important to compare different scenario possibilities? Is some specific data mandatory for you to choice between different two different possibilities?	For each ECM (Energy Conservation Measure) and scenarios composed of multiple ECM must be made explicit: • The urgency of the intervention to restore the functionalities or the security. • Energy benefits; • Economic benefits with the possibility to define a business plan with financial indicators (e.g. TIR …), also considering the use of possible incentives. The economic benefits will be contextualized in a LCA, taking into account the useful life cycle of the works; • Benefits coming from the comfort; • Benefits on the sustainability according to the recognized certification systems (LEED, BREEAM …); • Capital gain of the property when the actions have been implemented (due diligence); • Invasiveness of the actions on the property's activities.	N/A	Time, cost, easiness of implementation, benefits.	All data that could give me information on the benefits achieved both in economic and performance terms, and the costs that would be incurred with payback times which comes from the savings achieved.	Payback time , cost of ECM, comfort improvement.
	4. How are you planning to use the outputs of the platform? In which occasion? What for?	To coordinate a future integrated design.	I do not know this new platform, once I will see how it works I can answer properly.	Planning a redevelopment with variable scale from district to single building.	I do not know enough about the objectives of this platform and what it can generate as output.	As a comparison instrument to evaluate the best retrofit scenario.

BIM and CityGML related outputs						
	1. What would you use this updated BIM/CityGML files for?	To optimize the management of the facility building system by minimizing the costs of maintenance and supply of energy.	N/A	I believe it should be the starting point of the analysis.	For predictions of possible improvements, efficiency of the structure, extraordinary maintenance.	To make an optimization of the facility management.
	2. Do you consider mandatory the compliance of the BIM and CityGML files with existing software you are using? If yes, please provide the name of the software.	N/A	Absolutely yes. I use Allplan.	Yes: Autocad, TERMUS and Primus (ACCA).	Yes.	N/A
	3. Would you be able to implement changes in a BIM model following some technical descriptions?	I have no direct experience with this, but I can assume so.	Yes	Only after a proper training.	No.	I don't know now because I have never had the opportunity to work with this.
	4. Do you consider mandatory the inclusion of energy systems and building materials in the BIM and CityGML files which will be generated from the platform?	Absolutely yes in order to optimize the management process as in Step 1.	Yes	Yes.	Yes.	Yes of course.
	5. If so, what type of details would you like to be included for energy systems?	Energy Breakdown on monthly / yearly basis. Hourly times profiles of the use of the equipment and the employment of volumes served. Cost per unit of energy vector before and after, depending of the time slots of use	N/A	Type, consumption, unit cost.	N/A	Energy breakdown oh hourly basis with dynamic evaluation.

Pdf and xls related outputs						
	1. Which aspects are mandatory to understand a given retrofitting option?	The comparability of the results in terms of urgency, energy, cost, comfort, enhancing real estate value.	N/A	Time, cost, easiness of implementation, benefits.	N/A	A description of the work that is designed to be done and the economic value and the impact on the activities carried out in the building itself.
	2. What is the level of details you consider adequate (building or district)?	N/A	Lod 300	Numerical quantification.	Preliminary	N/A
	3. How would you like the information to be presented? Do you consider the presence of graphs mandatory?	Tables and Charts. It would be desirable having the possibility to select a synthetic output and an output of the detail, depending on the needs of the user.	Yes	I think that the graphics can give an immediate reading and the tables can give a more in-depth analysis.	Yes.	Yes of course. Graphics must be exported.
	4. Among the following categories, which one you would consider the most important in your decision making process? (and thus should be particularly detailed in the outputs)	Economic	Social	Economic	Environment	Energy
	For this specific category, which information are you needed to take decisions?	Financial and economic budget an LCA that allow an assessment of economic strategies with different time horizons.	-	Financial procedures and flows over time.	-	Energy sources available (e.g. district heating), the hourly climatic conditions in a year.
	5. In which format would you like to see this information presented (annual or monthly average, hourly time series)?	The time horizon should be variable. It is appropriate an hourly assessment in order to draw some considerations on the hourly peaks and sizing of equipment (if there is any demand / response), it should be done an annual budget to plan the energy supply contracts.	Annual	Annual.	Annual	Hourly.

	6. Would you consider the possibility to customise the content in the pdf or xls file (according to your needs or interests) an interesting feature?	Of course it should be allowed a degree of freedom in the output definition. I would expect the possibility of generating a DOC.	Yes	I consider it as a very interesting opportunity.	Yes.	Yes.
	7. In the OptEEmAL platform, you will be able to define the targets and constraints you have for your retrofitting projects. Do you think the pdf and xls outputs have to focus on these targets and constraints or provide only general information (or both)?	Constraints and objectives influence and guide the options for intervention. Data must be an input and once processed these influence the output.	N/A	Both.	Both.	Both.
	8. Generally speaking, the PDF file shall contain:	b. Inputs and outputs	b. Inputs and outputs	a. Only the outputs (results)	b. Inputs and outputs	b. Inputs and outputs
	9. Similarly, the PDF file shall contain:	b. All information (detailed inputs and outputs)	b. All information (detailed inputs and outputs)	a. Only a summary of the information (e.g. name of the district, total number of buildings, etc.)	b. All information (detailed inputs and outputs)	b. All information (detailed inputs and outputs)
	10. Generally speaking, the XLS file shall contain:	b. Inputs and outputs	b. Inputs and outputs	b. Inputs and outputs	b. Inputs and outputs	b. Inputs and outputs
	11. Similarly, the XLS file shall contain:	b. All information (detailed inputs and outputs)	b. All information (detailed inputs and outputs)	b. All information (detailed inputs and outputs)	b. All information (detailed inputs and outputs)	b. All information (detailed inputs and outputs)