



OPTIMISED ENERGY EFFICIENT DESIGN
PLATFORM FOR REFURBISHMENT
AT DISTRICT LEVEL

Optimised Energy Efficient Design Platform for Refurbishment at District Level
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Abbreviations and Acronyms

Acronym	Description
AIA	American Institute of Architects
BIM	Building Information Model
BPMN	Business Process Modelling and Notation
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
IFC	Industry Foundation Classes
IPD	Integrated Project Delivery
OptEEmAL	Optimised Energy Efficient Design Platform for Refurbishment at District Level.

Executive Summary

The OptEEmAL project provides a web-based platform for District Energy Efficient Retrofitting Design, which supports integrated methodologies for systematic delivery of optimised designs based on an integrated approach for building and district retrofitting projects.

The platform makes use of input data from district that are processed in a four-phase platform (diagnosis and formulation of scenarios; evaluation and optimisation; best scenario selection and data exportation) conducting an interactive design process with stakeholders.

This deliverable compounds different guidelines focused on guide the stakeholder's interactions with the OptEEmAL Platform described in section 3.

After some concepts regarding the IPD paradigm versus the traditional approach, presented in section 4, the following guidelines are presented in sections 5, 6, and 7:

- **OptEEmAL GUI- Step by step how to use guide and help in line** for guiding the user when using the GUI of the platform (Section 5)
- **E-guide on IPD implementation**, where main aspects of IPD approach are presented to the platform user (Section 6)
- **Stakeholder Guidelines:**
 - [CityGML files guidelines](#) for showing how to generate the CityGML file needed as input for the OptEEmAL tool, which describes the district. (Section 7.1)
 - [IFC files guidelines](#) to generate the IFC files, which represent the buildings within the district. (Section 0)

All these guidelines are available within the project Website as well as within the Platform with the respective link in the Platform GUI. Please, refer to the respective abovementioned sections.

1 Introduction

1.1 Purpose and target group

The main purpose of this document is to show in one individual document all the guidelines generated during the project for helping all the stakeholders in their interaction with the OptEEmAL Platform.

The guidelines cover from how to use the Platform to how implement the IPD approach when facing a retrofitting project going through a help in line and how generate IFC and CityGML files, which are needed as inputs for the Platform.

1.2 Contributions of partners

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

Table 1: Contribution of partners

Participant short name	Contributions
ACC	Overall content E-guide on IPD implementation and IPD approach within OptEEmAL General document approach
CAR	Stakeholder interactions with OptEEmAL platform Contribution to IFC guidelines General document approach Review of the document
NBK	OptEEmAL Graphical User interface, how to use guide
TUC	IFC files guidelines
ARG	Help in line GUIs development How to use the GUI
TEC	CityGML files guidelines

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

D5.2	Functional architecture specification, interfaces definition and overall platform design
D5.3	Functional modules and interfaces development and testing

2 Glossary of terms

Actor

A type of role played by an entity that interacts with the subject (e.g. by exchanging signals and data), but which is external to the subject. The actor could be human or an external/abstract system as it happens with the “time”. An actor initialises an action in the system.

Barriers

Barriers are restrictions introduced into the platform by the user through selection in a pre-configured list which directly constrain the use of the measures included in the Energy Conservation Measures catalogue. They can be technical barriers, normative barriers, social barriers... and are yes/no parameters.

Boundaries

Boundaries are restrictions introduced into the platform by the user through selection in a pre-configured list, where a determined value is selected. These numeric values limit how the retrofitting intervention should be (in terms of energy performance, comfort, environmental performance or investment) and therefore also limit the use of Energy Conservation Measures in an indirect way. They can establish, for example, the maximum or minimum value to be obtained in a DPI or the range of money to be invested.

Case study

A particular instance of something used or analysed in order to illustrate a principle. It involves an up-close, in-depth, and detailed examination of a subject (the case), as well as its related contextual conditions. In OptEEmAL, a Case Study is any case for which the platform will provide an energy efficient design solution, being such cases districts or buildings with specific boundary conditions (existing conditions, barriers and targets) and with a body of stakeholders, that promotes its intervention.

CityGML

CityGML is an open standardised data model and exchange format to store digital 3D models of cities and landscapes. It defines ways to describe most of the common 3D features and objects found in cities (such as buildings, roads, rivers, bridges, vegetation and city furniture) and the relationships between them. It also defines different standard levels of detail (LoDs) for the 3D objects, which allows the representation of objects for different applications and purposes, such as simulations, urban data mining, facility management, and thematic inquiries.

Contextual data

Contextual data is data that gives context to a person, entity or event. It is commonly used by research institutions and business organizations to market research and prediction. Contextual data is taken from various sources and may include socioeconomic background, educational history, health background, general environment and many other factors. In the OptEEmAL scope Contextual data refer to data collected for a specific location (district) and related to climate data, average yearly income of population and fuel price data. This information is used to represent the baseline condition of the district and to generate the District Data Model.

District

An area of a country or city, especially one characterized by a particular feature or activity. In OptEEmAL a district is considered as a set of buildings in a same location sharing energy systems and planned to be retrofitted in a same refurbishment project.

District Data Model

An ontologies-based framework for district information representation. The DDM enables the intertwining of standardized data models (e.g., CityGML, IFC) with ontologies in domains related to building energy efficiency at the district level (energy, social, environment, comfort, urban morphology and economic). The DDM provides a semantically integrated data model (including information about the geometry, materials, equipment, and indicators, at the building and urban scales) that the platform needs to carry out the calculation of the optimized retrofitting scenarios.

District Performance Indicator (DPI)

Data types that are measured or estimated in relation to a defined measurement boundary in order to assess the performance of buildings and/or district in the following fields: energy, environmental, comfort, social, economic and urban.

There are two types of District Performance Indicators:

1. Diagnosis indicators, which measure the performance in the previously exposed fields of the baseline scenario provided to the platform.
2. Evaluation indicators, which measure the performance in the previously exposed fields of the newly generated scenarios and the experienced improvement in the new scenarios in comparison to the diagnosis indicators.

District retrofitting

Any intervention aimed at improving the performance of a district in terms of energy, environment, comfort, etc. is understood under the term of “district retrofitting”. This will be carried out by implementing one or more Energy Conservation Measures at district or at building level.

End-user

An expert that interacts with the OptEEmAL platform in order to insert, analyse or retrieve data from it or also to operate, manage and configure the system. End-users are related to the actors intervening in a case study. The end-user can coincide with an actor (if this is a person).

Energy Conservation Measure (ECM)

Measure undertaken in a specific element in a building or in a district for reducing the energy consumption. It can be of different nature depending on the element on which it is applied. In particular, in OptEEmAL project for types of ECM have been considered:

- Passive: affecting the envelope of the building (e.g. Façade, windows, roof...)
- Active: Applied in energy systems of the building (Heating system, Cooling system,)
- Renewable: when an alternative energy source is considered (Solar thermal, Photovoltaic...)

Control: consisting in apply control strategies which affect the production and distribution facilities...)

IFC

IFC stands for Industry Foundation classes, a common standard for data exchange in the construction industry that allows sharing information regardless of the software application used.

Integrated Project Delivery (IPD)

Project delivery approach that integrates all of the participants involved in a building project from an early stage fostering interaction, communication, collaboration and trust among them. This enables the optimisation of project results, since insights from all participants can be provided earlier; and cost reduction, resulting in a win-win situation for all of the participants.

This approach defines two categories of participants, depending on their level of implication with the project: primary participants (Prime Designer, Prime Constructor, Owner and integrated project coordinator) and key-supporting participants (design consultants, agencies, suppliers, subcontractors...).

OptEEmAL only takes into consideration the primary participants as possible platform users, even though the other roles can be represented outside of the platform, and their role definition of each of them is explained in this glossary.

Optimisation

Action carried out by the optimisation algorithm, which task is to obtain through a series of iterations the optimal scenarios. In each of these iterations several scenarios will be created (including one or more Energy Conservation Measures to the baseline scenario) and evaluated (comparing the results of the DPIs in each of them). When the stopping criteria are met, the optimisation process will end and the optimal scenarios will be provided to the user.

Owner

Primary participant role defined in the Integrated Project Delivery approach, whose role during the project delivery is to provide feedback and define the objectives to be followed during the process. In OptEEmAL the Owner is a platform user who has to confirm or reject the steps that are to be taken to complete the project.

Pareto Front

A set of nondominated solutions, being chosen as optimal, if no objective can be improved without sacrificing at least one other objective.

Within OptEEmAL scope, the Pareto Front is a graphical representation of all the optimal scenarios that accomplish a Pareto multicriteria optimization. The output of the Optimisation Module is a Pareto Front containing the scenarios more interesting for the users according to their criteria and organized in those that comply with the boundaries and/or targets set.

Prime Constructor

Primary participant role defined in the Integrated Project Delivery approach, whose main responsibility during the project delivery remains to be providing strategic services, schedule production, cost estimating, etc., but from a much earlier stage in the process. In OptEEmAL they are primary platform users which will have to validate the strategies offered by the platform.

Prime Designer

Primary participant role defined in the Integrated Project Delivery approach, whose main responsibility during the project delivery remains to be designing services. However, the efforts of this participant will have to be much higher in earlier stages as usual. In OptEEmAL Prime Designers will have to implement technical data and check and validate the refurbishment strategies offered by the platform.

Prioritisation Criteria

Prioritisation criteria are a ponderation applied to the objectives introduced in the platform by the Owner which generate a type of ranking of what to be applied in the district. This enables a better assessment of the actions to be carried out in the refurbishment.

Requirement

A description and specification of the functionality desired for a system. It can also collect performance features of the system, such as availability, scalability, security, etc.

A functional requirement represents the main functionality needed to cover an objective in a software system and it is mandatory for its correct performance. These functional requirements can be end-user and technical. From the user point of view, a requirement represents a constraint imposed by the client for the development of a software product, while the developer defines the technical requirements. A Non-functional requirement complements those functional improving the behaviour and efficiency of the system or offering security.

Retrofitting Scenario

Each of the potential solutions to be applied in a case study, meaning one or a group of Energy Conservation Measures that can be implemented in the district or building in order to achieve the expected targets and overcoming the existing barriers.

Scenario

A scenario is the result of combining one or more Energy Conservation Measures from the catalogue to the baseline scenario.

(Baseline) scenario

The baseline scenario is the actual situation of the district and buildings in the project. No Energy Conservation Measures have been applied yet. DPIs from this scenario are calculated and are used as a reference to compare with the DPIs of the series of possible scenarios to be generated in the platform.

Simulation model

Model generated from the input provided by the platform users (in form of CityGML and IFC) which is used to make energy, environmental, economic... simulations by external tools that are to be invoked by the platform.

Stakeholder

Each of the actors involved in a retrofitting design process that has an interest or concern in the process.

Targets

Targets are selected by the user from a pre-configured list which defines possible goals to be obtained at the end of the district refurbishment. They are general assumptions that do not contain any numeric value that limits them in any way, i.e. reducing energy demand, introducing solar panels, etc.

Use case

A software engineering concept (used in the analysis and design phase of software development) representing a functionality which should fulfil a requirement or a set of requirements. It is defined as a list of steps (or actions) typically defining interactions between a role (“actor”) and a system to achieve a goal. In OptEEemAL, the set of services that the platform will provide is what has been named as “use case”.

Use cases form part of a methodology to capture the interrelationships between data, users, systems and tools involved in a case study aimed at optimizing the energy performance of districts and buildings. It enables to identify the components involved in a particular application scenario and their alignments.

3 Stakeholders and interactions with OptEEmAL platform

Pursuing energy-efficient buildings and district is not only a challenge in terms of the complexity of the design and the analysis required, but also in terms of the **number of stakeholders involved**. Moreover, each project is specific and it is not easy to identify the necessary stakeholders for all district retrofitting plans. EU-wide, each country has its own structural organizations.

The most common stakeholder involvement schemes based on a review of numerous district retrofitting plans in Europe are classified into three main categories: (1) executive group, (2) operational group and (3) interest group. The executive group includes politicians, city planning and study departments, as well as developers or investors and building stock Owners and managers. They are in charge of the direction in which a district retrofit should evolve or what are the main objectives or constraints to be set. They are also influenced by the main regulations, including the energy directives. The second group is the operational group, which includes contractors, builders, service providers, network managers and planning, design and engineering offices. They hold the technical knowledge to carry out a district retrofit, as well as the main interest in terms of efficiency in the process and cost reduction. Finally, the interest group is represented by inhabitants and NGOS, which are in the end the beneficiaries of such energy retrofits.

The adequate communication among stakeholders as well as their representation in the decision-making process is crucial to avoid modifications in the project in future stages that may result in a cost increase. It is necessary to bear in mind that whereas in the retrofit of a building the decisions to be taken are numerous and have a great impact on the results and final costs of the retrofit, in district retrofitting this impact becomes exponential due to its complexity and dimensions.

In OptEEmAL, being a tool to support the decision making process in the retrofit of districts, the two main **groups of stakeholders represented are the executive group and the operational group**. The communication among them, as well as their confirmation in every relevant decision of the design of the project retrofit is granted within OptEEmAL. To do so, the Integrated Project Delivery approach, as it will be later explained, has been implemented. To this end, three actors to represent the different stakeholders have been defined (Owner, Prime Designer and Prime Constructor).

These **stakeholders will interact** in the framework defined within OptEEmAL, whose concept is depicted below. As it can be observed, there are four main stages within the platform and only two where the interaction with the users is required: phase 1 and phase 4.

A brief definition of the phases is provided below:

- **Phase 1: problem statement:** in this first phase the problem will be defined by the user. To this end, interaction of the users with the platform will be required to: (1) Describe the current status of the district: with this objective, input data files (IFCs, CityGML), contextual data, or the description of the current Building Energy Systems will be introduced into the platform; and (2) Describe the problem to be solved: by inserting targets, boundaries, objectives to be accomplished and importance given to certain parameters (prioritisation criteria), as well as the verification and checking of the Energy Conservation Measures to be considered in the platform.
- **Phase 2: problem mapping:** this is an internal phase of the platform, where no user interaction is required. In it, the problem described by the user will be mapped, simulation models will be created and initial simulations will be performed in order to derive what the current performance of the district is (baseline).
- **Phase 3: problem solving:** after having obtained the current performance of the district (baseline) and counting on the definition of the problem inserted by the user, the optimisation process will be launched, which will consist on a series of iterations where combinations of Energy Conservation Measures will be tested and simulated, until obtaining the best solutions. This process is internal to the platform and does not require any user interaction.

- Phase 4: solution exporting:** when the best solutions have been obtained, the users should select the best among them. For each of the best solutions proposed, relevant information will be available for the users to download.

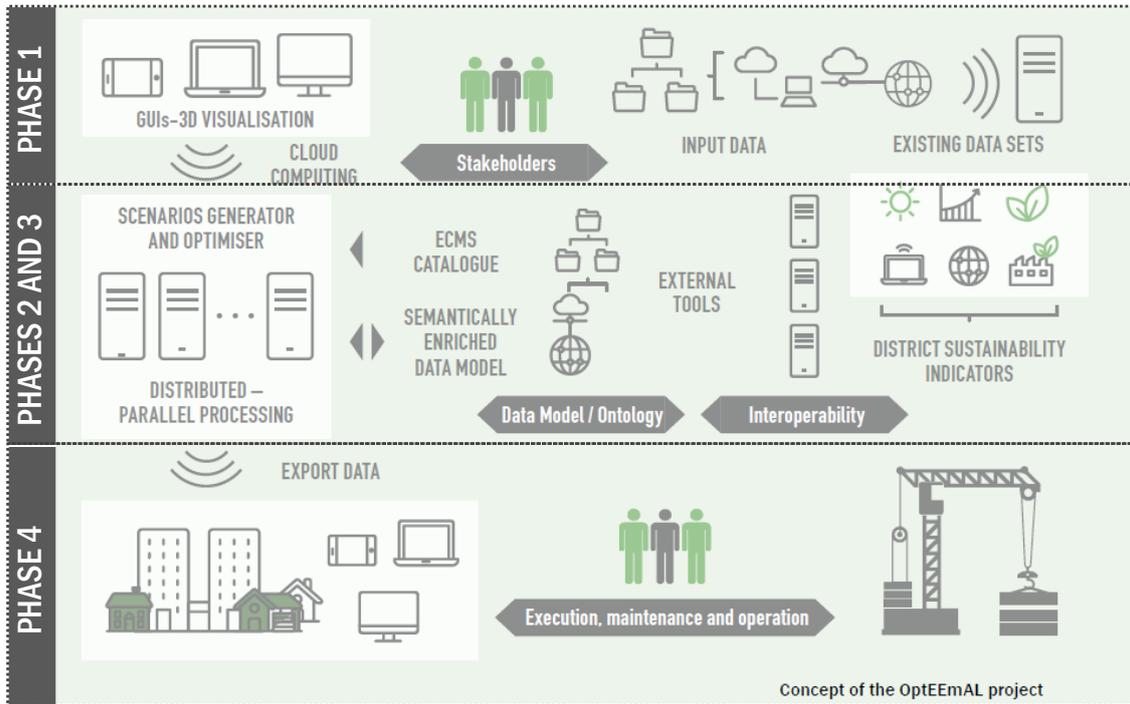


Figure 1: OptEEmAL concept and phases

Additionally, apart from the envisaged interactions described above, a chat has been introduced in the platform to assure the constant communication if required by the users. Please refer to section 5 for more information to this respect.

4 Integrated Project delivery (IPD)

“Integrated Project Delivery (IPD) is a Project Delivery approach that integrates people, systems, business structures and practices into a process that collaboratively harnesses the talents and insights of all participants to optimize Project results, increase value to the Owner, reduce waste, and maximize efficiency through all phases of design, fabrication, and construction.” [2007, AIA]

IPD can be applied to a variety of contractual arrangements and IPD teams can include members well beyond the basis triad of Owner, architect, and contractor. In all cases, integrated projects are uniquely distinguished by highly effective collaboration among the Owner, the Prime Designer, and the Prime Constructor, commencing at early design and continuing through to project handover.

4.1 IPD vs Traditional Project Delivery

An IPD approach requires an early contribution of knowledge and experience and a proactive involvement of key participants. Responsibility is placed on the most able person and decisions are taken by the basis of what is “best for project”.

This concept differs from the traditional one on how to define the main aspects of each one of the elements involved in the project. In that way the main characteristics of the working team in a traditional approach differs from the team in an integrated approach because there is no hierarchy in an IPD team being the team with this approach open and very collaborative and it is assembled very early. The project the traditional team is assembled progressively during the whole life of the project and the members are added the moment they are needed. The traditional team has a very strong hierarchy that contributes to differences in the decision making process.

Traditional Project Delivery		Integrated project Delivery
Fragmented, assembled on “just-as-needed” or “minimum-necessary” basis, strongly hierarchical, controlled	TEAMS	An integrated team entity composed key project stakeholders, assembled early in the process, open, collaborative
Linear, distinct, segregated, knowledge gathered “just-as-needed” information hoarded, silos of knowledge and expertise	PROCESS	Concurrent and multi-level, early contributions of knowledge and expertise, information openly shared, stakeholders trust and respect
Individually managed, transferred to the greatest extent possible	RISK	Collectively managed, appropriately shared
Individually pursued, minimum effort for maximum return, (usually) firstcost based	COMPENSATION/REWARD	Team success tied to project success, value-based
Paper-based 2 dimensional, analog	COMMUNICATIONS/TECHNOLOGY	Digitally based, virtual, Building Information Modeling (3,4 and 5 dimensional)
Encourage unilateral effort, allocate and transfer risk, no sharing	AGREEMENTS	Encourage, foster promote and support multi-lateral open sharing and collaboration, risk sharing

Table 3: Project elements in Traditional and Integrated Project delivery approaches (Source: AIA Council)

These changes in the elements’ conceptualization are due to the different way of the interactions between the different actors in the project. In a traditional approach it is the Owner who sets the goals, targets and barriers of the project with no interaction with the Prime Designer. The latter is who has to elaborate the actual and the optimized model depending on the information given by the Owner and there is no interaction with the Prime Constructor.

In an integrated process, all the main actors (Owner, Prime Designer and Prime Constructor) work together in the definition of the barriers, goals and targets, and assess together also the actual scenario of the project and look for an improved scenario together.

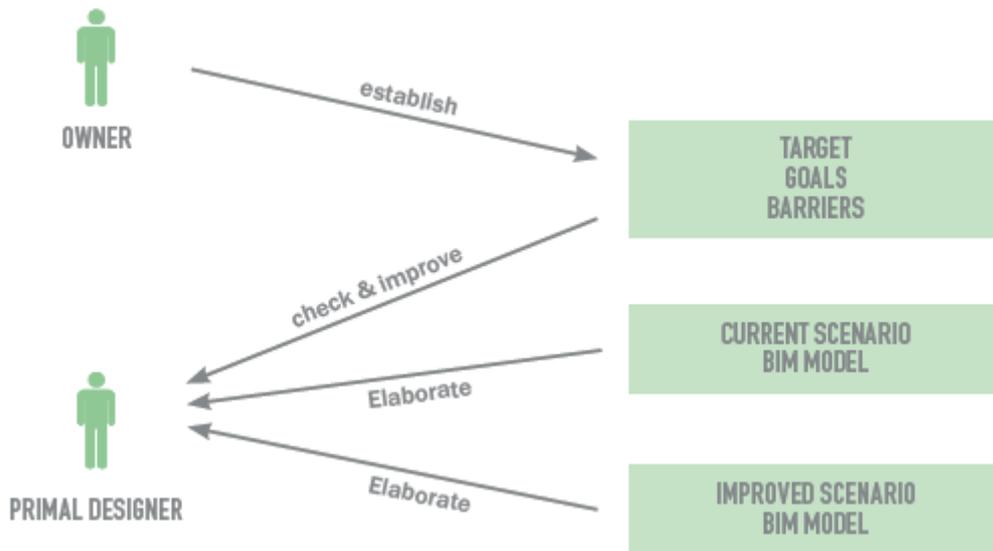


Figure 2: Traditional approach process use case diagram (UML notation)

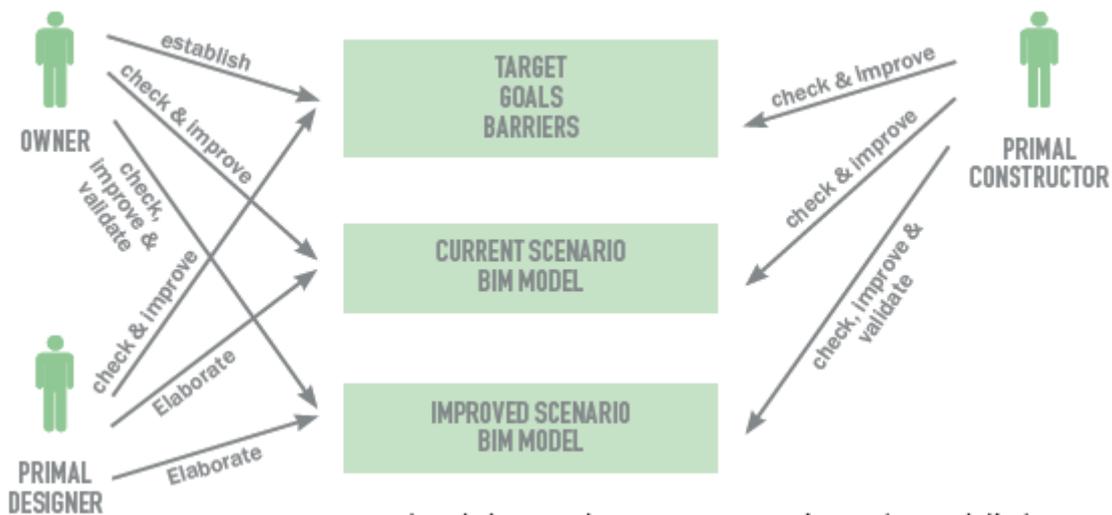


Figure 3: Integrated approach process use case diagram (UML notation)

In the OptEEmAL project, the IPD approach is applied in the first phases of the project in which the conceptualization, criteria and detailed design is carried out.

This process will provide all the needed documentation for starting with the project document implementation prior to the permitting and bidding process inherent to the project. In the figure below, a comparison between the traditional delivery versus the integrated delivery is displayed. Additionally, the phases covered with OptEEmAL are represented.

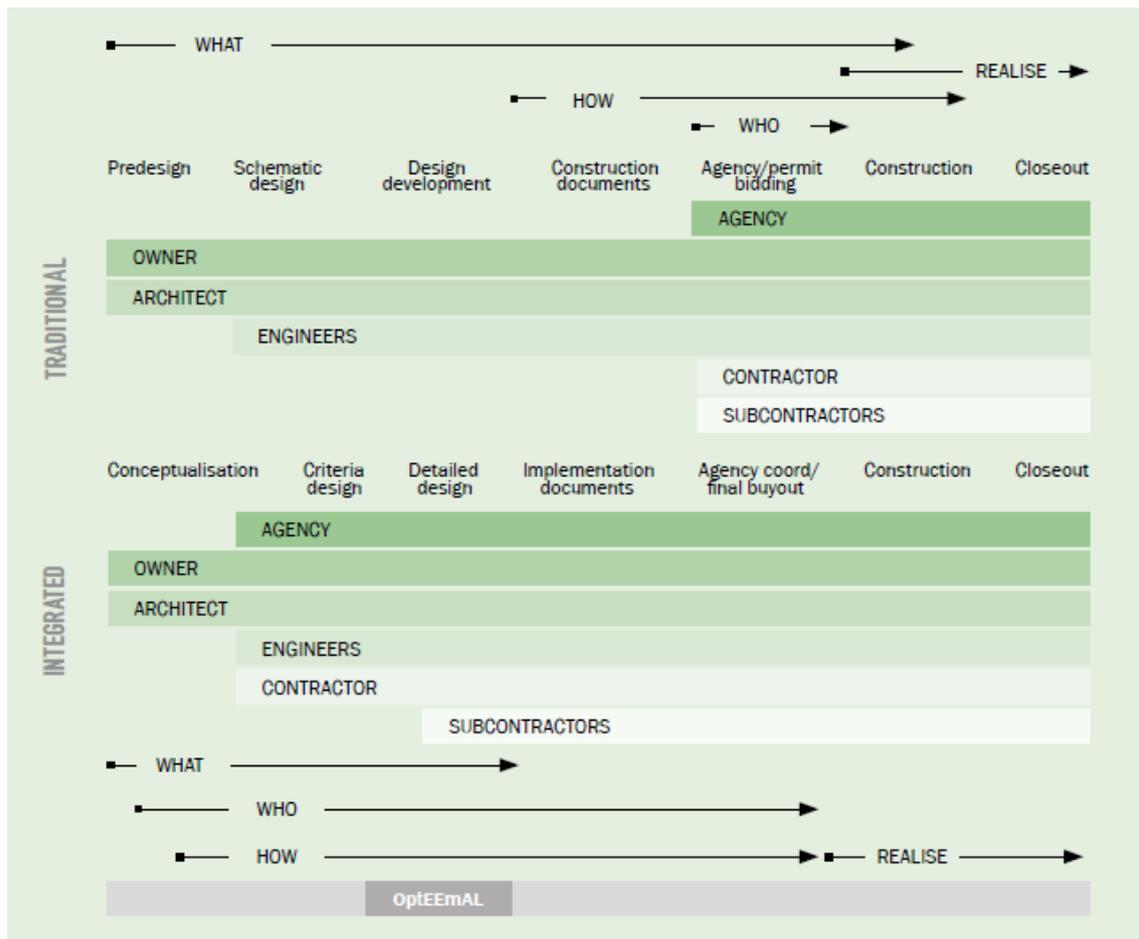


Figure 4: Traditional delivery vs Integrated delivery. Edited from source: AIA California Council

The main differences are that in a traditional approach workflow boundaries are created not aligned as they are in an integrated approach. An Integrated Delivery implies a very high team involvement in the early phases of design which will flow from determining what are the project goals, to who will build and to how the design will be realized.

Inputs from the broader integrated team coupled with BIM tools to model and simulate the project enable the design to be brought to a higher level of completion before the documentation phase is started. Thus the Conceptualization, Criteria Design, and Detailed Design phases involve more effort than their counterparts in the traditional flow.

This higher level of completion allows the implementation Documents phase to be shorter than the traditional Construction Documents phase, and the early participation of regulatory agencies, subcontractors, and fabricators allows shortening of the Agency review and Buyout phases. The combined effect is that the project is defined and coordinated to a much higher level prior to construction start, enabling more efficient construction and a shorter construction period.

4.2 Setting Up an Integrated Project

This section will cover three main phases when setting up an Integrated Project: (1) IPD conceptualization, (2) Criteria Design and (3) Detailed design. In the following subsections only the definition of these phases are provided, whereas in Annex I detailed BPMN diagrams are provided specifying every step.

4.2.1 IPD conceptualization

In the conceptualization phase, it is possible to establish a division in three parts.

In the first one, the team is formed but no contract is signed. Before the team formation, a proper communication of the initial intentions has to be done by the Owner in order to generate the confidence environment that is mandatory in the IPD approach.

For successfully accomplishing the IPD approach, and not only rely on the trust between the partners contracts between the parts have a paramount role. In the contracts the following subjects has to be included:

- Key participants bound together as equals
- Shared financial risk and reward based on project outcome
- Liability Waivers between key participants
- Fiscal transparency between key participants
- Early involvement of key participants
- Jointly developed project target criteria
- Collaborative decision making

Once the contract is signed, the entire group decides about the distribution of work, responsibilities individual goals and an initial schedule of meetings in the last part of this sub-process for ending this stage and starting the new one.

4.2.2 Criteria Design

The first step in this sub-task is to distribute the roles for this stage between the actors involved. This has to be done by the entire group by consensus. When the group has agreed on the work distribution, the designer develops a proposal for the process of the criteria design and conducts a series of meeting that involves the Owner as the ultimate decision maker, the constructor as the one responsible of taking into account the costs and the rest of actors as active information providers. The end of this process comes when the Owner agrees on the formulation for the goals proposed by the IPD group.

4.2.3 Detailed design

The Owner starts this process by inviting the IPD group to a meeting in which the criteria decided in the previous stage is revised. Once this is done, the entire group launches the Detailed Design phase. In the launch, the work distribution is agreed among the members of the IPD group and the acceptance of this distribution is explicitly stated to the entire group.

The designer then starts a estimation of the costs, how the solution will be validated the solution, the construction schedule and the prefabrication needs that take into account information coming from the Prime Constructor as well as from the secondary actors.

Then, thought a series of meetings where all the points of view are considered, detailed design information is produced by the Prime Designer. Once the design proposal is ready, the entire IPD group has to give acceptance of the proposal. Taking into account the golden vote of the Owner, if the Owner does not like the proposal, it does not matter if the group has agreed on it, but despite the Owner gives his approval, the consensus about the suitability of the solution is needed.

For finishing the stage, the roles that are going to be held during the construction phase are distributed by the IPD group and a formal acceptance is given by the Owner.

4.3 Defining Actors of the System

The project team ensures that the individual participant's tasks and responsibilities, or scope of services, are clearly set out and understood at the earliest possible stage. A carefully crafted matrix of parties, roles and responsibilities provides clarity for services, tasks, leadership and supporting roles and is often used for this purpose, though other means may be implemented. (AIA, 2007)

The actors considered within an IPD team can be classified into primary participants and key supporting participants. The first group entails the Owner, Prime Constructor and Prime Designer, which are the roles considered within the OptEEmAL platform. Nevertheless, all relevant actors related to Integrated Project Delivery are defined in general terms below.

4.3.1 Owner

The Owner must take a greater and more active role in evaluating and influencing the different design options. Because of IPD, the Owner will be called on more often to assist in resolving issues that arise in the project. As a member of the decision making body, the Owner will be involved in more project-related specifics and be required to act quickly in this regard to allow the project to continue efficiently.

Some types of Owner could be: private Owner (big companies to small private Owner), a public entity, Owner-builder, citizens...

4.3.2 Integrated Project Coordinator (IPC)

The IPC is an individual responsible for overall facilitation, coordination and direction of the integrated team. This role may or may not shift among members of the team depending on delivery model and project phase. Leadership and consensus building skills are critical to this role. In some instances, this role may be filled by an outside party.

The Integrated Project Coordinator (IPC) is primarily a facilitator, and may be a retained third party or one of the team members. In many cases the responsibilities will migrate. For example, the Prime Designer may be the IPC during the design phases while the Prime Constructor takes on that role as the project moves into construction.

IPC responsibility could migrate between different prime actors (Owner, primer designer or Prime Constructor) as urban planners, architects, constructors...

4.3.3 Prime Designer

IPD relies heavily on an extensive and thorough design process that incorporates input and involvement of other team members, including constructors, during the design phase.

The designer is necessarily involved in defining the design processes that will apply to the project. Designers are required to increase the volume of services provided in the design phase. The more interactions with other team members during the design phase necessitate a high number of iterations, in terms of documents with other team members. These interactions results in an additional responsibility to track them throughout the design phase.

Some types of Prime Designer, depending of the type and scale of the project, could be: urban planners, architects, engineers...

4.3.4 Design consultants and subcontractors

Design consultants perform more discrete functions than the primary participants, but they enter into contracts directly with either one of the primary participants, or with any Single Purpose Entity (SPE) the primary participants have formed. In either event, key supporting participants agree to be bound by the collaborative methods and processes governing the relationship among the primary participants.

The difference between the primary participants and the key supporting participants is a fluid distinction that will necessarily vary taking into account the importance of the supporting participants in the project.

Some types of design consultants could be: constructive designers, structure or system ones (ex. HVAC), programmers but also urban planners, architects, engineer as consultants.

4.3.5 Prime Constructor Manager

The nature of the constructor's scope of services in IPD is primarily affected by their early involvement in the project and their participation within the integrated team. The constructor's role increases in a significant way during early stages of design, in which constructors now provide strategic services such as schedule production, cost estimating, phasing, systems evaluation, constructability reviews, and early purchasing programs.

Constructors should provide expertise and fully participate in the design of the project. The result is a greater role in commenting on and influencing design innovation. This increased role during design requires the constructor to provide, on a continuing basis, estimating services and/or target value design services during the design phase.

Some types of constructor manager could be: construction companies, general contractors, Owner-builder, real estate developer, professional construction manager, small contractors, sponsor-builder...

4.3.6 Trade Contractors

These contractors are referred to as trade contractors rather than sub-contractors (as they are contracted directly by the client, rather than being sub-contracted by the construction manager). The separate appointment of trade contractors should reduce the cost of contracts, as the management element is being provided by the construction manager. It also allows the advancement of some works (such as groundworks or piling) which might begin even before design of the above-ground work is complete.

Some types of trade contractors could be: Ground works (piling), plumbing, HVAC, electrical work, masonry, stonework, tile setting and plastering, painting and paper hanging, carpentry and floor work, roofing, siding and sheet metal work, concrete work, water well drilling, miscellaneous special trade contractors...

4.3.7 Suppliers

They should be included from the beginning in the design phase. Specifically, they have to develop prices commitments through a continuous effort during the entire project.

In addition to shifting design decision making forward, redefinition of phases is driven by two key concepts: the integration of early input from constructors, installers, fabricators and suppliers as well as from designers; and the ability to model and simulate the project accurately using BIM tools.

Some types of supplies could be: facades constructive elements, photovoltaic systems, HVAC... The suppliers usually are those that make the elements in-house (industrialized elements).

4.3.8 Agencies

The use of BIM and early involvement and validation by agencies shortens the final permitting process. Agency Review commences in Criteria Design and increases in intensity during the final review period. This early involvement minimizes agency comments and required changes to the design as submitted for permit.

The agency has, among other obligations, to check the design for building code or regulatory criteria. In addition, analysis BIM software can use the model information to generate performance or criteria analyses that validate the design.

Although the regulatory agencies motives are not necessarily financial in nature, they are interested in the health, safety, and welfare of the future users of the project which should be goals shared by of all the core stakeholders.

Some types of agencies could be: regulatory agencies, insurers, financiers, organizations for citizens, ecological organizations...

4.3.9 Citizens

Citizens are not included in the IPD guide by the AIA, but they are part of our Platform and its validation. We are not sure if this is a good idea for having a positive feedback of the platform. Here the opinion of the coordinator and the partners has to be clear.

4.3.10 Actors in OptEEmAL consortium

During the OptEEmAL platform development and in order to represent all the relevant roles considered within IPD, the following roles were assigned within the OptEEmAL Consortium partners, the following assignation was defined. This assignation was used when testing the platform and also when defining necessary requirements to be fulfilled.

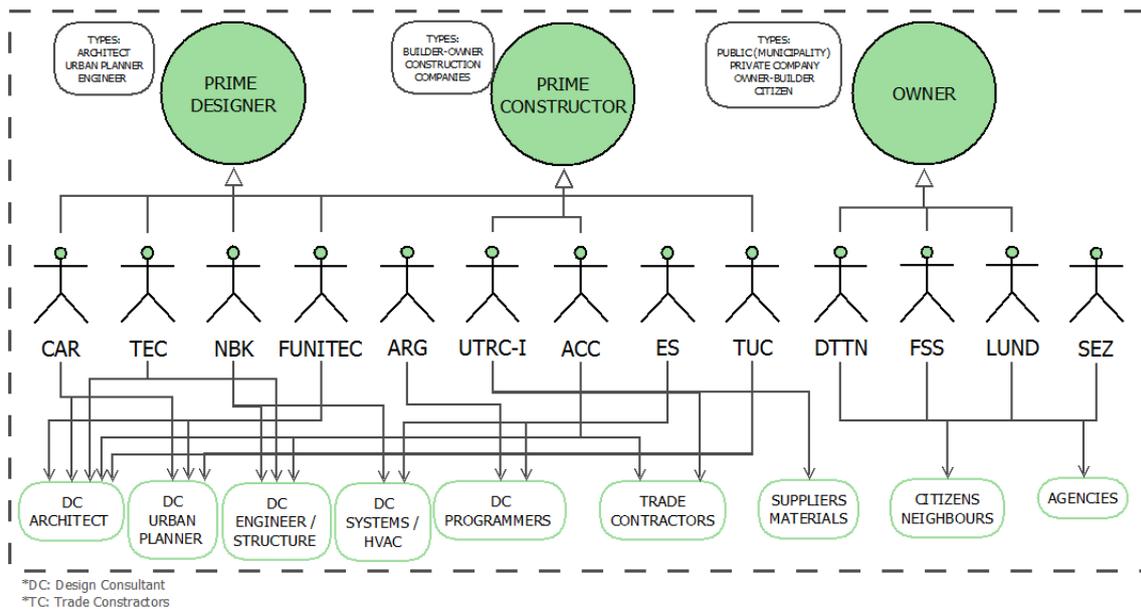


Figure 5: OptEEmAL actors

5 OptEEmAL Graphical User Interfaces

This section describes the different steps of the OptEEmAL platform and the associated GUIs. The purpose of this section is to show all the user interactions with the platform all along the OptEEmAL process.

This section is highly similar to the “how to use” guide of the platform elaborated in the frame of WP6. The major difference between this section and this guide is the narrative form (“the user” in this section vs “you” in the guide). In addition, some general principles of the platform (IPD methodology and groups, list of DPIs, etc.) are presented in the how to use guide and not in this section.

All the OptEEmAL Graphical User Interfaces (GUIs) are designed in the same way to ease the use of the different functionalities by the user. This general design is illustrated and explained in the following figures below.

The screenshot displays the OptEEmAL web interface. On the left is a dark sidebar with the OptEEmAL logo and a list of projects including 'TEST 4M 30 10 2018'. The main content area is titled 'TEST 4M 30 10 2018' with a 'Data Created' timestamp. A progress bar at the top shows 10 steps, with the first 9 completed. The 'IPD Group' section contains two 'Invite' forms for Prime Designer and Prime Constructor, each with fields for 'E-mail Address' and 'Name', and a green 'INVITE' button. Below these is a table with columns for Name, Email, Role, and Status, listing 'Maxime Pousse' as a 'tester' who is 'Joined'. A green 'NEXT' button is at the bottom right of this section. On the right, there is a dropdown menu for 'IPD Guide & Instructions', an 'Activity' section with 'Start Date' (01/11/2018) and 'End Date' (12/11/2018) filters, and a chat window showing messages from 'Luca Scaramella ES - Hi' and a 'SEND' button.

Figure 6: Overview of a classical OptEEmAL GUI

The screenshot shows the OptEEmAL web application interface. On the left is a dark sidebar with the OptEEmAL logo and a list of projects. The main content area is titled 'TEST 4M 30 10 2018' and includes a progress bar, an 'IPD Group' management section with input fields and 'INVITE' buttons, a table of group members, and a 'NEXT' button. On the right, there is an 'IPD Guide & Instructions' dropdown and an 'Activity' chat section with a message history and a 'SEND' button. A user profile for 'Maxime Pousse' is visible in the top right corner.

OptEEmAL logo: Return to homepage

Header section: Current project main information

User's profile: To edit your profile or Log out

Project's list: Use this section to change from one project to another

Step section: Step of the OptEEmAL platform

Main section: Actions are usually made in this part

IPD guide section: All IPD-related materials and information

Activity section: Displays the latest news/actions about your projects

Figure 7: Overview of a classical OptEEmAL GUI (with explanations)



5.1 Step by step how to use guide

5.1.1 STEP 0: Initial steps

The initial steps to be followed within the platform are depicted in the following sections.

5.1.1.1 Registering into the platform

When arriving of the OptEEemAL platform landing page (http://94.177.191.106/opteemal_DataInsertionModule/), the user has the possibility to login if he already has an account. If not, the user can create an account by clicking on the appropriate button.

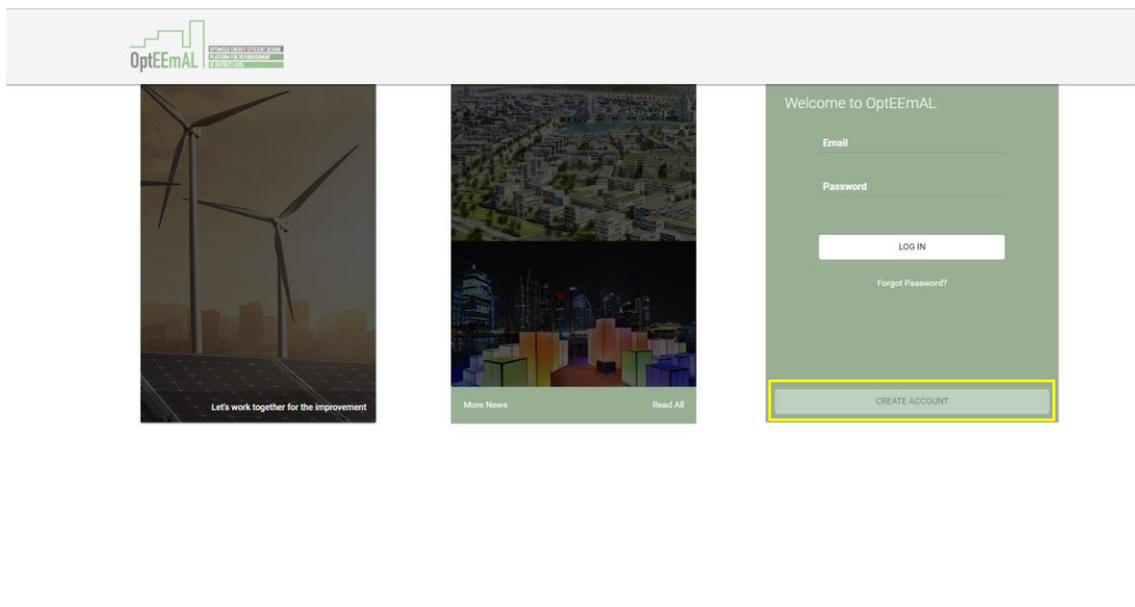


Figure 8: OptEEemAL platform landing page

When clicking on the “Create account” button, the user accesses to a form. After the completion of the form, an email confirmation is sent. The account is finally created after clicking on the link in the email confirmation.

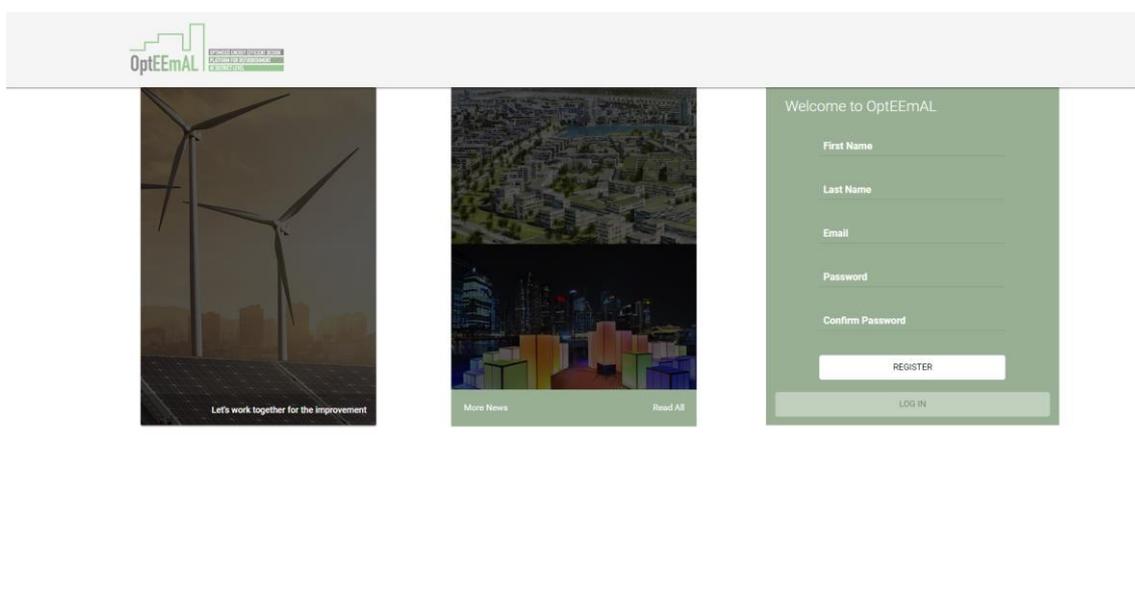


Figure 9: Form for account creation

5.1.1.2 Creation of a new project

A user can create a new project by clicking the “+” button close to the “Projects” list

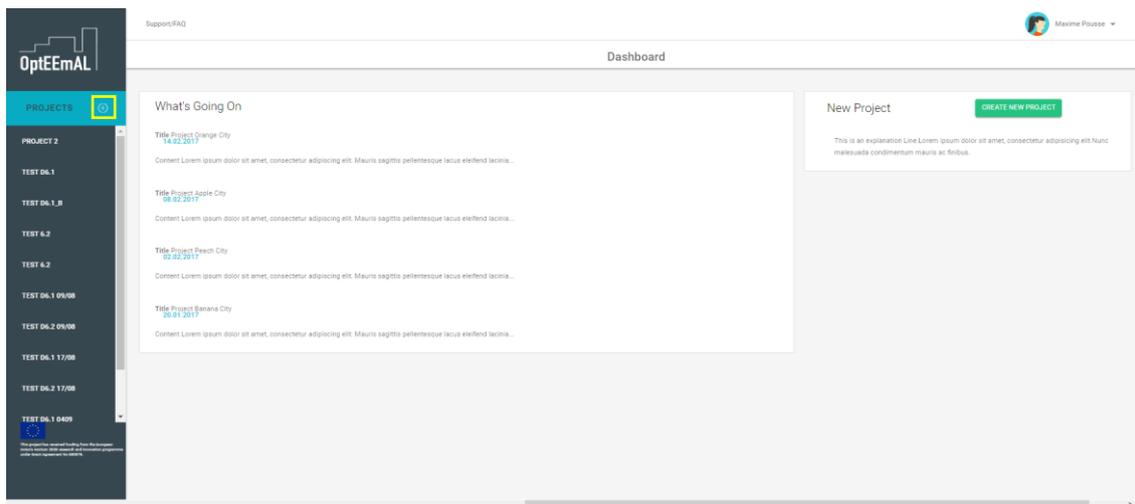


Figure 10: Create a new project

After clicking the “+” button, a pop-up appears. The user will have to fill in all the fields of the pop-up in order to finalise the project creation.

Create New Project

Contact Person Name	<input type="text" value="Owner"/>
Contact Email Address	<input type="text" value="owner@opteemal-project.eu"/>
Project Name:	<input type="text" value="Demo"/>
Project Description:	<input type="text" value="Retrofitting a district"/>
Project Keywords:	<input type="text" value="Energy, District, Retrofitting"/>

CREATE PROJECT
CLOSE

Figure 11: Information to be completed during project creation

When a project is finally created, it will appear in the left hand side of the GUI.

5.1.1.3 Project Settings

If the user needs to delete a project, they will have to click on the arrow close to its name in the top right corner of the GUI and then “Project settings”. It has to be noted that this also allows the user to edit their profile, access the different supporting guidelines and logout.

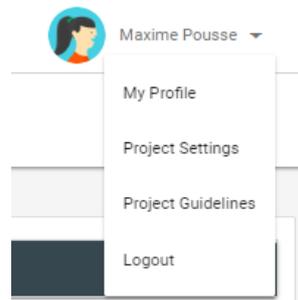


Figure 12: Accessing the “Project settings” screen

In the “Project settings” window, the user is able to delete existing projects and also archive them.

Project Name	Description	IPD Group	Options
TEST D6.1 0409	test	Susana Martin - Tester	<div style="display: flex; gap: 10px;"> ARCHIVE DELETE </div>
		Maxime Pousse - Owner	
		Max Pousse - Prime Constructor	
		Max Pousse - Prime Constructor	

Figure 13: Project setting screen

5.1.2 STEP 1: IPD group

In this step, the user has to create the Integrated Project Delivery (IPD) group. For more information about the IPD methodology and its implications in the use of the OptEEmAL platform, you can consult the IPD e-guide available here (http://94.177.191.106/opteemal_DataInsertionModule/Designed/index.html) and in Section 6 of this document. As an introduction, in OptEEmAL, there are three pre-defined roles in the IPD group:

- Owner
- Prime Constructor
- Prime Designer

Depending on the role the user has, different functionalities will be available in the platform. Please refer to Section 6.5.1.2 for an overview of the allowed actions for each user.

When a user creates a new project, its IPD role is automatically set as “Owner”. Then, through the Graphical User Interfaces (GUIs) of the platform, the Owner has to invite a Prime Constructor and a Prime Designer. Invitation is done by indicating the contact details and clicking the “Invite” button.

IPD Group

Invite Prime Designer

Invite Prime Constructor

Name	Email	Role	Status
Owner	owner@opteemal-project.eu	owner	Joined

Figure 14: Entering Prime Designer and Prime Constructor contact details

Once the “Invite” button has been clicked, the platform automatically sends an email invitation (see below) to the indicated contact.

Dear Prime Designer,

Owner has selected you to be part of the project that has been called DEMO to be part of the project playing the Prime Designer role.

This project will follow the Integrated Project Delivery approach as it is described in https://info.aia.org/SiteObjects/files/IPD_Guide_2007.pdf.

The project will use the platform OptEEemAL for the design stage of the project so that we kindly ask you to continue the process by logging in the platform using this [link](#).

Should you have any question, you shall contact DEMO in Owner@opteemal-project.eu.

With kind regards,

At this step, the status of the invited IPD group members is “Invited”

Name	Email	Role	Status
Prime Constructor	primeconstructor@opteemal-project.eu	Prime Constructor	Invited
Prime Designer	primedesigner@opteemal-project.eu	Prime Designer	Invited
Owner	owner@opteemal-project.eu	owner	Joined

Figure 15: Status of the IPD group after sending the invitations

When the invitation is accepted (by clicking on the link in the invitation) their status changes from “Invited” to “Joined”. Once all the statuses are “Joined”, the IPD group is officially created and the user can proceed with the next steps.

Name	Email	Role	Status
Prime Constructor	primeconstructor@opteemal-project.eu	Prime Constructor	Joined
Prime Designer	primedesigner@opteemal-project.eu	Prime Designer	Joined
Owner	owner@opteemal-project.eu	owner	Joined

Figure 16: Final status of the IPD group

5.1.3 STEP 2: Data upload

After the creation of the IPD group, the user has to insert all the needed input data into the platform. In this page, inserted input data are the CityGML file describing the district and the IFC files describing the buildings under study. The links (“matchings”) between the IFC files and the CityGML file also have to be made in this step. In order to elaborate files (both CityGML and IFCs) that are compliant with the OptEEemAL platform, the user has to consult the available guidelines (please refer to sections 7.1 and 0 within this document), which can be accessed by clicking on the arrow close to its name in the top right corner of the interface. Following the guidelines is critical to ensure the correct functioning of the platform.

5.1.3.1 CityGML file [Upload, check, delete or download]

In OptEEemAL, data upload starts with the upload of the CityGML file. In order to do so, the user has to click on the “Browse” button close to the “Select CityGML File to Upload” section. After clicking on it, the user can navigate to find the file to be uploaded. After having selected the file, the user can upload it using the “Upload CityGML” button. It must be highlighted that the uploaded file has to respect the guidelines available for download from the platform.

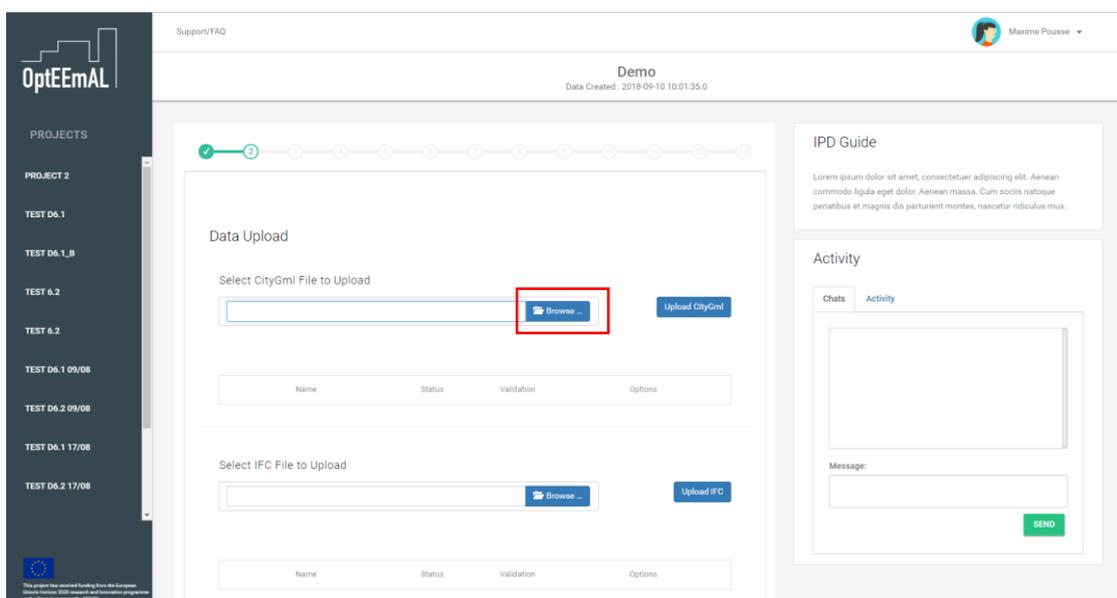


Figure 17: Opening browser in order to find the suitable CityGML file to be uploaded

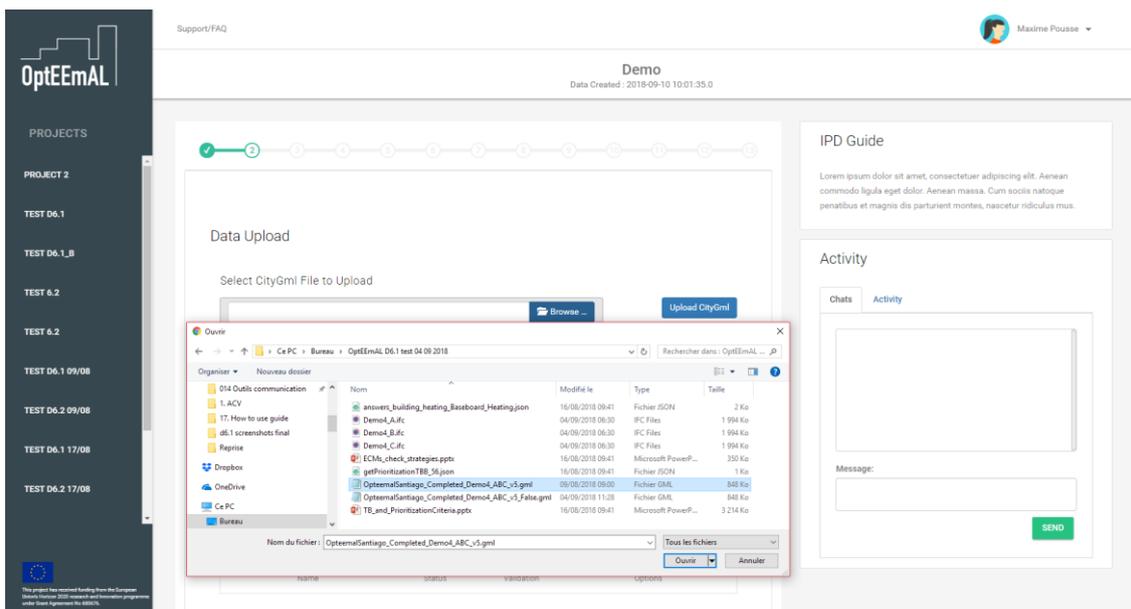


Figure 18: Looking for the suitable CityGML file to be uploaded

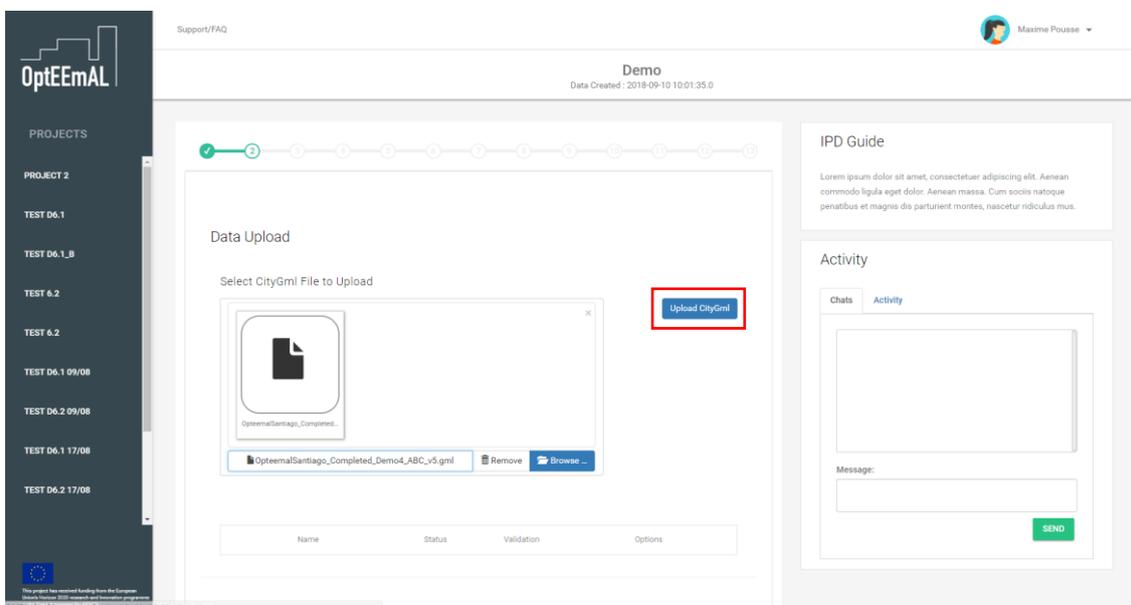


Figure 19: Uploading the CityGML file

Finally, once updated, the user has to check the file (check the compliance of the file with OptEEmAL requirements) by clicking the “Check” button. If the file is valid for use in OptEEmAL, a “Valid” inscription appears. If the file is not valid, an “Invalid” inscription appears. In the case the uploaded file is invalid; the user has to review it in order to make it compliant with the CityGML guidelines. If the file is “Valid”, the user can proceed with the IFC upload.

Note: The status of the CityGML file evolves from TEMP (when the file has only been uploaded) to ORIGINAL (validated).

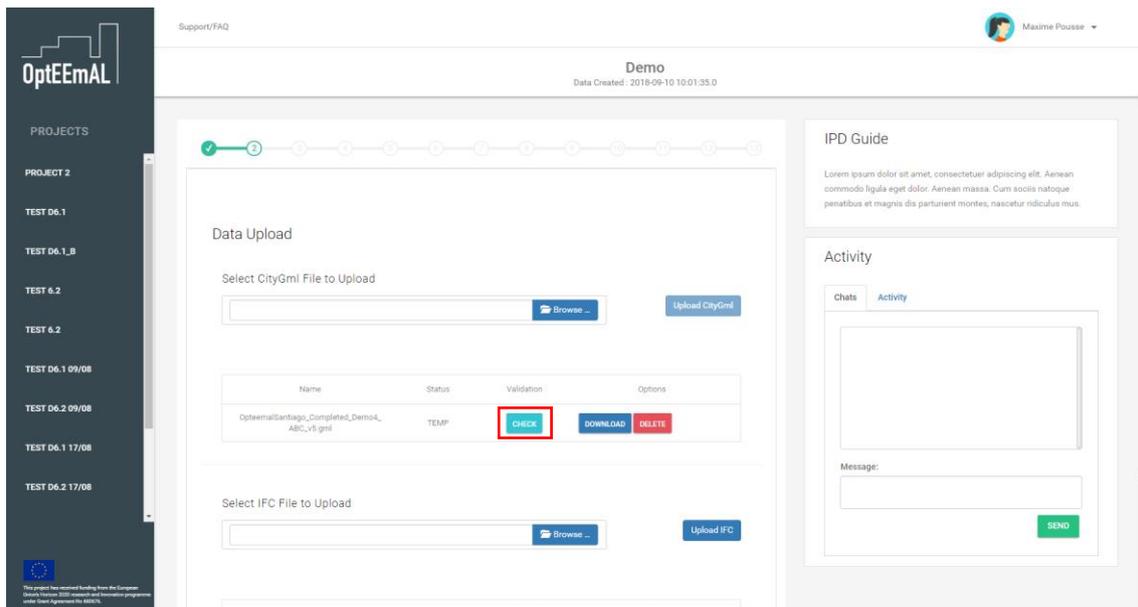


Figure 20: Checking the CityGML file

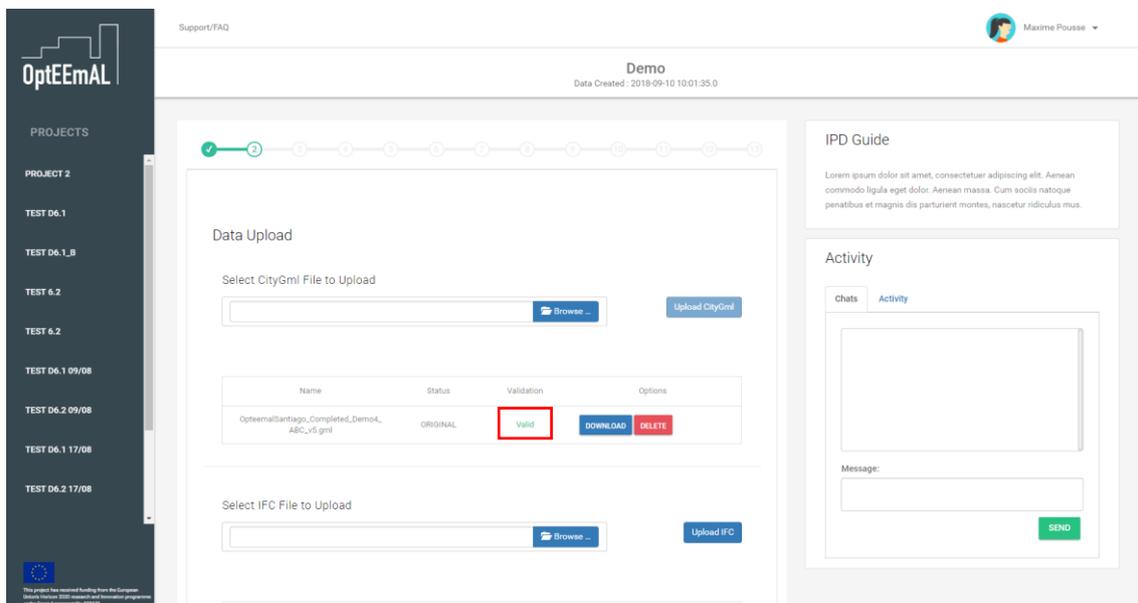


Figure 21 "Valid" status of the CityGML file

5.1.3.2 IFC files [Upload, check, delete or download]

The process for the IFC files is the same as the one described in the previous section for the CityGML file. The only difference lies in the fact that it is possible to upload several IFC files (describing the different buildings under study) while only one CityGML file can be uploaded. In the figure below the results obtained after uploading and checking the files for a district with two buildings are depicted.

Note: The status of the IFC files evolves from TEMP (when the file has only been uploaded) to ORIGINAL (validated). To launch the validation process for each file, the user has to click on the "Check" button.

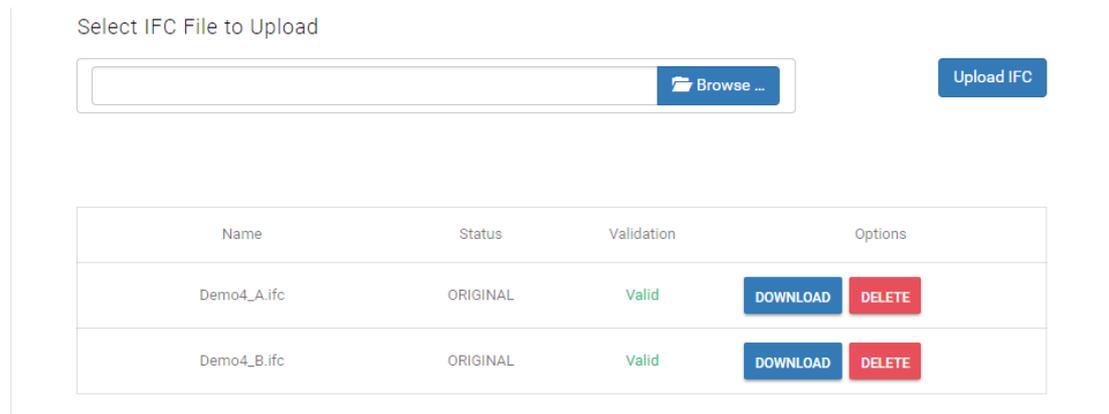
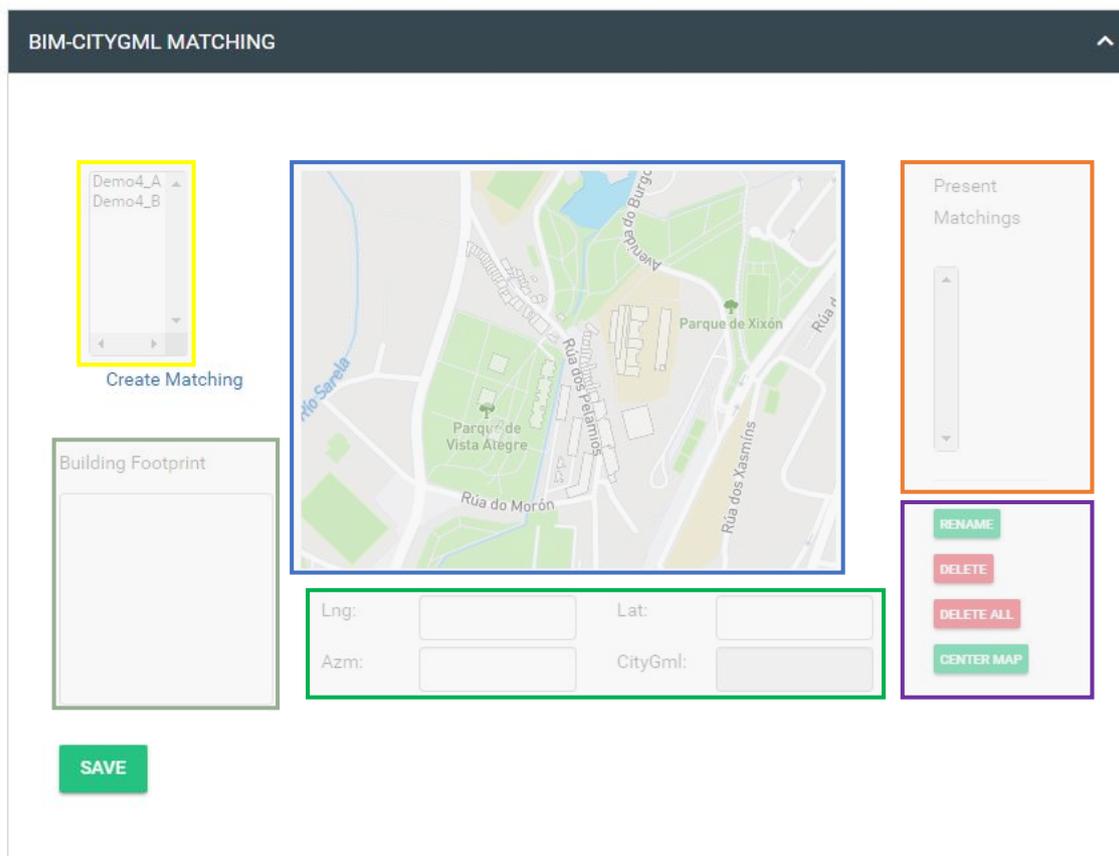


Figure 22: Results of the IFC files upload and check

5.1.3.3 IFC - CityGML matching

The BIM and CityGML matching is an important step in the use of the OptEEmAL platform as it allows the platform to know the links between those files. More precisely, this step is used to indicate to which buildings (within the CityGML file) the different uploaded IFC files are corresponding. The process to elaborate these matchings is explained in the following paragraphs. Prior to this, an overall explanation of the associated GUI is given.



Available IFC models: List of previously updated and validated IFC models

IFC building footprint: Displays the building footprint of the selected IFC model

Present matchings: List of already defined matchings

District map: Map of the district with CityGML building footprints represented

Useful buttons: Buttons to rename/delete matchings

Move/Rotate: Fields used to rotate/translate the IFC footprint on the district's map

Figure 23: Overview of the BIM-CityGML matching interface

The process to elaborate the matchings is the following:

- **Step 1:** Select, among the *Available IFC models*, the one for which a matching has to be created.

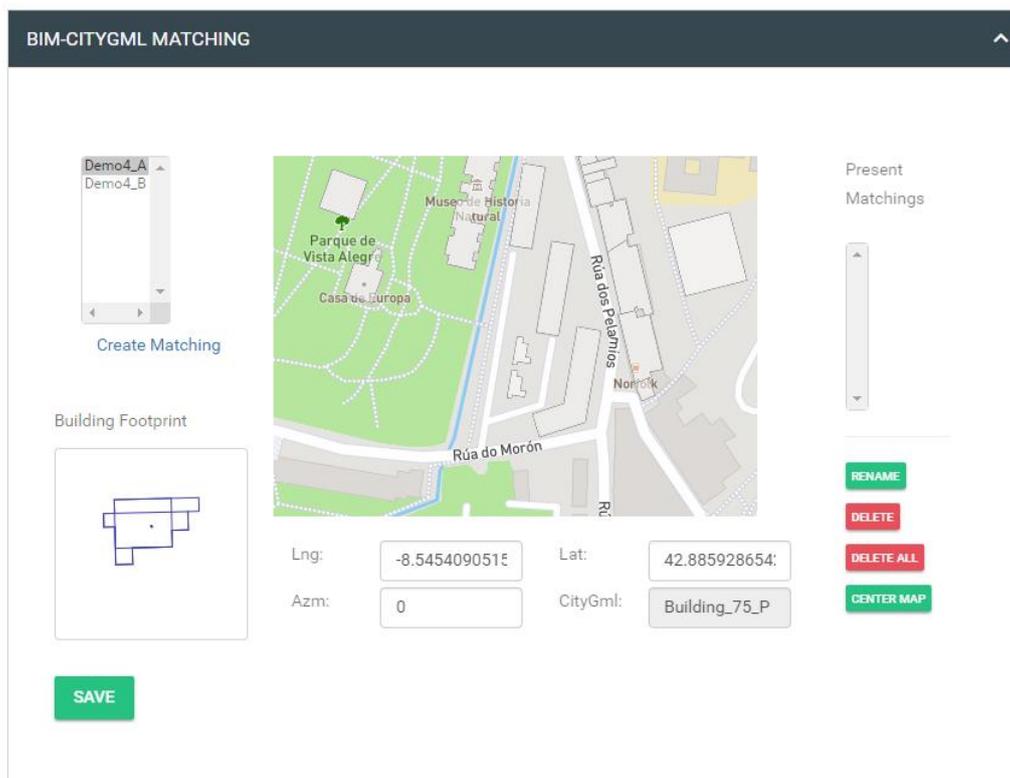


Figure 24: BIM – CityGML matching (step 1: selecting the relevant IFC model)

- **Step 2:** Select the corresponding building footprint on the *District map*

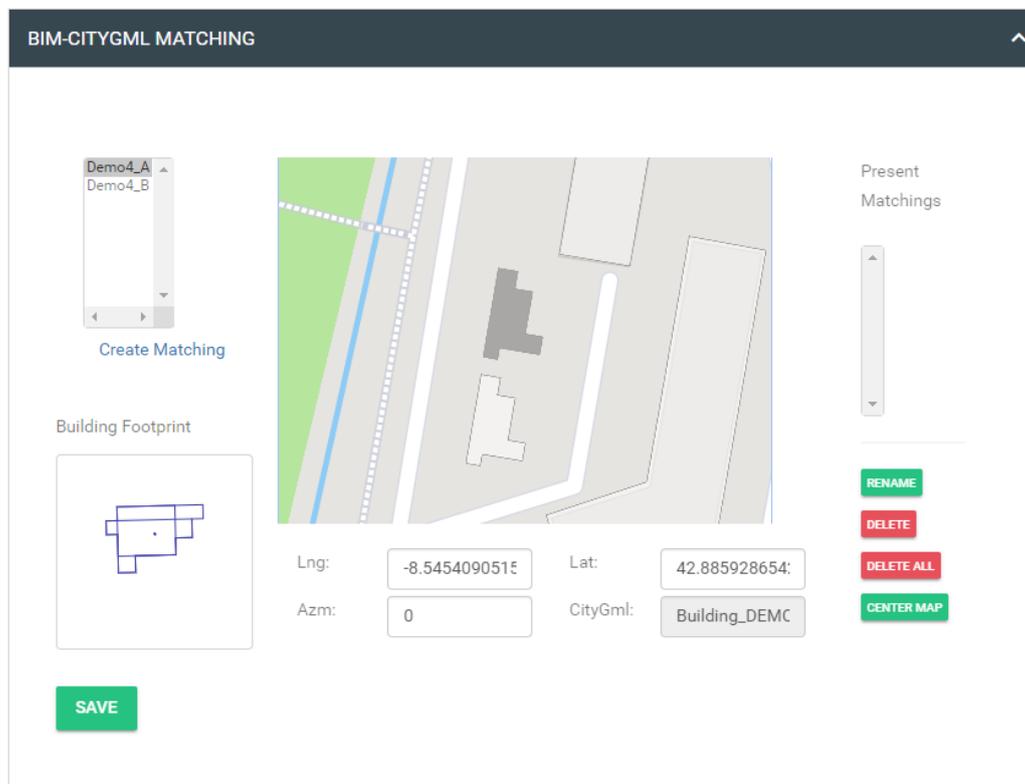


Figure 25: BIM – CityGML matching (step 2: selecting the relevant building footprint)

- **Step 3:** Associate the selected IFC model and building footprint by clicking on the “Create Matching” button

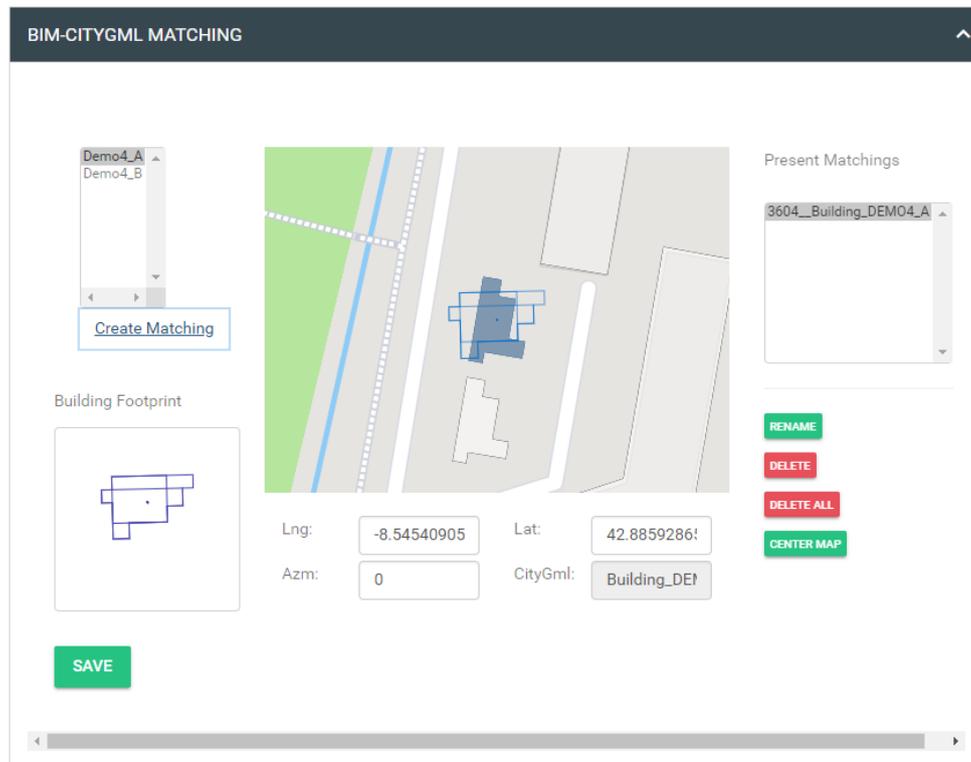


Figure 26: BIM – CityGML matching (step 3: displaying the IFC footprint on the district map)

- **Step 4:** Adjust the IFC footprint (blue lines) and the building footprint (dark grey area) to make them fit. For this, use the *Move/Rotate* fields. The *Move/Rotate* fields can be used by directly entering numerical values or by clicking on a field and using the keyboard arrows to move the IFC footprint.

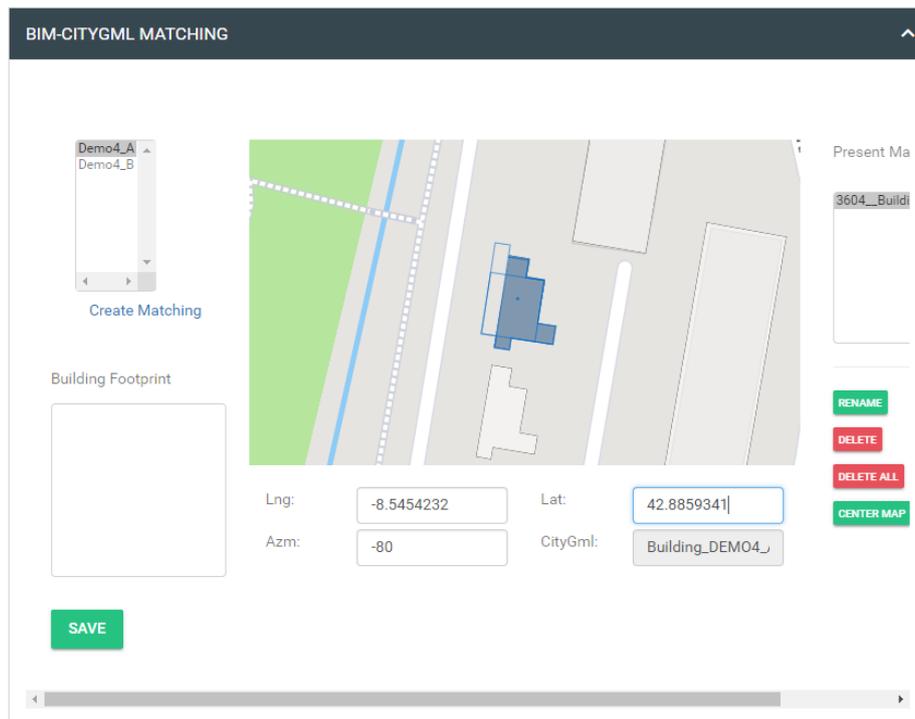


Figure 27: BIM – CityGML matching (step 4: adjusting the IFC and CityGML footprints)

- **Step 5:** Do Step 1 to Step 4 for all the other IFC models.
- **Step 6:** Save your matchings using the “Save” button

Note: It is important to click the “Save” button only after having done all the matchings. Indeed, when clicking the “Save” button, the platform starts calculating some parameters such as the shadows affecting the buildings under study. To properly run those calculations, the platform needs to know all the interactions between the buildings under study and the neighbouring buildings. Hence, all the matchings have to be defined before starting those calculations (i.e. before clicking the “Save” button). A warning pop up has been included in the platform when you click the “Save” button to prevent such action (see next figure).

Note: When the previously mentioned calculations are finished, the status of the IFC files will evolve from ORIGINAL (validated) to ENHANCED (validated and including information resulting from the calculations).

Note: The matching cannot be modified after saving. If this needs to be changed, files have to be deleted and the new matchings have to be saved.

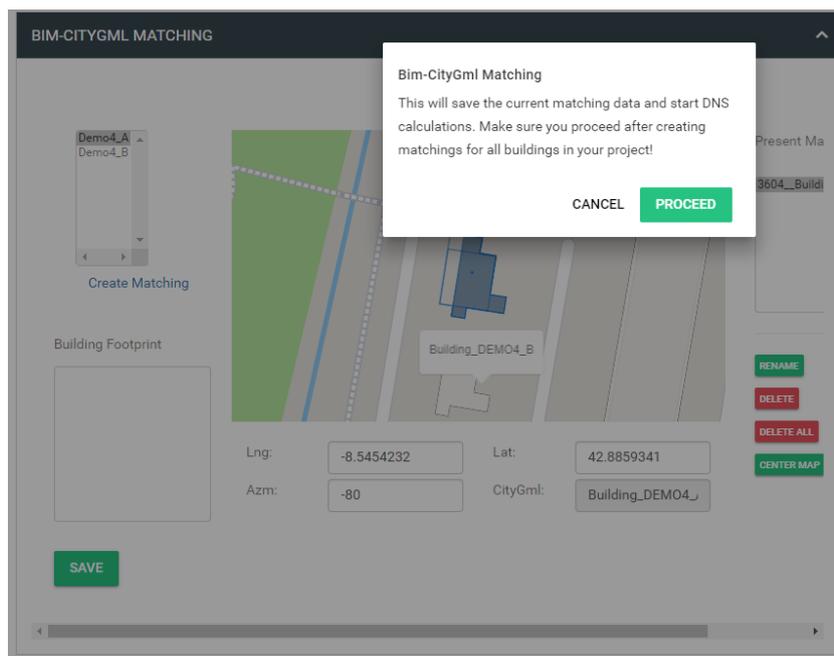


Figure 28: BIM – CityGML matching (warning pop up before saving)

When matchings are properly saved, a popup message appears. The user can then proceed with the next step by clicking on the “Next” button.

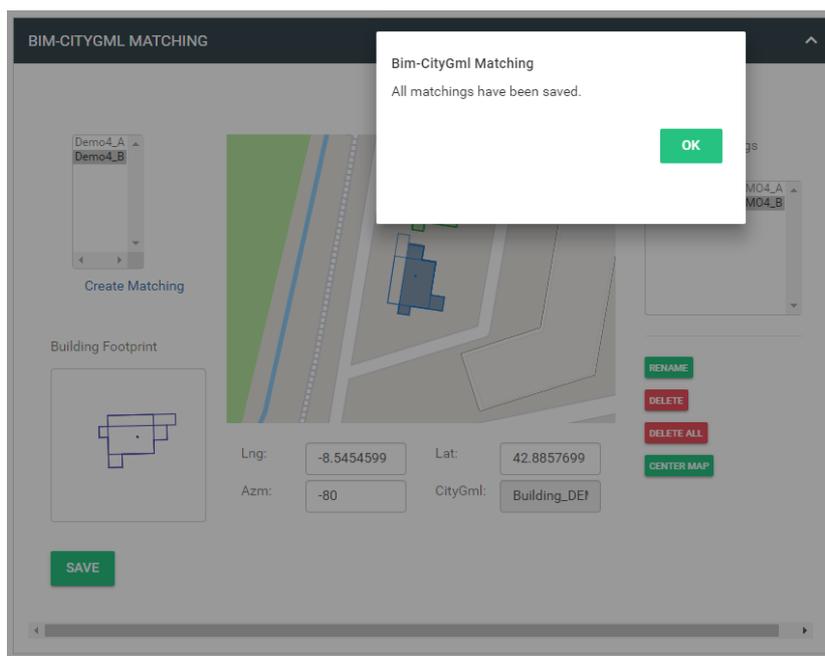


Figure 29: BIM-CityGML matching (popup confirming the correct saving of matchings)

5.1.4 STEP 3: Baseline Energy Systems

In this step, the user has to describe the existing energy systems at the district and building level. To do so, the user has to answer two questionnaires (one at district level and one at building level). The first questions asked are related to the district scale (Figure 53).

Note: The questionnaire will be available only when calculations from the previous step are finished (this could take up to several minutes). The calculations are finished when buildings appear in the building list

Note: Depending on the answers provided, additional questions might appear in the questionnaire (this is also true for the building scale questionnaire).

Demo
Data Created : 2018-09-10 10:01:35.0

Baseline Energy Systems

District Level Questions ^

Answer these questions regarding the district-level energy systems.

Q. Do you have a district energy supply system?

Yes

No

Building Level Questions ^

Please answer the questions below for building-level energy systems. You may select more than one building and answer the questions to apply the answers to all of the selected buildings.

Buildings

3605_Building_DEMO4_B.ifc

3604_Building_DEMO4_A.ifc

Figure 30: Baseline energy system questionnaire – District level

Once the district level questionnaire is answered, the user can proceed with the questionnaire at building level. Prior to answering the questionnaire, the user has to select the building(s) for which he wants to answer the questionnaire. Of course, in the end, answers need to be provided for all the buildings under study (Figure 54).

Demo
Data Created : 2018-09-10 10:01:35.0

Building Level Questions

Please answer the questions below for building-level energy systems. You may select more than one building and answer the questions to apply the answers to all of the selected buildings.

Buildings

3605_Building_DEMO4_B.ifc

3604_Building_DEMO4_A.ifc

Please answer these questions considering 3605_Building_DEMO4_B.ifc.

Q. Does this building have access to natural gas?

yes

no

Figure 31: Baseline energy system questionnaire – Building level

Note: Saving the answers provided will only work when answers are provided for all questions and all buildings. In order to save, you thus have to fill the questionnaire for all buildings (selecting them one by one if answers provided at different among them) and then proceed with the saving.

Note: In the building list (where you can select the buildings for which you want to answer the questionnaire), buildings for which no answers have been saved are mentioned in red. When answers are saved for a building, the building name appears in green ((Figure 55)

Demo
Data Created : 2018-09-10 10:01:35.0

Building Level Questions

Please answer the questions below for building-level energy systems. You may select more than one building and answer the questions to apply the answers to all of the selected buildings.

Buildings

3605_Building_DEMO4_B.ifc

3604_Building_DEMO4_A.ifc

Please answer these questions considering 3605_Building_DEMO4_B.ifc.

Q. Does this building have access to natural gas?

yes

no

Figure 32: Baseline energy system questionnaire – Building level saved

At the end of the questionnaire, the demand system for the different HVAC zones of the building (Figure 56) needs to be defined. The HVAC zones mentioned in this section are the ones that have been indicated by the user in the IFC model of the building. Thus, in order for the user to adequately identify each zone an appropriate name to each of them should be included in the IFC.

Demo
Data Created : 2018-09-10 10:01:35.0

Q. For each HVAC zone in this building, what is the demand system?
3605_Building_DEMO4_B.ifc

Zone_1:247818:

Zone_2:247829:

Zone_3:247830:

Zone_4:247831:

Zone_5:247832:

Zone_6:247833:

Figure 33: Baseline energy system questionnaire – Demand systems in the different HVAC zones

When all questions have been answered (i.e. all the building names are in green), the user can proceed with the next step by clicking the “Next” button.

5.1.5 STEP 4: Contextual data

In this step, the user will collect the remaining information needed to run the baseline calculations (climate data, socio-economic data...). To do so, the user has only to click on the “Query” button (Figure 57|Error! No se encuentra el origen de la referencia.). When clicking on this button, the platform automatically gathers the necessary information using web technologies.

Note: Contextual data automatically collected by the platform are gathered from the sources listed below. If the user has more detailed information, you can follow the process indicated below in order to modify this information.

- Climate data: Weather file from EnergyPlus
- Average yearly income: EUROSTAT
- Natural gas price data: EUROSTAT
- Fuel-oil price data: EUROSTAT
- Electricity data: EUROSTAT

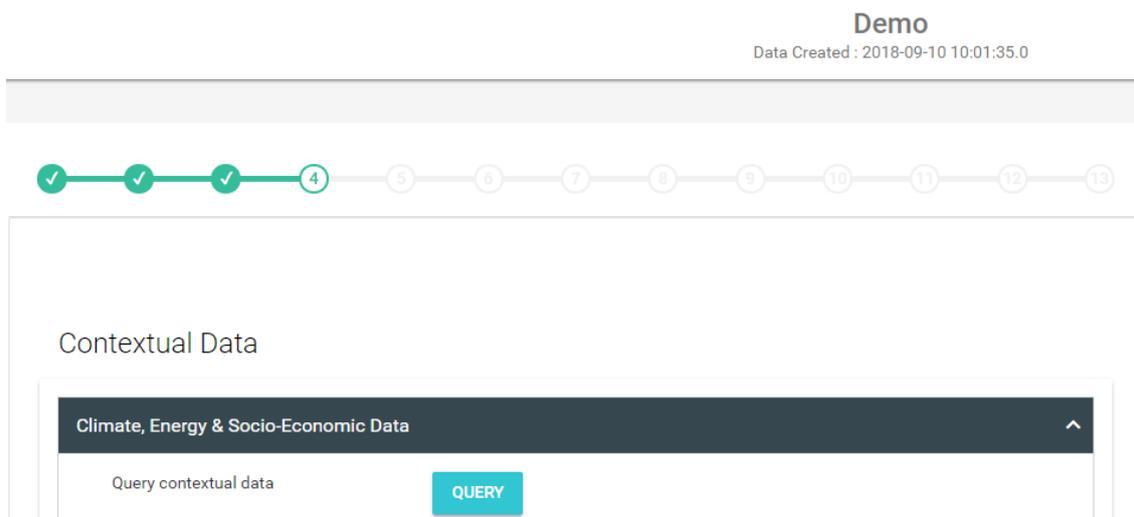


Figure 34: Contextual data – Initial screen

The results of the querying process are then displayed on the screen. Normally, the result of this process is “Found” for all the contextual data (Figure 58). If not, the user has to relaunch the querying process.

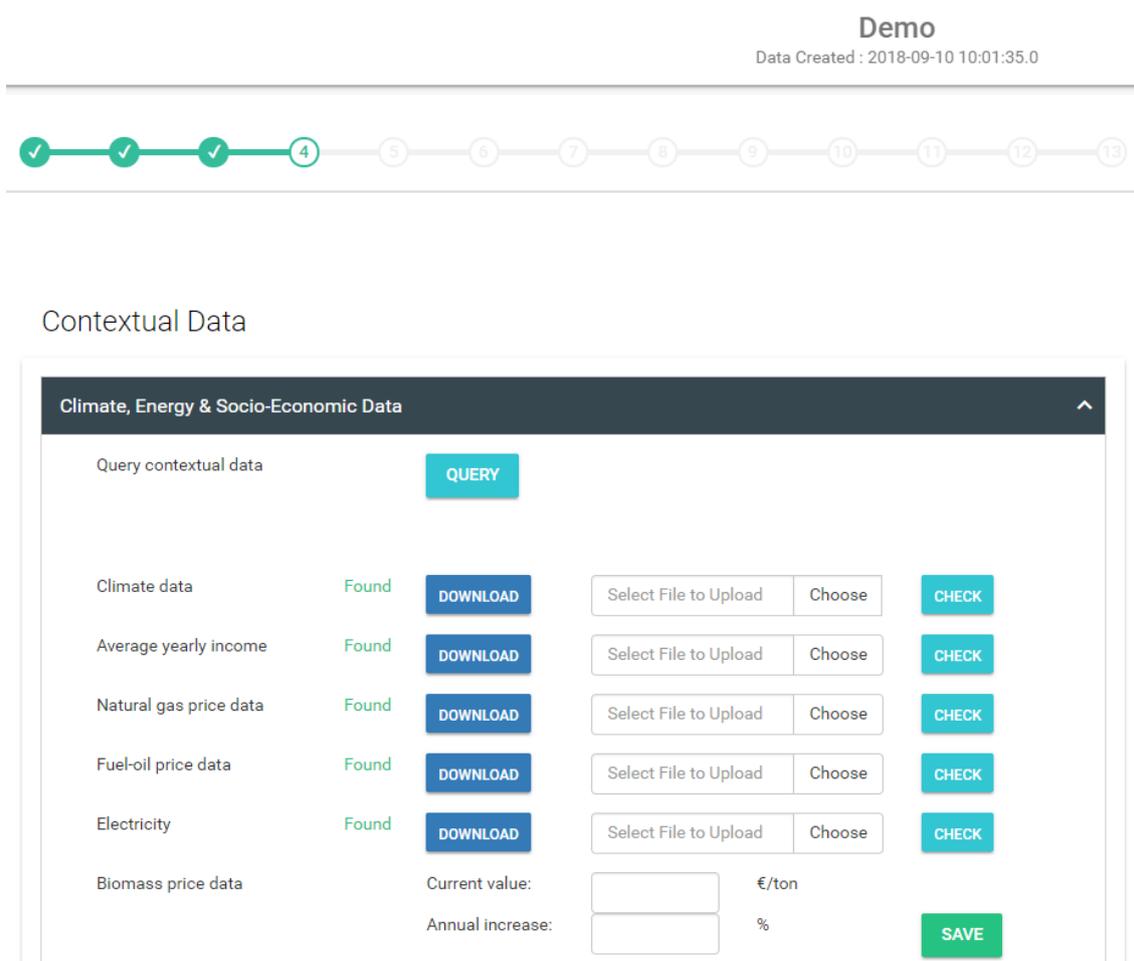


Figure 35: Results of the querying process

At this step, the user is able to download, check, modify and “re” upload the different files using the different buttons of the interface. This functionality is useful if the user wants to check the files which will be used in the simulations and/or modify them.

After having gathered (and eventually modified) the different files, the user has to introduce information related to biomass prices. This information is the current value (in €/ton) and the annual increase (in %) (Figure 59). This information is mandatory in order to save the collected information.

At this step, the user can click on the “Save” button and proceed with the next step.

Note: The OptEEmAL platform allows the user to visualise general information which is not needed in the calculations but which can be useful for the user (and other project members) in order to define the problem the platform will have to solve (i.e. the conditions of the district retrofitting project). It is important to note that this information is not mandatory to run the calculations. It is only displayed here for informative purposes. This information is mentioned in the “Site-related information” section of this step (Figure 59).

Demo
Data Created : 2018-09-10 10:01:35.0

Contextual Data

Climate, Energy & Socio-Economic Data
^

Query contextual data QUERY

Climate data	Found	DOWNLOAD	Select File to Upload	Choose	CHECK
Average yearly income	Found	DOWNLOAD	Select File to Upload	Choose	CHECK
Natural gas price data	Found	DOWNLOAD	Select File to Upload	Choose	CHECK
Fuel-oil price data	Found	DOWNLOAD	Select File to Upload	Choose	CHECK
Electricity	Found	DOWNLOAD	Select File to Upload	Choose	CHECK
Biomass price data			Current value: <input style="width: 50px;" type="text" value="22.5"/>	€/ton	
			Annual increase: <input style="width: 50px;" type="text" value="3"/>	%	SAVE

Site-related Information
v

Figure 36: Collected contextual data (in red the part dedicated to general site related information)

After having saved the contextual data, the user can launch the baseline calculation process clicking on the “Calculation baseline values” button. A popup message appears prior to launching the calculation process (Figure 60). A message is also displayed when the calculation process is started (Figure 61).

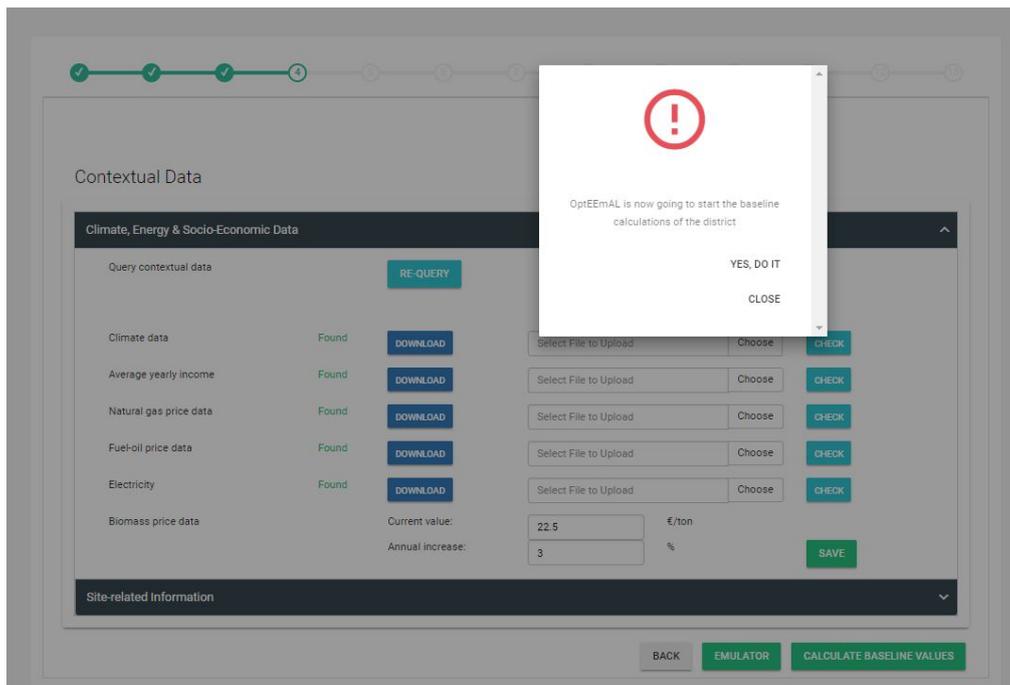


Figure 37: Popup message prior to launch the baseline calculation process

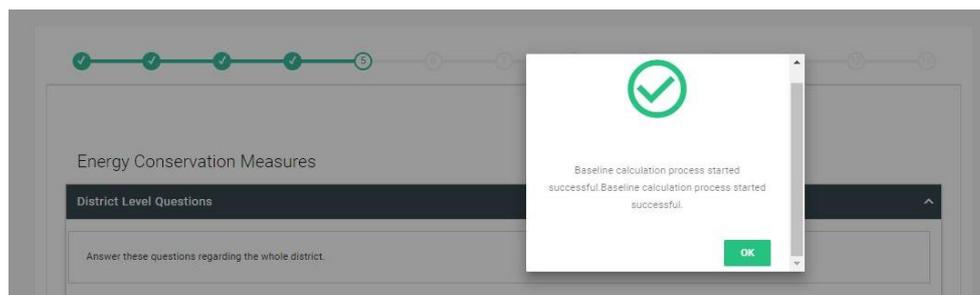


Figure 38: Popup message for the successful start of baseline calculation

When the user clicks on “OK”, he is automatically directed to the next step.

Note: The baseline calculation process is a “background” process in OptEEmAL (not visible from the user perspective). It means that the user will continue to define the problem (going through the next steps of the platform) while the platform will calculate the baseline situation. Results for the baseline situation will be displayed in a later stage of the process.

5.1.6 STEP 5: Energy Conservation Measures

In OptEEmAL, an Energy Conservation Measure (ECM) is an energy retrofitting measure that can be applied on a building to improve its energy performance. A scenario is a combination of ECMs to be applied on the different buildings of a district.

At this step, the user has to answer a questionnaire which will automatically select, among all the ECMs available in the OptEEmAL platform, the ones which can be applied on the buildings under study.

This page is also broken down into two parts: one dedicated to the district scale (upper part) and one dedicated to the building part (lower part)

Figure 39: Energy Conservation Measures questionnaire (overview)

First, the user has to answer the district scale related questions. Similarly to the Baseline Energy Systems questionnaire, this questionnaire evolves depending on the answers provided by the user.

Energy Conservation Measures

Figure 40: Energy Conservation Measures questionnaire (district scale related questions)

When all questions have been answered at the district scale, the user can continue with the questionnaire at building scale. To fill this questionnaire, the user has to select the buildings for which he wants to provide its answers using the checkboxes. It is also possible to select all buildings if answers are the same between the different buildings under study.

Note: Similarly to Baseline Energy Systems questionnaire, all the questions for all the buildings have to be answered before saving the answers.

Figure 41: Checkboxes for the selection of the buildings

When all the answers for all the buildings are answered, the user can save using the “Save” button and proceed to the next step.

5.1.7 STEP 6: Check Strategies

Based on the answers provided at the previous step, the platform automatically generates a set of applicable ECMs for the different buildings under study. In addition to this automatic choice, the user can disable other ECMs. This can be done using the Check Strategies screen.

Figure 42: Check strategies (overview)

As a first step, the user has to select a building. Once a building is selected, the list of automatically selected ECMs appears and the user can enable/disable the different ECMs using the checkboxes. The user is also able to edit the different cost items: sales price, installation cost and maintenance cost with its specific values (if available) (Figure 66).

Check Strategies

Based on your input, OptEEmAL has determined the following applicable Energy Conservation Measures. You may edit the sales price, installation and maintenance costs and/or remove them the pool of applicable measures by unchecking their checkboxes.

Buildings

3332_Building_...

3333_Building_...

District

Active						
ECM Name	Type	Application Scale	Applied <input checked="" type="checkbox"/>	Sales Price	Installation Cost	Maintenance Cost
Biomass boiler with 20 kW of nominal capacity	A	B	<input checked="" type="checkbox"/>	1960	108	1960
Biomass boiler with 40 kW of nominal capacity	A	B	<input type="checkbox"/>	3800	216	3800
Biomass boiler with 60 kW of nominal capacity	A	B	<input checked="" type="checkbox"/>	5562	324	5562
Biomass boiler with 300 kW of nominal capacity	A	BD	<input type="checkbox"/>	25500	1620	25500

Figure 43: Check strategies (enabling/disabling ECMs)

Note: When no answers have been saved for a given building, the building name appears in black. When at least one saving has been made, the building name appears in green (Figure 67)

Check Strategies

Based on your input, OptEEmAL has determined the following applicable Energy Conservation Measures. You may edit the sales price, installation and maintenance costs and/or remove them the pool of applicable measures by unchecking their checkboxes.

Buildings

3332_Building_...

3333_Building_...

District

Active						
ECM Name	Type	Application Scale	Applied <input checked="" type="checkbox"/>	Sales Price	Installation Cost	Maintenance Cost
Biomass boiler with 20 kW of nominal capacity	A	B	<input checked="" type="checkbox"/>	1960	108	1960
Biomass boiler with 40 kW of nominal capacity	A	B	<input type="checkbox"/>	3800	216	3800
Biomass boiler with 60 kW of nominal capacity	A	B	<input checked="" type="checkbox"/>	5562	324	5562
Biomass boiler with 300 kW of nominal capacity	A	BD	<input type="checkbox"/>	25500	1620	25500

Figure 44: Check strategies (saved answers for one building)

5.1.8 STEP 7: Baseline Performance

At this step, the user can visualize the baseline performance (i.e. the results obtained for the different DPIs considered in OptEEmAL). Results are presented per DPI category (energy, environmental, economic...). No action is required at this step.

Note: If the baseline calculation is not finished (or has not been performed), this page will indicate a “There is no data” indication in the different DPI categories.

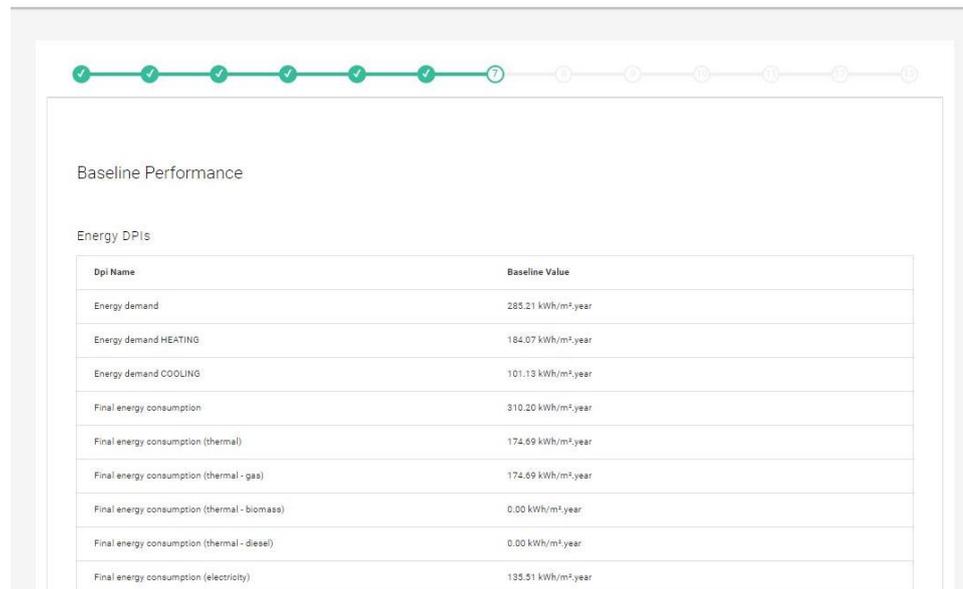


Figure 45: Baseline Performance results

5.1.9 STEP 8: Targets and Boundaries

Knowing the baseline performance, the user can then start to set the objectives of its retrofitting project. In OptEEmAL, “objectives” are defined as targets and boundaries. First of all, the user has to define the following mandatory targets:

- Investments (in €)
- Payback Period (in years)
- Energy Payback Time (in years)

Then the user can define optional targets (question 3 in the figure below) as well as boundaries (question 2 in the figure below).

Targets and Boundaries

Targets and boundaries are the constraints that you may want applied to your retrofitting project. Please fill the questionnaire below for OptEEmAL to consider these constraints in the simulations.

1. What are the maximum values you want to consider for these topics?

Investments (in Euro) €

Payback Period years

Energy payback time years

2. Are there values that you would like not to be surpassed?

Yes No

3. Are there target values that you would like to be achieved?

Yes No

Figure 46: Introduction of targets and boundaries

In order to enter the values for optional targets and/or boundaries, the user has to answer “Yes” to question 3 and 2 respectively. If the user answers “Yes” to one of these questions, then the list of DPIs appears and the user can enter the associated values.

2. Are there values that you would like not to be surpassed?

Yes No

3. Are there target values that you would like to be achieved?

Yes No

COMFORT MEASURES ▾

ECONOMIC MEASURES ▾

ENERGY MEASURES ▴

	Value	(unit)
Energy demand	<input type="text"/>	(kWh/m2.year)
Final energy consumption	<input type="text"/>	(kWh/m2.year)
Degree of energetic self-supply	<input type="text"/>	(kWh/kWh)
Net fossil energy consumed	<input type="text"/>	(kWh/m2)
Energy demand covered by renewable sources	<input type="text" value="50"/>	(%)

Figure 47: Entering optional targets and boundaries

After the introduction of the relevant values, the user has to save its answers by clicking the “Save” button.

5.1.10 STEP 9: Prioritization Criteria

The next step for the user is to enter its prioritisation criteria. Prioritisation criteria are weightings used to give more importance to certain DPI in comparison to each other. In OptEEmAL, two different ways can be used to define those criteria:

- Use pre-defined weighting schemes
- Use manual prioritisation criteria

Prioritization Criteria

Choose either Use Pre-defined Weighting Scheme for the simpler option or Use Manual Prioritisation Criteria for the detailed option.

Use Pre-Defined Weighting Schemes Use Manual Prioritisation Criteria

Use Pre-Defined Weighting Schemes

What is your main objective(s) to be achieved within the OptEEmAL platform?

To achieve a nearly-zero-energy district

To achieve a carbon-neutral district

To promote energy generation through renewable systems

Priority to energy generation through renewables (panels – solar thermal and photovoltaic)

To promote energy generation through a district heating network

To prioritise environmental issues.

To prioritise the reduction of operational energy costs

Do you want to prioritise economic aspects as well? Yes No

RESET SAVE

Figure 48: Selecting the desired option for prioritisation criteria definition

If the user wants to use pre-defined weighting schemes, he “only” has to select the main objective among the ones proposed by the platform. There is also an option to prioritise economic aspects as well if needed. After clicking on “Save” the platform shows the results of using this pre-defined schemes in terms of final weighting factors which will be considered in the OptEEmAL calculation process (Figure 72).

Use Pre-Defined Weighting Schemes

What is your main objective(s) to be achieved within the OptEEmAL platform?

To achieve a nearly-zero-energy district

To achieve a carbon-neutral district

To promote energy generation through renewable systems

Priority to energy generation through renewables (panels – solar thermal and photovoltaic)

To promote energy generation through a district heating network

To prioritise environmental issues.

To prioritise the reduction of operational energy costs

Do you want to prioritise economic aspects as well? Yes No

Prioritisation Criteria Results

COSTS		BENEFITS (Level 1)		BENEFITS (Level 2)	
Investments (in Euro)	21.04%	Local thermal comfort	3.05%	Energy use from Biomass	16.67%
Life cycle cost	11.23%	Energy demand	19.79%	Energy use from PV	16.67%
Payback Period	21.04%	Final energy consumption	34.52%	Energy use from Solar Thermal	16.67%
Global Warming Potential - GWP (kg CO2)	6.11%	Net fossil energy consumed	19.79%	Energy use from Hydraulic	16.67%
Primary energy consumption	37.73%	Energy demand covered by renewable sources	19.79%	Energy use from Mini-Eolic	16.67%
Energy payback time	2.85%	Energy use from District Heating	3.05%	Energy use from Geothermal	16.67%

Figure 49: Results of using pre-defined prioritisation criteria

The other option for the user is to define manually the weighting factors. This can be done selecting the relevant option at the top of the screen. Then, sliders can be moved to prioritise one DPI against another and in the end get a full set of weighting factors (Figure 73).

Note: For the manual definition of weighting factors, the user has to go through the three pages of manual definition before being able to save its choices and visualise the obtained weighting factors.

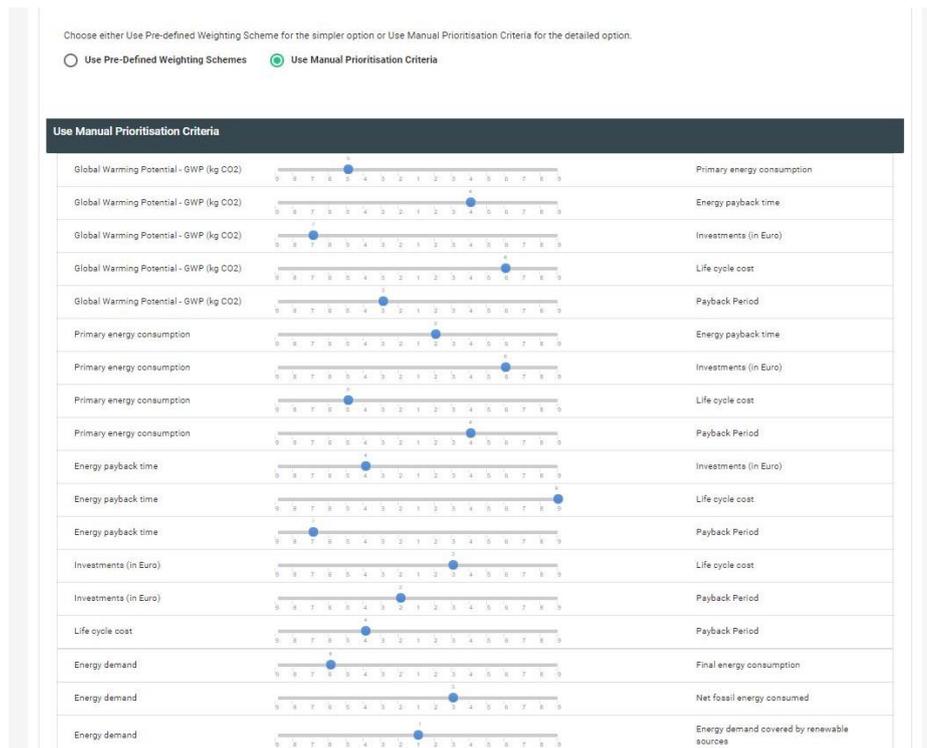


Figure 50: Manual definition of weighting factors

5.1.11 STEP 10: Problem Summary

At this step, the user can have a global picture of the “problem” to be solved that he has defined and visualise both the baseline DPI values (Figure 74) and the selected ECMs that are applicable, that is, that they will be considered in the process (Figure 75). This screen is only presented for information and no action is required from the user.

Problem Summary

Baseline Performance

Energy DPI's

DPI Name	Baseline Value	Target	Boundaries Min	Boundaries Max
Energy demand	285.21 kWh/m ² .year	n/a	n/a	n/a
Energy demand HEATING	184.07 kWh/m ² .year	n/a	n/a	n/a
Energy demand COOLING	101.13 kWh/m ² .year	n/a	n/a	n/a
Final energy consumption	310.20 kWh/m ² .year	n/a	n/a	n/a
Final energy consumption (thermal)	174.69 kWh/m ² .year	n/a	n/a	n/a
Final energy consumption (thermal - gas)	174.69 kWh/m ² .year	n/a	n/a	n/a
Final energy consumption (thermal - biomass)	0.00 kWh/m ² .year	n/a	n/a	n/a
Final energy consumption (thermal - diesel)	0.00 kWh/m ² .year	n/a	n/a	n/a
Final energy consumption (electricity)	135.51 kWh/m ² .year	n/a	n/a	n/a
Net fossil energy consumed	0.00 kWh/m ²	n/a	n/a	n/a
Energy demand covered by renewable sources	0.00 %	50	n/a	n/a
Energy use from District Heating	0.00 kWh/m ² .year	n/a	n/a	n/a
Energy use from Biomass	0.00 kWh/m ² .year	n/a	n/a	n/a
Energy use from PV	0.00 kWh/m ² .year	n/a	n/a	n/a
Energy use from Solar Thermal	0.00 kWh/m ² .year	n/a	n/a	n/a

Figure 51: Visualisation of baseline DPIs in the problem summary

TEST D6.1 180904

Data Created : 2018-09-04 11:21:23.0

Applied ECMs

Buildings

- 3541_Building...
- 3542_Building...

Active ▼

Passive ▲

ECM Name	Type	Application Scale	Sales Price	Installation cost	Maintenance Cost
Passive Façade External Thermal Insulation Composite System - EPS 50mm	P	B	26	45.45	26
Passive Façade External Thermal Insulation Composite System - EPS 100mm	P	B	35.5	45.45	35.5
Passive Façade External Thermal Insulation Composite System - EPS 150mm	P	B	45	45.45	45
Passive Façade External Thermal Insulation Composite System - EPS 200mm	P	B	54.5	45.45	54.5
Passive Façade External Thermal Insulation Composite System - EPS 250mm	P	B	64	45.45	64
Passive Façade Internal insulation + plasterboard - Mineral wool 40mm	P	B	24.6	15.84	24.6
Passive Façade Internal insulation + plasterboard - Mineral wool 60mm	P	B	27.2	15.84	27.2
Passive Façade Internal insulation + plasterboard - Mineral wool 80mm	P	B	29.8	15.84	29.8
Passive Façade Internal insulation + plasterboard - Mineral wool 100mm	P	B	32.4	15.84	32.4
Passive Roof Pitched Internal Insulation - Mineral wool 40mm	P	B	24.6	15.84	24.6
Passive Roof Pitched Internal Insulation - Mineral wool 60mm	P	B	27.2	15.84	27.2
Passive Roof Pitched Internal Insulation - Mineral wool 80mm	P	B	29.8	15.84	29.8

Figure 52: Visualise applied ECMs in the problem summary

If the user agrees with the information presented, he can start the optimisation process clicking on the “Start Optimisation” button. In this case, a warning message is presented to the user indicating that the calculation time for the optimisation can be significant. If the user confirms, then the optimisation process is launched.

Note: If any of these parameters needs to be changed, you should go back to the corresponding step to edit the required information.

5.1.12 STEP 11: Optimization Progress

This screen is used to present to the user the status of the optimisation process. The message will go from “Started” to “Finished” if the optimisation process has successfully ended. In addition, an error message will be displayed to the user if the optimisation process has not ended successfully.



Figure 53: Optimisation progress

5.1.13 STEP 12: Select Optimal Scenario

When the optimisation process is finished, the user can visualise the Pareto Front resulting from the optimisation. Among this set of scenarios, the user has to select the one that suits the best its objective. To do so, the user is able to select a scenario (by clicking directly on the graph or on the right side of the screen in the “scenarios” section).

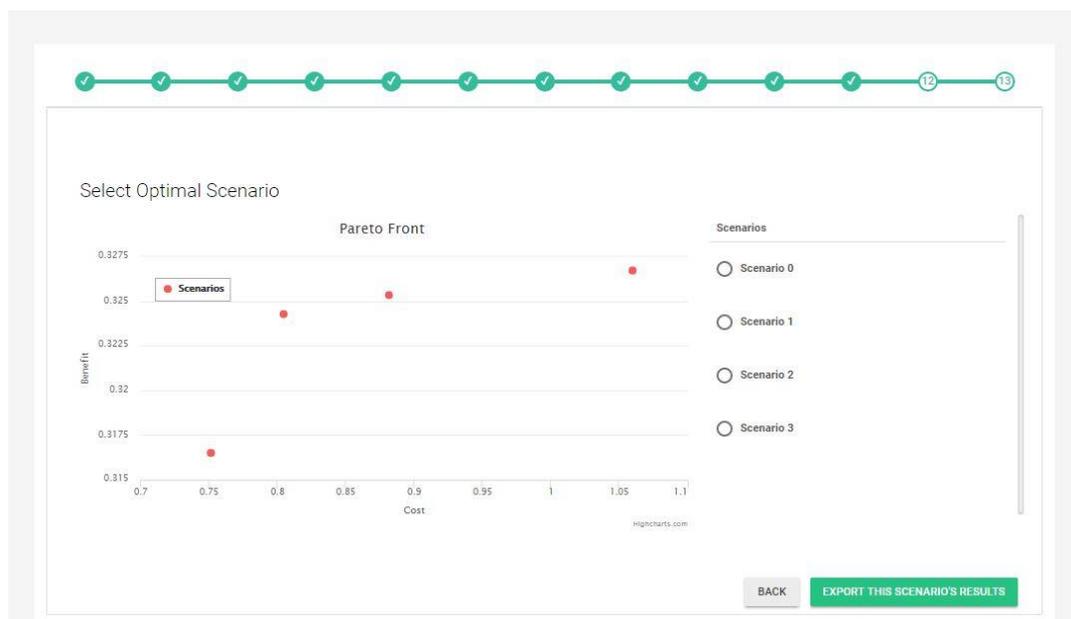


Figure 54: Visualisation of the optimisation results

After having selected a scenario, the user is able to visualise the values for each DPI for this scenario (Figure 78) as well as the ECMs that have been considered in this scenario for each building of the district (Figure 79).

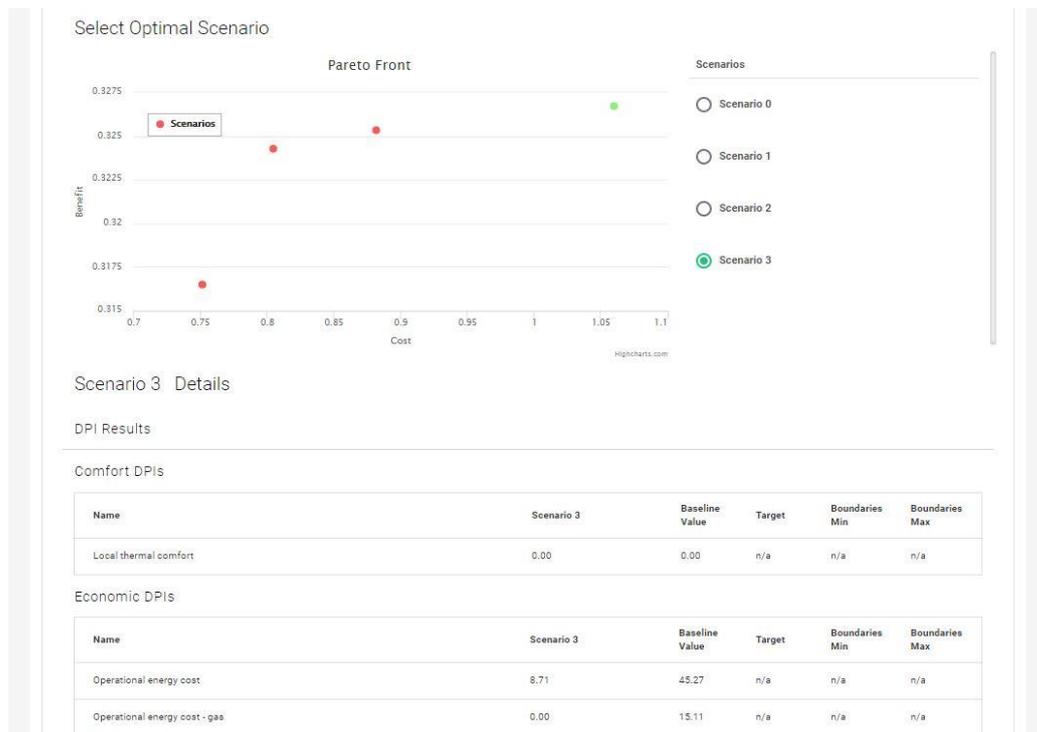


Figure 55: Visualisation of detailed results (DPIs) for a selected scenario

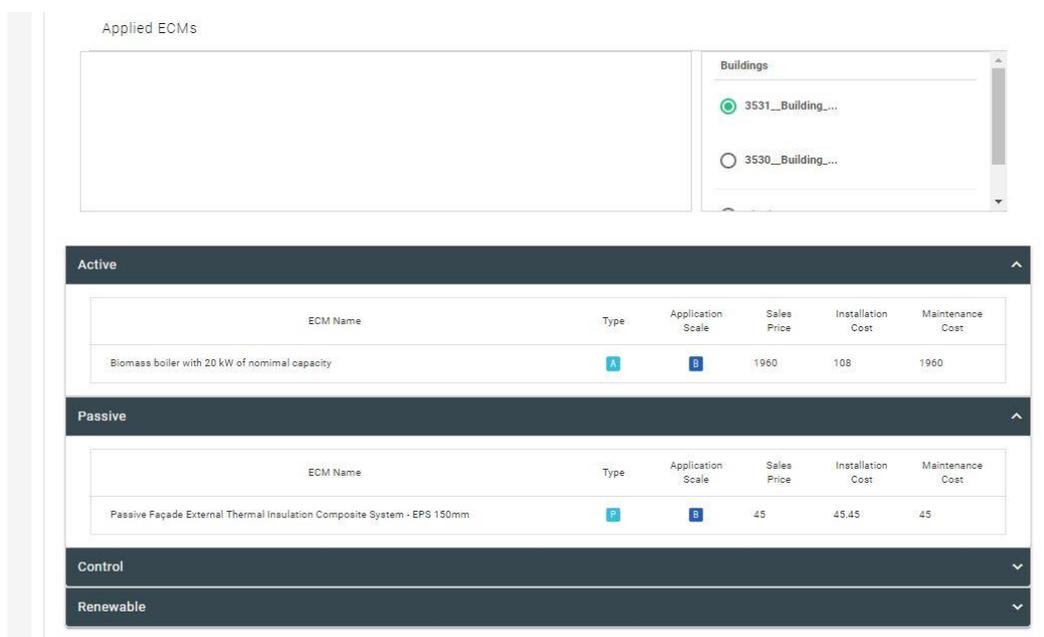


Figure 56: Visualisation of detailed results (applied ECMs) for a selected scenario

After having selected its optimal scenario, the user can generate all the information associated to this scenario by clicking on the “Export” button.

5.1.14 STEP 13: Export

After the generation of the files to be exported, the user can download the different files presented in the figure below. These files are:

- **Reports (in xls format):** Those reports contain detailed information about the baseline results, the problem definition, the final scenario or the applied ECMs (see example in Figure 82).
- **IFC or CityGML files** (clicking on the “Download” button in the relevant section): Those files are the ones uploaded by the user in the beginning of the OptEEmAL process (“Data upload” section). The user can download the different IFC files for the different buildings studied or the CityGML file of the district under study.
- **RDF files** (clicking on the “Open” button in the relevant section (Figure 81): Those files are the different data models (EnergyCarrier, SocialData, UrbanData...) in RDF format generated all along the OptEEmAL process.

Export

Reports

Name	Download
Baseline results	DOWNLOAD
Problem definition	DOWNLOAD
Final scenario	DOWNLOAD
ECM general info	DOWNLOAD

Type	Name	Models	Download
District	District	OPEN	Not Found
IFC	3541_Building_DEMO4_A	OPEN	DOWNLOAD
IFC	3542_Building_DEMO4_B	OPEN	DOWNLOAD

[BACK](#)

Figure 57: Files to be exported by the user

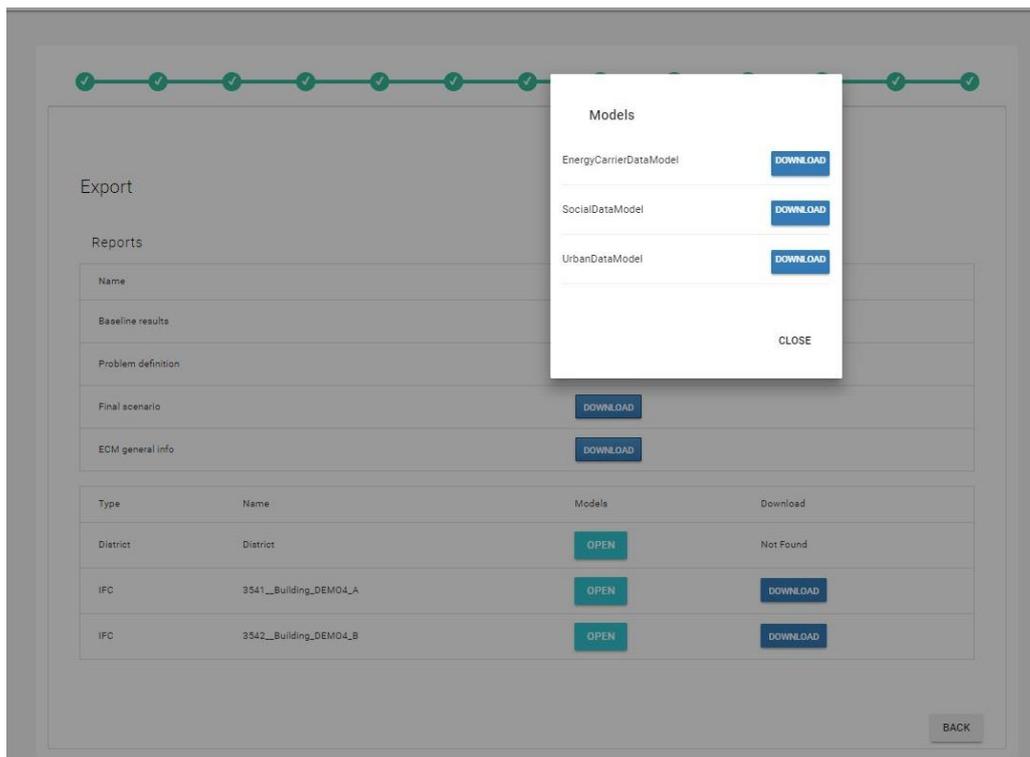


Figure 58: Available data models for download

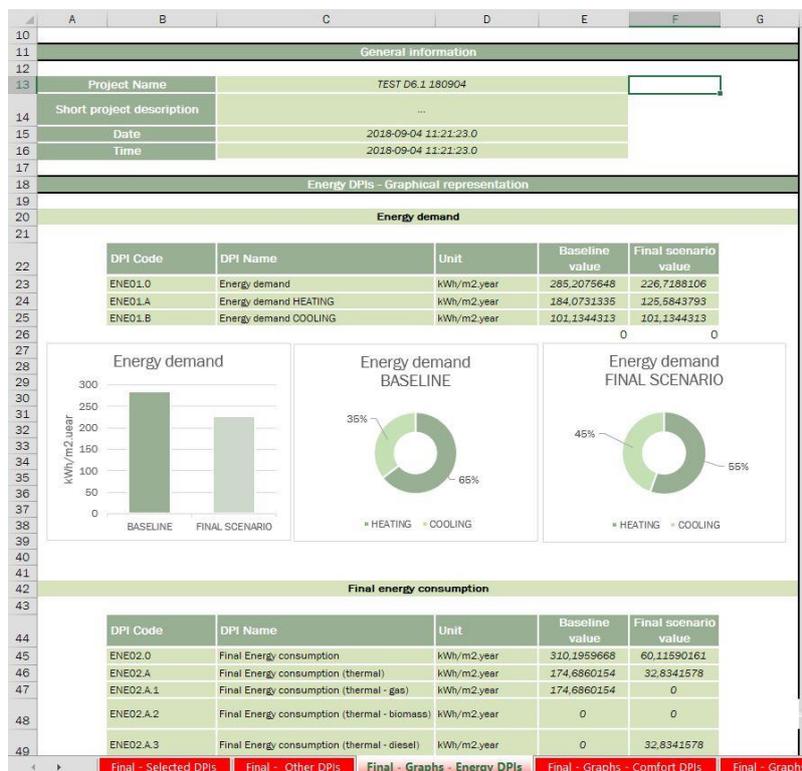


Figure 59: Report example

5.2 Help in line

The following instructions are showed to the user in each of the thirteen steps of the OptEEemAL process as a reference for knowing which interaction with the application is required.

STEP1: IPD Group

As the *Owner* of this new project, the first action is to invite the representatives of the building and the architectural sectors to your project. These representatives are referred to as the Prime Constructor and the Prime Designer. Together with you, they will form the IPD Group of your project. You will work in collaboration to specify the existing status and the intended status of the district that you want to have refurbished.

Please type the names and e-mail addresses of the representatives that you want to assign the roles of the Prime Designer and the Prime Constructor into the invitation text boxes, and click on the invite buttons. This will send invitational e-mail messages to these individuals. If they accept the invitations, you will see their names and roles in this project's IPD Group list along with your name. Please invite only one representative for each of the roles.

STEP2: Data Upload & Matching

OptEEemAL platform makes use of one CityGML file and as many BIM files as needed for the buildings that are aimed to be refurbished. The CityGML file must contain the geometries of the target buildings in the project's district, along with those structures that would cast shadow on the buildings that will be refurbished. The CityGML file and the BIM files must be prepared in accordance with the specific *Guidelines for CityGML Files*, and the *Guidelines for BIM Files*.

You must upload the CityGML file that represents the district, and the BIM files that represent the models of the buildings. If more than one building is being constructed using and they are using the same blueprint, only one BIM file will be adequate; you do not need upload separate BIM files for those buildings.

After the file upload is complete, you must click the "Check" buttons next to the row of each file. OptEEemAL platform will check the files for compatibility with the platform. The files that fail this test must be revised according to the *CityGML Guidelines* and the *BIM Guidelines*. Status of the files passing the test will be changed from TEMP to ORIGINAL.

After the validation step, you must assign the BIM blueprints to the proper CityGML geometries. To do so, reload the page, and then click on one of the file names in the list of BIM files next to the map, and click on the appropriate CityGML geometry (building footprint). Finally click the "Create Matching" button. This will create a locational matching between the building's BIM footprint and CityGML geometry. Change and fine tune the latitude, longitude and rotation of the BIM footprint to match the borders of the CityGML geometry for a better geometrical match. Keep in mind that only one CityGML geometry can be used in only one matching, whereas the same BIM file may be used in more than one matching.

When you are done with specifying the matchings, click the SAVE button once. The platform will inform you that the matchings have been saved. You may advance to the next step after this message.

WARNING: If you delete the CityGML file that you uploaded, all of the proceeding steps will be nullified, and you will have to complete those steps again. If you make any changes to any of the matchings after they are saved (such as latitude, longitude, rotation or name changes) and save the new values, you will have to perform again the proceeding steps of the platform.

STEP 3: Baseline Energy Systems

This step requires that you fill out a questionnaire about the energy systems of your district. The energy systems are divided into two: district-level and building-level systems. You must complete the district level questions once and fill out the building-level questions per each building. If more than one building has the same type of energy systems, you may select all of them, and fill out the questionnaire once for all of the selected buildings.

STEP 4: Contextual Data

The location of the district affects the climate data, energy and socio-economical values. The OptEEmAL platform performs a search for you based on the location of the district. Once you perform a QUERY, you may download and examine the data found by the platform. In case these data is correct, you may upload your own data with the same format as the found files. The files that you want to upload must be checked before further processing. Thus, you must click the CHECK button next to the upload button of each file.

After completing this step and saving the data, the OptEEmAL platform will be able to compute the energy performance of the district, namely the Baseline Performance. While it is computed, you may proceed to the next step.

STEP 5: Energy Conservation Measures

This step contains a questionnaire for the OptEEmAL platform to determine the applicable optimization measures, which are called the Energy Conservation Measures. Fill out the questionnaire considering the district level context, and considering building-level context for each building.

STEP 6: Check Strategies

Based on your answers in the previous step, the applicable Energy Conservation Measures were determined by the OptEEmAL Platform. You may disable any of the measures that you deem inapplicable, or change the sales price, installation and annual maintenance costs of individual measures.

STEP 7: Baseline Performance

Once the baseline performance of the district has been computed, you will see the values in various fields here. This page is intended to inform you about the existing energy performance of your district, and it will represent the base level at the end of the optimization phase.

STEP 8: Targets and Boundaries

The OptEEmAL Platform needs to know about the financing and return of investment that you target regarding your refurbishment project. This step consists of three sections. Fill out the first section according to your project's intended values. Later, fill out the second section for any values that you want not surpassed by the optimization algorithm. Finally fill out the third section considering any target values that you want to be achieved in the optimization phase.

STEP 9: Prioritization Criteria

The OptEEmAL Platform needs to know about the criteria that you want to be prioritized in the optimization phase. You may specify these in one of the two provided options. If you want to make use of pre-defined criteria considering popular prioritization aims, you may use the “Use Pre-Defined Weighting Schemes” option. If you want a more detailed approach to specify your district’s prioritization requirements, select the “Use Manual Prioritization Criteria” option. This option will show you several optimization criteria ordered in a pair-wise manner. For each pair-wise comparison, set the slider as close to the option as you deem important compared to the opposing one. Once you are finished with every pair, save your selection by clicking the SAVE button.

STEP 10: Problem Summary

You are presented with a summary of the result of the choices that you made in the previous steps and the baseline performance of the district. These are intended to be informative only. If you need to change anything, you should go back to the relevant step and make the necessary changes. When you are comfortable with the summary of your choices, start the optimization phase by proceeding to the next step.

STEP 11: Optimization Progress

Current status of the optimization phase is shown in this page. You may proceed to the next step once the optimization is finished.

STEP 12: Select Optimal Scenario

During the optimization phase, the OptEEmAL Platform has performed many computations considering the data that you entered. Each scenario shown here represent an outcome of the optimization, with different Energy Conservation Measures applied to the baseline state of the district, resulting in different amounts of cost and benefit. You may select any of the scenarios to see their energy performance levels, in comparison with the baseline values. The graph shows relative performance of each scenario in terms of cost and benefit. Keeping in mind that the concepts of cost and benefit shown in the graph are of indicative and relative nature, you may select any of the scenarios and proceed to the next step to export its reports.

STEP 13: Export

OptEEmAL Platform generates and shows the reports and files for the scenario that you have selected in the previous phase. Please wait for all the reports to be generated, since the report generation may take a while. Once they are ready, you may download them to examine the applied measures and other details.

6 E-guide on IPD implementation

In order to illustrate and explain how the Integrated Project Delivery approach (IPD) has to be applied when using the OptEEmAL platform the following E-Guide has been developed. It is integrated within the Platform's GUI in a box where, all the IPD related materials information is included, in each step of the thirteen steps in the OptEEmAL process.

As already mentioned the first action for interacting with the platform is to register in the platform and create or access to a project. At the same time as a new project is created the IPD group has to be created. This is the first STEP.

6.1 Introduction

From the "Integrated Project Delivery" by The American Institute of Architects:

"Integrated Project Delivery (IPD) is a project delivery approach that integrates people, systems, business structures and practices into a process that collaboratively harnesses the talents and insights of all participants to optimize project results, increase value to the Owner, reduce waste, and maximize efficiency through all phases of design, fabrication, and construction.

IPD principles can be applied to a variety of contractual arrangements and IPD teams can include members well beyond the basic triad of Owner, architect, and contractor. In all cases, integrated projects are uniquely distinguished by highly effective collaboration among the Owner, the Prime Designer, and the Prime Constructor, commencing at early design and continuing through to project handover.

This paradigm intends to change the traditional way of developing a construction project for enabling that disparate groups could come together around a shared goal, across departments, geographies reducing this way modifications in the construction site."

6.2 IPD Concept

The IPD concept can be described as to come back to the "master builder" concept in which all the disciplines are integrated from the beginning into a common goal without separating each other's responsibilities.

The reason why that is something to look for is because several studies¹ prove that the construction industry has suffered a decline in its productivity since the 60's while almost the rest of industries have seen their productivity radically improved. The idea behind IPD is that this productivity reduction is due to adverse relations among the main stakeholders (Owner, general contractor and architect).

¹ US Bureau of Labour statistics

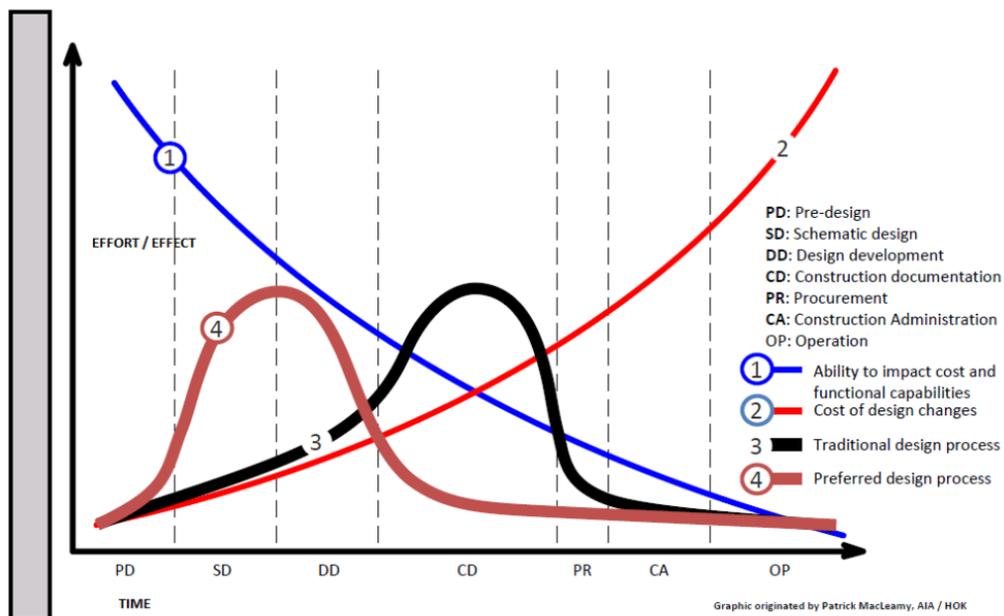


Figure 60: McLeamy Curve, from the AIA

By increasing the collaboration and the effort in the design phase, a decrease of effort needed during the implementation phase will be expected thanks to the reduction of potential modifications.

6.3 IPD Platform scope

The OptEEmAL platform has been designed to be useful in the project stage after the schematic design and before the elaboration of the construction documents, which can be labeled as "Design development" or "Detailed design". The platform provides the needed material for being in position of elaborating the implementation documentation that is needed for starting the physical construction.

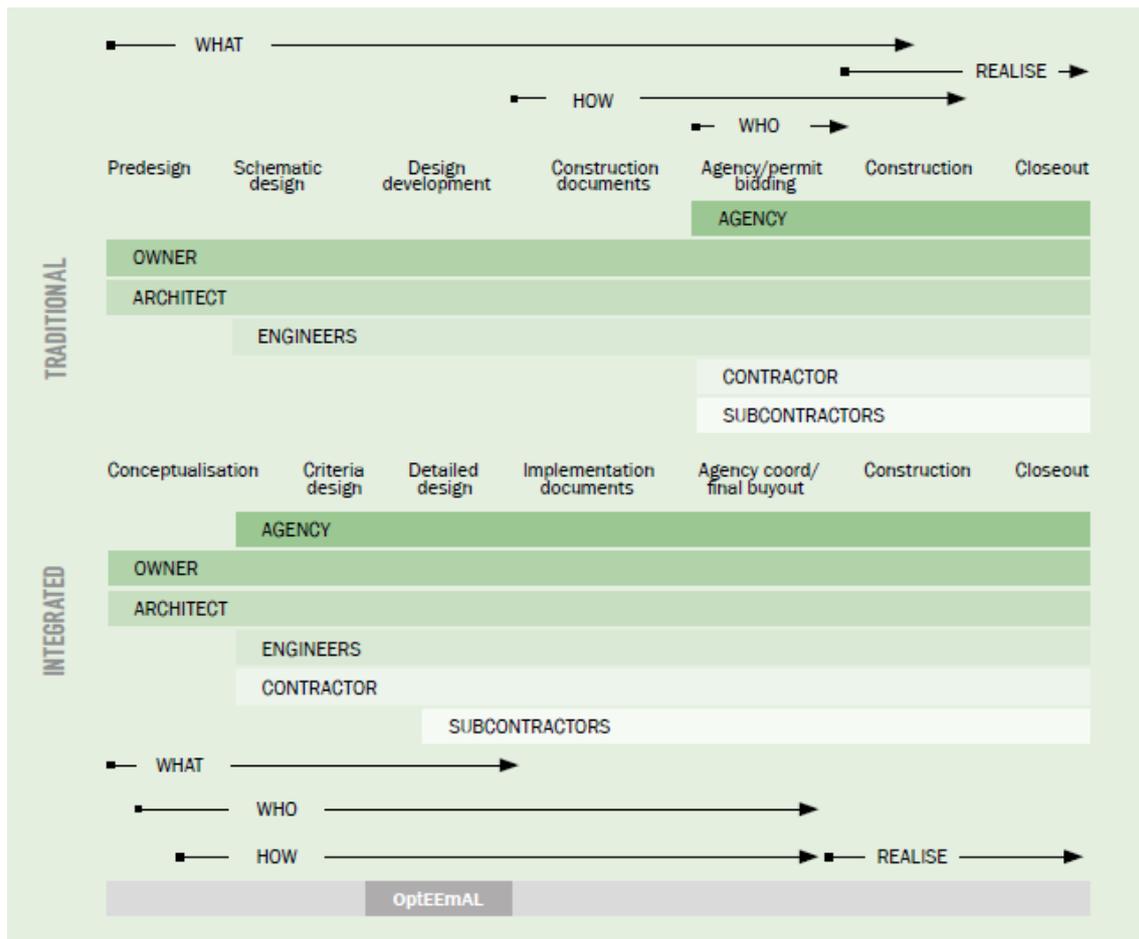


Figure 61: Stage in which the OptEEemAL platform is useful

As can be seen in the figure, more questions are expected to be decided in the IPD approach than in the traditional approach. Specifically it is expected that the role of "who is going to be in charge of the construction" has to be defined in the platform, in order to ease the introduction of the "how it is going to be done" in the design.

This is why it is needed to have the three main roles (Owner, designer, contractor) defined into the platform.

6.4 Considerations to take into account before using the platform

There are some considerations that should be taken into account when trying to apply the IPD paradigm that would ease the use of the paradigm and would improve the benefits of having it.

6.4.1 IPD Team Development

The IPD Team is the core of IPD. All participants in a project come together as an integrated team with the common objective of achieve a successful project. That means, within the IPD approach, when a problem occurs along the project life, all participants work together to solve the incidences.

It is crucial to compound the best possible group able to adapt its performance to the IPD concept.

The IPD team has to be formed as soon as possible the project is created. It can be established based on trust, comfort and familiarity which sometimes comes from a preexisting work

relationships or without regard to any pre-existing relationships among the members but in any case it has to be established as early as possible.

In the IPD group there are two categories of members:

- **Primary participants** with involvement, responsibilities throughout the project, from the beginning to the end. They have to be bounded together by a contractual relationship established for the project. In this category the Owner, architect and contractor are included.
- **Key supporting participants** have a vital role in the project but perform more discrete functions than the primary members. The primary designer and subcontractors are example of Key supporting members and enter into contract directly with either one of the primary participants.

The distinction between primary participants and key supporting participants can vary from one project to another. In this sense, for example a structural engineer can be a primary or a key supporting participant depending on the project nature. In the majority of projects, this would be a key supporting participant, as the role is not involved during the whole project. On the contrary, this is not the case of a bridge construction project, for example, in which the structural engineer's involvement is substantial all along the project.

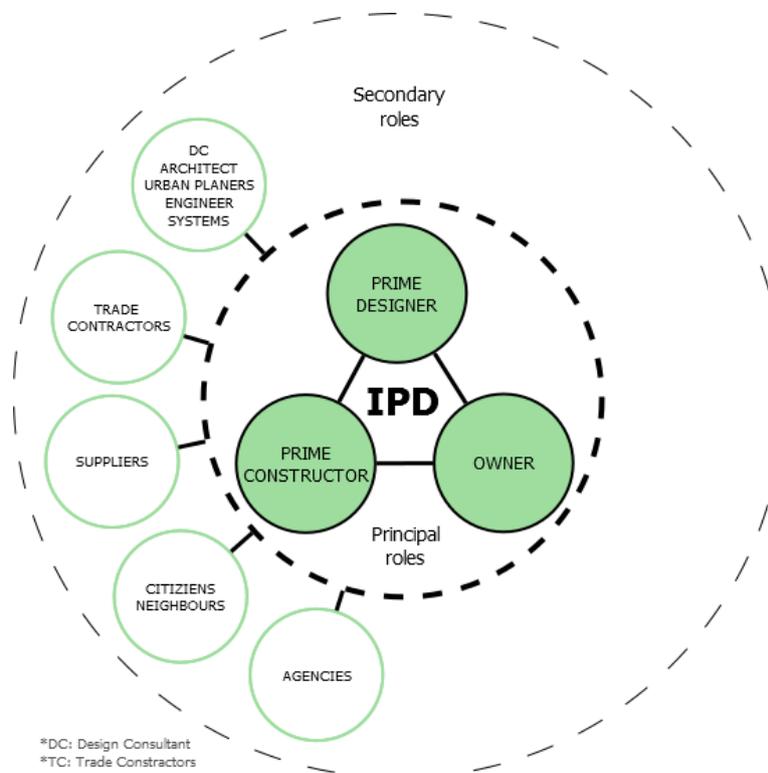


Figure 62: Example of actor classification in IPD

In OptEEmAL three roles are defined:

- Owner: who creates the project and will lead in the definition of objectives to be achieved.
- Prime Constructor: in charge of building technologies
- Prime Designer: in charge of the design of the solution

Once the team is built, it is very important to establish a team atmosphere where collaboration and open communication is possible.

In this step of the OptEEmAL platform, this collaborative atmosphere is possible as the entire IPD group members are connected to the project and all the information related to the project is shared.

6.4.2 Roles, responsibilities and scopes of services

In contrast with a traditional approach, IPD seeks to break down the silos of responsibility. This is not to say, however, that IPD participants do not have separate work scopes for which they are responsible (having always common goals in mind). It is because of that fact that it is of paramount importance to clearly define each one of the work scopes. The approach needs participants to be more involved in the project-related specifics.

The individual responsibilities² of the roles defined in the OptEEmAL IPD team are the following:

6.4.2.1 Owner's responsibilities

The Owner shall work with the Prime Designer and Prime Constructor to identify the Owner's project objectives, including budget and time criteria, space requirements and relationships, flexibility and expandability requirements, special equipment and systems, and site requirements (when necessary). The Owner shall provide full information in a timely manner regarding requirements for the Project, including the **Owner's Program** and other relevant information according the type of project (e.g. use habits, bills, comfort quality, access to direct tests, etc.).

The **Owner role** within the OptEEmAL framework may include the proper housing tenant, it means a public or private organization (e.g. Fomento de San Sebastián S.A, TRENTO); the promoter, that may be represent by public organization (e.g. LUNDS KOMMUN) and the end user, who inhabit the building.

6.4.2.2 Prime Constructor responsibilities

The Prime Constructor shall furnish preconstruction and construction administration and management services, collaborate with the Prime Designer in the designer's development of the Project Plan and Project design, and use the Constructor's diligent efforts to promote the delivery of the Project in an expeditious manner.

Consistent with the collaborative approach, the Prime Constructor shall assist the Prime Designer in the development of the Project design but shall not provide professional services which constitute the practice of architecture or engineering unless the Prime Constructor needs to provide such services in order to carry out his/her responsibilities for construction means, methods, techniques, sequences and procedures, or unless such services are specifically called for by the Contract Documents. The Prime Constructor shall provide all labor, materials, equipment and services necessary to complete the Work, all of which shall be provided in full accord with and reasonably inferable from the Contract Documents as being necessary to produce the indicated results. The Prime Constructor shall be responsible for the supervision and coordination of the Work, including the construction means, methods, techniques, sequences and procedures utilized. The Prime Constructor represents that he/she is an independent Constructor and that in his/her performance of the work, he/she shall act as an independent Constructor. The Prime Constructor's duties, responsibilities and limitations of authority shall not be restricted, modified or extended without written consent of the Management Group.

6.4.2.3 Prime Designer responsibilities

The Designer shall furnish or provide all the design and engineering services necessary to design the Project in accordance with the Owner's objectives, as outlined in the Owner's Program and other relevant information defining the Project.

Consistent with the collaborative approach set forth in this Agreement, the Prime Designer shall draw upon the assistance of the Prime Constructor and others in developing the Project design, but the Prime Designer shall retain overall responsibility for all design decisions as required by applicable

² The description of individual responsibilities of the Owner, designer and contractor is based on the Consensus DOCS 300 Standard form of Tri-Party agreement for Collaborative Project Delivery.

state laws. Cost and schedule are design criteria and the Prime Designer, in collaboration with the IPD Group, shall ensure that design fully considers cost and schedule implications. The Prime Designer represents that he/she is an independent contractor and that in his/her performance of the Services he/she shall act as an independent contractor. The Designer's duties, responsibilities and limitations of authority shall not be restricted, modified or extended without written consent of the Management Group.

6.4.3 Defining and measuring project outcomes

As in the case of a traditional project, in IPD, risks of not meeting the objectives remain. In the case of IPD, all success has to be measured according to the fixed objectives expressly, together with the economic implications that carried the total or partial achievement of the goals established. For that reason, it is mandatory to specify in the IPD agreements the projects goals and the consequences of not achieving them.

The metric and review plan for the project monitoring is included in the IPD project plan, according to the IPD methodology. In contrast with a traditional project, not only the usual cost, schedule and scope performance measurement is considered in IPD, but also an overall performance of the project is evaluated.

6.4.3.1 Goals and Standards

Goals, as well as the project program, are determined by the Owner, although the standards for evaluating the goals achievements and for determining the project success degree have to be a consensus decision. All project actors have to feel comfortable with the agreed project outcomes as it may determine the compensation and bonus policy.

In the case goals are economic, standards for project duration and cost have to be defined accordingly, other type of goals such as those related to energy efficiency, construction creativity or quality are more difficult to measure and is recommended to go to a weighted index modulus, comparison structures or even may require independent evaluators.

When and how the standards will measured have to be agreed jointly.

6.4.3.2 Costs

The prime metric of any project is the overall project cost. It is established at the beginning of the project at a very incipient stage and it is tracked all over the project life with agreed upon emphasis on life cycle and sustainability components. The project cost includes the actual work cost, together with the non-incentive based compensation (fees for services) as well as the appropriate contingencies. The potential for a direct connection between the design and quantity survey during all phases creates a powerful tool to determine and manage the project cost, which constitutes one of the prime opportunities to see the efficiency possible with IPD.

In the conceptualization phase, the IPD team confirms whether the project can be built for the expected investments and satisfy the Owner's goals. Setting the target price of a project is a collaborative exercise in the IPD methodology in which different issues have to be considered as each project actor has a direct economic interest in where the target price is set. The Owner's interests push to a lower price whereas the Designer and the Contractor seek a higher target price. These discrepancies are managed by an adequate participant selection, open book estimating and proper use of independent consultant when necessary.

6.4.3.3 Schedule

In IPD, the construction time is reduced thanks to the extensive planning and changes in project processes. This is one of the main potential benefits of IPD, which makes it determinant when selecting IPD instead of a traditional methodology by Owners. Linking schedule, phasing and detailed construction sequencing during the design can be translated into more efficient material

procurement. The time from the completion of design to the beginning of the active work is reduced thanks to the possibility of early ordering of materials by key supporting participant trade contractors to coordinate with the development of design.

6.4.3.4 Project Quality

The use of technological tools, like BIM by the IPD team, reduces errors within design documents as well as it reduces the conflicts between trades. The collaborative atmosphere in IPD leverages the use of this type of tools being the quality of service, design and execution integrated into the project.

The measurement of quality has to be appropriate for the project type and is compared with previously completed projects of similar nature.

6.4.3.5 Operational Performance

The performance criteria establishment is carried out during early design and updated/refined together with the design development. In addition, it has to be aligned with the project goals and set with the advice of the major trades participating in the project along with the associated design professionals.

6.4.3.6 Sustainability

IPD approach, in front of traditional approaches, offers the opportunity to set more ambitious goals for sustainability thanks to the possibility of metric establishment for lifecycle goals for all aspects of a project, melding into the overall goals (and incremental steps monitored through the design and delivery process) of rating criteria as LEED®, or setting goals for carbon footprint and renewable energies use.

6.4.4 Legal considerations and contracts

IPD approach is based on a different establishment of responsibilities for all the project actors involving them in the very beginning of the design phase of the project. In that way, the key point for the success of project lies in the collaborative design process sharing the financial risks and rewards among all the parties. For that purpose, a very clear agreement between the parts, which allows for a complete sharing of risks and rewards, is required. To this end, Owner, designer and constructor should agree to work together from the very beginning under one master agreement to carry out the project with mutually agreed-upon goals and target costs. Owner

According to AIA's guide (2007), the main legal aspects to be considered within IPD approach are the following³:

6.4.4.1 Non Standard contracts

Contractual relationships within an integrated approach are quite different from the traditional ones. Therefore modifying a standard non-integrated contract form can be difficult and can increase the cost of reaching the agreement.

The AIA has developed standard forms that can be used for negotiating and executing an IPD agreement.

6.4.4.2 Professional responsibility and licensing

IPD approach is not different from the traditional approach in terms of professional responsibilities and business licenses. All participants remain responsible for its individual scope. Collaboration between Designers and Constructor does not imply a decrease of discipline in these terms. If IPD

³ The American Institute of Architects (AIA National/AIA California Council). (2007) "Integrated Project Delivery: A Guide". Version 1. p. 17. Available online: https://info.aia.org/SiteObjects/files/IPD_Guide_2007.pdf

services are not provided through a separate legal entity specifically created for the project (e.g. limited Liability Company), the entity may be required to obtain design and/or construction licenses, depending upon individual state laws.

6.4.4.3 Insurance

Using BIM and other tools to construct a building virtually in advance of actual construction substantially diminishes the risk of design errors and omissions. If the participants adopt “no suit” clauses, the risk of incurring internal first-party claims for economic loss can be eliminated through these waivers. However, where participants do not waive first party claims but assume non-traditional liability, traditional insurance products may not be available in today’s insurance market. Insurance for third-party claims for personal injury and property damage may also not be available. It is now incumbent upon the insurance industry to develop and offer alternative insurance products that align with the project goals and the specific risk allocation terms established among the IPD project participants.

Furthermore, the development and underwriting of bonding and insurance require a new approach that recognizes the risk sharing framework of IPD. This may require more than the customary interaction with surety and insurance markets. Traditional legal risk management operates on a philosophy in which risk follows duty and the more duties one owes to more parties, the more legal risk one incurs.

6.4.4.4 Entity formation

While it is entirely possible to structure an IPD project purely through contractual arrangements between the separate participants (and it is anticipated that most will be so formed). It is also possible to carry out such projects through the creation of a single purpose entity, such as a Limited Liability Company (LLC). There can be tax and management issues to address where a separate legal entity is created to carry out the project.

6.4.4.5 Joint liability and joint venture

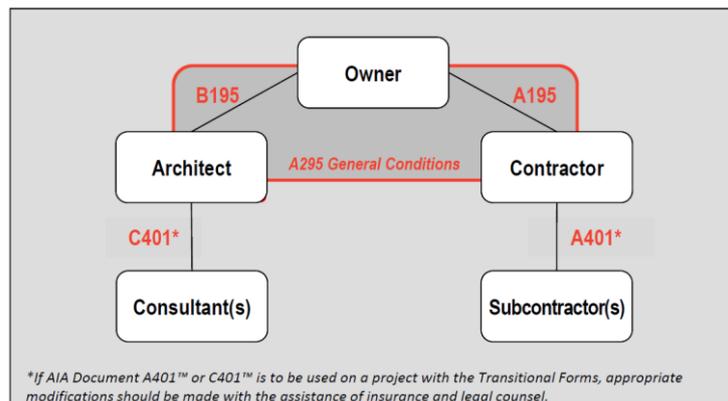
IPD arrangements contemplate a high degree of collaborative effort. In many cases, project participants share, to one degree or another, the success or failure of the overall venture. In this regard, IPD arrangements are more likely to be classified as joint ventures than the independent contractor arrangements typically encountered under traditional models. A unique risk feature of joint ventures is the joint liability of all joint ventures. Therefore, if all major IPD participants are deemed joint ventures, they may be liable to third parties for the failings of their joint venture partners. In this way, the construction team might well bear the risk of design error and the design team could be at risk for construction errors. This risk can be managed through careful planning (e.g., appropriate insurance products and structuring the legal relationships between the parties) and contract drafting.

6.4.5 Types of IPD Contracts

6.4.5.1 Transitional documents

As integrated project delivery is an emerging methodology process there are some transitional documents to set a comfortable first steps into the IPD approach. This type of methodology tries to influence in the participation with a collaborative project delivery approach that utilizes the talents and insights of all the participating partners of the project through all the phases of design and construction. The structure is similar to the existing Construction Manager as Construction agreement.

Figure 63: Responsibility groups distribution



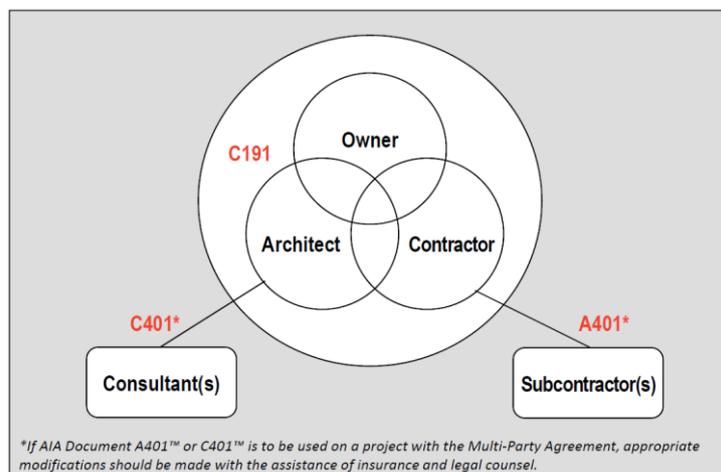
The relevant AIA Documents for this purpose are the following:

- A401-Contractor/Subcontractor Agreement
- A195-General Conditions of the Contract for IPD
- C401-Architect/Consultant Agreement
- B195- Owner/Architect Agreement

6.4.5.2 Multi-Party Agreement

These types of agreements fully integrate all the projects parties into IPD. The Owner, Architect and Contractor as a minimum should enter in one unique contract (Multi-Party Agreement). This type of agreement allows sharing a risk and reward in a fully integrated collaborative project.

Figure 64: Responsibility groups distribution



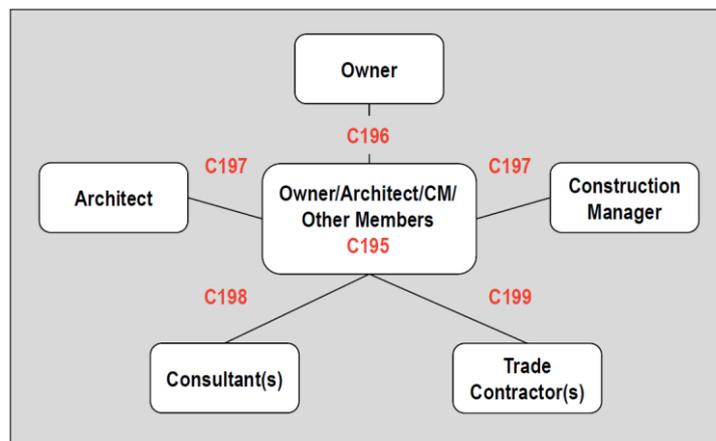
The relevant AIA Documents for a multi-party agreement are the following:

- A401-Contractor/Subcontractor Agreement
- C191-Multi-Party Agreement for IPD
- C401-Architect/Consultant Agreement

6.4.5.3 Single Purpose Entity (SPE)

These types of agreements fully integrate all the projects parties into IPD. The contract created a limited liability company (Single Purpose Entity) for the purpose of furnishing the planning, design and construction of the project through separate contracts with appropriate entities. The Single Purpose Entity (SPE) allows complete sharing of risk and reward in a fully integrated collaborative process.

Figure 65: Responsibility groups distribution



The relevant AIA Documents for this purpose are the following:

- C195-SPE Agreement for Integrated Project Delivery
- C196-SPE/Owner Agreement for IPD
- C197-SPE/Non-Owner Member Agreement for IPD
- C198-SPE/Consultant Agreement for IPD
- C199-SPE/Contractor Agreement for IPD

6.5 How to use the platform to following the IPD paradigm

The OptEEmAL platform is a web-based Platform for District Energy-Efficient Retrofitting Design, which supports integrated design methodologies for the systemic delivery of optimised designs, based on an Integrated Project Delivery (IPD) approach for building and district retrofitting projects and can help reduce uncertainties and the time during this process, resulting in significantly improved solutions when compared to business as usual practices.

The platform makes use of input data from the district (geometrical, materials, renewable energy resources, existing energy systems, social aspects, economic data, barriers, specific targets, etc.) that is processed in a four-phases platform (1. Problem statement, 2 problem mapping, 3 problem solving and 4 solution exporting) conducting an interactive design process with the stakeholders and obtaining, at the end of the process, an optimal retrofitting design according to the stakeholders' priorities.

The key features of the platform are:

- The involvement of all stakeholders during the process is ensured by establishing the proper interfaces that will guarantee that the results represent the interests of all involved players (architects, engineers, building managers, local administrators, citizens and policy makers), through defining goals and prioritisation criteria, and checking and validating the generated scenarios.
- Existing tools are integrated in the OptEEmAL web-based platform to ensure their interoperability in order to provide high quality validated solutions for building and district retrofitting projects, taking into account the subsequent operation and maintenance phases, and the interactions of the design process with the district in terms of key indicators (namely District Performance Indicators) that capture aspects related to energy, comfort, economy, social wellbeing, environment, and urban morphology through a common and standard data model.

- A systemic strategy to develop retrofitting design projects is delivered, based on the retrofitting objectives, allowing the key stakeholders to select the best scenario according to their prioritisations, through an optimisation process for the evaluation of different retrofitting alternatives.

OptEEmAL contributes to follow the contractual processes established by the IPD methodology through the BIM adoption, contributing to the EUPPD principles and improving the competitiveness of the European Construction sector in the field of “green” construction technologies.

OptEEmAL involves the different actors of the project through the IPD approach. “Validated” selections are made by ensuring communication and validation of the different actors at various stage of the project.

6.5.1 IPD-Roles and interactions step by step in the Platform

The interaction with the platform is structured into 13 steps, once a project is created by the Owner. In each step, the IPD- actors involved and the way they can interact with the platform is different depending on the permissions allowed defined. The permissions have been defined following the IPD paradigm.

Within the platform GUI the role assigned to the user is specified in each screen:

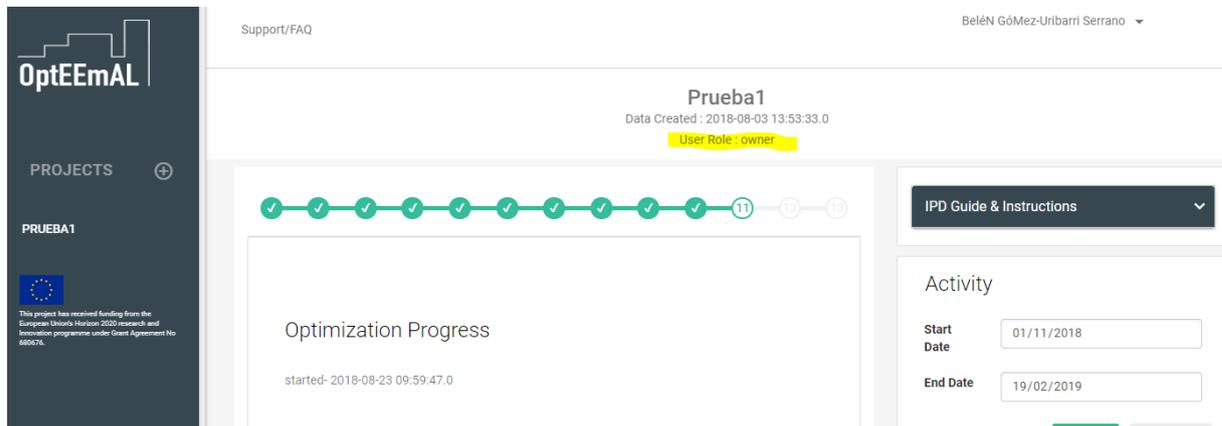


Figure 66: User Role in the Platform GUI

6.5.1.1 Step by step IPD considerations

Going through the 13 steps, in which the platform is divided, the interactions on each of the IPD roles is described in the following tables.

STEP 1: IPD GROUP

Definition: The IPD group within OptEEmAL entails three predefined roles: (1) Owner, (2) Prime Constructor and (3) Prime Designer.

The user who creates the IPD group takes automatically the role of Owner, who has to invite a Prime Constructor and a Prime Designer. For that reason in this step the Owner is the only one who has permission to edit the IPD group and an automatic invitation is sent by email through the platform to the Prime Constructor and to the Prime Designer selected by the Owner. The platform will inform the Owner when the IPD members have accepted the invitation by changing the status of the IPD member from “invited” to “joined”.

IPD Considerations

Owner: any user creating the IPD Group will be assigned the Owner role.

Prime Designer: will receive an invitation email, which he will have to accept to join the project.

Prime Constructor: will receive an invitation email, which he will have to accept to join the project.

User Role : owner

Step 1

1 ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ 11 12 13

IPD Group

Invite Prime Designer

Enter E-mail Address

Enter Prime Designer's Name

INVITE

Invite Prime Constructor

Enter E-mail Address

Enter Prime Constructor's Name

INVITE

Name	Email	Role	Status
Belen	belen.gomezuribarri.serrano.ext@acciona.com	owner	Joined

Figure 67: STEP 1 screen: IPD Group

STEP 2: DATA UPLOAD

Definition: Once the IPD group is created, all needed input data has to be inserted into the platform, namely: (1) a CityGML file describing the district in study and (2) IFC files, describing the buildings which are going to be refurbished (BIM models). Additionally, both IFC files and CityGML have to be matched within this step.

The responsibility to create the CityGML file and the IFC files is the Prime Designer's. For that reason the Prime Designer will have permission to upload, check and download the CityGML file of the district as well as the buildings' IFC files. The platform gives the possibility of interaction among all IPD Group members. In that way the Owner and Prime Constructor will be allowed to download both inputs: CityGML and IFC files (BIM). The last task in this step is the BIM- CityGML matching. This task can only be done by the Prime Designer. With this action a locational matching between the building's BIM footprint and CityGML geometry will be created, allowing the platform to know the links between those files.

IPD Considerations

Owner: will be able to view the whole process and download files (CityGML and IFCs).

Prime Designer: in charge of generating CityGML and IFC files and allowed to upload, check and delete files.

Prime Constructor: will be able to view the whole process and download files (CityGML and IFCs).

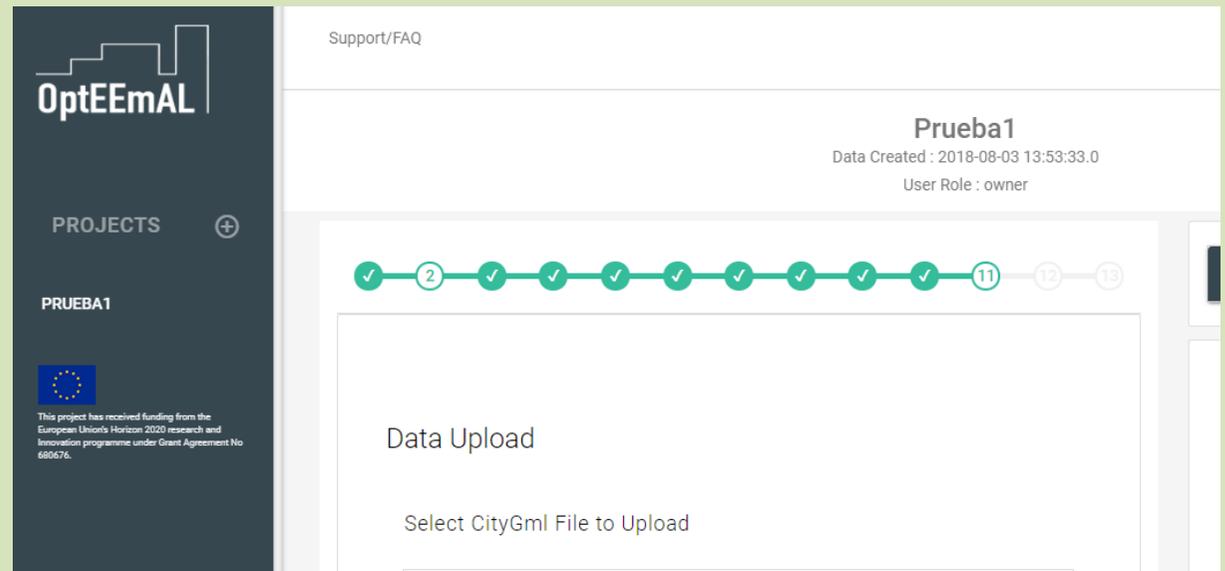


Figure 68: STEP 2 screen: Data Upload

STEP 3: BASELINE ENERGY SYSTEMS

Definition: At this step, all the existing energy systems at district and building level have to be defined. This task is done by the Prime Designer by answering two questionnaires: one for each level description (district and building). At the same time this description can be viewed by the Owner and the Prime Constructor following the IPD paradigm.

IPD Considerations

Owner: will be able to view the whole process.

Prime Designer: will have to answer both questionnaires to define Baseline Energy Systems existing in the district.

Prime Constructor: will be able to view the whole process.

Step 3

✓ ✓ 3 ✓ ✓ ✓ ✓ ✓ ✓ ✓ 11 12 13

Baseline Energy Systems

District Level Questions

Answer these questions regarding the district-level energy systems.

Q. Do you have a district energy supply system?

Yes

No

Figure 69: STEP 3 screen: Baseline Energy Systems

STEP 4: CONTEXTUAL DATA

Definition: Additional data is required at this step for running the baseline calculations e.g. climate, energy and socio-economic data, among others.

The OptEEmAL platform can gather these data by using web technologies when querying them by the Prime Designer. Also other unstructured data will be accessible for all users to view.

Once all the contextual data is saved, the OptEEmAL platform can proceed with the baseline values calculation.

IPD Considerations

Owner: will be able to view the whole process and check unstructured data.

Prime Designer: will query contextual data and will be able to edit or upload it as well.

Prime Constructor: will be able to view the whole process and check unstructured data.

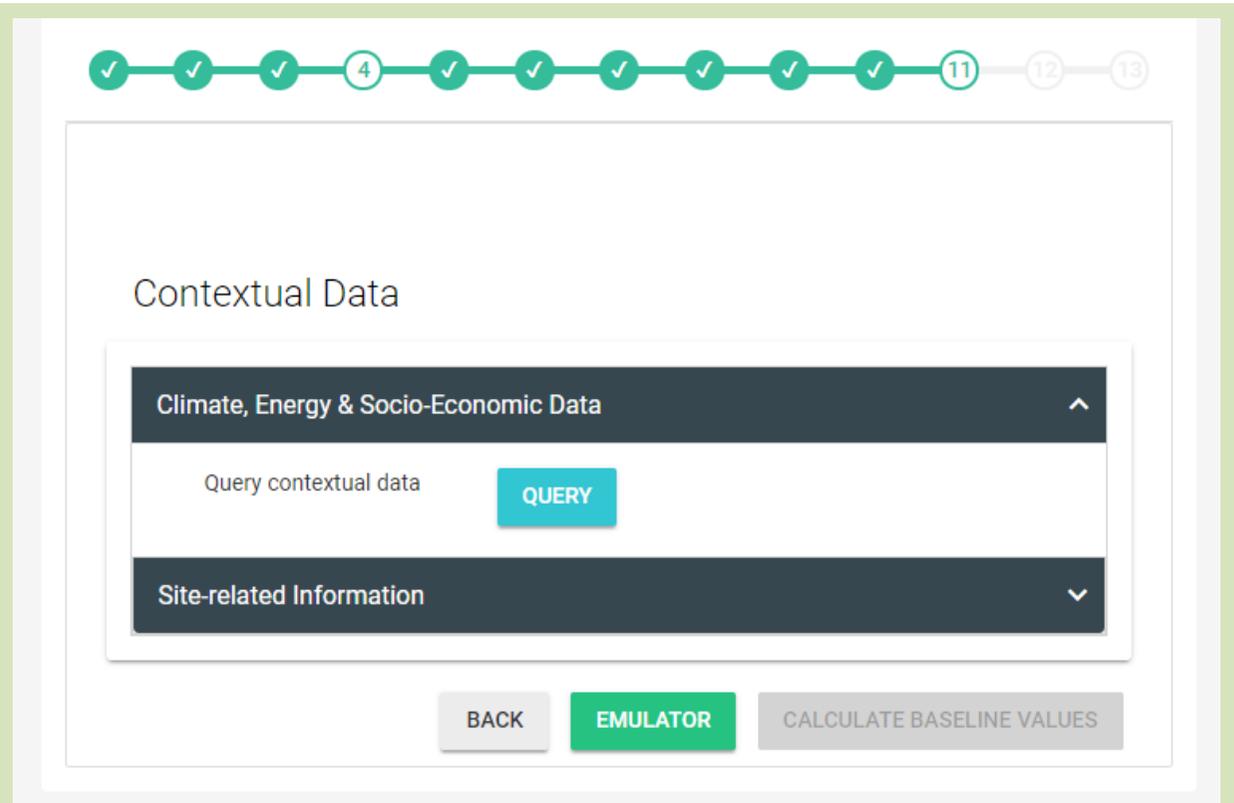


Figure 70: STEP 4 screen: Contextual Data

STEP 5: ENERGY CONSERVATION MEASURES

Definition: At this step different Energy Conservation Measures can be applied at district and at building level. The selection of the most suitable measures is done by following two questionnaires, one for each level (district and building).

Based on the results of these questionnaires, the selection of the applicable ECMs is performed internally by the OptEEemAL platform and presented in the next step.

IPD Considerations

Owner: will be able to view the whole process.

Prime Designer: will be able to view the whole process.

Prime Constructor: will have to answer the questionnaires for the district and for every building (or groups of buildings when the answers are the same).

Figure 71: STEP 5 screen: Energy Conservation Measures

STEP 6: CHECK STRATEGIES

Definition: At this step the applicable measures determined in the previous step by the platform can be particularized to the project in progress. They can be completed by editing sales prices, installation and maintenance costs and/or remove them from the pool of suitable measures that the IPD group wants to be assessed in the project.

This task is assigned to the Prime Constructor, for that reason at this step he is the only one that can edit them when the other members of the IPD group can view them in order to evaluate the measures in a collaborative way.

IPD Considerations

Owner: will be able to view the whole process.

Prime Designer: will be able to view the whole process.

Prime Constructor: will check the strategies presented, and will uncheck unnecessary ECMs, as well as modifying the prices, if required.

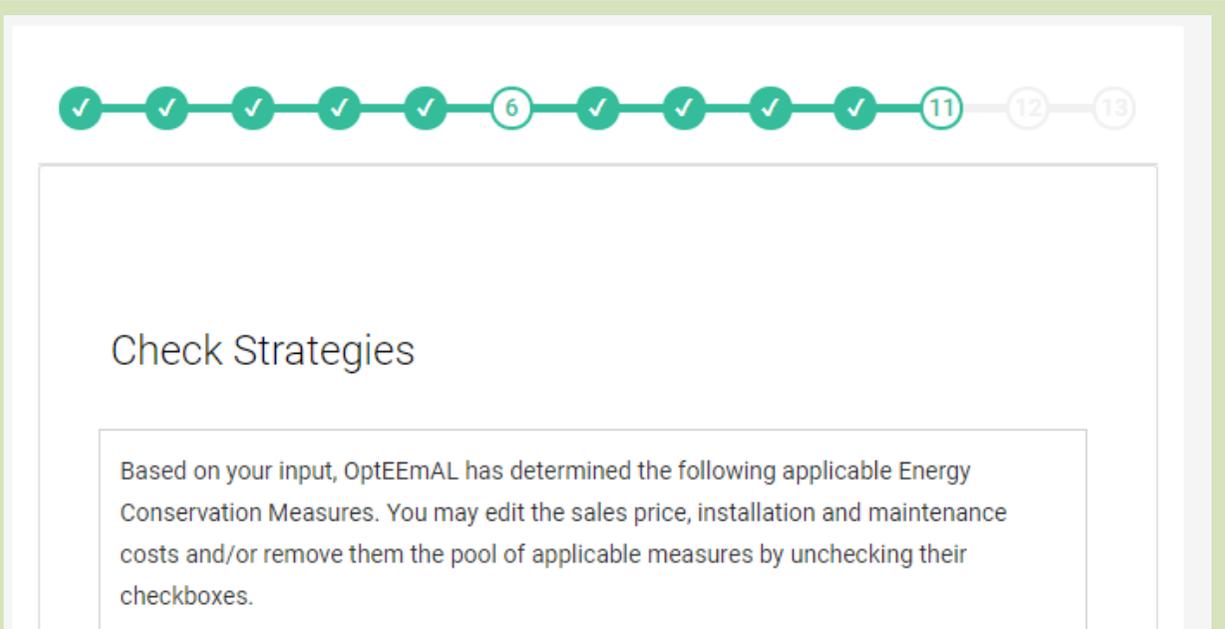


Figure 72: STEP 6 screen: Check Strategies

STEP 7: BASELINE PERFORMANCE

Definition: At this step the energy values performed by the platform for each of the scenarios selected in the district is shown and no actions is allowed to any of the IPD group members. They can only view them.

IPD Considerations

Owner: no actions envisaged, only viewing.

Prime Designer: no actions envisaged, only viewing.

Prime Constructor: no actions envisaged, only viewing.

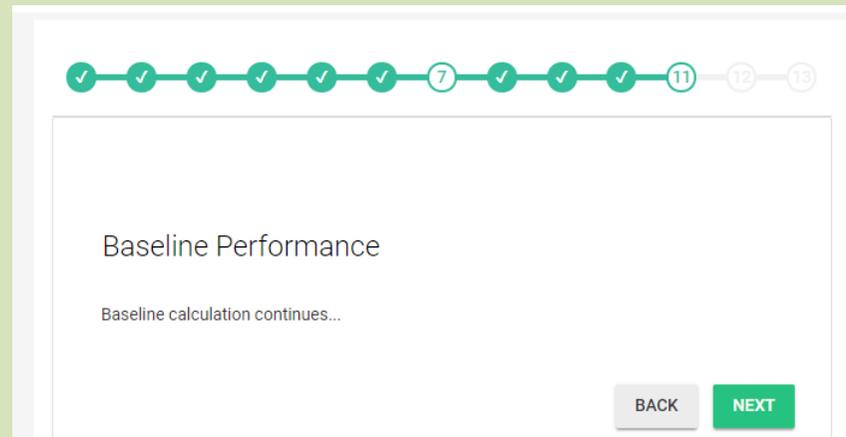


Figure 73: STEP 7 screen: Baseline Performance

STEP 8: TARGETS AND BOUNDARIES

Definition: At this step, additional information regarding the particular objectives of the project in study in terms of investments, Payback period and energy payback time or other targets or boundaries inherent to the project are added.

IPD Considerations

Owner: will be the one defining targets and boundaries.

Prime Designer: will be able to view the whole process.

Prime Constructor: will be able to view the whole process.

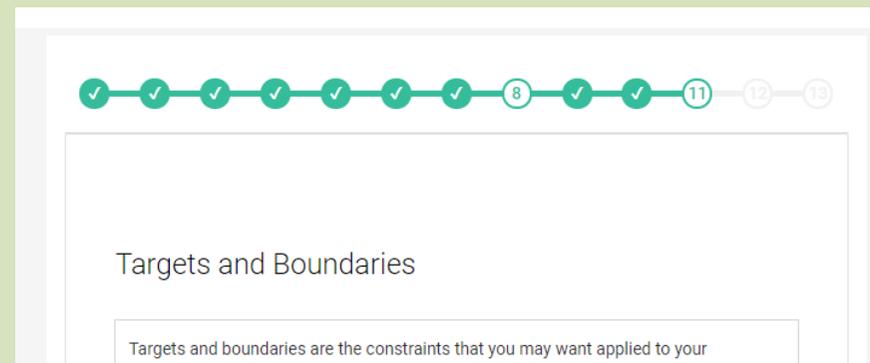


Figure 74: STEP 8 screen: Targets and Boundaries

STEP 9: PRIORITIZATION CRITERIA

Definition: For completing the optimization process, the platform needs to know the prioritization criteria to the Owner of the project who has to set these criteria at this step, giving different weights to the DPls in the project following his interests in the project. This information is shared with the other members of the IPD group.

IPD Considerations

Owner: will be able to view the whole process.

Prime Designer: will be the one the prioritization criteria.

Prime Constructor: will be able to view the whole process.

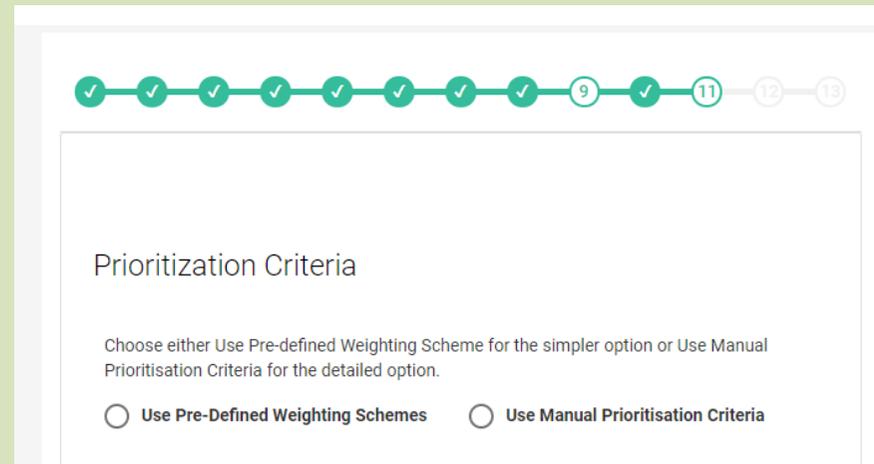


Figure 75: STEP 9 screen: Prioritization Criteria

STEP 10: PROBLEM SUMMARY

Definition: the overall situation defined is displayed. No action is required apart from the confirmation to start the optimization process.

IPD Considerations

Owner: will visualise the results and launch the process.

Prime Designer: will visualise the results.

Prime Constructor: will visualise the results

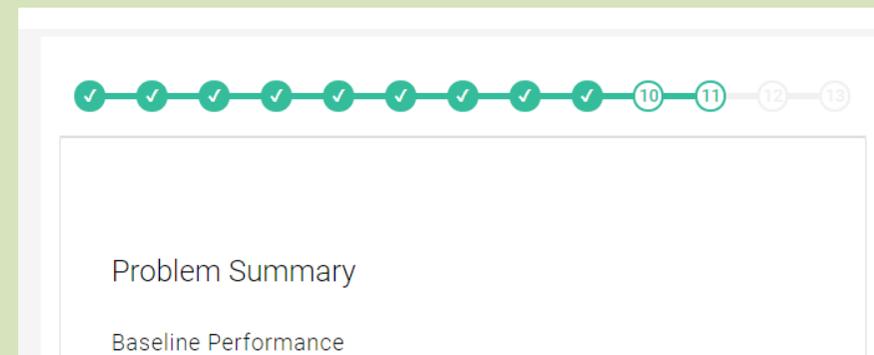


Figure 76: STEP 10 screen: Problem Summary

STEP 11: OPTIMIZATION PROGRESS

Definition: At this step, all IPD members will be able to visualise the progress of the optimisation, but no action will be required by any of them.

IPD Considerations

Owner: no actions envisaged, only viewing.

Prime Designer: no actions envisaged, only viewing.

Prime Constructor: no actions envisaged, only viewing.

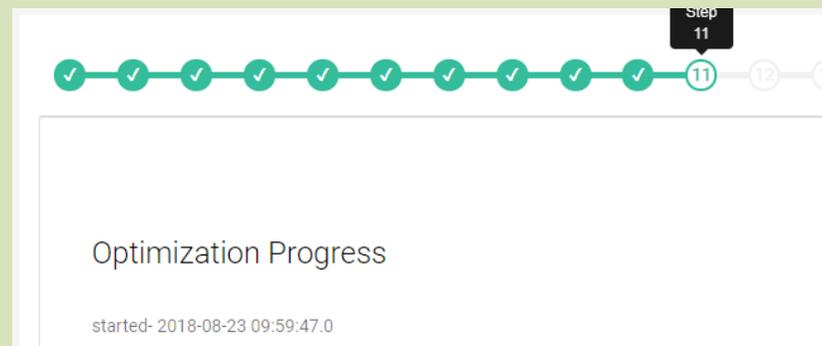


Figure 77: STEP 11 screen: Optimization Progress

STEP 12: SELECT OPTIMAL SCENARIO

Definition: The result of the optimisation is presented as a Pareto Front in this step. All IPD members can visualise the DPis measured and ECMs applied for each of the different scenarios in order to collaboratively select the scenario which better achieves their objectives.

IPD Considerations

Owner: will view and collaborate in the decision.

Prime Designer: will be the one selecting the best scenario.

Prime Constructor: will view and collaborate in the decision.

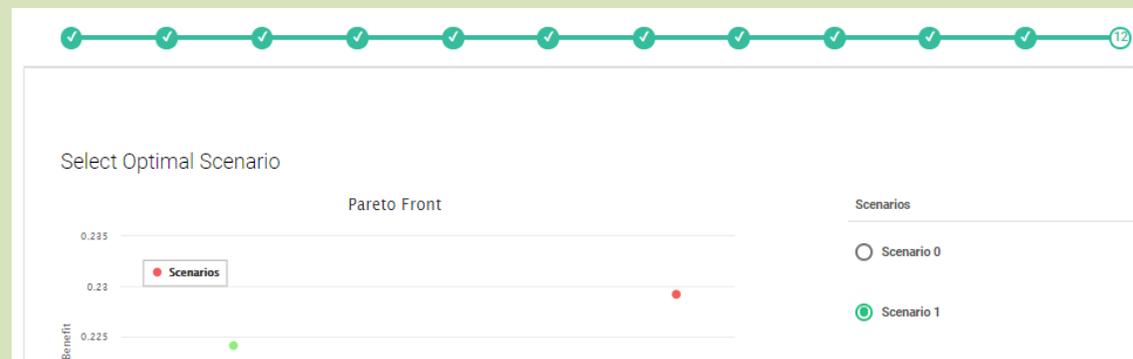


Figure 78: STEP 12 screen: Selected Optimal Scenario

STEP 13: EXPORT

Definition: At this last step, all the reports and files for the scenario selected in the previous step are generated and showed, and can be exported by all the project actors: Owner, Prime Designer and Prime Constructor.

IPD Considerations

Owner: will be able to export all files.

Prime Designer: will be able to export all files.

Prime Constructor: will be able to export all files.

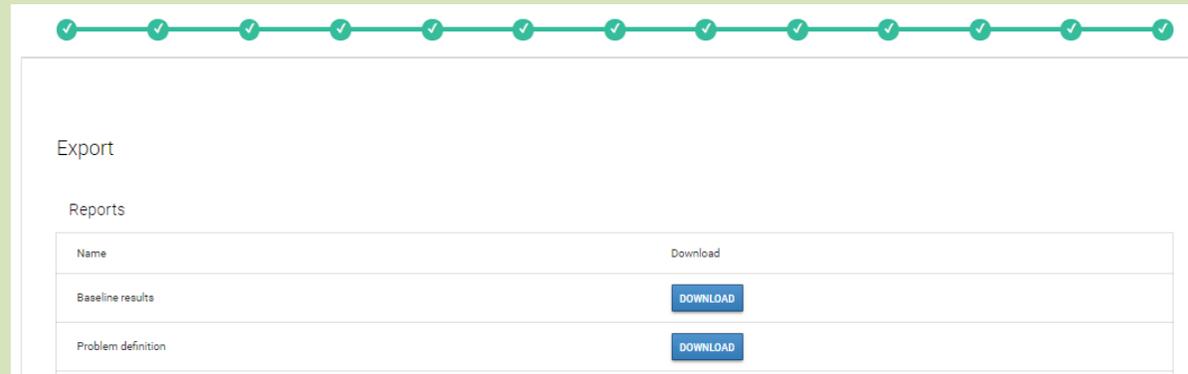


Figure 79: STEP 13 screen: Export

COMMON CHAT

Definition: During all the process, a common chat is active thanks to which all the actors can communicate in order to share information and point of views.

IPD Considerations

Owner: will be able to interact with all users and check the activities log.

Prime Designer: will be able to interact with all users and check the activities log.

Prime Constructor: will be able to interact with all users and check the activities log.

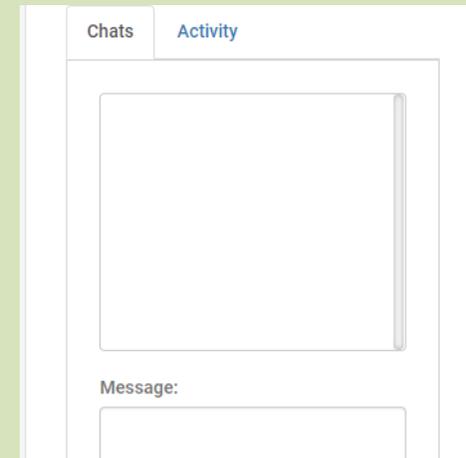


Figure 80: Common Chat

6.5.1.2 Summary of interactions

The summary of interactions of the different actors with the platform is depicted below. In addition, a fourth actor in all the process is included: the platform administrator. This actor is able to edit in each of the steps in which it is needed an interaction with the platform. The following table depicts the envisaged actions each of the actors can perform within the platform, namely:

1. **View:** visualise what is shown on the screen, without being able to edit any parameter
2. **Edit:** be able to interact with the platform, click on buttons, upload or download files, etc.

Table 4: OptEEmAL allowed actions for each of the actors

Steps		Use Case	Owner	Constructor	Designer	Admin
STEP 0	Initial steps	Registering into the platform	Edit	Edit	Edit	Edit
		Creation of a new project	Edit	View	View	Edit
		Project Settings	Edit	View	View	Edit
STEP 1	IPD Group	IPD Group creation	Edit	View	View	Edit
STEP 2	Data Upload	Upload CityGML	View	View	Edit	Edit
		Check CityGML	View	View	Edit	Edit
		Delete CityGML	View	View	Edit	Edit
		Download CityGML	Edit	Edit	Edit	Edit
		Upload IFC	View	View	Edit	Edit
		Check IFC	View	View	Edit	Edit
		Delete IFC	View	View	Edit	Edit
		Download IFC	Edit	Edit	Edit	Edit
STEP 3	Baseline Energy Systems	Current Building Energy Systems' definition	View	View	Edit	Edit
		Query Contextual Data	View	View	Edit	Edit
STEP 4	Contextual Data	Edit/Upload Contextual Data	View	View	Edit	Edit
		Check Contextual Data	View	View	Edit	Edit
		View unstructured data	View	View	View	View
		ECMs questionnaire	View	Edit	View	Edit
STEP 5	Energy Conservation Measures	ECMs checking	View	Edit	View	Edit
STEP 6	Check Strategies	View DPIs results	View	View	View	View
STEP 7	Baseline Performance	Setting objectives (targets and boundaries)	Edit	View	View	Edit
STEP 8	Targets and Boundaries	Define prioritization criteria	View	View	Edit	Edit
STEP 9	Prioritization Criteria	Problem Summary visualisation	View	View	View	View
STEP 10	Project Summary	Launch optimisation	Edit	View	View	Edit
		View progress	View	View	View	View
STEP 11	Optimization Progress					

STEP 12	Select Optimal Scenario	Optimal Scenario selection	View	View	Edit	Edit
STEP 13	Export	Export Excel files, District data model, enhanced IFC and CityGML models	Edit	Edit	Edit	Edit
N/A	-	View All Logs	View	View	View	Edit
		Common Chat	Edit	Edit	Edit	Edit
		Guides	View	View	View	Edit

7 Stakeholders Guidelines

7.1 CityGML files guidelines

CityGML is a common semantic information model for the representation of 3D urban objects that can be shared over different applications. The latter capability is especially important with respect to the cost-effective sustain-able maintenance of 3D city models, allowing the possibility of selling the same data to customers from different application fields. The targeted application areas explicitly include city planning, architectural design, tourist and leisure activities, environmental simulation, mobile telecommunication, disaster management, homeland security, real estate management, vehicle and pedestrian navigation, and training simulators.

CityGML is designed as an open data model and XML-based format for the storage and exchange of virtual 3D city models. It is implemented as an application schema of the Geography Markup Language 3 (GML3), the extendible international standard for spatial data exchange and encoding issued by the Open Geospatial Consortium (OGC) and the ISO TC211. CityGML is based on a number of standards from the ISO 191xx family, the Open Geospatial Consortium, the W3C Consortium, the Web 3D Consortium, and OASIS.

CityGML defines the classes and relations for the most relevant topographic objects in cities and regional models with respect to their geometrical, topological, semantical, and appearance properties. "City" is broadly defined to comprise not just built structures, but also elevation, vegetation, water bodies, "city furniture", and more. Included are generalization hierarchies between thematic classes, aggregations, relations between objects, and spatial properties. CityGML is applicable for large areas and small regions and can represent the terrain and 3D objects in different levels of detail simultaneously. Since either simple, single scale models without topology and few semantics or very complex multi-scale models with full topology and fine-grained semantical differentiations can be represented, CityGML enables lossless information exchange between different GIS systems and users (Gröger *et al.* 2012).

Initiatives such as CityGML Quality Interoperability Experiment (Wagner and Ledoux 2016) aim to define data quality requirements for a general CityGML data specification. They have created recommended implementation guidance for CityGML encoded 3D data, and provided a suite of tools to carry out quality assurance on CityGML data.

Within OptEEmAL project, a CityGML model is needed for each project. One of the needs of the CityGML is when matching IFC buildings and buildings in CityGML. In addition, the geometry and semantic information contained in the CityGML model is also used in the simulation. In order to have correct and valid CityGML files, a set of guidelines have been defined in order to use in OptEEmAL project.

A guide for OptEEmAL CityGML input file has been developed describing the set of rules that all CityGML files used as input to the OptEEmAL platform should comply with. These rules should be followed by the designer of the CityGML files.

The CityGML guidelines are available in the OptEEmAL website, in the following location (OptEEmAL guidelines):

<https://www.opteemal-project.eu/press-corner/publications/further-downloads.html>

7.2 IFC files guidelines

Within the OptEEmAL project, a BIM-based BEP simulation input data files' generation has been developed, making the BEP simulation modeling process much more expedient and therefore, less vulnerable to modeling errors. Among the most frequently used open-BIM schemas, IFC4 has been selected.

However, applying an automated data transformation from IFC data to input data of BEPS tools is not a straightforward but a tedious task often due to imperfections of the provided IFC files. Although commercial BIM authoring tools (Revit, Archicad, Vasari) support exportation of IFC files, their quality is not always acceptable in the context of BEPS input data generation. Even Revit and its IFC4 Design Transfer View (DTV) exporter, which currently seems to be the most mature tool, is far from being perfect: while IFC schema can capture data about material thermal properties, internal gains (schedules and densities) and 2nd-level space boundaries, requested from the BEPS perspective, relevant information is missing or incorrect in the exported IFC4 DTV files.

Since lack of training of the BIM designer contributes significantly to these data imperfections, a set of design guidelines have been developed to help the designer define properly all the requested information within BIM. A document that presents this set of design guidelines as they apply for Revit has been created (see Figure 83) – similar guidelines can be developed for other BIM authoring tools.

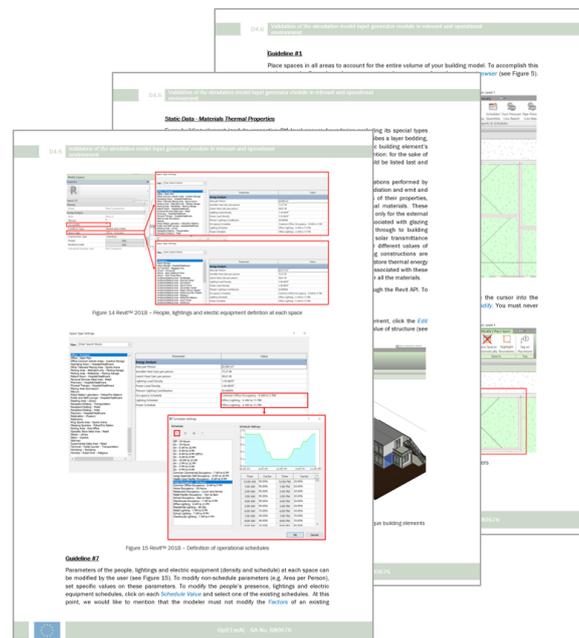


Figure 81: BIM design guidelines for an BIM preparation in Revit™

The guidelines are provided as a set of modelling rules belonging to two broad categories: Static and Dynamic Data. Static data rules cover the building geometry, construction materials, glazing information, and so forth, while dynamic data rules cover the specification of time-varying parameters such as occupancy and internal gains schedules. These rules ensure that: (i) spaces have been placed in all areas of the building; (ii) each space is bounded properly; (iii) material thermal properties for opaque and transparent building elements have been set; and (iv) building type and its infiltration class has been defined.

Part of these guidelines refers to a modified version of Revit IFC4 DTV exporter installation and the exportation setup: to overcome limitations of the default Revit IFC4 DTV exporter on exporting information about thermal properties of each building entity's construction material and internal gains (schedules and densities), which have been properly set following the aforementioned guidelines, and to guarantee correct exportation of such information, the default exporter (which is an open source component) has been modified to create a bespoke OptEEmAL version that addresses these shortcomings. The OptEEmAL IFC Exporter supports the latest version of Revit (2018.3).

The BIM Design Guidelines' document is available in the OptEEmAL website, in the following location (OptEEmAL guidelines):

<https://www.opteemal-project.eu/press-corner/publications/further-downloads.html>

8 Conclusions

All along the project, the stakeholders have been strongly considered. They have been the focus in the platform development. In WP1, all the interactions with the stakeholders have been deeply analysed and described under the IPD approach.

The participation of the stakeholders it is not limited to platform users but also as input data providers. It is important to highlight that the procedures for interacting with the OptEEemAL tool have to be well defined, clear and accessible to the users in order to offer all the high potential inherent to it.

As a result of this work, different guidelines have been developed in order to guide the users when using the OptEEemAL tool in a refurbishment project under the IPD paradigm.

This deliverable gathers all the guidelines in one individual document:

- **How to use guide:** In this guide all the steps are deeply described, in an easy way, leading the user through the Graphical interface of the OptEEemAL tool with useful comments on each functionality of the tool.
- **Help in line:** This is an online guide within the OptEEemAL Graphical Interface. It resumes, in each process' step, the actions that the user has to carry on and it is showed at every step during the OptEEemAL process.
- **Guide on IPD implementation:** The aim of this guide is to lead the user to follow the IPD paradigm when using the OptEEemAL tool. In this guide not only the main aspects of the IPD approach are described, but also how this approach has to be applied all along the thirteen steps in which the OptEEemAL procedure is structured.

As already mentioned, stakeholders also interact with the platform as input data providers. In this aspect, it has been identified, during the project life, that a very critical point is the generation of the CityGML and IFC files. These files are the basis for modelling the district and buildings to be refurbished within the optimization process made by the platform. They are not easy to generate and have to accomplish determined features to be useful in the OptEEemAL procedure.

In order to avoid the incompatibility of these inputs and to solve the lack of knowledge of the user in this aspect, **two additional guidelines** have been developed.

The development of these guides were out of the scope of the project in a first step, but it was decided, by the consortium, to extend the initial project approach in order to do the OptEEemAL process more accessible to the users and to develop two simple guides to lead the user in the CityGML and IFC files development.

All the guidelines presented in this report are public and accessible to the user in the project website being also downloadable.

9 References

- [01] LAZAROU, G. C., ROSCIA, M., 2012. Definition methodology for the Smart cities model. *Energy* 47 (2012), pp. 326-332.
- [02] LOKEN, E., 2007. Use of multi-criteria decision analysis methods for energy planning problems. *Renewable and Sustainable Energy Reviews* 11 (2007), pp. 1584-1595.
- [03] AIA National. 2007. *Integrated Project Delivery: A Guide*
- [04] T. Maile, J. O' Donnell, V. Bazjanac, C. Rose, "BIM - Geometry modelling guidelines for building energy performance simulation", *Building Simulation Conference 2013, Chamberry France*.
- [05] G.N. Lilis, G.I. Giannakis, D. Rovas, "Automatic generation of second-level space boundary topology from IFC geometry inputs", *Automation in Construction* 76, p. 108-124, 2017.



10 Annex I: Schemes of the IPD design phases

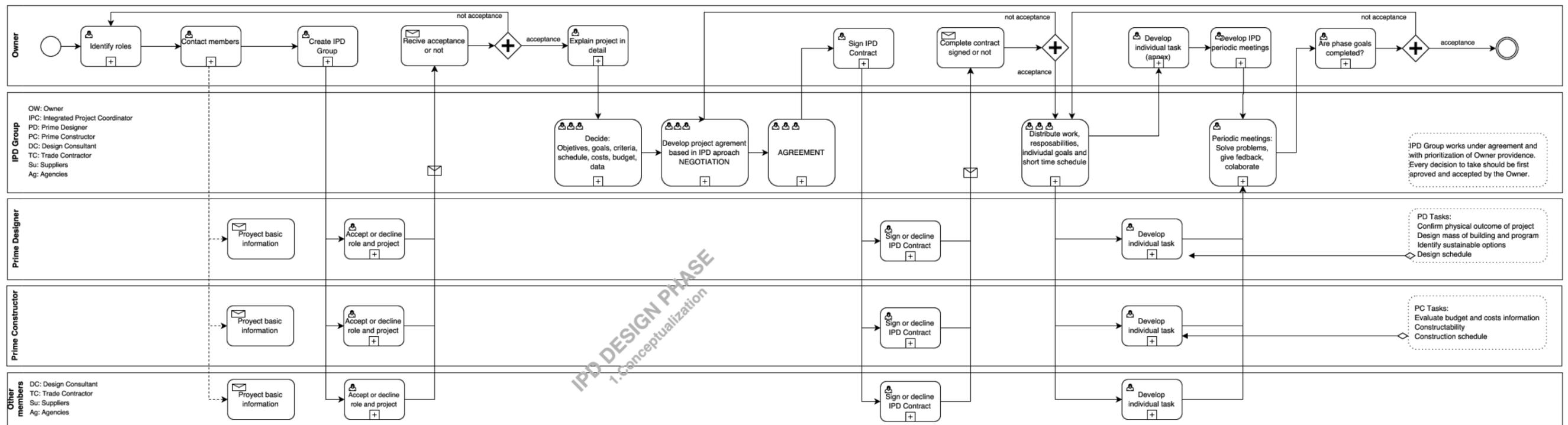


Figure 82: IPD design phase 1: Conceptualization

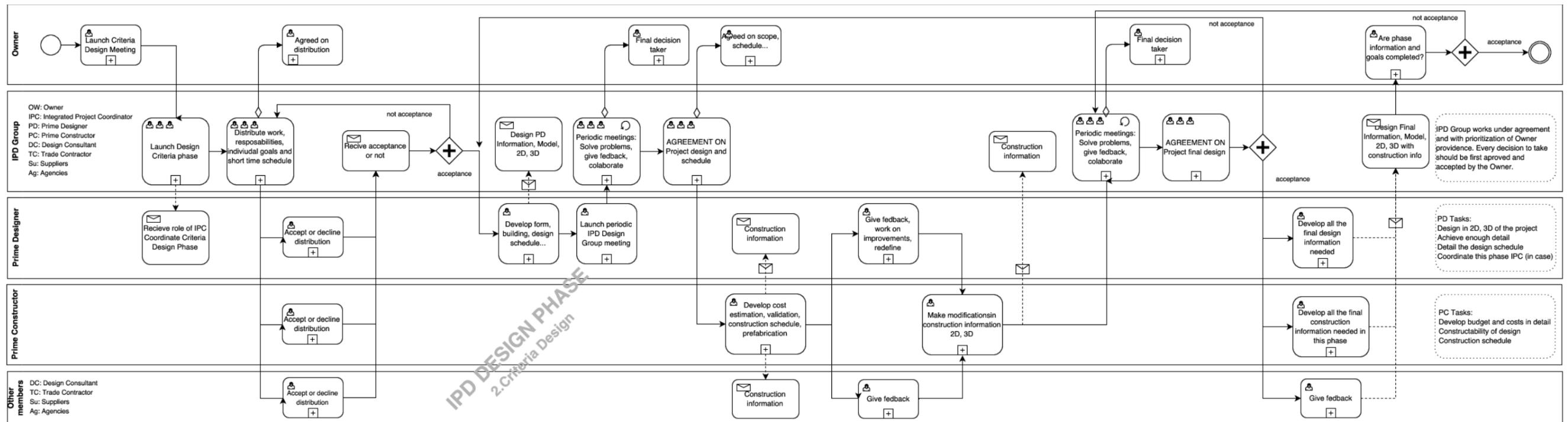


Figure 83: IPD design phase 2: Criteria Design

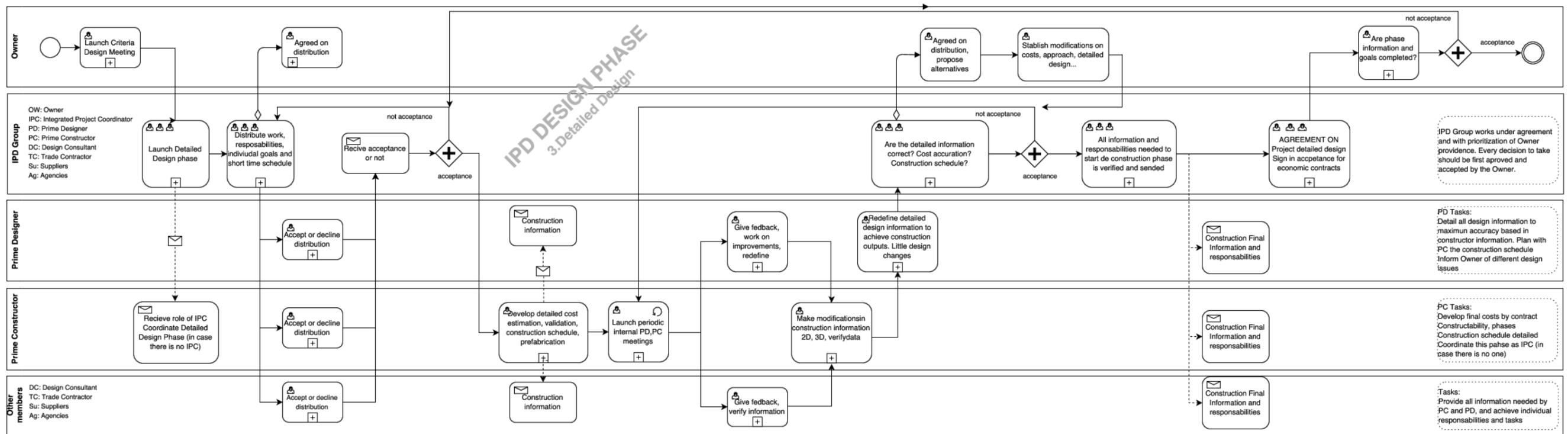


Figure 84: IPD design phase 3: Detailed Design