Smart Grid Energy Management Staff Exchange

SMARTGEMS energy network

D3.1 Guidelines for integrated design towards smart / zero buildings and smart grids. Report on the design phase

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1. Summary

The present work focuses on smart and zero energy building's analysis on the design phase and aims to provide guidelines for integrated design procedures towards smart/zero buildings and smart grids.

This is a mandatory requirement based on the fact that by 31 December 2020, all new buildings shall be nearly zero-energy consumption buildings. New buildings occupied and owned by public authorities shall comply with the same criteria by 31 December 2018.

ZEBs are buildings that work in synergy with the grid, avoiding putting additional stress on the power infrastructure. Achieving a ZEB includes apart from minimizing the required energy through efficient measures and covering the minimized energy needs by adopting renewable sources, a series of optimised and well balanced operations between consumption and production coupled with successful grid integration.

To this end research work has been implemented and skills have been developed through secondments from academia to industry and vice versa in the field of integrated design for buildings. Table 1 presents the list of persons involved in the deliverable.

Since buildings are major consumers in smart grids, the integrated design task assists to develop a collaborative method for designing buildings for smart grids. The IED process is an innovative approach able to support and manage the growing complexity of the building market sector. Requires multidisciplinary collaboration, including key stakeholders and design professionals, from conception to completion. Decision-making protocols and complementary design principles must be established early in the process in order to satisfy the goals of multiple stakeholders while achieving the overall integration design objectives.

Table 1: Seconded researchers and activities presented in Deliverable 3.1

Researchers	Sending Organisation	Organisation of Destination	Research Field
Theoni Karlessi	UoA	IDEA	ID/Site Visits/Library building assessment
Luca Venezia	IDEA	UoA	Site Visits /Library building assessment
Pietro Muratore	IDEA	UoA	Site Visits /Library building assessment
Laura Standardi	AEA-Loccioni Group	UoA	Site Visits /Library building assessment
Georgios-Evrystheas Kyriakodis	UoA	AEA-Loccioni Group	Summa 3D modelling assessment
Ioannis Kousis	UoA	AEA-Loccioni Group	AEA 3D modelling assessment
Vassilis Lontorfos	UoA	AEA-Loccioni Group	KITE Summa 3D modelling assessment
Margarita-Niki Assimakopoulos	UoA	NUS	NUS building occupancy patterns

The design of NZEB requires an interdisciplinary approach. Reducing the energy demand in the design phase demands specifications of the different designers and engineers such as architects, building physics or façade designers. For this reason, the introduction of a design team is compulsory for the design of NZEBs. In this context the building design phase is of particular importance. IED is a valuable assisting approach to reduce the complexity of the design process, to ensure the implementation of defined, to identify pros and cons of alternative variants of design concepts and to allow decision makers to decide based on transparent facts. The choices are no longer taken from a single profession, but from a work team through a participatory process; choosing from a wide range of possibilities to identify the best solution, taking into account the quantitative aspects (high energy performance efficiency and high indoor comfort), economic (cost/benefit), functional, aesthetical aspects and energy efficiency parameters to be achieved. Only if IED is applied from the very beginning of the design phase we can assume that a cost-effective solution for NZEB can be identified, because only at the early design phases changes of the general design concept can be implemented at low cost. Therefore, the application of IED is part of the best way towards the intended NZEB at low cost.

The work in this Deliverable is structured in 3 levels:

- **Level 1: Integrated Design procedure and decision making protocols**

Integrated design concept is analysed providing the principles of ID process and defining decision making protocols. It is emphasised that the creative problem solving process runs parallel in time with the process of monitoring the compliance with project targets, which have been defined in the design basis. The ID steps represent concrete tasks that to a certain extent go beyond conventional design processes. This means that an adaptation of the scope of services is required. Client's and Tenant's requirements are presented including capital cost, delivery risk, operational cost and minimization of building unsuitability risk. The objectives of services and remuneration models are also investigated. The importance of certification and consultancy aspects is highlighted providing also quality assurance aspects and evaluation of the design quality criteria.

- **Level 2: Assessment of best practice examples through site visits**

Within the frame of the secondments hosted in the University of Athens site visits at best practice example NZEB buildings which follow the integrated design concept from the design to the construction and operation, integrating at the same time smart technologies have been carried out. The buildings are documented and their ID characteristics are presented providing also recommendations for smart grid integration.

The activities included sites visits, meeting with the building responsible and assessment of the performance of 4 best practice buildings in Greece:

- A.N. Tombazis and Associates Architects Office Building
- Apivita Commercial & Industrial S.A.
- Stavros Niarchos Foundation Cultural Center
- Karelas Office Park

The buildings have adopted the ID procedures from the early stages of design until the final completion and operation. Throughout the secondment activities the applied smart technologies have been investigated in relation with the integration to smart grids.

- **Level 3: Assessment of selected case buildings**

Case building were fully assessed during the secondments and the methodology that was developed included the audit and analysis of the building's existing situation, with parameters as Site details and Location, Time, Daylight data and Simulation Weather file data. Except of the above-mentioned, the Layout drawings is described as well as the Activity, Construction, Openings, Lighting, HVAC and Generation data. To enhance the prospects of building's connection into the smart grid an overall integration design objective is required, thus a thermal simulation model has been developed using the appropriate tool. Also, to estimate and establish the best case scenario concerning the energy consumption of the HVAC system as a function of thermal comfort, an Internal CFD analysis for each thermal zone separately is implemented.

The buildings that are analysed are:

- SUMMA building, Ancona, Italy
- KITE lab, Ancona, Italy
- AEA building, Ancona, Italy
- Library building, University of Athens, Greece
- NUS building, Singapore

The purpose of CFD analysis is enumerated analytically below:

1) Accurate assessment of occupancy; thermal comfort is essential for successful building design.

2) Assessment of Comfort as it can vary considerably for different thermal zones depending on factors such as the location of supply diffusers, radiators, computer equipment, etc.

3) Detailed evaluation of both HVAC system and air flow (cold/hot air) inside each thermal zone.

4) The HVAC system requires more than simply making sure that mechanical heating or cooling system offer sufficient capacity to offset spatial loads.

5) It is equally important to determine that the delivery system is providing an adequate distribution of temperature and fresh air throughout the space.

The correlation of measured and simulated values has also been examined in order to assess the performance and implementation of smart technologies at the buildings.

Innovativeness of the approach of the present work is multiple and can be defined as follows:

- Analysis of Integrated Design methodology vs conventional procedures
- Application of detailed white box models based on physical knowledge of the system and thermal balance equations vs black box and grey box models that use only measured input/output data and statistical estimation method as well as a priori knowledge on the system. White box models were also used because of the accuracy, the calculation speed and it’s usage for optimization and control.
- Evaluation and application of innovative solutions and systems as the High Concentrating solar thermal system for combined thermal and electrical production to drive a double effect absorption chiller system producing heating and cooling to satisfy the thermal needs.

2. Introduction

As the EU energy industry is clearly moving towards a new era of reliability, availability, and efficiency that will contribute to the improvement of Europe's economic and environmental sustainability, smart technologies provide the opportunity for new applications with far-reaching interdisciplinary impacts: providing the capacity to safely integrate more renewable energy sources (RES), smart grids and distributed generators into the network; delivering power more efficiently and reliably through demand response and comprehensive control and monitoring capabilities in order to achieve zero energy targets. The integration of smart technologies requires a holistic approach that takes into account all aspects of sustainability.

The methodological approach is based on a cycle expansion of three phases (Fig.1): 1. The users/consumers aspects, focusing on smart and zero energy buildings analysis, 2. The smart grids penetration at community and city level, offering the technological platform for fast moving towards sustainable communities by exploiting the ICT and energy systems development in the maximum degree 3. Development of smart applications and smart grids optimised operation.

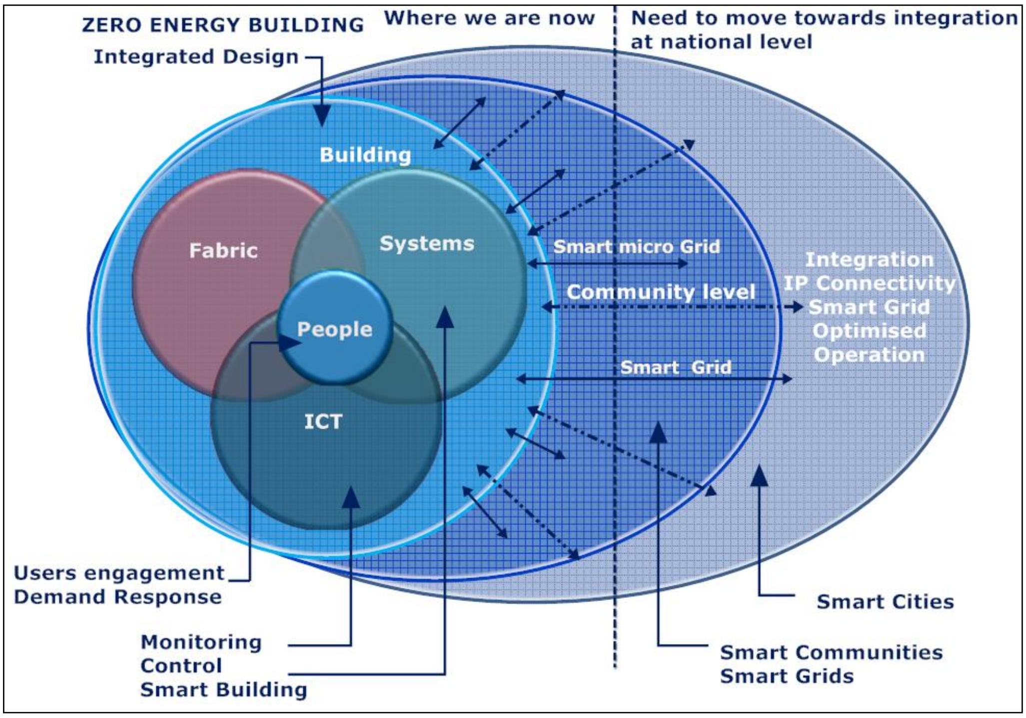


Figure 1: The methodological approach of smart technologies

The main objective of WP3 is the design of common projects concerning smart buildings in an interdisciplinary nature in order to accelerate the process towards zero energy buildings. This describes the first phase which is also the core of the cycle approach. The methodological approach is designed to enhance the researchers' competitiveness and promote the ideas sharing from research to market and vice versa. The researchers from the academic and the industrial sector, through their secondments perform specific tasks to further enhance skills and collaboration. The smart buildings and integration in smart grids work package is focusing on the a) smart buildings' design phase b) smart buildings' operational phase and c) zero energy buildings and integration with smart grids.

Phase 1 starts from the users'/consumers' aspects by focusing on smart and zero energy buildings' analysis [1]. This is a mandatory requirement based on the fact that by 31 December 2020, all new buildings shall be nearly zero-energy consumption buildings. New buildings occupied and owned by public authorities shall comply with the same criteria by 31 December 2018[2], [3]. This is the core of the cycle approach.

ZEBs are buildings that work in synergy with the grid, avoiding putting additional stress on the power infrastructure [4]. Achieving a ZEB includes apart from minimizing the required energy through efficient measures and covering the minimized energy needs by adopting renewable sources, a series of optimised and well balanced operations between consumption and production coupled with successful grid integration [5].

This Deliverable focuses on the design phase and aims to provide guidelines for integrated design towards smart/zero buildings and smart grids.

To this end skills have been developed through secondments from academia to industry and vice versa in the field of integrated design for buildings. Since buildings are major consumers in smart grids, the integrated design task assists to develop a collaborative method for designing buildings for smart grids. The integrated design process requires multidisciplinary collaboration, including key stakeholders and design professionals, from conception to completion. Decision-making protocols and complementary design principles must be established early in the process in order to satisfy the goals of multiple stakeholders while achieving the overall integration design objectives.

The design of NZEB requires an interdisciplinary approach. Reducing the energy demand in the design phase demands specifications of the different designers and engineers such as architects, building physics or façade designers. For the demand side concept of a building the best possible heating or ventilation system should be applied. Activating of thermal mass for example requires the interaction between the structural designer and HVAC engineers. Alternative energy systems have to fit to the concept design and the building energy systems. For this reason, the introduction of a design team is compulsory for the design of NZEBs. In this context the building design phase is of particular importance. IED is a valuable assisting approach to reduce the complexity of the design process, to ensure the implementation of defined targets, to identify the effectiveness of alternative choices and methods of design concepts and to allow decision makers to implement the appropriate solutions based on transparent and solid methodologies. Only if IED is applied from the very beginning of the design phase it is highly probable that a cost-effective solution towards NZEB can be identified, because only at the early design phases any deviation from the general design concept can be implemented at low cost. Therefore, the application of IED constitutes the best way towards the intended NZEB at low cost. Experience from several demonstration projects and best practice exmples shows that IED leads to highly energy efficient solutions at least cost over the life cycle of the building, because the integration of all required expertise already in the early design phase brings forward the most approprite and thus cost-efficient solutions [6].

3. Methodology

In order to provide a holistic approach the following methodology was implemented:

- Integrated design concept is analysed providing the principles of ID process and defining decision making protocols. Client's and Tenant's requirements are presented including capital cost, delivery risk, operational cost and building unsuitability risk reduction. The objectives of services and remuneration models are also investigated. The importance of certification and consultancy aspects is highlighted providing also quality assurance aspects and evaluation of the design quality criteria.
- Within the frame of the secondments hosted in the University of Athens site visit at best practice example NZEB buildings which follow the integrated design concept from the design to the construction and operation, integrating at the same time smart technologies have been carried out. The buildings are documented and their ID characteristics are presented providing also recommendations for smart grid integration.
- Case building were fully assessed during the secondments and the methodology that was developed included the audit and analysis of the building's existing situation, with parameters as Site details and Location, Time, Daylight data and Simulation Weather file data. Except of the above-mentioned, the Layout drawings is described as well as the Activity, Construction, Openings, Lighting, HVAC and Generation data. To enhance the prospects of building's connection into the smart grid an overall integration design objective is required, thus a thermal simulation model has been developed using the appropriate tool. Also, to estimate and establish the best case scenario concerning the energy consumption of the HVAC system as a function of thermal comfort, an Internal CFD analysis for each thermal zone separately is implemented. The purpose of CFD analysis is enumerated analytically below:
  1. Accurate assessment of occupancy; thermal comfort is essential for successful building design.

2. Assessment of Comfort as it can vary considerably for different thermal zones depending on factors such as the location of supply diffusers, radiators, computer equipment, etc.
3. Detailed evaluation of both HVAC system and air flow (cold/hot air) inside each thermal zone.
4. The HVAC system requires more than simply making sure that mechanical heating or cooling system offer sufficient capacity to offset spatial loads.
5. It is equally important to determine that the delivery system is providing an adequate distribution of temperature and fresh air throughout the space.

The correlation of measured and simulated values has also been examined in order to assess the performance and implementation of smart technologies at the buildings.

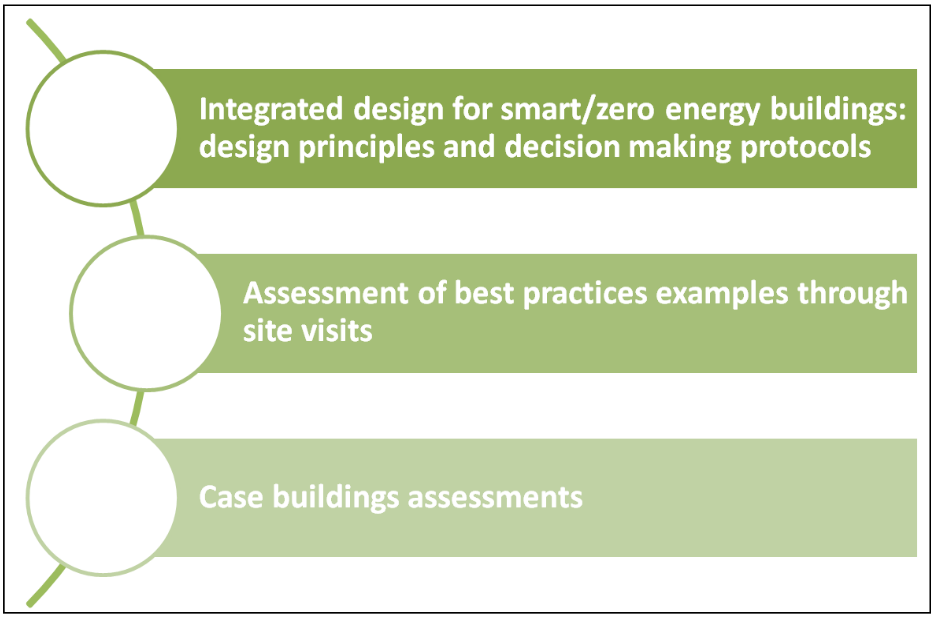


Figure 2: The methodology of implemented work

4. Integrated design in smart and zero energy buildings

Directive 2010/31/EU (EPBD recast) Article 9 requires that “Member States shall ensure that by 31 December 2020 all new buildings are nearly zero-energy buildings; and after 31 December 2018, new buildings occupied and owned by public authorities are nearly zero- energy buildings”. Member States shall furthermore “draw up national plans for increasing the number of nearly zero-energy buildings” and “following the leading example of the public sector, develop policies and take measures such as the setting of targets in order to stimulate the transformation of buildings that are refurbished into nearly zero-energy buildings”.

A nearly zero-energy building is defined in Article 2 of the EPBD recast as “a building that has a very high energy performance. The nearly zero or very low amount of energy required should be covered to a very significant extent by energy from renewable sources, including energy from renewable sources produced on-site or nearby”. The specific EPBD Concerted Action activities around “Towards 2020 - Nearly zero-energy buildings” will support the Member States by the exchange of experiences with already existing high performance buildings(ranging from low energy buildings to passive houses, zero-energy and zero-emission buildings, and even to energy surplus houses). The discussion topics include the most common building and service system solutions, calculation methods, promotional means, available subsidies and other incentives, supporting documents (e.g. guidelines), etc., as well as study tours to interact with experts at national administrations and visits to relevant sites.

There are different national applications of the definition of nearly zero-energy buildings: in some countries NZEBs concept is well established and they act as best practises exaples providing valuable experience to other that are at a level of development oth this concept.. Through such information exchange, Member States participants are mutually supported in the development of the national plans for increasing the number of nearly zero-energy buildings. To achieve a suitable definition, related facts , findings and experiences need to be seen in a broader societal context and need to be transferred into a well defined standard, taking into account financial, legal, technical and environmental aspects. Analysing the implications identified above, it becomes obvious that most of them interact or require the consideration of a holistic approach [7].

Consequently, the principles for an nZEB definition should based on the same broad perspective, addressing the present and future challenges and benefits. Hence, a proper and feasible nZEB definition should integrate the following characteristics [8]:

- To be clear in its aims and terms, to avoid misunderstandings and implementation failures.
- To be technically and financially feasible.
- To be sufficiently flexible and adaptable to local climate conditions, building traditions etc., without compromising the overall aim.
- To build on the existing low-energy standards and practices.
- To allow and encourage open competition between different technologies.
- To be ambitious in terms of energy and environmental conditions considering innovativeness and technology development.
- To be elaborated based on the agreement of the main stakeholders involved (politicians, designers, industry, owners, investors, users etc.).
- To be inspiring and to enforce faster adoption acting also as example for other projects

Within this context, one main objective is the design of common projects concerning smart buildings in an interdisciplinary nature in order to accelerate the process towards zero energy buildings through integrated design. Figure 3 presents a synthesis of the Integrated Design process taking into account climate parameters, building design strategies, systems integration and use/operation [9].

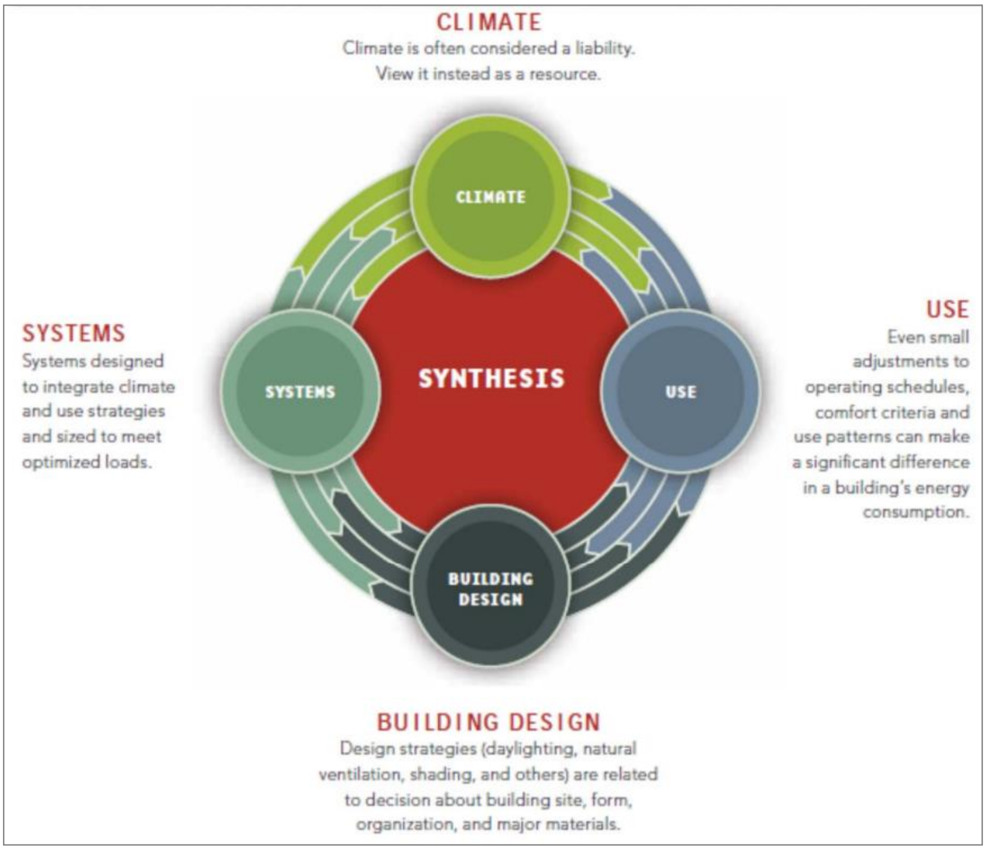


Figure 3: Synthesis of ID process

4.1 ID process principles and guidelines

Integrated design is an approach that considers the design process and the physical solutions as a whole system, which provides optimized buildings throughout the lifecycle. Firstly, for the purpose of reaching high sustainability performance, the project should be developed and discussed by an integrated, multidisciplinary team.

ID emphasizes a decision process rooted in well based choices with regard to the project goals, and on systematic evaluation of design proposals in every stage of the development. This approach for building design is paralleling the principles of environmental management referred in the international ISO 14001 standards. Here, the identification, definition and prioritization of goals, as well as the development of an evaluation plan with milestones, are central and critical issues.

of the integrated approach emphasizes that the very early phases need more attention because well informed decisions here will pay off in the following stages of the design process and eventually in the lifecycle of the building (Figure 4) [6]. The IED approach is an effective way to realize nZEBs because it involves different specialties to interact on energy performance issues in the early stages of the design process. The Figure 4 shows the difference between a traditional approach (grey area) and an IED process (orange area). With the integrated design process the design phase requires more effort than the construction and documentation phase. At the same time, the cost's curve trend changes with the decision making time phase, in the IED approach it is high during the design phases (blue line) while in a traditional approach (green line) it is high during the construction and operation phase due to project changes [6], [10].

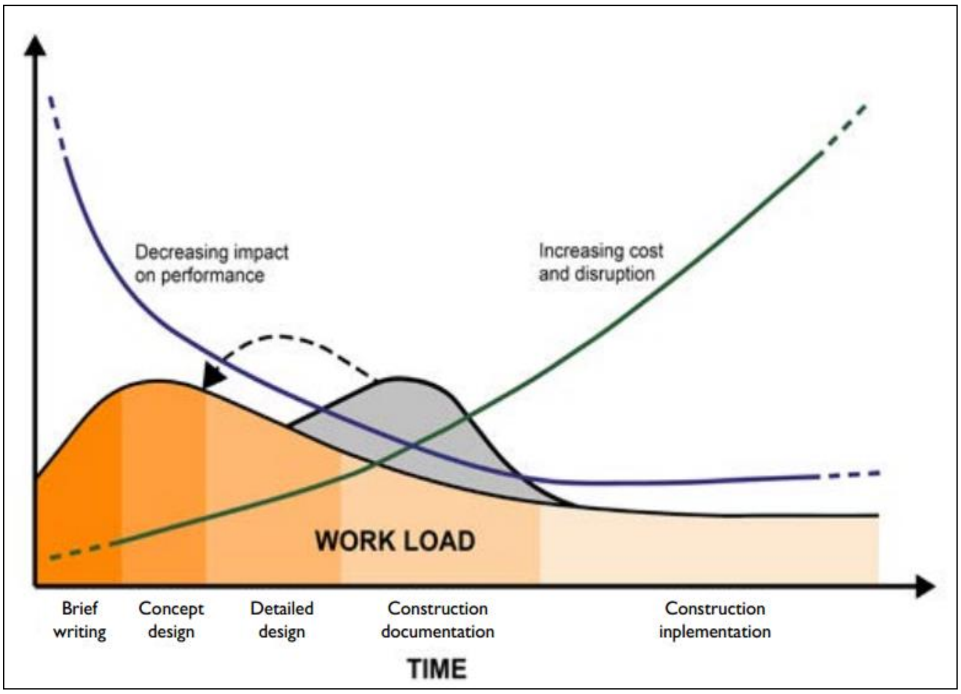


Figure 4: Early design phases impact on performance, costs and disruption. (www.integrateddesign.eu)

Well informed planning at the beginning of te project can allow buildings to reach high energy performance and reduced operating costs at minor extra capital cost. Considering the whole life cycle of a building, the running costs are higher than construction and refurbishment costs; thus, it becomes obvious that a short-sighted approach to squeeze the first design phase regarding resources should be avoided. Experience from building projects applying ID shows that the investment costs may be about 5 % higher, but the annual running costs will be reduced by as much as 40-90 %. The process of ID emphasizes that the performance of buildings should be assessed in a lifecycle perspective, both regarding costs (LCC) and environmental performance (LCA). Figure 5 indicates the cost effectiveness of Integrated Planning vs Traditional Planning through the lifecycle of the building.

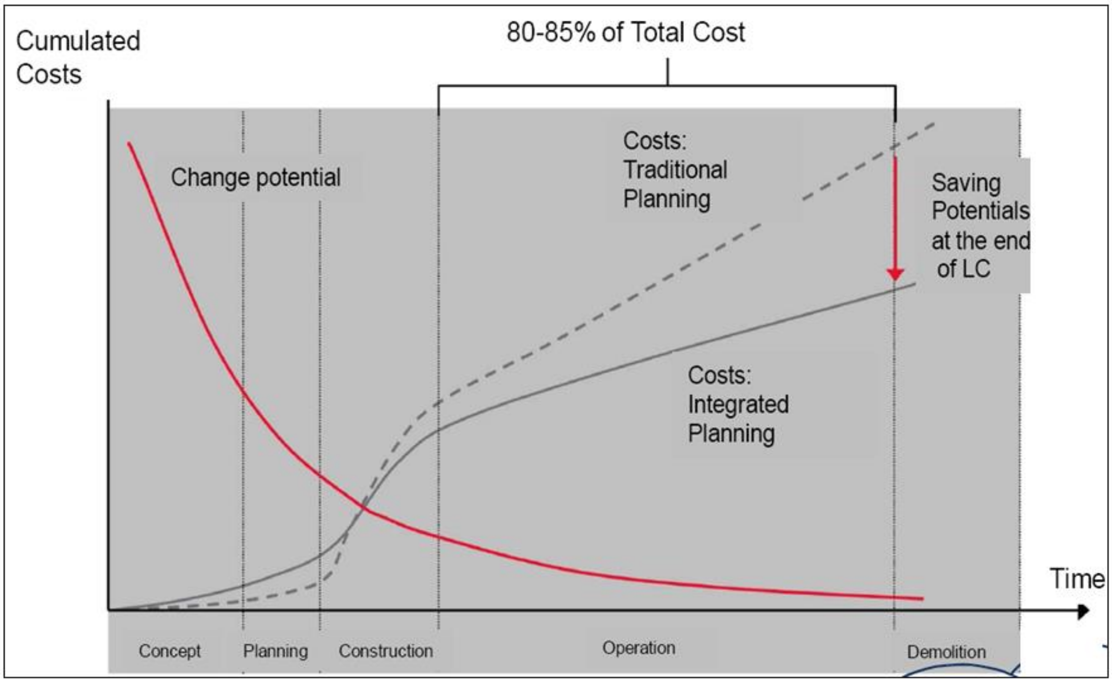


Figure 5: Traditional Vs. Integrated Planning

Six steps can be identified for a successful Integrated Design implementation [6], [10]:

1. *Project development:* discussion of the project ambitions and challenge initial client presumptions, initiating ID process and preferably make partnering contracts.
2. *Design basis:* selection of a multi-disciplinary design team, including an ID facilitator, motivated for close operation, analysis of the boundary conditions. Also define objectives and specify the project ambitions, preferably as functional goals.

3. *Iterative problem solving:* facilitate close cooperation between the architect, engineers and relevant experts through workshops, seminarsetc. Use of both creative and analytical techniques in the design process. Discussion and evaluation of the multiple concepts and finalise optimised design.
4. *On track monitoring:* Use goals/ targets as means of measuring success of design proposals, make a Quality Control Plan, evaluate the design and document the achievements at critical points/milestones.
5. *Delivery:* Ensure that the goals are properly defined and communicated in the tender documents and building contracts, motivate and educate construction workers and apply appropriate quality tests, facilitate soft landing. Make a user manual for operation and maintenance of the building.
6. *In use:* Facilitate commissioning and check that the technical systems etc. are working as assumed, monitor the building performance over time regarding e.g. energy consumption, user satisfaction etc.

The procedure is depicted in Figure 6.The figure emphasises that the creative problem solving process (2) runs parallel in time with the process of monitoring (3) the compliance with project targets, which have been defined in the design basis (1). The ID steps represent concrete tasks in a circular iterative way rather than a linear approach. That to a certain extent goes beyond conventional design processes. This means that an adaptation of the scope of services is required.

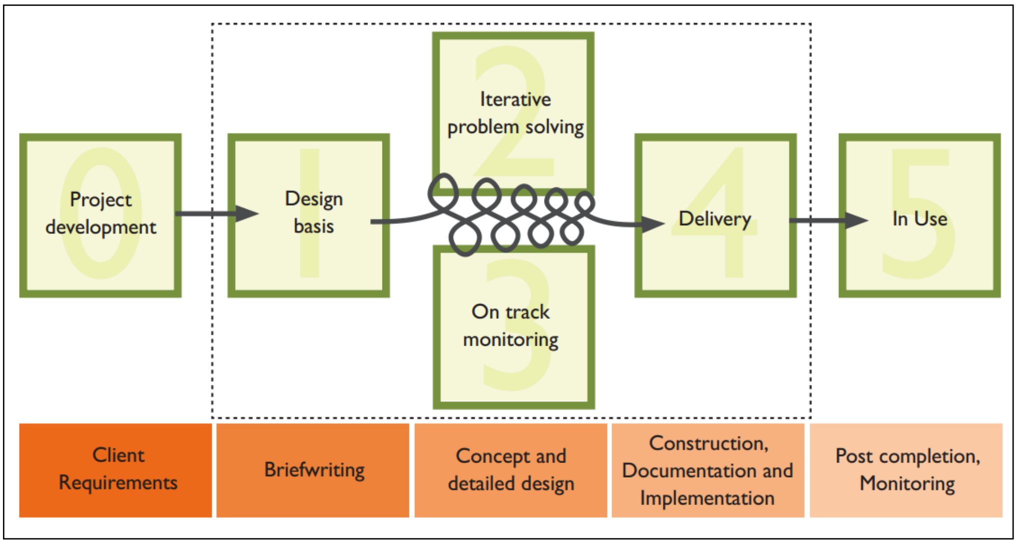


Figure 6: Overview of the ID process

➢ Benefits

Integrated Design processes result in higher energy and environmental performance: all related building aspects are addressed through open multidisciplinary discussions and design decisions in early project phases, where knowledge and experiences are exchanged to provide th most effective solutions.

It also contributes to the reduction of CO_2 emissions as optimized design is prioritized combined with advanced technical systems and control mechanisms.

Indoor climate is significantly improved: the building and technical systems work together in a logical symbiosis in order to achieve sufficient indoor air quality, temperature control and daylight access/ solar protection.

Running costs and maintenance of the building are reduced: efficient technical systems are more cost effective, both in terms of initial investment costs for manufacturing and installation and in terms of running costs and maintenance.

An important benefit is the reduction of risks and construction defects as improved planning leads to less building faults. This results to significant financial savings. Early involvement of users and inclusion of their requirements in the design process may improve the overall performance of the building in the operation phase, as well as increase user satisfaction. A high performance building increase the attractiveness and can yield higher rental costs which can be compensated for by a lower energy bill thus the sales value of the building will increase. A green image enhances also the building profile and benefits the building owner or tenant organization.

- **Barriers**

Despite the important benefits there are certain barriers that need to be addressed as:

1) Conventional thinking: The building sector is considered to be rather slow and reluctant in accepting and adopting new ways of working. ID calls for decision processes and design methods that challenge familiar habits, and require high communication skills. Professionals on both sides of the table must practice in collaboration, and maybe adjust their working habits.

2) ID doesn’t seem a cost-effective approach: Developers traditionally pay more attention to construction costs than lifecycle costs (LCC). However, when energy consumption and maintenance is included in the calculations, it usually supports investments in planning for high performance and robust solutions.

3) Time constraints in initial design phase often press engineers and developers to underestimate the value of thoroughly and integrated planning, and propose high speed and inappropriate solutions when analysing the boundary conditions of a building. It can be challenging to convince the developer that the initial phase is crucial, and that giving time for design iterations often pay off in better concepts and later phases.

4) As the ID process requires close and constant collaboration between stakeholders who may have diverging goals, conflicts could be accentuated. It is therefore crucial that the team members do not insist on strict and definite demands within their fields of expertise, but rather endeavour to work with a holistic approach.

The inclusion of a “design process facilitator” should be considered, in order to organize the process, especially in cases where the architect and client lack knowledge of collaborative working or where the project has particularly challenging performance goals. It is highly recommended that he/she should be assigned and contracted separately to the client in order to guarantee effective coordination and management of the ID process and to avoid the resolve of issues of private interest. Supervision and on-track monitoring throughout the design process should be performed by a facilitator or other person with the authority and experience to challenge both the design team and the client. This facilitator should also be responsible for reporting to the client any variations against the project goals originally defined. A process facilitator such as a BREEAM or LEED Accredited Professional (AP) may be the right option in cases where environmental goals are pursued through an environmental assessment scheme.

4.2 Scope of services

One basic element of ID, which is not common in conventional design processes, is the requirement of comprehensive evaluation of the multiple concepts and technical solutions prior of taking definite decisions. This requirement implies that design work needs to be applied in several projects because a comprehensive evaluation can only be implemented if the concepts and technical solutions in question are available in a sufficiently advanced design.

A principal characteristic of ID is an up-stream shift of work load from detailed design and construction documentation towards the phase of concept design. This characteristic has also an impact on the scope of services. The importance relies not only in the certain tasks that will be implemented, but also at the timeframe of implementation. Dynamic thermal simulations, estimation of indoor conditions and daylight calculations have became a standard tool for the design of complex buildings over the last years. Very often these procedures are applied too late in the process acting not as evaluation of the process but mainly aim at proving that the selected design variants work. From an ID perspective these instruments need to be used as decision-supporting tools for filtering out the most suitable variants. This purpose can only be achieved if they are applied already very early in the design process and if they include the comparative analysis of a broader range of design variants; the same accounts for life cycle cost assessment (LCCA). Considered from an ID perspective an estimation of the future costs, which are usually calculated rather late during the detailed design phase, is not adequate. Instead, ID uses LCCA to compare different design variants from an economic point of view and this kind of comparison is only useful if its results can be fully taken into account without causing larger disruptions in the design process as a whole. Thus it is concluded that thhe LCCA needs to be applied at the very beginning of the design process. Figure 7 depicts the series of the most important typical ID related tasks in the design phases and when they should be implemented or at least initiated. The accurate timing of tasks is crucial in order to fully claim for the benefits of ID [11].

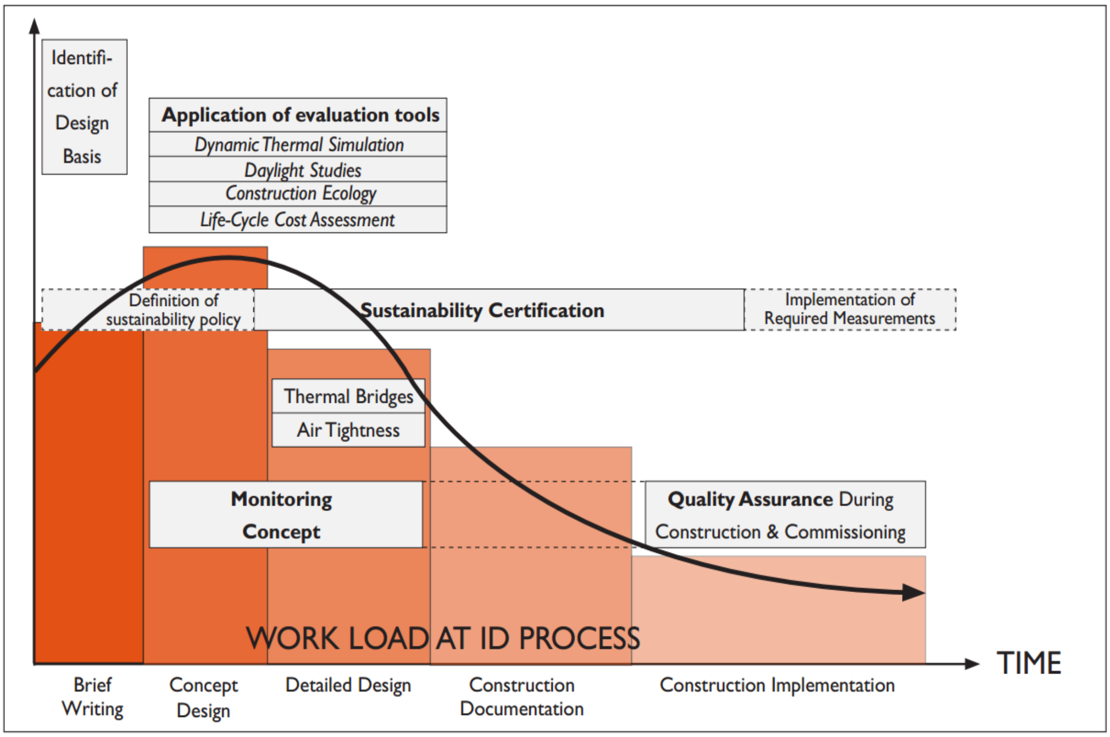


Figure 7: Timeframe of ID related tasks (www.integrateddesign.eu)

4.3 Remuneration models

The impact of ID on the remuneration of design services can be divided into four aspects:

- Qualitative aspects resulting from the fact, that quality targets (e.g. energy performance, sustainability targets etc.) are the usual targets of ID processes;
- Quantitative aspects arising from extra tasks which are not part of a conventional design process;
- Time-related aspects reflecting the fact that ID is shifting design efforts towards the early design phases;
- Structural aspects considering that ID introduces an ID facilitator as additional stakeholder. The first two elements are reflected in a generic approach for an ID-related remuneration model for design works, which we call 3-level-model because it states that remuneration for design works committed to ID consists of three different elements (Figure 8).

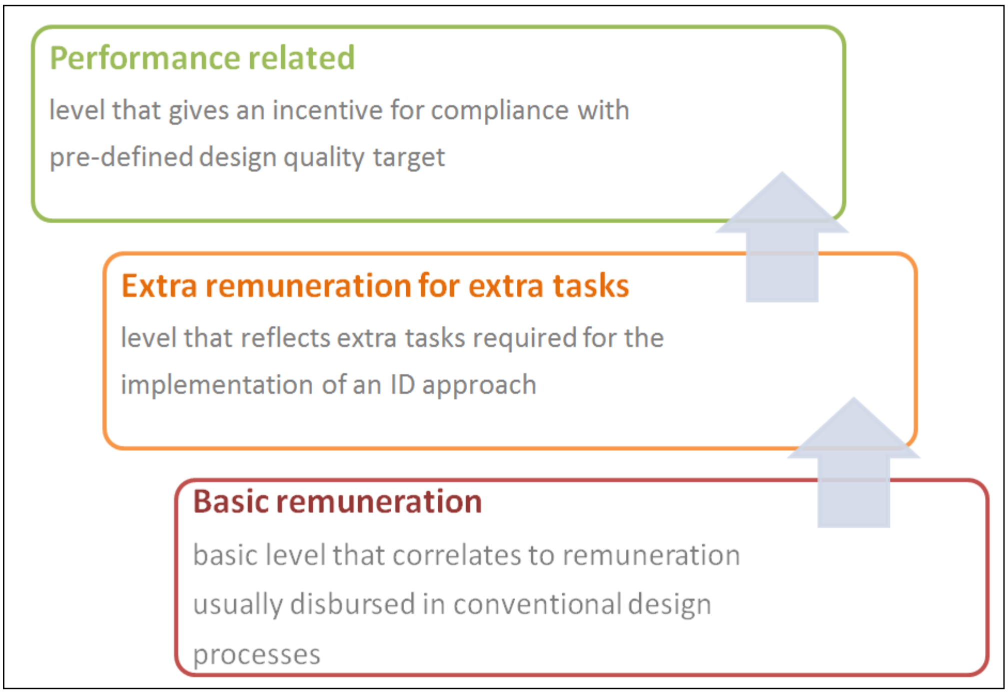


Figure 8: The 3-level-model for ID-related remuneration of design works. (www.integrateddesign.eu)

Level 1- Basic remuneration

The basic remuneration is in accordance with the standard remuneration for conventional design processes. From country to country – but also from client to client – this "standard remuneration approach" shows considerable differences. In principle three different approaches are possible and may be blended in different ways:

- Remuneration based on a certain percentage of construction cost;
- Time-dependent remuneration (e.g. for force account works, which are added later to a running contract);
- All-inclusive price which is fixed before the design works start.

Level 2- Extra remuneration for extra tasks

This level of remuneration reflects the additional tasks which are not necessarily implemented in a conventional design process, but which are required for ID. If the basic remuneration is not sufficient to cover these tasks they need to be disbursed separately. This might be accomplished either by granting an extra percentage of the construction cost or by foreseeing additional time-dependent actions or fixed remunerations for the accomplishment of specific tasks.

Level 3- Performance related remuneration

The third level of remuneration reflects the ambition of ID to contribute to the improvement of design quality. With respect to remuneration this ambitious goal could be supported by introducing an incentive for the designer to address the quality target defined at the beginning of the design process. The way of measuring the design quality is the main challenge of this process. Despite the difficulty of these aspects, a limited share of performance-oriented remuneration seems to be feasible, since several quality criteria and performance indicators can be checked by well-established verification methods and partly also by neutral verification bodies (e.g. sustainability certificate at the design stage). The performance-related part of remuneration tries to enforce the ID procedures and strengthen the attention of design processes on quality aspects – such as energy performance, user comfort and a broad range of other sustainability criteria – contrary to the linear ordinary process and the the omnipresent focus on compliance with construction costs. The three-level-model, as presented above, is seen as generic approach which needs to be adapted to national requirements such as fee structure for

architects and engineers, which are settled by respective professional bodies in many countries. Existing legislation needs also to be taken into account. In addition, the approach has to be modified for different organisational models of design and construction works – such as separate contracts for different design tasks; general planner approach; general contractor approach. Altogether, it has to be underlined that ID is not necessarily more expensive than conventional design, even if the three-level-model might imply this. The focus on early design phases will have a clear cost-cutting impact later on. It can be assumed that this impact exceeds the extra-cost of the early design phases.
Typically, there are several additional services arising from the ID process related to the identification of the design basis conditions, the application of evaluation tools, the sustainability verification, consultancy and quality assurance issues.

4.4 Application of evaluation tools

The appropriate application of evaluation tools requires an analysis of the design basis conditions identifying the aspects that should be considered:

- Identification of the client's sustainability policy and requirements: This can be done by considering sustainable design schemes (Passivhaus certification scheme, BREEAM, LEED, DGNB, ITACA etc.);
- Evaluation of the local climate and analysis of the prevailing meteorological conditions during summer/winter and day/night). Investigation of the preconditions influencing building orientation, surrounding buildings, obstacles, sun angle, shading, micro-climate, daylight availability, outdoor air quality, noise sources, acoustic intensity etc.;
- Determination of relevant boundary conditions for building concept regarding thermal, visual and acoustic comfort, indoor air quality, operational and embodied energy etc.;
- Integration of (preferably on-site) renewable energy sources: Location, availability of natural resources, climate, studies on the feasibility of integrated geothermal systems.

The following evaluation tools may be part of iterative problem solving and/or part of on track monitoring. They are aimed at supporting the design team in filtering out the optimal design variant by checking to which degree different variants fulfil the defined project goals and targets.

1. Dynamic Thermal Simulation of a building or reference zones in order to assess annual indoor temperature and humidity ranges as well as hourly heating, cooling and power loads for building operation: Assessment of different design alternatives, solutions and scenarios, building forms and functions;

- Energy performance calculations: Demand and supply, energy required for heating, cooling, humidification, dehumidification, ventilation, pumping, artificial lighting, electric equipment;
- Indoor conditions assessment: thermal comfort estimation based on calculation tools
- Determination of shaded facades: sun study, optimisation of shading device;
- Project-related climate studies: Insolation, total available solar energy and average temperatures, Mollier-Chart (temperature-humidity), wind rose

2. Calculation of benchmarks referring to ecology aspects of the construction (different kinds of material related indices many of which are now defined only on a national or regional basis): Thermal and optical characteristics of materials such as solar reflectance and infrared emmitance, Index of global warming potential, index of photochemical ozone creation potential, index of acidification potential and others;

3 Life-cycle cost assessment: Economic evaluation of different variants to identify cost optimal solutions over the life-cycle of the building (as complementary information to construction cost);

4.5 Sustainability certification

If the sustainability policy for the project has been set on the basis of sustainability certification schemes (e.g. BREEAM, LEED, DGNB, ITACA), its achievement has to be checked at certain check-points by assessing the fulfilment of single criteria. Depending on the sustainability certification scheme selected, this refers to criteria in the following fields:

- Management: Project brief and design, LCC, commissioning and handover
- Location and Transportation: accessibility, land protection and facilities
- Sustainable sites: construction activity pollution protection, environmental site assessment, heat island reduction, tenant design and construction guidelines
- Water Efficiency: water use reduction, water use metering
- Energy and atmosphere: reduction of energy use and carbon emissions, energy efficient equipment, advanced energy monitoring, demand response
- Materials and resources: life cycle impacts, material efficiency, waste management, recycling
- Health and well-being: visual comfort, indoor air quality, thermal comfort, acoustics, safety and security
- Innovation

These schemes foresee an accredited person in charge of the assessment. Besides an informal check by the design team, most sustainability certification schemes offer the possibility to conduct a formal pre-check by issuing design certificates at different stages of the design process. Figure 9 presents all aspects of sustainability for high performance NZEB buildings.

Figure 9: Sustainability aspects for high performance buildings

4.6 Consultancy and Quality assurance

Consultancy regarding an optimized building design and overall performance refers e.g. to building envelope, thermal quality, facade openings, solar radiation with respect to the local climate conditions and focuses on the detailed design phase.

- Thermal bridges calculation: Minimization of condensation risks, minimization of thermal losses;

- Ventilation and Air tightness: Critical points.

The procedure includes the verification of the results achieved with regard to the quality criteria set for the project (sustainability policy, user comfort etc.) through:

I. Measurements: Blower door test, thermography etc.
II. User survey coupled to comfort monitoring;
III. Indoor quality monitoring of installation and setting of technical systems;
IV. Energy monitoring: Energy data analysis aiming at the detection of short-comings in building operation;

Other actions within this framework are:

1. Work sessions with the design team for general interdisciplinary issues and guidelines;

2. Work sessions to develop the specific targets of energy performance and environmental concepts for design issues, such as

   a. Heating, cooling, humidification, dehumidification andventilation

   b. Daylight and solar control;

   c. Indoor climate control;

   d. Energy supply strategy (e.g. co-generation, solar heating and cooling, PV, etc.):

   e. Energy monitoring concept: smart meters and systems

   f. Use of materials

   g. Water saving

   h. Outdoor environment and landscape

4.7 Measurement of design quality criteria

In the context of remuneration the quantifiable performance criteria that can be applied, are:

1. <u>Criteria for energy performance:</u> Different benchmarking at each level of the ID process can be applied as a measure of the energy performance E.g. net heat demand, net cooling demand, final energy demand, primary energy demand, etc. The performance level requires adjustments and clarifications, as well as the verification methodology (e.g. a standardised calculation methodology such as a building simulation).
2. <u>Criteria for environmental quality</u>: Sustainability criteria are reflected by sustainability certificates. Thus, sustainability certificates may also be used to define and measure quality. The quality target “LEED Gold” can be measured by applying for a design certificate for LEED; Since the sustainability certificates include a wider range of different topics and criteria as described in paragraph 4.5 , the client might wish to select specific focus areas within the frame of sustainability certificates. The achievement of the (sub-) targets defined for these focus areas (such as ecological materials or recyclability) can be measured by applying the verification methodologies prescribed by the selected sustainability certificate.

3. Criteria for life-cycle cost: The usual criterion for economic performance and evaluation in the construction sector is compliance with target values on construction cost. From an ID point of view the construction cost target could or should be complemented by a life-cycle cost analysis. In principle, both values are measurable, although in practice a very clear -definition of the verification methodology is necessary.

The aspect of measurability of the performance criteria for design quality – as described above – is closely linked to the timeframe of measuring the performance of the design team. Obviously, that there is no best solution, but each point in time has advantages and disadvantages in regard to the measurability of design quality so an optimum method can be selected. Table 2 provides a short overview of criteria.

Table 2: Overview of the measurability criteria of ID

Timeline	Measurability	Advantages	Disadvantages

after concept design respectively after detailed design	verification only through calculated quality criteria	design quality (compliance with design targets) depends prevailingly on the design team	several quality criteria are not measurable at this stage
after construction documentation	several quality criteria are already closer to reality	more quality criteria are measurable than in the earlier design stages	increasing influence of suppliers on the quality by submission of tender materials
after construction implementation	some quality criteria can be measured directly already	clearer and more distinct picture of the final quality of the project compared to the predefined quality targets	execution of construction work introduces an additional impact on quality
after a certain period of operation	operation-related quality criteria can be directly measured	selected quality criteria can undergo a reality-check (e.g. energy consumption, comfort parameters etc.)	besides design quality, also quality of execution of construction work and operational quality have an important impact on the overall result

The assessment of quality of design work is a complex challenge that offers no simple or obvious solution. Although in theory it is possible to measure certain design-related quality aspects at different points in time, using performance indicators etc, there is hardly any experience of integrating performance aspects into the designer´s remuneration.

On the other hand, ID puts forward quality targets and therefore a reflection of this aspect in the remuneration of the designer would be a logical step. Therefore performance-related remuneration elements are proposed to become part of the generic approach for an ID-related remuneration model. Taking the complexity of the topic into account, it is clear that performance related elements are not suitable to become a major part of the designers' remuneration, but they may serve as extra incentives for performing work better than standard. Bearing in mind this limitation, we think that performance-related parts of remuneration for designers are feasible.

4.8 Defining Client's objectives

There are no obligatory requirements referring to the ID process so each Client can choose to approach the aims of Integrated (Energy) Design in a way that best suits their priorities. However, a typical framework could be adopted, highlighting both the iterative procedure and the additional methods available.

Key to ID as stated before is the appointment of a core design team from the start of the project that are instructed to work collaboratively and openly to satisfy the Client's objectives and ensure an environmental and energy efficient building operation. Clients should therefore ensure that the core team are appointed at the initial stage of the project. .

All information related with the site's environmental factors should be gathered by, or for, the design team, and presented in an easily understood format to all parties. Clients should therefore ensure that appropriate surveys, data collection and reports are both budgeted for in the initial development appraisals and commissioned as early as possible. Inevitably, the Client expectations for the site (especially if the land/building has already been acquired or there is a potential Tenant) are the basis of the procedure. This step determines the brief and gives the design team the opportunity to review elements that may be restricting the optimum design or cost outcome. To this end, an open forum meeting or workshop involving all the design team with the initial Client brief circulated in advance with an invitation to feedback at the meeting is essential. Clients should ensure that time and budget is allowed for this stage, and where a future Tenant is known, he could be involved in the process. The second part of this step is to translate the agreed brief into clear targets for the design team to deliver through the design stage, construction and with the completed project.. Where possible, these clear targets should be contractually embedded. An obvious difference between ID and traditional design development is that, for concept designs, the design team should be required to present several alternative proposals in an iterative way. This helps the reduction of the risk of a single solution becoming overestimated whilst ensuring different approaches are explored. It is important for the effectiveness of the process that Clients ensure the engagement ofany known Tenants, and that the design team's appointments reflects the requirements, and moderate time and costs, for undertaking this approach. The series of meetings and workshops, together with a requirement for multiple early concept designs that are assessed both creatively and analytically are the tangible differences of an ID approach versus conventional approaches. The final workshop session for the design team and client should select the optimum design solutions addressing the client's requirements. It should be ensured that the core team presents all the information needed for this meeting, and that any known Tenants or building end-users are present to input into the final selection of the scheme to be developed. Upon the selection of the final design, an updated version of the Client's brief and targets must be generated to accurately represent what is intended to be delivered: Where Tenants are present such updates may also be required to any Agreement to Lease. This updated Brief and associated goals can be used to form contractual obligations, incentive payments or delivery metrics for both the design team and contractor defining the financial aspects of the project. The client objectives should directly feed in to the development outline and detailed specifications and the specific targets reflected in these documents. As a successful project implementation scheme, ID is reliant on communicating the critical issues, notably the client brief and targets, through the whole construction team delivering the building work. This should include embedding the ID goals into all relevant and contractual documentation, but also plans to communicate them to all involved stakeholders. Another aspect that could be taken into consideration is site training in relevant skills. ID is also efficient on communicating the presumptions and optimum usage methods to the end users of the project as well. In this regard, Building User Manuals, "Soft Landing" contracts and early engagement with the building management personal are important.

4.8.1 Capital cost reduction

Adopting an ID approach to design can be an effective measure to reduce the overall capital cost of the project. However, this overall cost reduction is realised in a later phase ofthe project, and inevitably the initial stages of design work will result in slightly higher costs due to the extra work effort at the early design phases whilst the core design team develop the optimised scheme design. The slight increase in core design team costs are offset through the improved design delivered through the IED process. Typically, an IED approach will add 0.2% to the project costs before planning, but deliver 3% cost saving on the overall capital spend. Cost reductions are realised through a more coordinated and rationalised design that is better understood by the core team, with potential for notably better interaction between architectural envelope and internal services often yielding some of the largest savings. The process of ID can also operate with the adoption of Building Information Modelling (BIM). BIM is a coordinated set of data about the design (often, but not necessarily in 3D) which is developed by the whole design team, and as such fits with the collaborative approach of ID.

4.8.2 Delivery risk reduction

The collaborative design approach embodied within ID reduces the risk inherent in building design and construction processes through better coordination at early stages in the design development, and a better understanding of the underlying design principles by all key parties through improved communication and collaborative working. This risk reduction is complex to quantify, even through the trial ID projects, since it would require identical “non-ID” projects to be coupled for comparative analysis. However, the risk reduction encounters the reduction of problems and deviations which could otherwise result in an increase in project construction budget as well as those which could occur delays to the project implementation.

4.9 Defining Tenant's objectives

Construction projects are frequently formed based on anticipated future space requirements identified by companies; such companies then enter in to Agreements to Lease (pre-lets) with developers who, as experienced construction Clients, then design and construct buildings in order to accommodate the company's requirements. At the completion of the building, the company then occupies the space created at previously determined rental rates. Typically, the building asset would also usually be sold by the developer (if not already) to an investment portfolio to other stakeholders. As this remains a proven delivery mechanism, however it does contain a fundamental dysfunction between the future Tenant's requirements and the developer (Client's) motivations and initial targets; the Tenant will typically be driving for low maintenance & operational costs and insist in solutions fitted to their needs, whereas the Client will be proposing low capital construction costs and 'standardised' solutions acceptable to a wide number of tenants. However this proposal might neglect the specific needs of the project. The usual approach to address this issue is through the specifications and requirements embedded in the Agreement to Lease, and for larger schemes a degree of ongoing monitoring through the design development by an appointed team. Many of these specifications will include the principles of collaborative work even though, such references are not adequately or clearly defined in the contract. The ID process provides a clearer mechanism for ensuring the Tenant's requirements which are also highly considered throughout the design process. This also requires the use of ID by Clients as part of Agreements to Lease which provides an improved outcome for the Tenant.

4.9.1 Operational cost reduction

The ID approach is fundamentally intended to assist design teams to ensure that schemes are designed to satisfy the defined objectives whilst using the minimum building operational energy. This is achieved through the creation of multiple design concept and assessing their energy performance. The engagement with this process, foresees that the Tenant is able to directly steer the developer Client and retained design team towards lower operational cost buildings. It is acknowledged that the developer Client will incur marginally increased design costs for this process, which in result will finally be passed on through future rental to the Tenant. This slight increase in core design team costs is typically more than offset in the construction process through the savings of the proper construction solutions, coordination and efficiency. The adoption of ID can therefore be considered, at worst, as “Cost neutral” for a developer Client. Tenants should therefore resist any developer Clients that attempt to add cost for a requirement to use an ID approach.

4.9.2 Building Unsuitability Risk reduction

The ID approach provides a collaborative design scheme starting with a detailed analysis and refinement of the developer objectives, which for the Tenant is likely to be directly or indirectly derived from the intended specifications in the Agreement to Lease. This provides an initial opportunity to refine the original briefing document and allows the Tenant to gain the benefit of the design teams’ construction experience to review, and challenge, their requirements in order to provide the optimum solution. This interactive process provides benefits both for the Tenant by allowing the opportunity to improve the initial specification and plan based on the design team’s experience (but not the obligation), as well as ensuring the design team have a thorough understanding of the Tenant’s needs in a more explicit way than can be achieved through a written and approved document. Consequently, the ID approach can provide an effective scheme which tailored to the tenant’s and client’s needs by a combination of the requirements being better quantified and better understood by the whole design team. Figure 10 summarizes the various benefits of a green buildings for developers, owners and tenants.

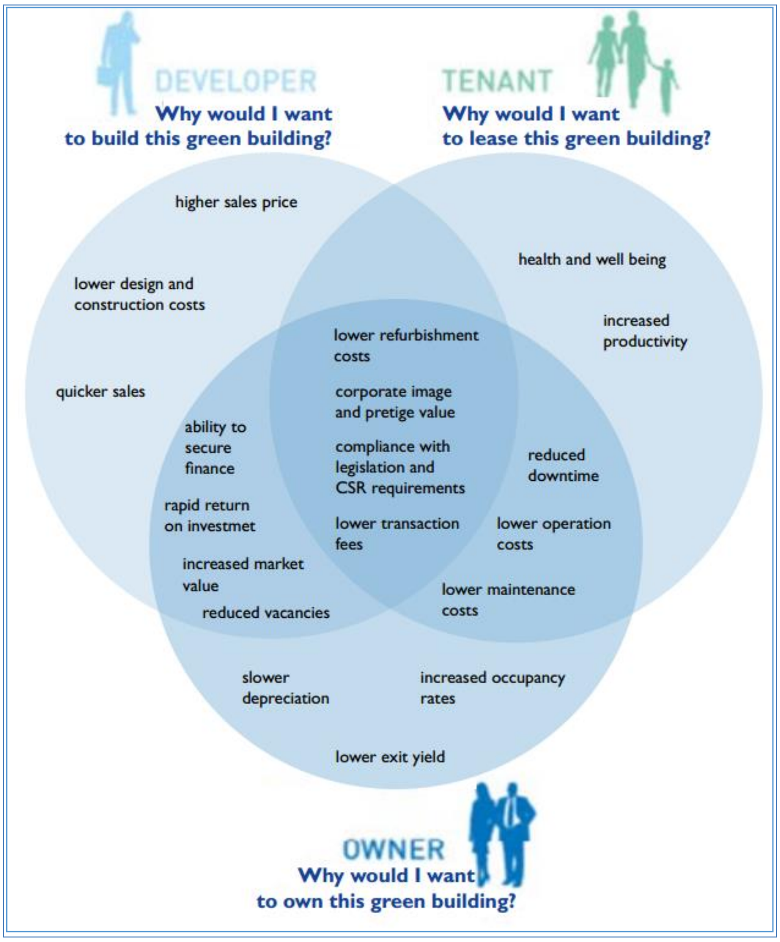


Figure 10: The interplay of Green Building benefits for developers, owners and tenants (WGBC 2013)

5. Research activities in the Smart GEMS Project

During the secondments in the framework of the Smart GEMS Project several buildings were addressed in this activity in order to:

- Identify and discuss best practices in good designing;
- Analyse the energy needs and simulate improvements from the industrial point of view in order to identify and propose possible improvement related to cost and energy savings in existing buildings.

Implemented research activities can be divided in two categories:

- **Assessment of best practice examples through site visits**

These activities were performed during the secondments that were hosted in the University of Athens and included sites visits, meeting with the building managers and assessment of the performance of 4 best practice buildings in Greece:

- **A.N. Tombazis and Associates Architects Office Building**
- **Apivita Commercial & Industrial S.A.**
- **Stavros Niarchos Foundation Cultural Center**
- **Karelas Office Park**

The buildings have adopted the ID procedures from the early stages of design until the final completion and operation. Throughout the secondment activities the applied smart technologies have been investigated in relation with the integration to smart grids.

- **Case buildings assessments**

Case building were fully assessed during the secondments and the methodology that was developed included the audit and analysis of the building's existing situation, with parameters as Site details and Location, Time, Daylight data and Simulation Weather file data. Except of the above-mentioned, the Layout drawings is described as well as the Activity, Construction, Openings, Lighting, HVAC and Generation data. To enhance the prospects of building's connection into the smart grid an overall integration design objective is required, thus a thermal simulation model has been developed using the appropriate tool. Also, to estimate and establish the best case scenario concerning the energy consumption of the HVAC system as a function of thermal comfort, an Internal CFD analysis for each thermal zone separately is implemented. The buildings that were analysed were:

- **SUMMA building, Italy**
- **KITE lab, Italy**
- **AEA building, Italy**
- **Library building, Greece**

5.1 Best practice examples-site visits

5.1.1 A.N. Tombazis and Associates Architects Office Building

The building is located at Polydrosso, Halandri (Figure 11). It is a residential area, on the northern part of Athens, with relatively low traffic. The presented building is the office building of the architectural group A.N. Tombazis and Associates Architects– Meletitiki Ltd. This is one of three office buildings, which are designed as one complex around a common courtyard. Apart from the architectural practice “MELETITIKI – Alexandros N. Tombazis and Associates Architects” Ltd., the complex houses a contracting company and different engineering companies (Figure 12). One of the main issues was saving energy and enhancing comfort and architectural quality. The building was constructed during 1990-1995 and the design as well as the construction was a leading example in the field of sustainability and integrated design in Greece.

The building is located in a residential area in the municipality of Maroussi Athens. The block consists of three office buildings from which the east building is the A.N. Tombazis and Associates Office Building.

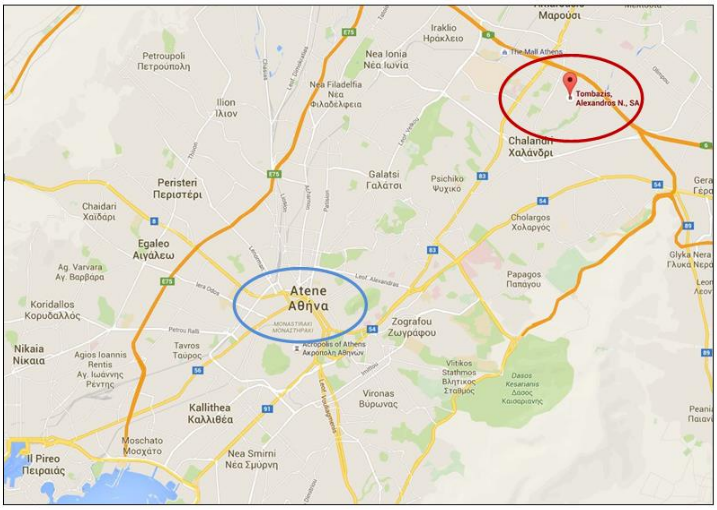


Figure 11 Location of Tompazis Office Building (red) and city center (blue)

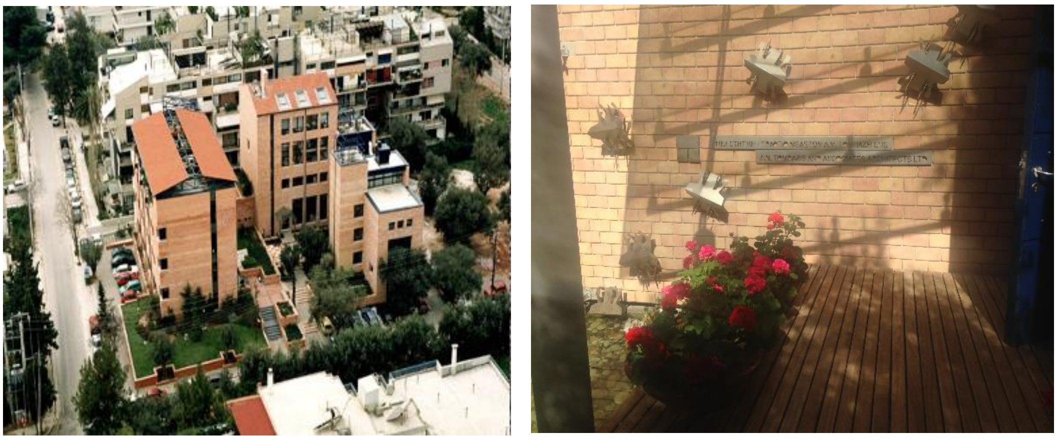


Figure 12 a. The block of buildings that includes the Tombazis building (left)

b. Entrance of Tompazis building (right)

The total building area is 1100 m^2. The design is developed in three levels, and basement with parking area. The two long sides of the Office Building are facing east and west. For reasons of bioclimatic design, the building is narrow and long, approximately 8 x 35 m. Thus all workspaces are adequately supplied with daylight through side windows. As many as possible of the mature olive trees that existed on the site have been saved or transplanted. An important feature of the landscaping is the pond, a sculpture by G. Zongolopoulos and the wooden decks that lead to the entrances of the buildings (Figure 13).

Figure 13 Artificial pool, sculpture, and entrance of the Tombazis building**.**

The interior of the building is one open space developed on three split level decks interconnected at two points by two open steel stairs with wooden treads that have been designed in such a way, so as to provide minimum visual obstruction and can be seen as bridges. Metal trusses support the concrete slabs of the different levels of the building. In order to combine the structural and mechanical depth and increase the perception of openness of the interior space, metal trusses support the concrete slabs of the different levels of the building (Figure 14).

Figure 14: Interior spaces

The local environmental conditions are the following:

- Microclimate: Suburban
- Average ambient temperature: January 10ºC, July 26.5ºC
- Global irradiation: 1581 kWh/m^2
- Sunshine hours: 2818 h

The present office building is an interesting example of a well-designed building from architectural and energy point of view. The shape and the orientation, as well as, the interior planning of the building (it is an open space) give the possibility to exploit the local climate for energy conservation and daylighting purposes. The installation of a BEMS gives the possibility to control all the systems (such as ceiling fans, night ventilation fans, etc.) installed in the building as well as to monitor energy consumption. The building is also equipped with 7 split and 2 single package air-to-air heat pumps for cooling and heating purposes (back-up system). Rainwater is collected and used for irrigation and flushing of the double mode toilets.

The shape of the building and the location of the workstations, near the windows, allow an efficient use of the daylight. The building gets daylight from both sides by windows and from the roof by way of clerestories. Also, these clerestories are equipped with reflective curtains in order to distribute the daylight “deeper” in the building.

- The building including most of the basement is naturally lit by means of sill to ceiling windows that area provided on both long east and west facing facades and clerestories above the two stair wells.
- The east- and west-facing windows are provided with exterior fabric awnings positioned at approximately 15 cm from the wall, which provide both shading and glare control.
- The south-facing clerestory is provided with a light shelf on the south side.

Ceiling recessed downlights and task lighting compose the artificial lighting system. Artificial lighting is used only in case natural lighting is not adequate. The control of the artificial lighting system is manual on/off (Figure 15 b.)

Another important element of building is the shading devices. They are exterior blinds for the windows and interior blinds for the skylights. The material is white plastic cloth, and its height can be adjusted, through a rotation mechanism. On the last level of the building, skylights are constructed, in the middle of the ceiling. They are covered with panels of cloth, which hang from the roof (Figure 15 a.)

a. **b.**

Figure 15 a. Natural and b. artificial lighting

Special attention has been paid to a combination of natural ventilation and passive cooling with mechanical ventilation. A central unit controls the system. In this region, the heating and cooling loads of an office-building normally cause high electricity demand. The following extra measures are taken:

- Natural cooling is achieved by evaporative cooling due to the presence of vegetation and water pond, by solar protection of the building shell and by cross ventilation.
- Ventilation and cooling is achieved by cross-ventilation, when appropriate and by automatically controlled ceiling fans, which extend the comfort range from 25°C to 29°C. When temperatures exceeds 29°C a zoned all-air heat pump back-up air-conditioning system turns on.
- Cooling is further enhanced by radiation by the mechanical night ventilation provided by two extraction fans on the roof, which by way of the lower night time exterior temperatures provide a temperature drop of about 3°C the next day.
- The thermal mass of the building is very high.

The exterior of the building is clad with fair-faced cement bricks and has increased 10cm insulation. The U-values of the ground floor, roof and external walls are 1.41 W/m^{2}K, 0.45 W/m^{2}K, and 0.40 W/m^{2}K respectively.

Acoustics have been given special attention due to their importance in the large open interior space. Metal acoustic panels are suspended from the concrete decks of the different levels in an open configuration that allows for movement of air between the panels and ceiling.

Measurements for a full year (April 1996-March 1997) show the following results: The overall consumption (heating, cooling, lighting, night and day ventilation and equipment) is 90.1 kWh/m^2. The total consumption for heating is 35.7 kWh/m^2 and 4.7 kWh/m^2 for cooling. The energy consumption for lighting is 3.1kWh/m^2 which on average represents 3.5% of the total energy consumed. A large amount of energy 24.7kW/m^2 is consumed for PC's. As the building is properly designed to reduce the energy consumption for cooling, this parameter represents only the 5% of the total energy consumption. Additionally, the energy consumption for the artificial lighting system is also low (4%), a proof of the right natural lighting design of the building. This is about 10 times cheaper to run this building than another of this type in Greece: in fact, office buildings have a total annual consumption (for heating and cooling) from 50 to 240 kWh/m^2/year, while the Tombazis office building consumption for heating and cooling is 41.4 kWh/m^2/year.

The energy used for heating, cooling and electricity was obtained from meter readings for 9 different points in the building and from energy bills. The *total yearly energy consumption* for the monitoring period (May 2008-May 2009) was 79.7 kWh/m² (corrected for hours of use) with a breakdown as follows: i) heating 29.2 kWh/m², ii) cooling 18.8 kWh/m² iii) lighting 2.7 kWh/m² iv) ventilation 1.2 kWh/m² v) PCs 15.5 kWh/m² vi) other 12.3 kWh/m². Regarding lighting, the national average is about 30-40% of the overall building consumption, while in such a building is up to 3.5%. The total construction cost was about 1,000,000 €.

5.1.2 APIVITA Commercial & Industrial S.A.

The new APIVITA building is in tune with the company's philosophy and values, symbolizing sustainability, innovation and a unique way of connecting the workplace with the natural environment. It is located in the Industrial Park of Markopoulo, Attica, Greece, in an area that was once an olive grove; this is an example of a building of NZEB principles in design phase (Figure 16).

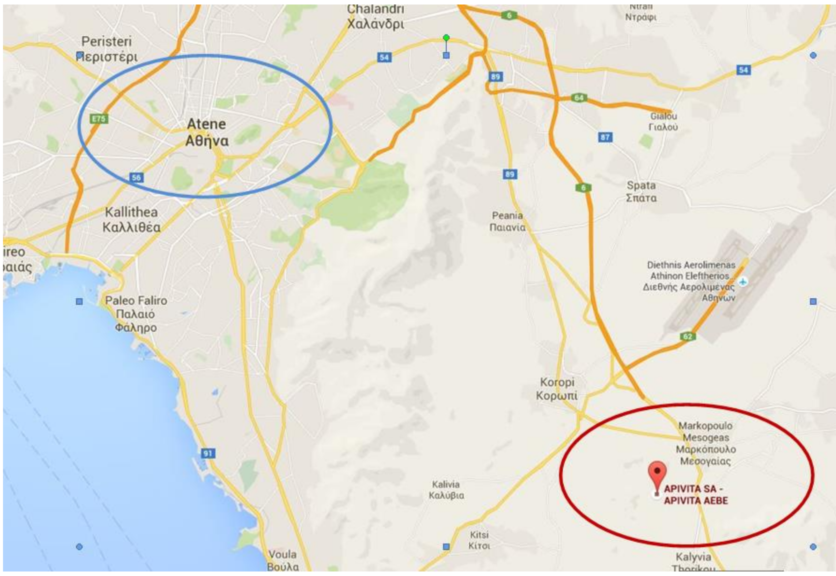


Figure 16: Location of APIVITA Building (red) and city center (blue)

In terms of architectural design, the building simulates a beehive, which brings together all the company's activities, such as offices, training, museum, laboratories, cosmetics production, honey packaging, bee pollen and royal jelly, personnel dining hall, SPA and events. The building covers a total surface of 6,830 m² in five levels, two underground and three aboveground, in an area of 6,170 m² (Figure 17).

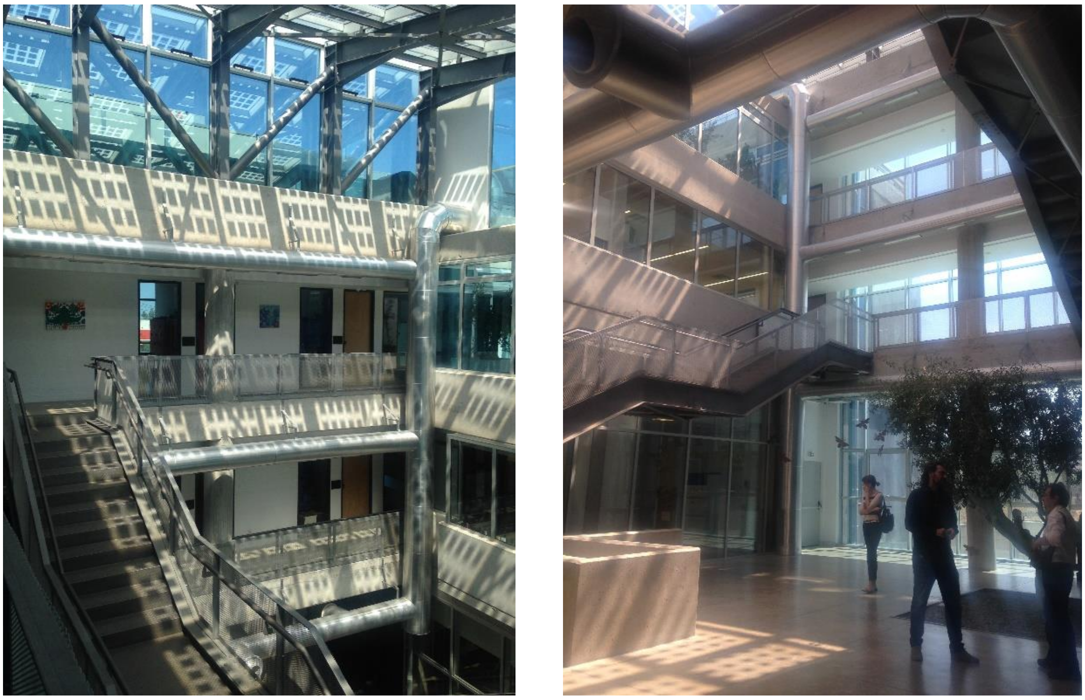


Figure 17: APIVITA interior space

The key feature of the central atrium is an olive tree, the symbol of serenity, protection and fertility. It is known that APIVITA combines the ancient Greek tradition with the rich Greek flora, focusing on the life of the bee, and creates natural, ecological, effective and holistic cosmetics. It draws inspiration from the beehive, and therefore the society of the bee. The beehive and the society of the bee lead to the main features are cooperativeness, dedication to a common goal, respect to one another and to the environment, the attempt to achieve high qualitative goals.

As a natural outcome of these elements, the beehive worked as an archetype for the construction of the new facilities, in terms of togetherness, allocation and use of the space and mainly functionality, having as a dominating criteria the comfortable, human living of the employees.

As an extension of the factory, right opposite, there is the space of interactive contact with the Greek biodiversity, a miniature of the sources of inspiration of the company: the olive trees, the working society of the bees and a labyrinth made from lavenders and rosemaries, which invite us to forget for a while our daily concerns, to recharge our energy levels and understand the uniqueness of the principles of the company.

The construction of the building was based on the following criteria:

- Simplicity, aesthetics and functionality
- Natural lighting and ventilation
- Respect to natural resources and local biodiversity
- Bioclimatic Design
- Reduction of ecological footprint
- Thermal and visual comfort
- Recyclable, natural and ecological Greek building materials.

To manage the natural sources the following technologies are used:

- a system for geothermal energy exploitation
- photovoltaics
- a rainwater tank, where water from the building and from the environment are gathered, to be used for watering.
- biological waste cleaning and disposal of the water for watering
- green roofs on the first and second floor
- large plantations in the surrounding space, with aromatic, pharmaceutical Greek plants and herbs, fruitful trees and species of the local flora with about 200 species and 5000 plants in their gardens located also on the roofs and balconies, so that the microclimate serves the biodiversity (Figure 18).

The building is mainly made of glass and the energy needs are in charge of geothermal energy system and PV production. Additionally, rain water from the building and from the environment is collected, filtered with a double-pass osmosis treatment and then used for watering.

Natural light infiltrate the building and in winter the solar radiation heats the air; on the contrary, in summer it helps the air ventilation due to proper openings at the top and the bottom. Moreover, interior plants improve air quality.

Figure 18: Plantation in the area of APIVITA building

The offices are situated on the first and the second floor of the building, in a rectangular space with clean geometric lines. The ground floor hosts the two main production lines, namely cosmetics and honey packaging. The first floor underground hosts the packaging department, as well as the accompanying storage rooms. In the same floor we can also find the restaurant. The storage rooms for the packaging materials and the engine rooms are situated on the second floor underground.

The main goal of the architectural design was to shield the building from external environmental factors.

The shaded patio in the entrance area and the four glazing storeys allow natural light to infiltrate the building. Thus, during the winter, the solar radiation entering the building from the southern wall heats the air. During the summer, it acts as a ventilation hopper due to the proper openings at the top and the bottom that facilitate the air movement. The interior planting acts as a natural air purifier and maximizes the energy benefits by cooling the air.

All building materials are certified with ISO, and most of them are ecological-natural and recyclable, the spaces were constructed according to FDA standards (production, packaging, weighing, sampling) and for the lighting of the offices and all internal spaces there are lights of low consumption, while for the outside spaces they are LED.

On the surrounding space there was an attempt to maintain the local flora of the area so the herbs planted outside the building are endemic, aromatic, Hippocratic plants and herbs; olive trees that existed there before were planted back and the planting was enriched with fruitful Greek and endemic trees. Further to the green roof on the first floor, a botanical garden was created with Greek aromatic, pharmaceutical and Hippocratic plants and herbs, which are used by the company at the production of its products.

About the ID process: The design process of the building adopted from the very early stages the company's philosophy of sustainability, simplicity and functionality. All stakeholders were involved in the project from the early stages and formed a partnership. The project team worked together adopting a holistic approach towards all major aspects: energy, environmental, comfort, economic.

5.1.3 Stavros Niarchos Foundation Cultural Center

The Stravros Niarchos Foundation Cultural Center (SNFCC) is located in Faliro in Greece (Figure 19). The SNFCC has been designed by Renzo Piano and it comprises three main parts: the National Library of Greece, the Greek National Opera and the Stravros Niarchos Park of 170,000 m2 aiming to restore the site's lost connections with the city and the sea (Figure 20). The construction of the SNFCC has created about 1,500 jobs and, approximately, about 160 million € of annual throughout the Greek economy as a The SFNCC park and the roof of the Opera include Mediterranean flora: this will increase enormously in the area and new ecological systems will be introduced. The large site's green surface will cause a decrease in carbon emissions and an improvement in the air quality.

Sustainability is one of the SNFCC's fundamental values. The creation of an environmentally friendly and sustainable infrastructure for the buildings and the Park is an important goal in the design and construction of the Stavros Niarchos Foundation Cultural Center. Through environmentally innovative designs and practices, the project aims to earn at least Gold and ideally Platinum LEED certification, the first such designation in Greece and the first for a project of this scale in Europe.

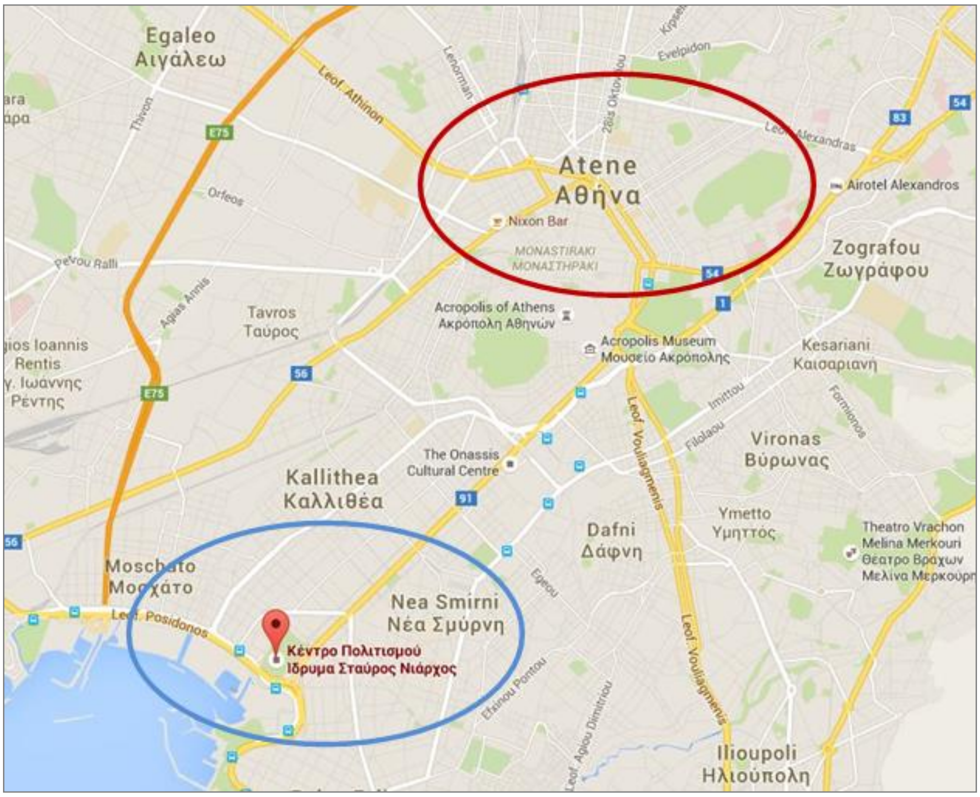


Figure 19: Location of the SNFCC (in blue)

Figure 20: The Stavros Niarchos Foundation Cultural Center and Park © Yiorgis Yerolymbos

As one of Athens' earliest seaports in Faliro Bay, Kallithea has always had a strong relationship with the water. To permit the view of the sea from the site, an artificial hill was created at the south (seaward) end of the site. The sloping park culminate in the cultural centre building, giving it spectacular views towards the sea.

Both opera and library are combined in one building, with a public space, known as the Agora, providing access and connections between the two main facilities. The opera wing is composed of two auditoria, one (450 seats) dedicated to traditional operas and ballets, the other (1,400 seats) for more experimental performances. The library is intended not only as a place for learning and preserving culture, but also as a public resource, a space where culture is truly accessible to share and enjoy (Figure 21, 22).

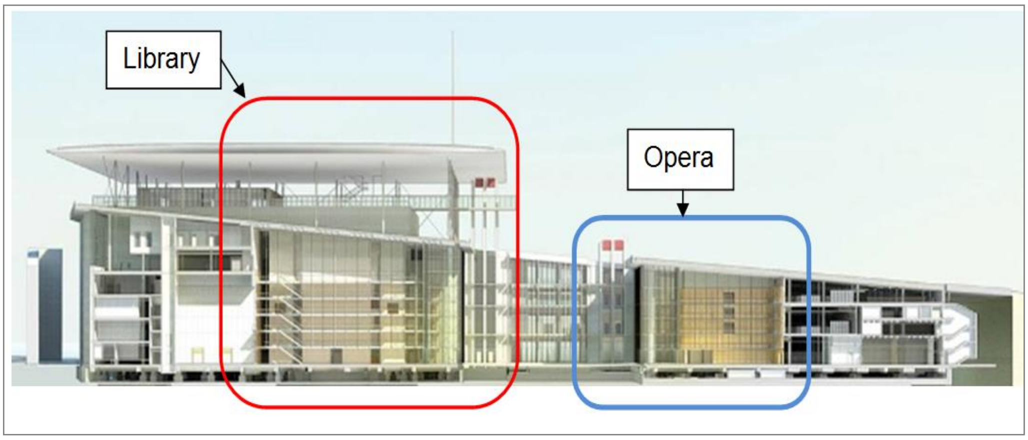


Figure 21: The design of the Library and Opera

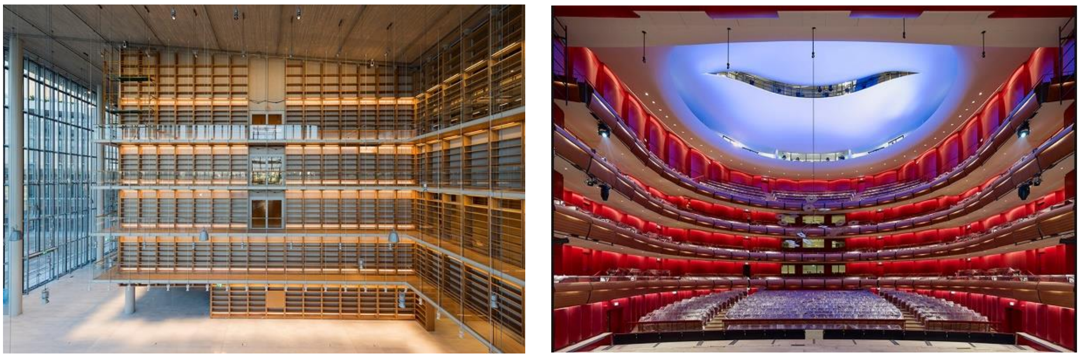


Figure 22: The Library building (left) and the Opera building (right) of the SNFCC © Yiorgis Yerolymbos

The entirely glass-walled library reading room sits on top of the building just underneath the canopy roof. A square horizontal transparent box, it will enjoy 360-degree views of Athens and the sea.

The site's visual and physical connection with water continue in the park with a new canal that will run along a north–south, main pedestrian axis, the Esplanade (Figure 23). The canopy roof provides essential shade and it is covered with 10.000 sq. m of photovoltaic cells, enough to generate 1.5 megawatt of power for the library and opera house (Figure 24). This field of cells should allow the building to be self-sufficient in energy terms during normal opening hours. Wherever possible, natural ventilation will be used.

The visual connection with the water will continue to the park, where it will focus on a channel to the side of the Esplanade, the main pedestrian axis of the site, in the north-south direction.

Figure 23: The Esplanade of SNFCC © Yiorgis Yerolymbos

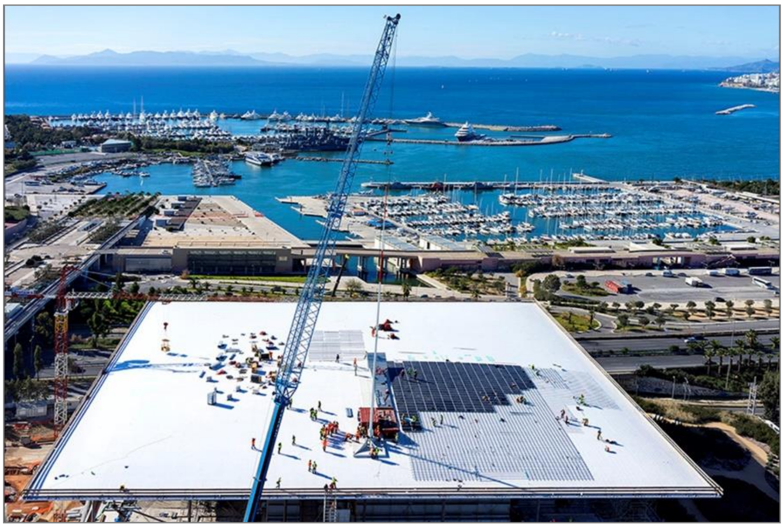


Figure 24: Works during the installation of the PV system at the roof © Yiorgis Yerolymbos

About the ID process: Before the commencement of any procurement or construction activity all technical documents produced by the Contractor (Construction Drawings, Method Statements, Material submittals etc.) are subject to the review and approval of SNFCC specialists. Such a procedure coupled with the everyday general and contractual correspondence necessitates the exchange of enormous amounts of documents within and between the three main participating entities i.e. the (a) Project Designers, (b) Employer and its Representatives and (c) Contractor and its Consultants/ Subcontractors. The overall project design is driven by the highest environmental goals and international standards which are summarized in the following principles: Strict Compliance with the Environmental Impact Study and Environmental Terms approved by Greek Authorities Achievement of Platinum LEED certification Compliance with the highest international environmental standards. The same principles, which have already been applied in the design, are followed in every day construction activities. The key participants in this special task are the SNFCC consultants and auditors, which include LEED specialists, third party environmental inspectors and the Contractor's LEED certified supervisors. Monitoring results are documented by a thorough and systematic record keeping. The status of the environmental conditions on site is constantly audited and evaluated through both periodical and ad hoc meetings recorded in monthly reports.

5.1.4 Karelas Office Park

The Karelas Office Park of 61,574 m^2 is located southeast of Athens following sustainability and innovativeness concepts (Figure 25). The complex has a built area of 30,000 m^2 above ground and 30,000 m^2 underground. The total value of the project was 119 million euros and it was completed in 2012 (Figure 26). Gardens full of Mediterranean flora are spread all over the roof and there is also a path where people can have a walk and relax enjoying the plants and the view (Figure 25, 28). The building was the first in Greece that was certified with a LEED GOLD certificate.

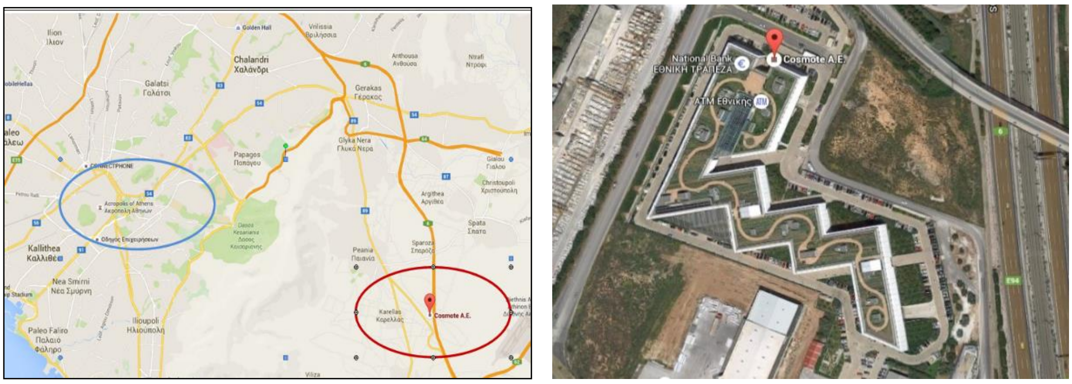


Figure 25 Location of Karelas Office Park (left) b. The green rooftop of the building (right)

Figure 26: Façade movable shading devices

The company aim is to achieving reductions in energy consumption whilst simultaneously satisfying the thermal comfort needs of its users. The main entrance has glass ceiling that enables natural lighting and walls are covered by bamboo steaks (Figure 27).

The measures implemented within the business network including the following:

- Free Cooling techniques from the very beginning of the Network construction.
- High Efficiency Rectifiers in Network BTS with high load.
- Modernization of the Network Telecom Equipment.
- Hybrid Systems with batteries and GNs.
- Use of renewable sources of Energy (Wind Turbines, Photovoltaic Systems).

- Data Centers operation according to EU Code of Conduct.
- Solar vacuum tubes in the main Warehouse premises in Avlona.
- Roof Garden in the Karelas Office Park.
- Building Energy Upgrade resulting in improved comfort conditions whilst achieving significant energy saving accomplished in the biggest Call-Center Building.
- Building Management Systems in Office Buildings and Data Centers.
- Smart metering and tele-management systems.
- Energy model predicting the CO_2 footprint.
- Recycling of used material (paper, etc.)
- Special treatment of waste that contaminate the environment (e.g. electronic equipment, lead batteries, etc.)
- Monitoring of materials used and waste generated
- Corporate Responsibility Report with targets and measurements.

Following the presentations, the project participants were taken on a tour of the Karelas Office Park where some its implemented energy saving measures were presented. The technologies demonstrated included the following (as seen in the pictures). Figure 29 presents the central solar thermal system of the building for hot water needs.

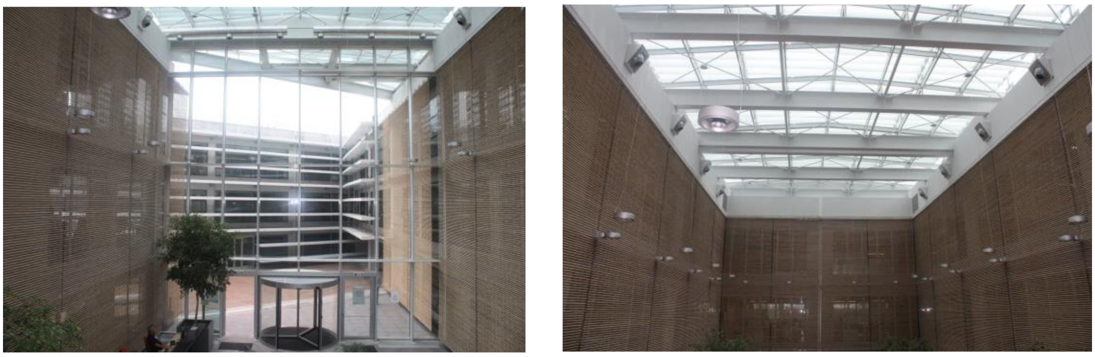


Figure 27: Building atrium for natural day-lighting (left), Atrium façade bamboo shading devices (right)

Figure 28: Roof garden

Figure 29: Central Solar Thermal System

5.2 Case buildings assessments

Table 3 summarizes basic information and Integrated Design concepts for the buildings under investigation

Table 3: The buildings under study for IED and NZEB concepts

Building	Type	Location and Year of construction	Main characteristics	Energy consumption	Concepts of IED
SUMMA	Offices & Warehouse	Via Fiume, 16, 60030 Angeli di Rosora, Ancona, Italy 1985 constructed	**External Walls (Summa):** Cladding, Insulation (Polystyrene), Plasterboard (U_v=0.452 W/m^{2}K) **External Walls (TM):** Cladding, Plasterboard (U_v=1.365 W/m^{2}K) **Internal Walls:** - (U_v=1.674 W/m^{2}K) **Roof:** Acciaio, fiberglass (hardboard), concrete (U_v not provided)	119.4MWh (2014 before the implementation of the Heat Pump and without regarding energy coming from the micro grid, also few of the recorded values are reconstructed and missing data of December 2014)	• Approximately 100 implemented smart meters recording the energy consumption of the building and also the produced energy by the PV systems. • Renewable energy production by the installed PV systems on the roof of the building. The results show a cumulative energy production of 34.525kWh. • Reduced CO_2 emissions throw RE production. • Connection with the micro grid and the thermal storage establishing energy efficiency. -- • Although half of the building (Summa) is well insulated (U_v=0.452 W/m^{2}K), the remaining part

Building	Type	Location and Year of construction	Main characteristics	Energy consumption	Concepts of IED
			Windows/Doors: Double glazed (U_v=2.510 W/m^{2}K / U_w =2.347 W/m^{2}K / U_g =2.763 W/m^{2}K) **Industrial Door:** (U_v=3.509 W/m^{2}K / U_g=5.468 W/m^{2}K / U_w=3.309 W/m^{2}K)	In comparison with the recorded energy data of 2015 and 2016 the energy consumption of the building is at least one order of magnitude reduced.	(TM warehouse) has poor thermal performance (U_v=1.365 W/m^{2}K) Sliding doors cause a poor value in air tightness, resulting in an infiltration rate of 1,63 ac/h
KITE Lab	Offices, Laboratories and Test rooms	Via Fiume, 16 – Angeli di Rosora (AN), built at 2015	Combination of different types of uses. Typical rectangular construction, constructions are still in progress in the 6th test room of the building. Improved insulation, highly efficient HVAC systems installed, connected with the micro-grid and the thermal	Data provided from April 2016 and forth. Consumption for April to August 2016 is 132 MWh or 37.6 kWh/m^2	The Kite Lab building is a newly constructed building that meets the most of the necessary directives to follow the IED procedures. First of all the cell of the building is constructed to meet the demands of a NZEB building. Furthermore all of the specifications of the materials, components and HVAC systems are described in various documents. The building is self-sustainable by means of renewable energy consumption in some extent. The connection with the micro-grid ensures that all energy produced by the hydro plants and the various PV systems is distributed throughout

Building	Type	Location and Year of construction	Main characteristics	Energy consumption	Concepts of IED
			storage. Installation of highly efficient PV panels.		the network. The Thermal storage ensures that the excessive energy is saved and distributed in less productive parts and times. Each of the HVAC systems installed is highly efficient strengthening the general efficiency of the grid. All components are well documented. The building is yet until today modified and optimized. Smart metering ensures that each component is monitored and recorded for further analysis. With the use of the 3d modeling of the building further analysis and optimization of the buildings systems can be conducted.

Building	Type	Location and Year of construction	Main characteristics	Energy consumption	Concepts of IED
AEA	Offices, Laboratories, production line	Via Flume n. 16 – 60030 Angeli di Rosora (An), 2002	The scope of the optimization procedure is to suggest measures which will result in the best energy performance, taking also into account the bulding's incorporation in Loccioni's micro grid. • Use of innovative materials for the construction • Replacement of the systems for heating, cooling and hot water with the best available technologies (geothermal heat pumps, district heating/cooling systems,	558,747 kWh (for 2014)	The choice and/or the combination of the above measures would be made, provided that these are the economical/technical solutions. This would be the result of the optimization process taking into account not only the investment/installation costs but also the variable running costs. The scope after all is to ensure that the AEA Building would be an nZED Building meeting the IED standards.

Building	Type	Location and Year of construction	Main characteristics	Energy consumption	Concepts of IED
			absorption/adsorption chillers, hybrid boilers). • Installation of PV systems with improved collectors. • Thermal/Chemical storage		

Building	Type	Location and Year of construction	Main characteristics	Energy consumption	Concepts of IED
Library Building	Library Offices	University Campus, Athens, 2009	The Science Library building is composed by 4 floor, each one has a useful surface area about of 1,580 m^2 and a volume about of 5500 m^3, built in 2009. Overall, the existent centralized HVAC system provide heating cooling and ventilation for about of 22,000 m^3 of useful volume	Thermal power [kW] provided by the 7 distribution sub-system of HVAC system used to size the solar thermal power and absorption chillers system. At peak conditions: heating 405.3 kWh Cooling 713.7kWh	Enhancing the Integrated Design concept of the building there was the definition of the size of a CSP (Concentrating Solar Plant) useful to drive an absorption heating and cooling system to cover completely the cooling energy needs of a building and partially the heating, working in heating mode with the integration of the existent HVAC system

5.2.1 SUMMA building

5.2.1.1 Introduction

The aim of the specific report is to present the work at AEA Srl (Loccioni Group) regarding integrated design and NZEB concepts for buildings. Since buildings are major consumers in smart grids, the integrated design task will assist to develop a collaborative method for designing buildings integrated in smart grids. The integrated design process requires multidisciplinary collaboration, including key stakeholders and design professionals, from conception to completion. Decision-making protocols and complementary design principles must be established early in the process in order to satisfy the goals of multiple stakeholders while achieving the overall integration design objectives.

One of the key objectives of this work concerns the development of skills for smart buildings' operation in order to assist the penetration of smart technologies. Specifically, smart controls and advanced monitoring for buildings' design and operational phase are investigated in the main core of AEA buildings; the headquarters. Furthermore optimal operation and testing by using advanced modelling techniques are exercised.

In order to enhance the prospects of building's connection into the smart grid an overall integration design objective is required, thus a thermal simulation model has been developed using the appropriate tool. The building that has been selected to be modeled is a 2-storey office building at AEA's property, the oldest building that exists in the area. The building was retrofitted in 2010 and a high number of smart meters where installed for monitoring energy consumption and energy production from the installed photovoltaic panels on the roof. Also, to estimate and establish the best case scenario concerning the energy consumption of the HVAC system as a function of thermal comfort internal CFD analysis is performed for each thermal zone separately. The purpose of CFD analysis is enumerated analytically below:

1. Accurate assessment of occupancy; thermal comfort is essential for successful building design.

2. Comfort can vary considerably from one side of a room to another depending on factors such as the location of supply diffusers, radiators, computer equipment, etc.
3. Detailed evaluation of both HVAC system and air flow (cold/hot air) inside each thermal zone.
4. The HVAC system requires more than simply making sure that mechanical heating or cooling system offer sufficient capacity to offset spatial loads.
5. It is equally important to determine that the delivery system is providing an adequate distribution of temperature and fresh air throughout the space.

5.2.1.2 Innovation of approach

Nowadays, the building sector is the largest consumer of energy in European Union, corresponding to 40% of total energy consumption and 36% of CO_2 emissions. Currently, about 35% of the EU's buildings are over 50 years old. By improving the energy efficiency of buildings, we could reduce total EU energy consumption by 5% to 6% and lower CO_2 emissions by about 5%.

Two main directives have been conducted to describe analytically the actions and plans of each European country. The 2010 Energy Performance of Buildings Directive and the 2012 Energy Efficiency Directive.

Under these legislations:

- All new buildings must be nearly zero energy buildings by 31 December 2020 (public buildings by 31 December 2018)
- EU countries must set minimum energy performance requirements for new buildings, for the major renovation of buildings and for the replacement or retrofit of building elements (heating and cooling systems, roofs, walls, etc.)
- EU countries have to draw up lists of national financial measures to improve the energy efficiency of buildings
- EU countries make energy efficient renovations to at least 3% of buildings owned and occupied by central government
- EU governments should only purchase buildings which are highly energy efficient

- EU countries must draw-up long-term national building renovation strategies which can be included in their National Energy Efficiency Action Plans [12]

In order to predict the performance of buildings under real conditions, simulation modeling processes have been adapted from engineers, designers and building physicists. Three main methodological branches are considered dominant for building energy related simulation and assessment [13]:

- White box models: Based on physical knowledge of the system and thermal balance equations. These are often obtained through energy simulation software like EnergyPlus, TRNSYS, etc.;
- Black box models use only measured input/output data and statistical estimation method.
- Grey box models: A mix of the first two categories using input/output data as well as some a priori knowledge on the system. A popular grey-box model is the equivalent RC.

In this study a white box model to simulate Loccioni Summa building was developed due to its high accuracy, reasonable calculation speed and reliability for optimization and control.

5.2.1.3 Description of SUMMA building

The building is located at Angeli di Rosora (Figure 30), a valley in the middle of Italy’s mainland. Angeli di Rosora is a small village of the province of Ancona 40km away from city centre. The area is surrounded by small hills crossed by a river. The microclimate is highly affected by local conditions characterized by moderate winters, humid and hot summers and quite high levels of rainfall. Thus it is classified as a 4A according to ASHRAE climate zones [14].

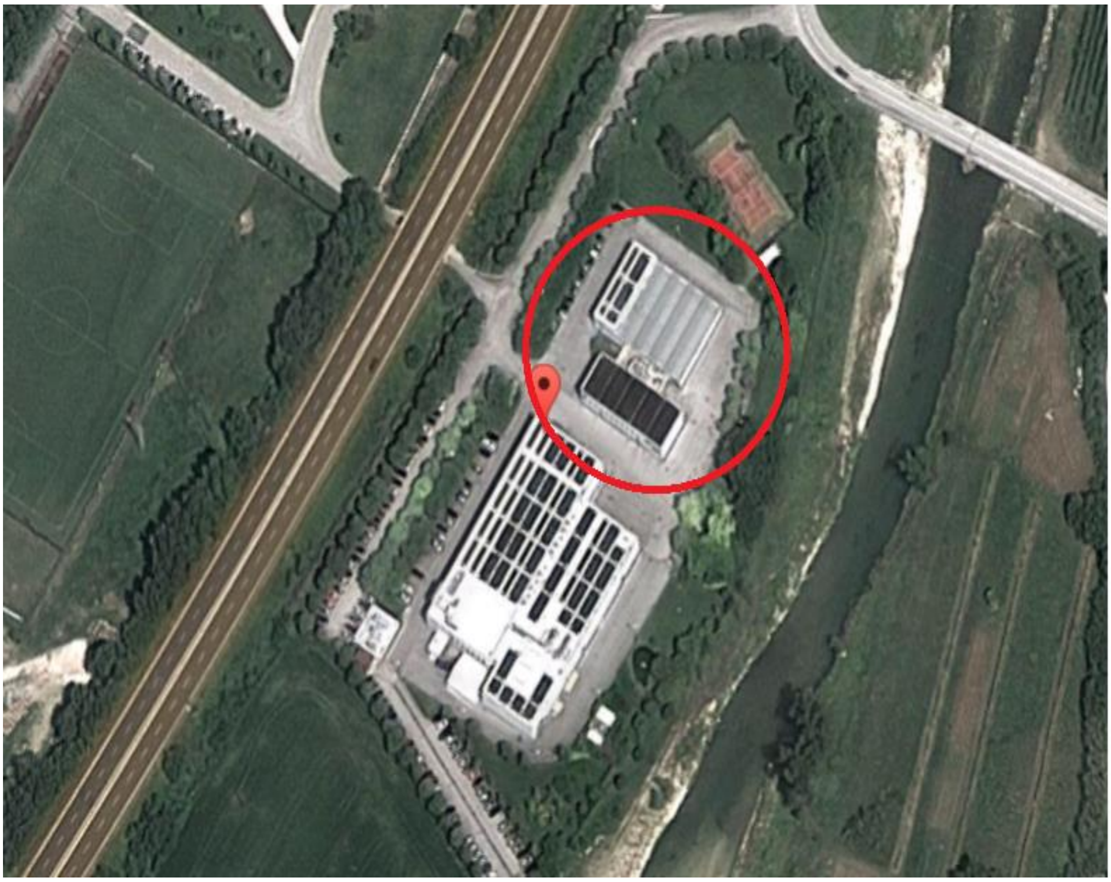


Figure 30 Satellite image of the selected building.

Summa building, together with the other four buildings of Leaf Community, are connected into the company's micro grid. In 2008 the company launched the “leaf community” project, accepting the challenge of sustainability, carbon footprint minimisation and renewable sources deployment. The company created around its headquarters a double grid installing solar panels on buildings' roofs, river micro-hydro power production units as well as biomass implants. The electric grid is built to have only one connection point with the main electrical grid and an internal medium voltage (MV) distribution system, to which all the sustainable plants and industrial buildings are connected.

Figure 31: Loccioni's Micro grid connection.

The micro grid connection enhances the prospects of energy efficiency for the Leaf Community. The energy produced from the roof of each building may be used for operational purposes and surplus energy is distributed to the micro grid. Surplus energy may be used by other buildings, stored using batteries or forwarded to the national grid.

The impact of the micro grid and the electrical storage has both economic and environmental benefits. On the one hand it is crucial for the company to consume its own produced electricity. In that way, the savings of electrical consumption and additional fees corresponding to Italian economic regulations are established. Also the company is reducing the emissions of GHGs ensuring environmental remediation. Finally, in future, by reducing even more the energy consumption (especially for cooling) of each building could lead to a more stable path of energy efficiency.

5.2.1.4 Geometry

The building consists of two rectangular shaped constructions; a major one which includes the offices and a smaller used as a warehouse. The offices comprise of two floors, the ground floor which is split in 13 thermal zones including:

- 4 Meeting Rooms
- Communication Room
- Control Room
- Conference Room
- Entrance and Offices
- 2 Bathrooms
- Kitchen
- 2-Storey Rooms

The first floor includes:

- Offices
- Meeting Room
- Library
- Bathroom
- Wardrobe

The ground floor and the first floor are connected with an internal staircase (Fig. 34c). Figures 32, 33 display the ground plan of the building for both floors. The area and the volume of each floor of the building as well as the area of the occupied roof are presented in Table 4. The orientation and the size of the building's windows and doors are presented in Table 5.

Table 4: Area and volume of each floor of SUMMA building.

	Area	**Volume**
	(m^2)	(m^3)
Ground floor	856.74	4094.6
1st floor	180.5	505.4
Occupied Roof	552.0	
Total	1037.24	4600.0

Table 5: Orientation and size of building's windows and doors.

Type of opening	Number	Opening orientation	Floor	Height (m)	Width (m)
Window	3	EAST	Ground floor	1.9	1.2
	7	EAST	Ground floor	1.2	0.8
	5	EAST	Ground floor	1.2	1.2
	4	EAST	1st floor	1.3	0.9
	2	EAST	1st floor	1.3	2.0
	11	WEST	Ground floor	0.8	1.0
	11	WEST	Ground floor	2.1	1.0
	8	SOUTH	Ground floor	1.25	2.3
	4	SOUTH	Ground floor	1.25	1.0
	8	SOUTH	1st floor	1.25	2.3
	4	SOUTH	1st floor	1.25	1.0
	8	NORTH	1st floor	1.3	2.3
	10	NORTH	1st floor	1.3	1.0
	1	NORTH	Ground floor	0.9	2.8
	1	NORTH	Ground floor	0.9	0.8
	2	NORTH	Ground floor	1.2	2.0
	11	NORTH	Ground floor	1.2	1.0
Door	2	WEST	Ground floor	2.0	1.0
	1	WEST	Ground floor	4.0	3.4
	1	EAST	Ground floor	4.0	3.4
	1	EAST	Ground floor	2.0	0.9
	1	NORTH	Ground floor	2.4	1.4
	3	NORTH	Ground floor	2.4	1.3

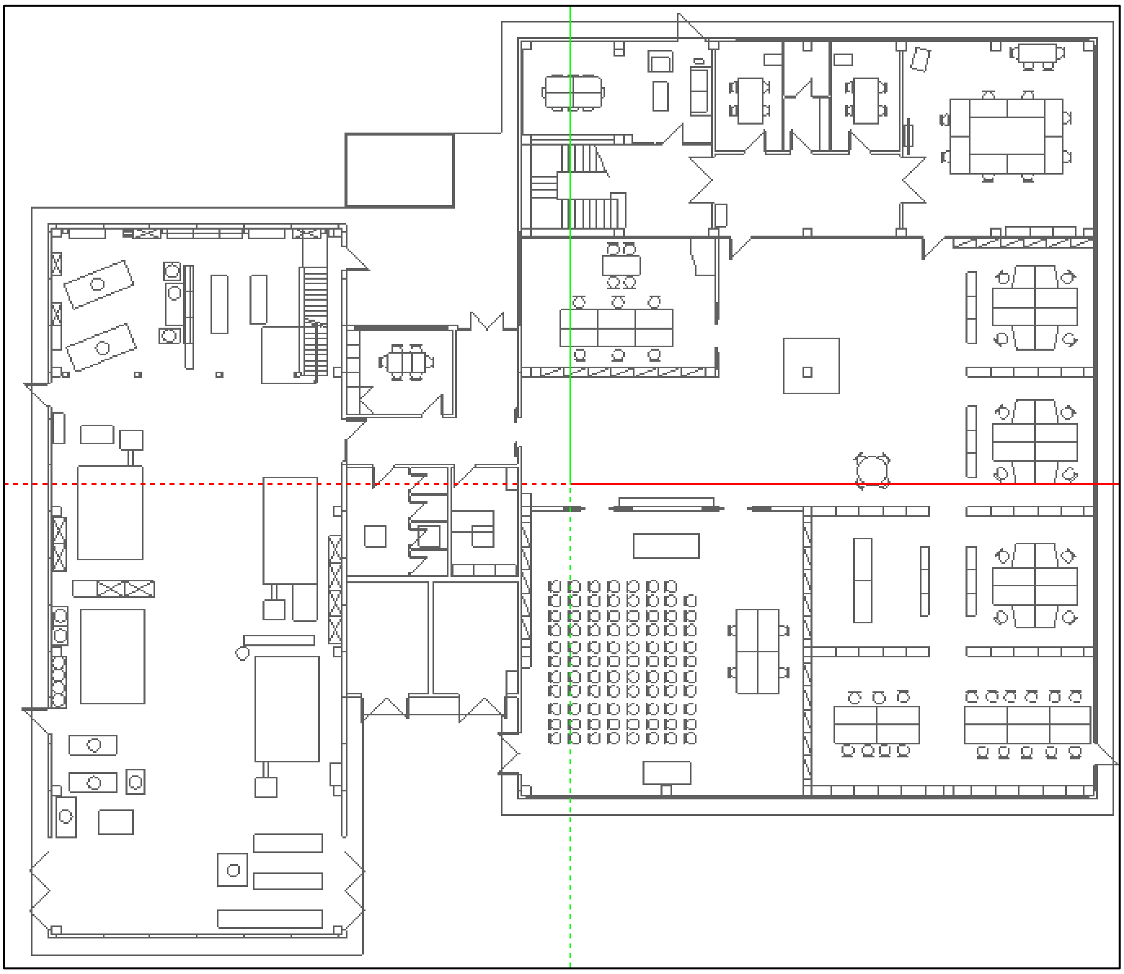


Figure 32: CAD drawing for Ground Floor of SUMMA building.

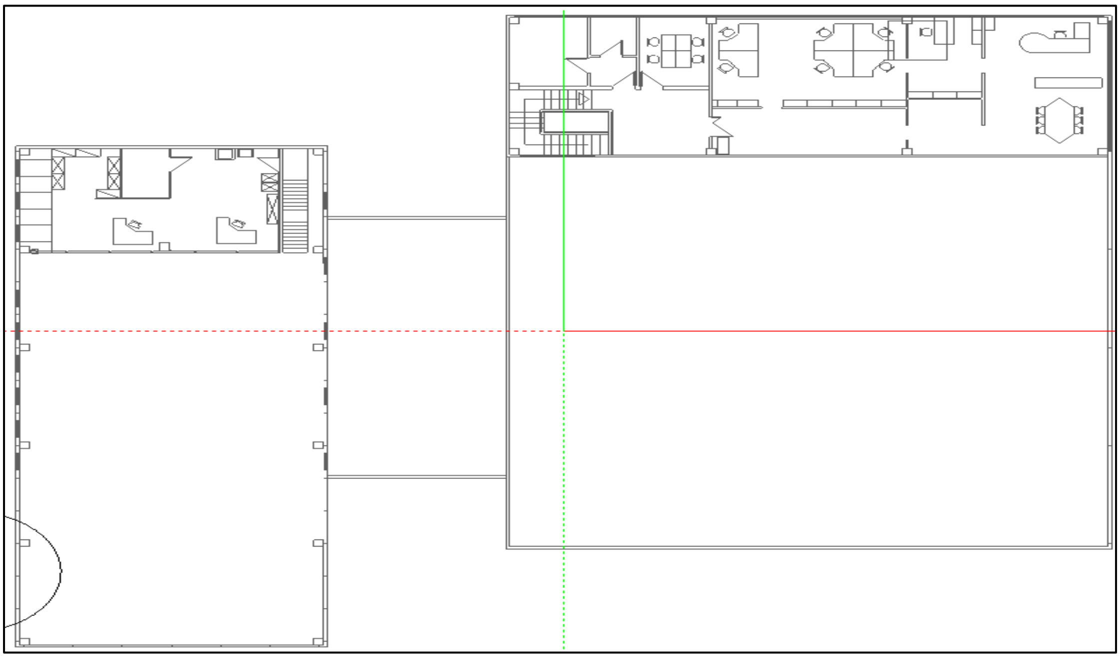


Figure 33: CAD drawing for First Floor of SUMMA building.

Following the geometry and the openings/doors that exist in the building and taking into account the parameters that play a significant role in propagation and exchange of heat, the whole rectangle building was split into different thermal zones, as shown in Figure 34.

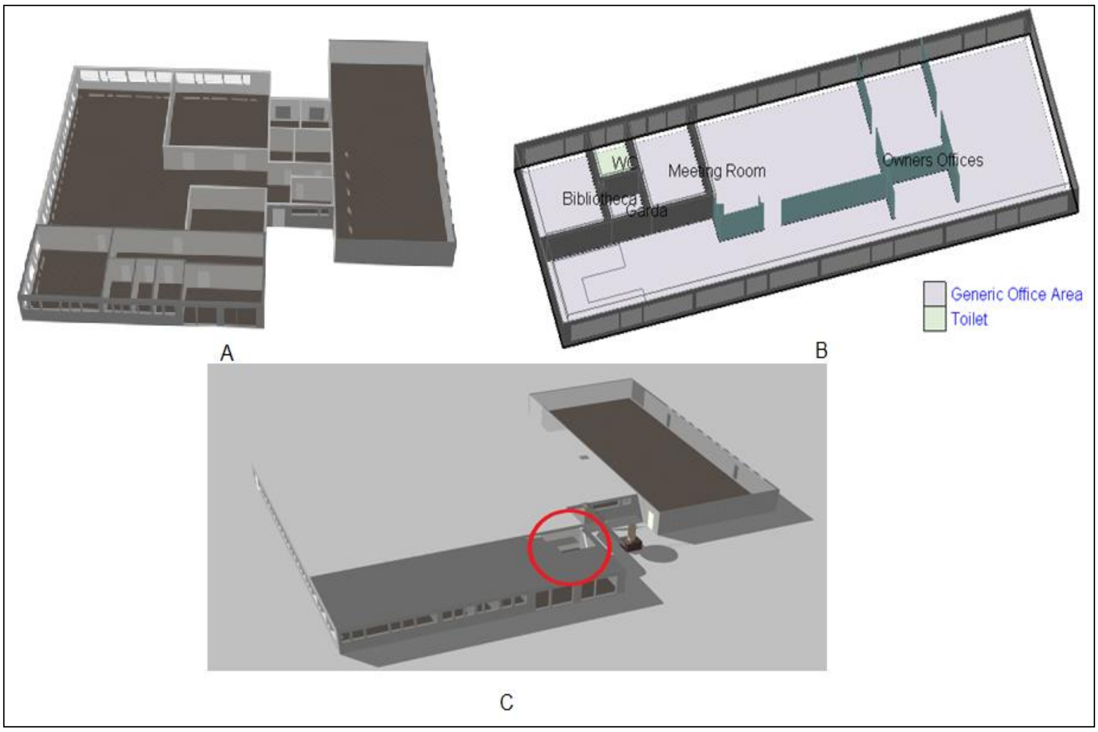


Figure 34: Ground Floor (A), 1st Floor (B) separation in different thermal zones.

5.2.1.5 Thermophysical characteristics

The load bearing structure of the office building consists of 3 layers. The outermost layer is of aluminum cladding, the innermost of typical Plasterboard and some of the external walls contain in the middle a standard insulation from polystyrene. The windows have been recently replaced by double glazing windows. The thermophysical characteristics of the building components are presented in Tables 6-8.

Table 6: Thermophysical characteristics of the building envelope

Building envelope	
Walls	U value = 0.452 – 1.365 W/m²K
Roof	U value = not provided SR = not provided
Windows	Uw = 2.347 – 2.401 W/m²K Ug = 2.763 W/m²K
Floor	U value = 1.674 W/m²K

Table 7: Construction Template information for the baseline condition.

Construction	U-value (W/m²*K)	Thickness (mm)	Materials (Outer to Inner)
Construction	U value (W/m²*K)	Thickness (mm)	Materials (Outer to Inner)
Roof	Not provided	Not provided	Not provided
Internal Walls	Not provided	Not provided	Not provided
External Walls (Summa)	0.452	283	Gypsum plaster(20mm)-outer, cladding(200mm), Insulation polystyrene(50mm), plasterboard(12.5mm), Gypsum plaster(5mm)-inner
External Walls (TM)	1.365	237	Gypsum plaster(20mm)-outer, cladding(200mm), plasterboard(12.5mm), Gypsum plaster(5mm)-inner
Floor	1.674	150	concrete(300mm)

Table 8: Openings Template information for the baseline condition.

Openings	Glazing Template
Glazing type	Double
Thickness	6 mm
Gas	None
Glazing U - value	2.76 (W/m²*K)
Frame type	Wood/Aluminium
Frame U - value	2.50 (W/m²*K)
Shading	Blind with medium reflectivity slats
Doors	Exit/Industrial Door
Material	Glass/Aluminium
Thickness (glass)	10/6 mm
U - value	2.574/3.509 (W/m²*K)

5.2.1.6 Operational conditions

A major task of the simulation methodology was the identification of the activity and the corresponding schedules of the occupants in active situation. For this purpose several interviews with the person working at the reception area and the communications manager were conducted. Some of the major inputs on activity template are described in Table 9:

Table 9: Activity Template information for the baseline condition.

Activity	Unit	Scale
Occupancy (Density of people)	(people/m^2)	0.01-0.2 according to thermal zone
Winter Clothing	(clo)	1
Summer Clothing	(clo)	0.5
Metabolic rate	(met)	1.5
Holidays	(days)	0-30
DHW consumption	(L/m^2-day-person)	0.1
Heating setpoint Temperature	ºC	21(±2)
Target Illuminance	(lux)	500
Cooling setpoint Temperature	ºC	25(±2)
Relative humidification setpoint	%	40
Relative dehumidification setpoint	%	40
Electrical equipment	(W/m^2)	.....

5.2.1.7 Installed systems

Internal gains resulting from occupancy, lighting and electrical equipment act as a heat source for each thermal zone and affect the environmental parameters. Thus, an integrated assesment of these factors was appropriately completed. In order to prepare the necessary lighting template, the simulation tool requires converting the lighting power according to the form below:

Max Lighting power (W) = Lighting energy (W/m^2/100lux) x Zone floor area (m^2) x Zone Illuminance requirement / 100.

For example the lighting system of the "Communication Room" zone emitting 14W/m^2 is equal to:

Max Lighting power (W) = 648W/46,93m^2 ≈ 13,81W/m^2 ≈ 2,76W/m^2-100lux

Also, the lighting energy should be a function of the maximum electrical power input to lighting in a zone, including ballasts, if present. This value is multiplied by a schedule fraction during the simulation to get the lighting energy in a particular time step. The illuminance level of each zone is set at 500lux by the BEM system.

In parallel a template referring to electrical equipment must be imported into the model at the initial stage of the building modelling for the estimation of internal gains (Table 10). Different recessed luminaire types met in Summa building are presented in Fig. 35 while Table 10-11 presents the lighting power of each zone.

Table 10: Lighting Template information for the baseline condition.

Lighting	Lighting Template
Lighting type	Low standard- incandescent
General lighting	0.32-2.76(min-max) (W/m^2-100 lux)
Visible Fraction	0.18
Radiant Fraction	0.42
Convective Fraction	0.40
Lighting control	Yes

Figure 35: Different recessed luminaire types met in Summa building.

Table 11: Lighting power of each zone.

Zone	Lighting Power
1st Floor	**[W]**
Hall	168
Owners Offices	952
Meeting Room	112
WC	20
Wardrobe	20
Library	20
Ground Floor	**[W]**
Meeting Room 1	100
Meeting Room 2	216
WC	1080
Meeting Room 3	216
Meeting Room 4	864
Hall	175
Communication Room	648
Conference Room	1350
Entrance & Offices	5259
Kitchen	72
WC	144
Warehouse	792

Electrical equipment has been verified by energy auditing of the building in collaboration with the building manager. The installed devices and the characteristics are depicted in ANNEX 1. In Figure 36 an example of electrical equipment template is presented.

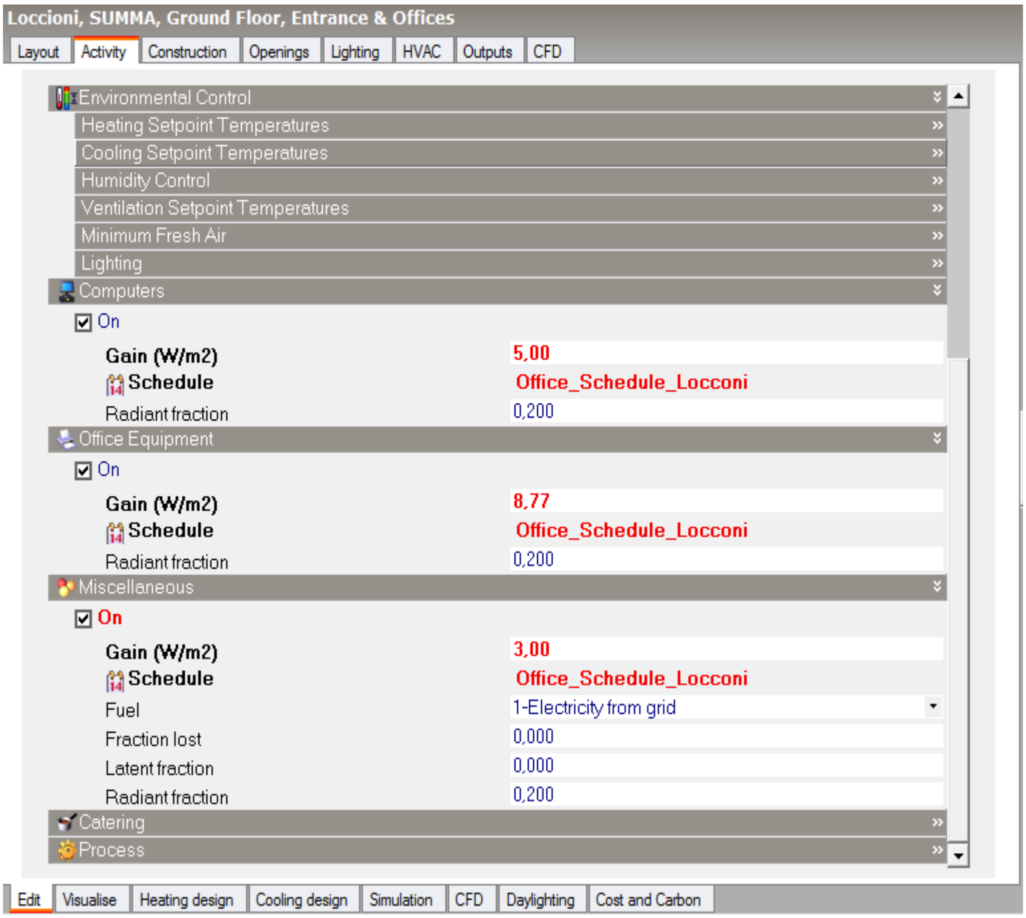


Figure 36: Sample of electrical equipment template used in the simulation.

Table 12 presents some of the major energy intensive devices located in the warehouse and others used in the offices.

Table 12: Dominant electrical devices used in the building.

Electrical Device	Power (kW)
Daikin AKZT437	3.48
LUBE 285060CN	-
MAZAK INTEGREX 200IV	28
MAZAK VTC-300C	11
DART VMC-1000	7.5
NORBLAST	0.14
LEONARD RCL 2.4	18.5
Dyson Airblade	1.6
Xerox Digital Printer/Copier	0.08-1.1(standby-fully operational)

There is an installed water to water heat pump system which is used both for heating and cooling using electricity from the grid (Power: 213.51 kW/ COP= 5.57) as depicted in Figure 37.

Figure 37: Water to water Heat Pump in the storey of ground floor.

Natural ventilation is used rarely by opening of the windows during recess. Mechanical ventilation is distributed in the building by fans placed in the ceiling (Power: 3.4-24.6kW), (Figure 38).

Figure 38: FCX fan placed in the ceilings of Summa building.

5.2.1.8 Energy cost

According to the utility company (ENEL), the cost of the kWh for electricity in 2015 was 0.06750 €/kWh for consumption between 08:00-19:00 in working days and 0.05250€/kWh between 19:00-08:00 in working days, weekends and official holidays.

5.2.1.9 Energy savings calculation methodology

This section presents the methodology adopted for the energy savings. More specifically, the methodology corresponds to the ASHRAE Guideline 14-2002 “Measurement of Energy and Demand Savings” and in the International Standard ISO 16346:2013 “Energy performance of buildings – Assessment of overall energy performance” as described in the “Methodology for the calculation of the Energy Savings, LV, July 2014” report.

In order to calculate energy savings a whole building calibrated simulation method was developed based on a multi-zone energy model, dynamic simulation with a 8760 hours weather file, using Design Builder software [15].

The comparison between measured data and the outputs of the model simulation correspond to hourly data. The acceptable tolerances are measured by the statistical indexes of Mean Bias Error (MBE) and Coefficient of Variation of the Root Mean Squared Error (RMSE) defined below:

Hourly mean bias error:

$$MBE = \frac{\sum_i (Tmeas - Tsim)i}{\sum_i (Tmeas)i}$$

Coefficient of variation of the root mean squared error:

$$CV\ (MSE) = \frac{\left(\sum_i (Tmeas - Tsim)^2/(n-1)\right)^{1/2}}{\overline{Tmeas}}$$

The maximum tolerances are presented in the following Table 13:

Table 13: Maximum tolerances for the BEM and CV statistical indexes.

Index	Hourly data	Monthly data
BEM	10%	5%
CV (MSE)	30%	15%

Until the above tolerances are met the model is refined so that an acceptable calibration is achieved. Occupant behaviour, electrical operation schedules, interior air temperature set-points, airing, opening of interior doors, etc. are estimated using data from sensors, metering, user interviews and in-situ observations. It is important that the values observed in the meters (real values) are comparable to simulation results (estimated values).The calibration process is sensitive, so the "parameters adjustment" is done taking into account all the information referenced above.

5.2.1.9.1 Baseline simulation model

As mentioned in the previous section the baseline simulation model has been developed using Design Builder software. The required data which have been entered as inputs in the model consist of four general clusters:

1. Climatic Data
2. Geometry and Thermophysical properties
3. Operational conditions
4. Energy systems

Climatic data consist of hourly data that corresponds to the same time period as the energy use data (January 2015 – December 2015) including:

- Outdoor Dry Bulb Temperature [°C]
- Atmospheric Pressure [kPa]
- Outdoor Relative Humidity [%]
- Global Solar Radiation [W/m^2]
- Diffuse Solar Radiation [W/m^2]
- Wind speed [m/s] and Wind Direction [degrees]

The aforementioned data have been obtained as described above by the following sources:

1. Local weather stations;
2. International weather database (Meteonorm);

Energy data was monitored in the exact same period with smart meters as described in section 2 and consist of:

- PV's Energy Production [kWh]
- HVAC system Energy Consumption

The geometric data was obtained by drawings (plans, cross-sections, prospects) and validated by audit on site while the thermophysical properties of the building envelope components were obtained by National and European reference data according to typology, age, structure and location of the building. The operational conditions were collected by an accurate building inspection and by employments interviews. The conditions include:

- Building operation schedule
- Number of occupants and related activities
- Internal heat sources (appliances, personal computers, artificial lighting);
- Natural and/or mechanical ventilation rates

The energy systems were taken into account to calculate the primary energy consumption in the building. The following aspects were taken into account to define the standard conditions:

1) Indoor climatic conditions (temperature and relative humidity set-points, and the respective set back points)
2) Schedules of the heating and cooling systems
3) Efficiencies of the energy systems including the Coefficient of Performance Index.

5.2.1.9.2 Baseline input data

This section describes specifically the input data used for the Baseline simulation as mentioned above.

Climatic Data

The climatic data were collected from MyLeaf portal for the period January 2015 – December 2015 including:

- Outdoor Dry Bulb Temperature [°C]
- Global Solar Radiation [W/m^2]
- Diffuse Solar Radiation [W/m^2]

While EnergyPlus is quite flexible in the format of the data used in simulations, DesignBuilder requires:

- Each line to represent one hour;
- Each file must have exactly 8760 records, one for each hour of the year, starting on Jan 1 and ending Dec 31. The years do not have to be consecutive but should ideally be set to 2002. The climatic data processing was performed with Elements Tool. Figure 39, 40 depicts the hourly values of the data.

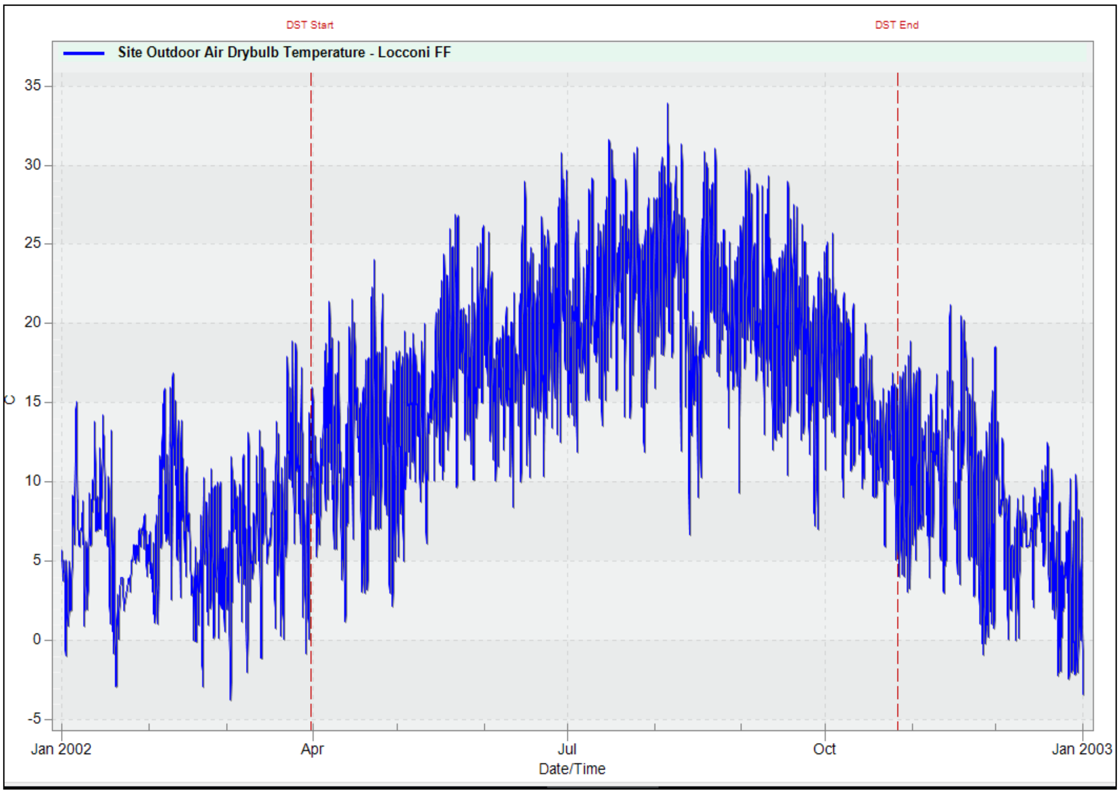


Figure 39: Site Outdoor Air Dry Bulb Temperature profile for the examined period ideally set to 2002.

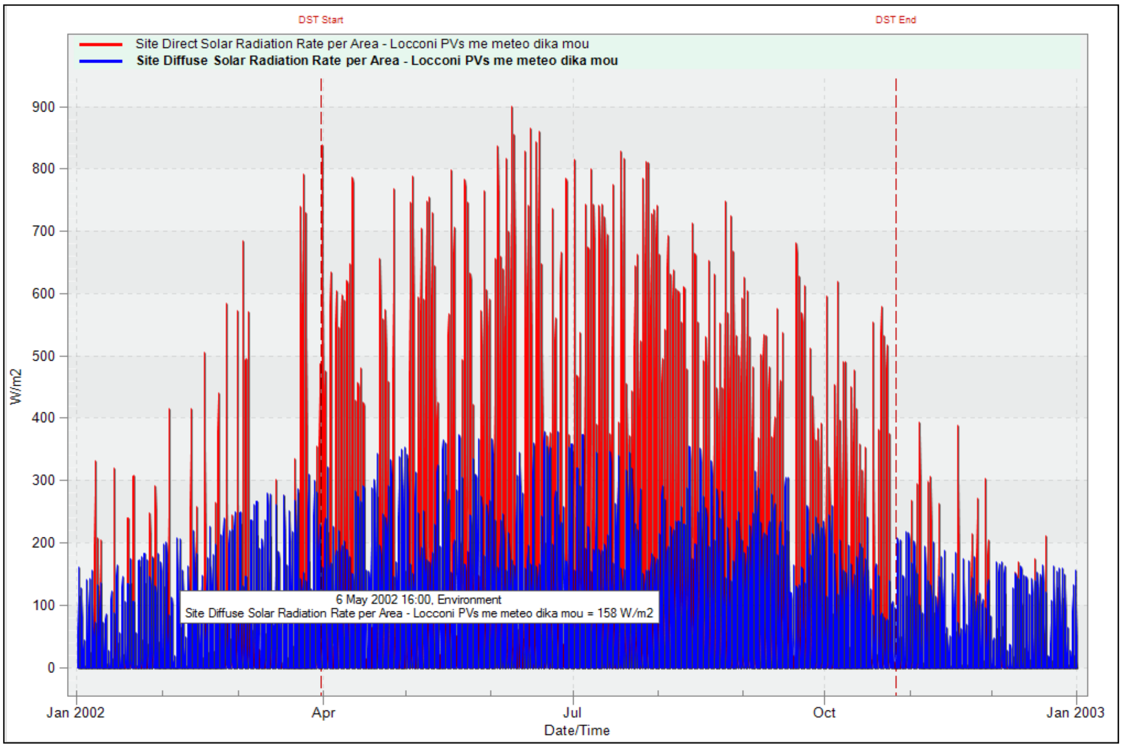


Figure 40: Site Direct Solar Radiation Rate per area (red) and Site Diffuse Solar Radiation Rate per area (blue) for the examined period ideally set to 2002.

5.2.1.10 Direct monitoring methodology

Approximately 100 smart metering devices recording energy consumption of Leaf buildings and micro grid infrastructure have been installed and operated. Five different types of sensors are installed in several outputs. And data can be downloaded periodically. In the following sections the monitoring procedure and the instrumentation used is described. The following parameters have been measured:

- Energy use
- Building environmental parameters including thermal comfort conditions
- Meteorological conditions

Energy Use

Smart meters have been installed in several electrical nodes in Summa Building. Types of sensors include (Figure 41); :

- Ducati Mack Smart
- Ducati Smart+
- Schneider PM3250
- Schneider PM710
- Siemens Pac 3200

These are powerful compact power monitoring devices suitable for use in industrial, government and commercial applications where basic metering and energy monitoring is required. The meters may be used as standalone devices monitoring over 50 parameters or as part of an industrial control, building automation or global power monitoring system. Metering and monitoring applications range from simple analog voltage and amplitude meter replacements to stand-alone sub billing or cost allocation installations with multiple tariffs.

Most of them provide open communications and protocols for easy integration into any local or remote monitoring system. Simple configuration of the meters can be done from the front display.

The data is stored in a portal for remote access in which the monitored values can be elaborated in intervals of 10 minutes, hourly, monthly or annually.

Figure 41: Different types of Smart Meters implemented in Summa and Micro grid

Figure 42 shows the Energy portal page; where data is extracted for the whole building.

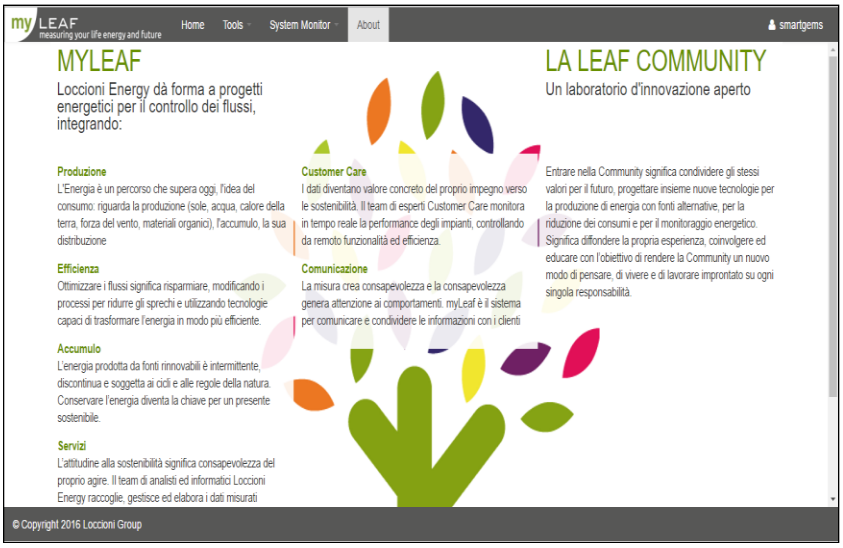


Figure 42: Energy data remote access provided by MyLeaf Portal

5.2.1.12 Conclusions

The present study described the development of the thermal simulation model of Summa building, 3D model using Design Builder simulation tool. Model calibration and validation procedures, followed internationally acceptable standards and protocols [17-19], taking into account energy measurements.

The energy consumption diagrams show that energy consumption for cooling is almost twofold than for heating. A revamping of HVAC system is not accepted because of its recent replacement. Thus, passive cooling techniques can be implemented in the building in order to reduce the total energy consumption of the building as well as the cooling loads. Two of most common passive cooling technologies contain the use of cool and photocatalytic materials and natural night ventilation. The roof of Summa building is exposed in solar radiation during the daytime. Cool roof technology can lead to a reduction in cooling loads for an insulated building up to 35%, according to recent studies, while the heating penalty is up to 4% [20]. Moreover natural night ventilation is a passive cooling technique that is proposed to take advantage of the cold night ambient air to cool down the structure of the building so that it can absorb heat gains in the daytime. This reduces the daytime temperature rise improving indoor thermal comfort conditions and reducing energy consumption for cooling. Recent study has shown that night ventilation can offer energy savings of 7.6% [21]. Furthermore, external insulation can be implemented in the Warehouse in order to mitigate heat conduction exchanges. By decreasing cooling loads renewable energy can be further exploited combined with effective demand response control techniques.

5.2.2 KITE lab

5.2.2.1 Introduction

In Europe energy consumption of the buildings reaches 40% of total energy as well as 36% of CO_2 emissions. It is essential that new designs and approaches are introduced in order to mitigate these values. A successful mitigation technique on this account is the integrated design towards minimizing energy consumption and CO_2 emissions. It is expected that up to 80% of the operational costs can be saved through integrated design.

Particularly, the increase of nearly zero-energy buildings (NZEB) must be taken into account. National action plans in each member state of the EU encourage the use of integrated design principles specifically towards the renovation and refurbishment of existing structures. Furthermore, the use of low cost efficient energy renewable technologies is encouraged in each of these refurbishments as well. Renewable sources such as a PVs installation is a low cost yet very efficient way to reduce energy operational costs.

In a successful ID approach a wide variety of personnel is required in order to compose a sufficient design. Different designers, engineers, etc. must contribute with their knowledge to the final result.

Certain parameters are greatly affecting the final result of the ID. The thermal mass of a building is one of the most important aspects that must be taken into account. Changes made to the thermal mass of the building must be properly served by parallel changes in the HVAC systems.

Until now a complete IED approach has not been standardized. Different objectives must be met, such as the development of a common tool-kit for the IED of NZEB or the EU-wide promotion and dissemination activities.

In the current section the simulation process of the Kite lab is presented. The optimization and calibration of the cell and construction components are described. A 3D white-box modeling approach is effectively exploited as tool towards estimating the final thermal and energy performance of the building. While the whole process may be time consuming and demands the use of extensive information about the building, the final result is very reliable and accurate.

5.2.2.2 Objectives

The objectives of the 3D modelling are briefly described below:

- Optimization of the building following real consumption. Simple ways of interfering with the building form is for example the further use of shades, ensuring the higher energy performance regarding cooling.
- The optimization of the HVAC systems function. Following different strategies for cooling and heating may reduce the high impact of HVAC operation.
- Supplementary, more effective use of systems and controls may result in lower running costs. Better maintenance and revamping of existing systems are proposed.
- Essential for every IED approach is the user aspect. All actions altering the building behavior must always take into account users' requirements and overall comfort (optical, thermal, etc.).

- User engagement is another important issue. Useful conclusions may rise concerning the different patterns and behavior of the users. Following the results of the 3D modeling certain educational approaches should be introduced.
- Higher performance buildings, with lower costs and better control result in general in the increase of their commercial value.
- Finally, the exposure of the building as NZEB with “greener” performance may benefit the building owner or tenant organization.

5.2.2.3 Methodology

The main steps of the methodology of the 3D modeling procedure are briefly described below:

- Data collection, analysis and processing
- Division of the building structure into various thermal zones
- Building 3D design using Open Studio SketchUp Plugin
- Surface matching
- PVs installation design
- Importing weather file
- Importing materials, constructions & composing of construction sets
- Importing opaque and non-opaque elements
- Importing internal loads
- Compiling proper schedules and schedule sets
- Full space type compilation

5.2.2.4 Data collection, description of the site and building

A certain list of information was required for the proper construction of the model. At first the analytical drawings of the building were collected in order to design the building cell, the openings, windows and doors as well as perform the distinction of the thermal zones of the building.

The internal and external walls, doors, windows and other components information were obtained. Certain information about the thermal conductivity and the thickness of each component was used to properly build-in the models’ accuracy. Access was provided to the myLeaf platform to collect data needed for the calibration and evaluation of the model.

The building is situated inside the Loccioni group facilities, located across the SS 76 (Figure 54) and south-west of the AEA lab of the facilities. Google maps have not been updated to include Kite built in 2015.

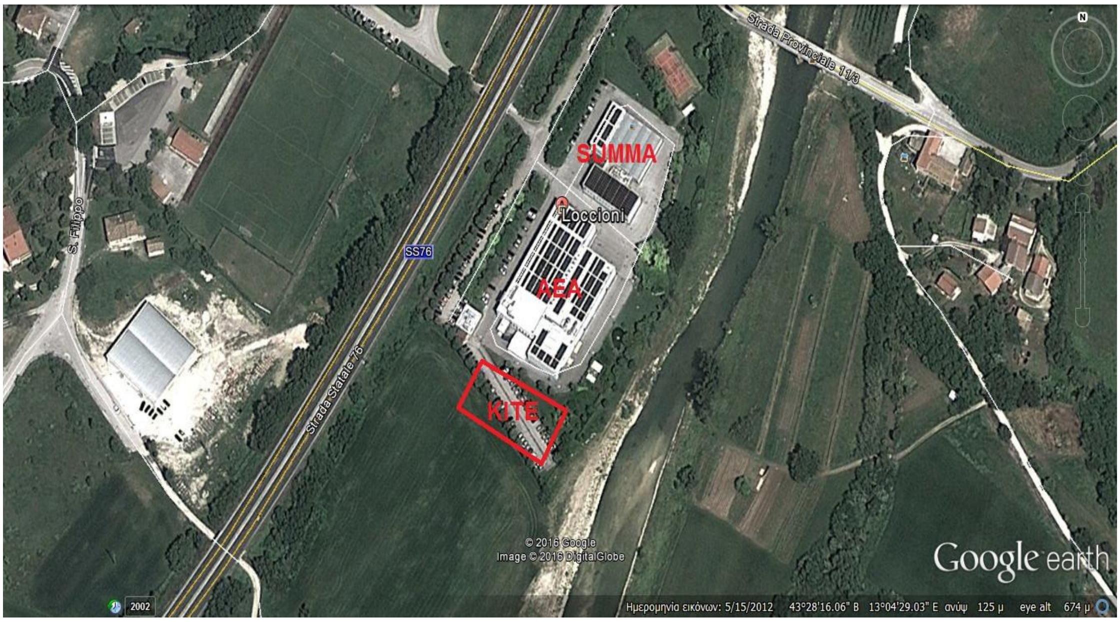


Figure 43 Location of KITE lab

The lab itself is a two-storey building of minimal industrial design. At Figure 55 the view of the lab is presented as viewed from the SS 76 highway.

Figure 44: View from the SS76 highway

Kite is located near Angeli di Rossora in the Marche province in Italy. The landscape mainly consists of small hills with fields and forest being alternated. In the south-west are the regional national park of Golla della Rossa and Frasassi. In the north-east at 30 km distance is the Ancona city situated on the coast. It is expected that both the mountains at the west as the sea coast at the east affect the microclimate of the region.

5.2.2.5 The Micro-grid

The Kite Lab building is part of the micro-grid (Figure 56) of the Loccioni Group. The Micro-grid is at large a self-sustained organism, incorporating the use of renewable energy sources (such as the PVs and the hydro plants) and thermal and electric storage facilities.

Figure 45: View from the SS76 highway

Specifically, a large PVs plant is situated in the company compound including regular cells as well as a concentrative PV installation of great performance. Supplementary, each building in the micro-grid has installed PVs in every rooftop to serve each buildings energy demands.

Part of the micro-grid are also 2 small hydro plants using the nearby river current. Further construction plants of a third one are in progress, increasing the energy production and sustainability of the compound.

Excessive energy production in regular days or during weekends in particular can be stored for later use. This is achieved with the use of a water to water thermal storage solution. Furthermore, electric batteries are used in accordance with the PVs installations.

The micro-grid is connected in paralled with the national grid. Overall, energy demands are served by the micro-grid but the compound is not completely self-sustained especially at winter when clear sky conditions are scarce. At times like that the PVs production is lowered, thus making necessary the national grid contribution.

Within the smart-grid application the buildings and their correspondent demand response may play a significant part in the energy balance [38]. Therefore the control and better handling of buildings energy behavior are greatly related with the smart-grid behavior in general.

5.2.2.6 Design of the building envelope

In order to design the building envelope Autocad (.dwg) files were provided with detailed plans of the building. It was deemed necessary that every different area of the building would be designed separately and the distinction of the thermal zones would be done afterwards. The plan used for the basement floor is shown below (Fig.57).

Figure 46: CAD drawing of the basement floor

From the above drawing the design of the first floor was derived. The separate spaces designed were the entrance with the stairs, the 1st and 2nd office, the toilet, the 1st and 2nd laboratories, the magazzino, the corridor and the 6 sala test rooms along with a small unallocated space between sala 5 and 6. From these spaces the entrance, the corridor and the magazzino were developed until the second floor as they are uniform spaces along the two floors. Next the the 2nd floor was developed taking into account the following drawing (Fig.58).

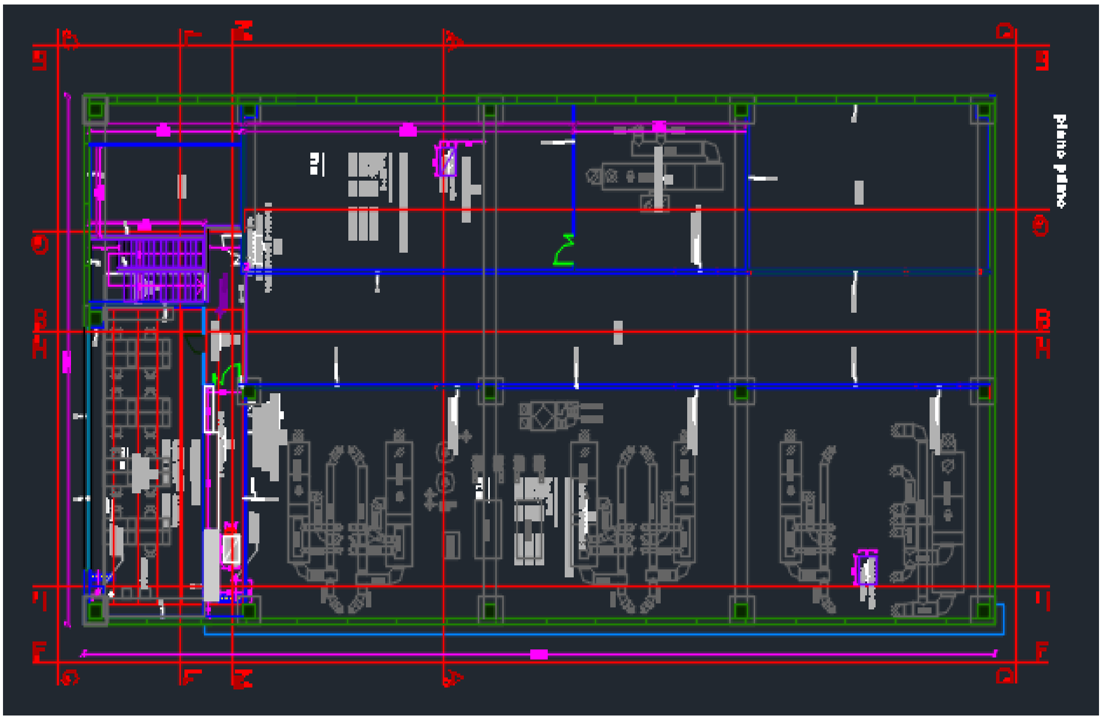


Figure 47: CAD drawing of the second floor

In the second floor, spaces were divided accordingly to the basement floor. The uniformed spaces entrance, corridor and magazzino remained, while the new spaces designed were the 3 technical spaces and the 3rd office of the 2nd floor. Lastly the roof was designed to fit the plans, taking into consideration the detail of tilted sides of the roof that permit the natural lighting of the building. The design was based in the drawing of Figure 59.

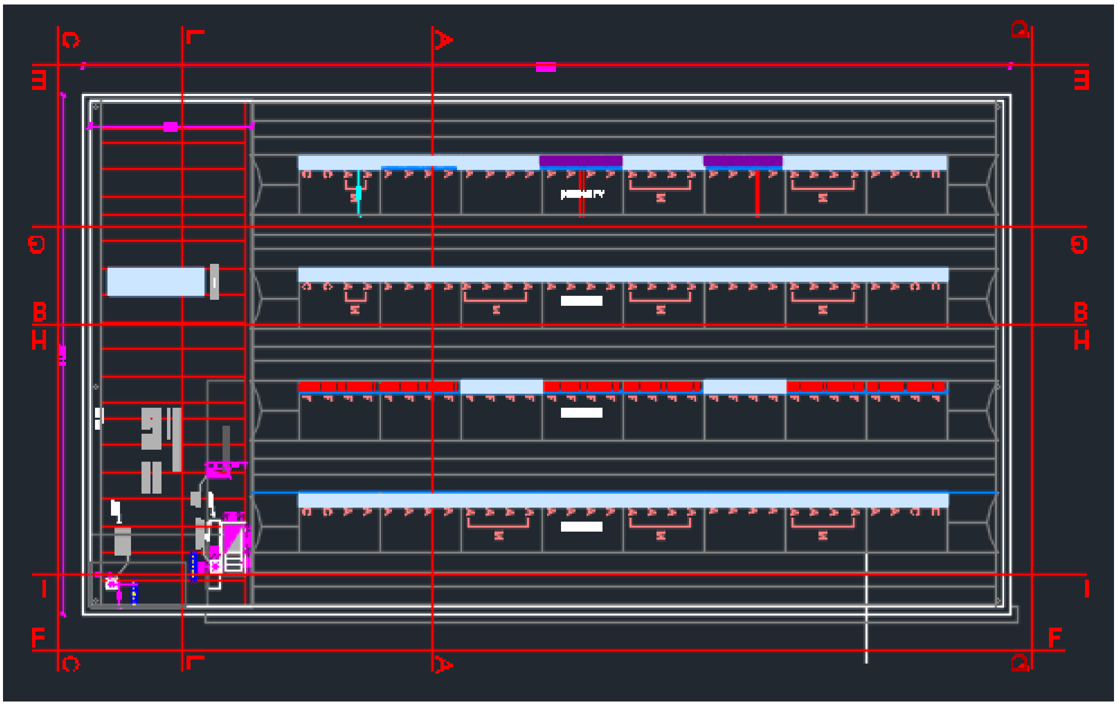


Figure 48: CAD drawing of the roof

The final result of the building envelope design is presented in the Figure 60.

Figure 49: The final design of the building

Extra care was given to the design of the tilted roof, so to represent the exact lighting conditions of the building. The plans that were used are presented in Figure 61.

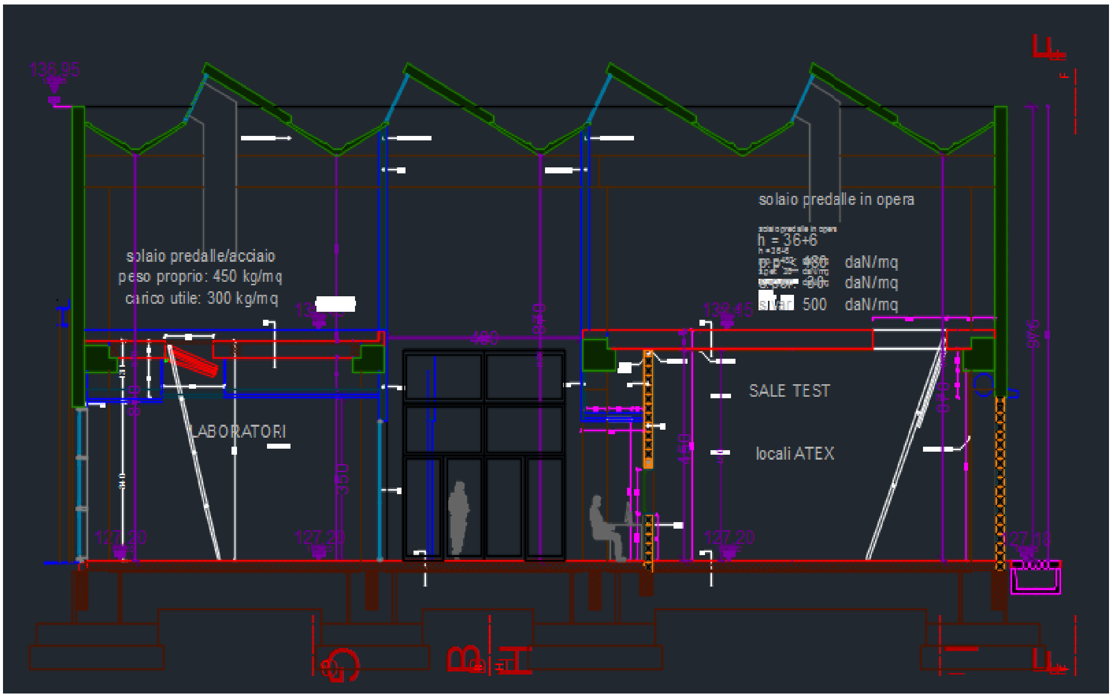


Figure 50: The tilted rooftop components

After sketching the exact details of the rooftop was developed as presented in Figure 62.

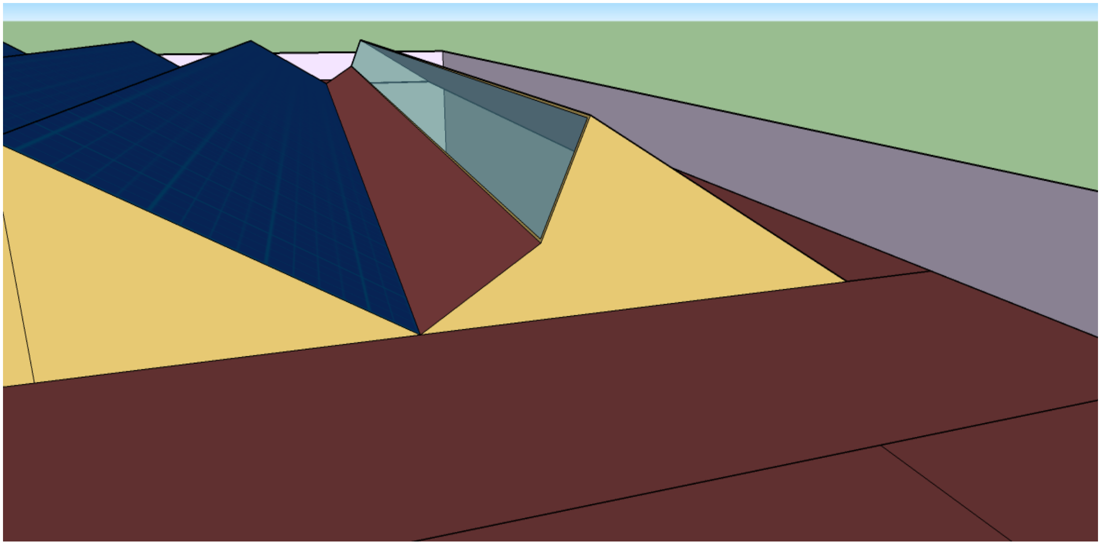


Figure 51: The tilted rooftop 3D design

5.2.2.7 Design of the openings, doors and windows

The construction was completed with the design of the openings, doors and windows. Due to the open software character of the Sketch Up Open Studio plug in, certain specific calibrations must be made [39-40]. It is essential that each opening that corresponds to two tangent spaces must be drawn and be aligned exactly. In Figure 63 the extracted Sala rooms are illustrated with openings aligned in both sides of the Salas and Corridor spaces.

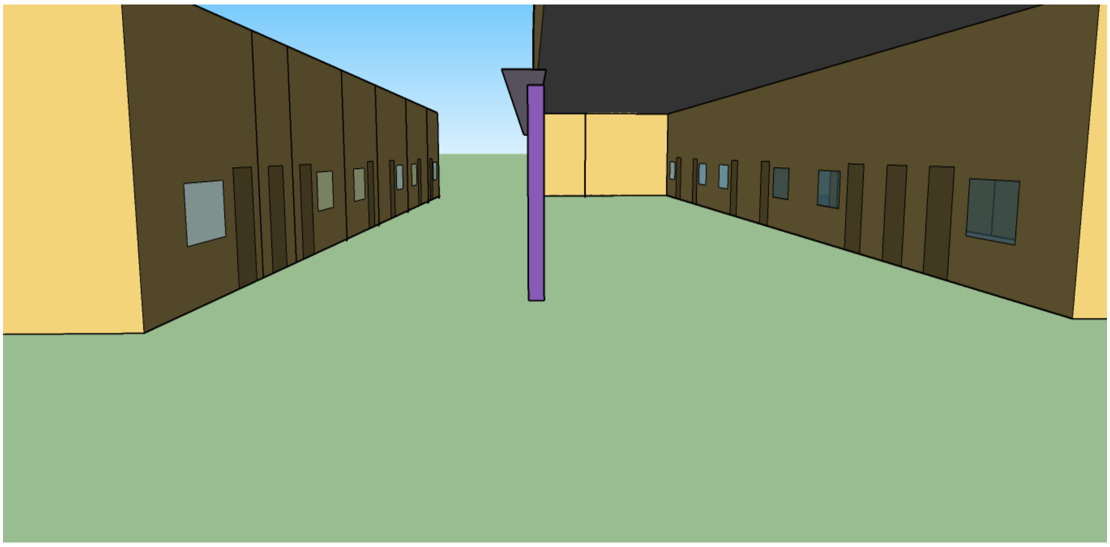


Figure 52: The aligned openings, Salas and Corridor

The same technique was used in every internal opening of the building to ensure the proper exchange of light and heat mass, while adjusting the proper infiltration rate. The final result can be described by the complete opaque and transparent views of the model (Figures 64, 65).

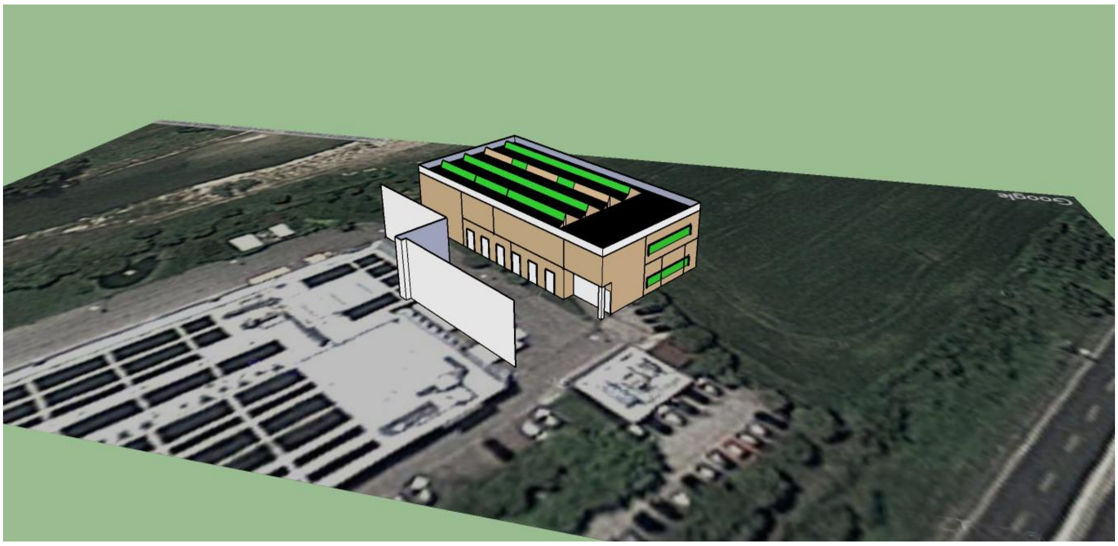


Figure 53: Opaque view of the complete model, contour based on materials

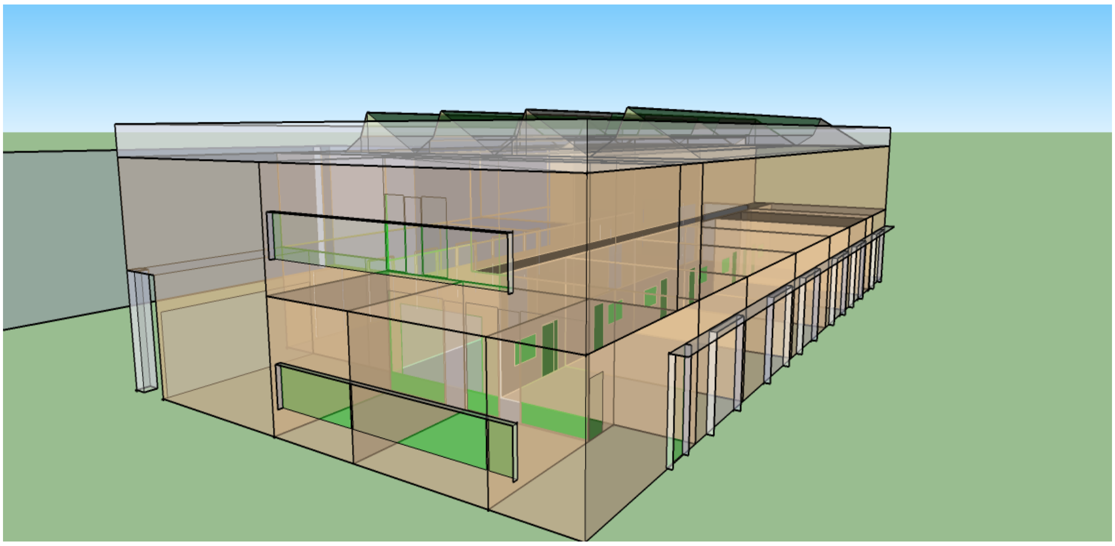


Figure 54: Transparent view of the complete model, contour based on materials

The design of each of the openings was made using the Autocad drawings provided. Both external and internal CADs drawings were used such as the ones in Figures 66-67.

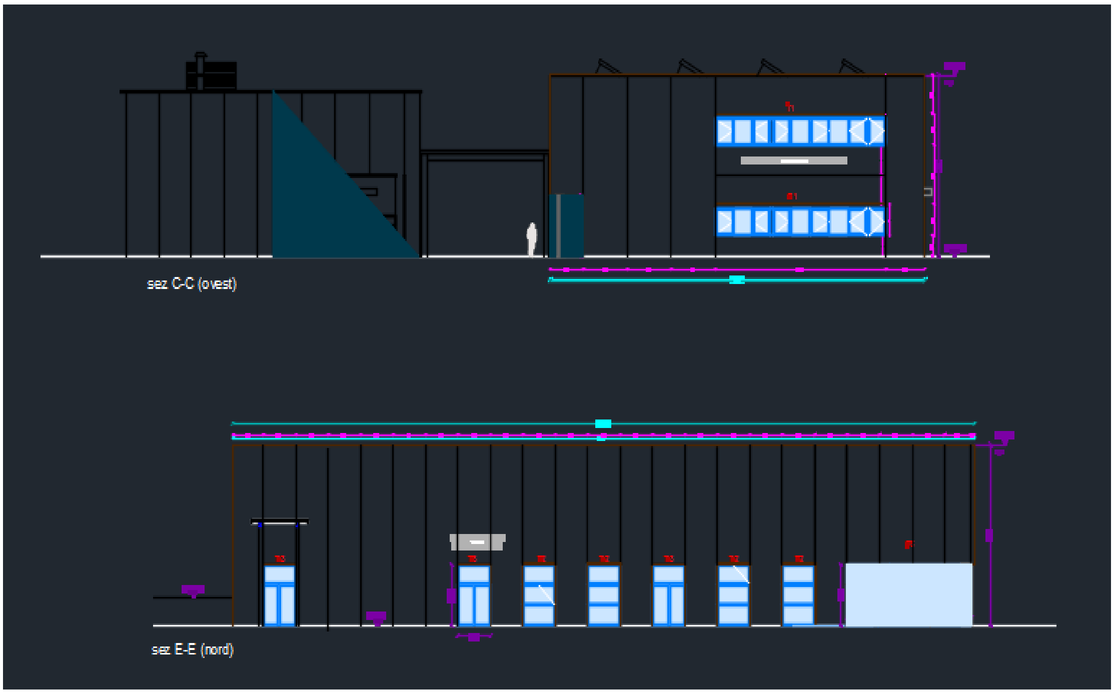


Figure 55: Example of external CAD drawing for the design of openings

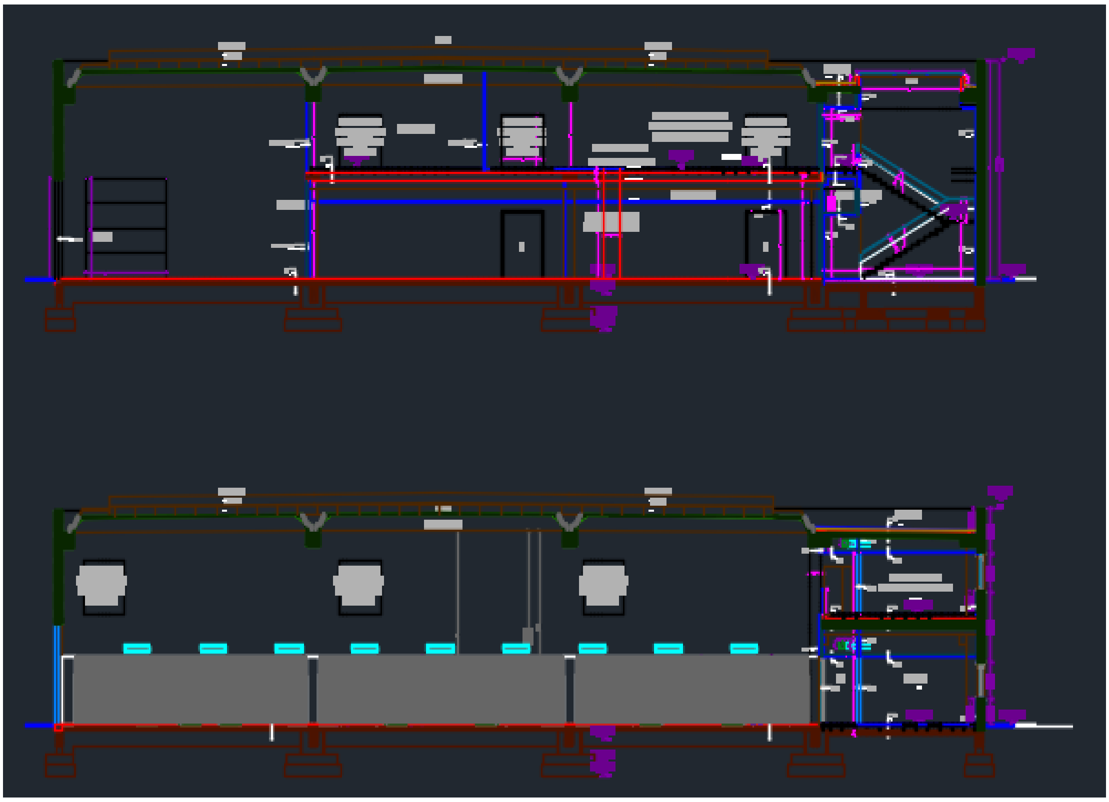


Figure 56: Example of CAD drawing for the design of internal openings

5.2.2.8 Surface matching

One of the most strenuous procedures for the completion of the 3D modeling of the building is the surface matching. Each different wall, roof, floor, opaque and non-opaque openings must be matched with each correspondent neighboring one. Because of the nature of the design of the Sketch Up software described earlier, each separate zone must contain the same characteristics as each neighboring one. For example an interior window between two zones must be designed in the same position for both of them. Without this technique surface matching is not possible.

After successfully designing the different zones, lines in each neighboring zone lines were drawn in every cross section aligning different components to enable the matching of surfaces. All external surfaces do not need surface matching as it is obvious. The building with all surfaces matched (green represents internal surfaces, blue external) is presented in Figure 68.

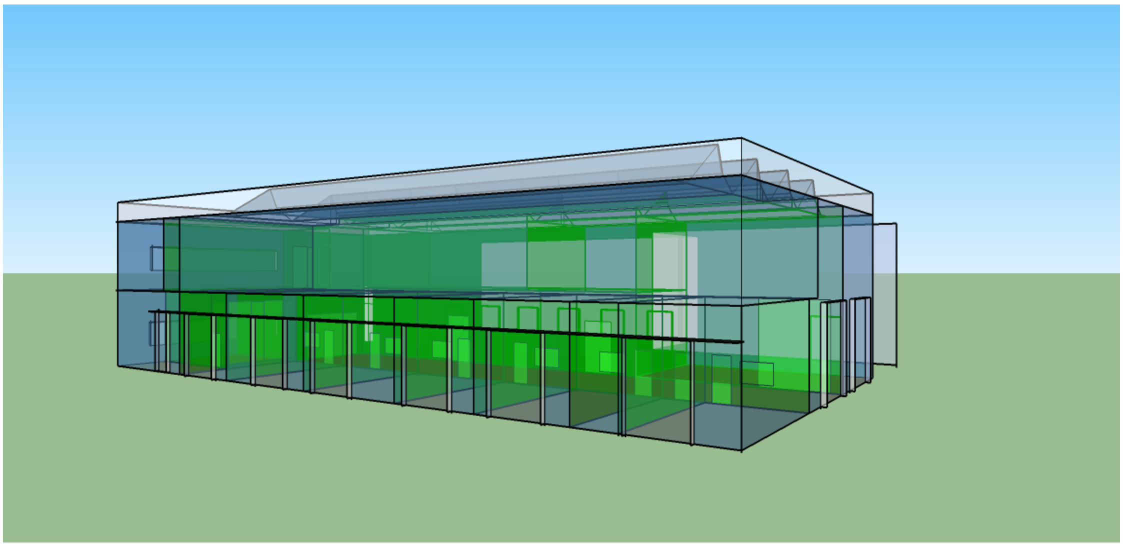


Figure 57: The fully surface matched building

Surface matching is very important for the proper functioning of the model as it permits the continuous communication between zones. Therefore different phenomena of heat or radiation transfer are calculated correctly.

5.2.2.9 Design of the Photovoltaic roof installation

In order to properly design the photovoltaics installation on top of the Kite lab the necessary specifications were provided [41-44]. Firstly the blue-prints

(Figure 69) of the installation was used to define the space covered by the PVs and implement it into the model.

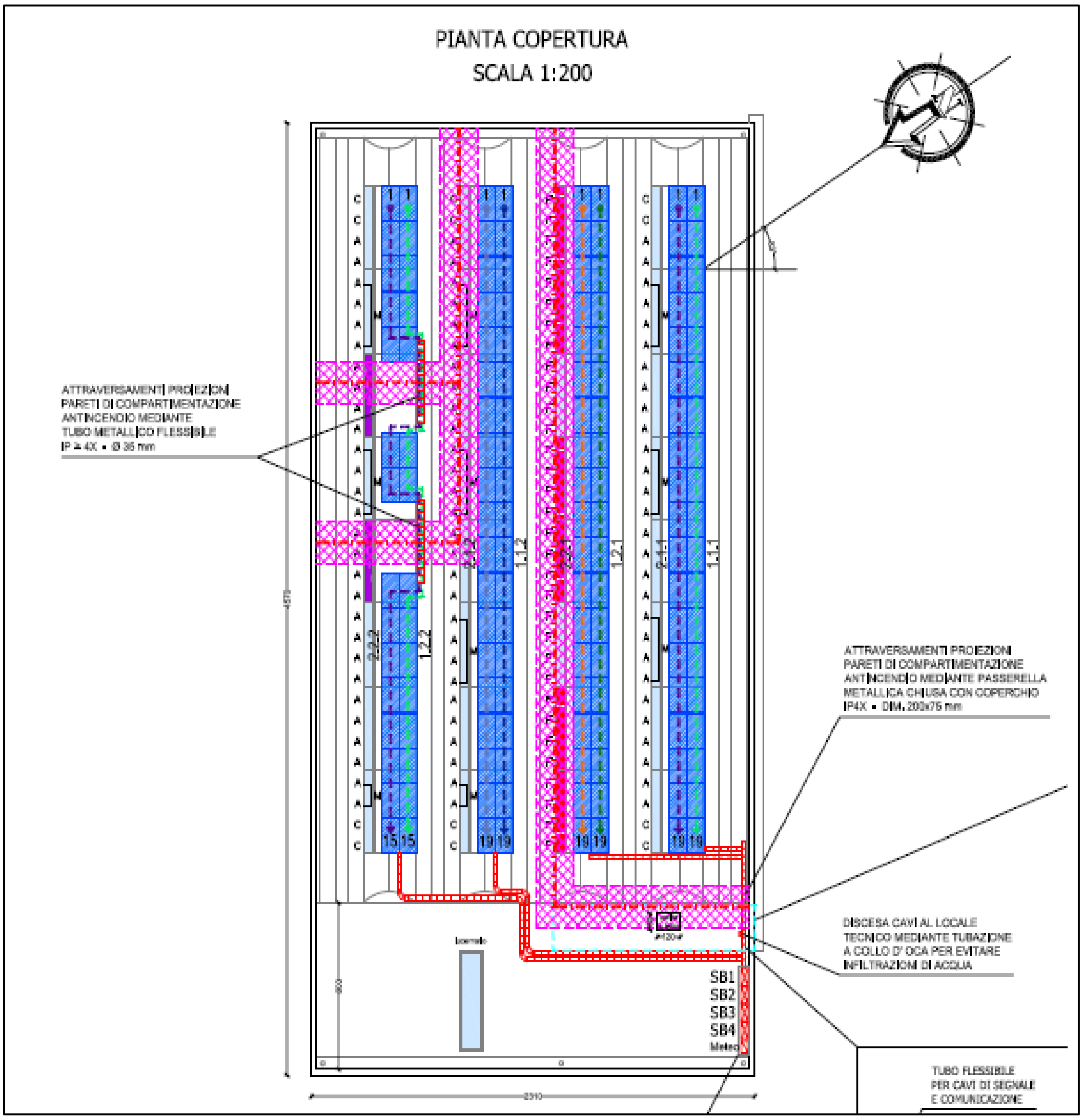


Figure 58: Design of the photovoltaic installation used for the modelling

The result is presented in Figure 70.

Figure 59: The PVs covering part of the rooftop

In the same pdf file some technical specification (Figure 71) was provided as for example the space covered by the PVs which is approximately half of the available in each tilted rooftop.

CARATTERISTICHE IMPIANTO	
SUPERFICIE UTILE NETTA IMPIANTO	238 m^2
POTENZA PANNELLO FOTOVOLTAICO	260 Wp
N° PANNELLI FOTOVOLTAICI	144
POTENZA COMPLESSIVA IMPIANTO	37,44 kWp
STIMA PRODUCIBILITA' ANNUA	42000 kWh
ANGOLO DI AZIMUT (RIFERITO AL SUD)	33° (SUD-OVEST)
ANGOLO DI TILT	28°

COORDINATE GEOGRAFICHE SITO DI INSTALLAZIONE:
LATITUDINE **43° 28' 15" (43,47084°) NORD**
LONGITUDINE **13° 04' 28" (13,07445°) EST**
ALTITUDINE **124 m s.l.m.**

Figure 60: Technical Specifications of the PV installation

The actual space covered by the PVs cannot be represented in the Sketch up model, but a coverage rate was applied instead. That is the reason why in the model the installation seems to cover all the area available. The specifications of the PVs incline a maximum efficiency of 0.15, which was induced in the model. The model of the PVs is polycrystalline of Solsonica model S610 [45] of 260W power (Figure 72), covering an area of 238m^2.

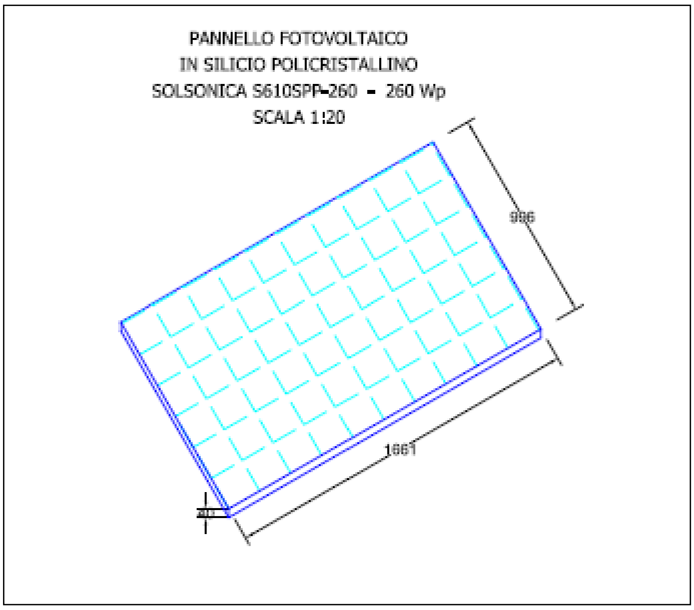


Figure 61: The type of PVs installed

5.2.2.10 Kite Lab final 3D model

The final result of the sketching is presented in Figures 73-76. Different views of the structure including all the surfaces, the sub-surfaces, the openings and doors are displayed. A shading component was designed at the east of the building to describe the AEA lab that resides next to the Kite one.

Figure 62: South-east view of the building

Figure 63: North-east view of the building

Figure 64: North-west view of the building

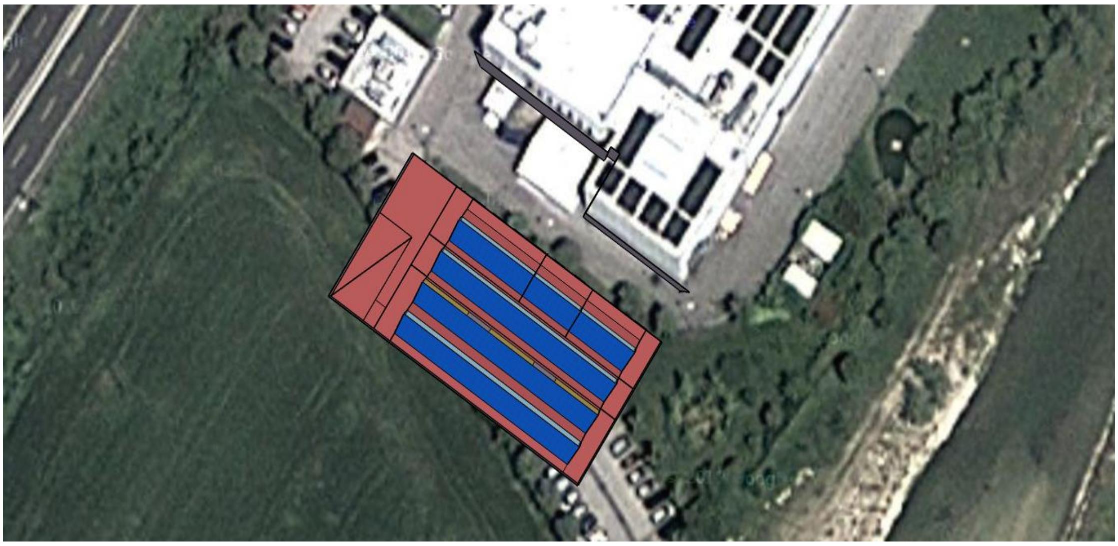


Figure 65: Top view of the building

5.2.2.11 Distinction of thermal zones

The next step was the integration of the thermal zones into the model. During the design of the building in Sketch Up each space was designed taking into account that it corresponds to a different thermal zone. Normally this is not the case, for example the entrance and the corridor is in fact one unified space which in case are connected with no walls dividing the two spaces. In overall, 16 different thermal zones, regarding the use, the type of the space and the natural distinction with walls and opaque openings were created. The result is presented in Figure 77.

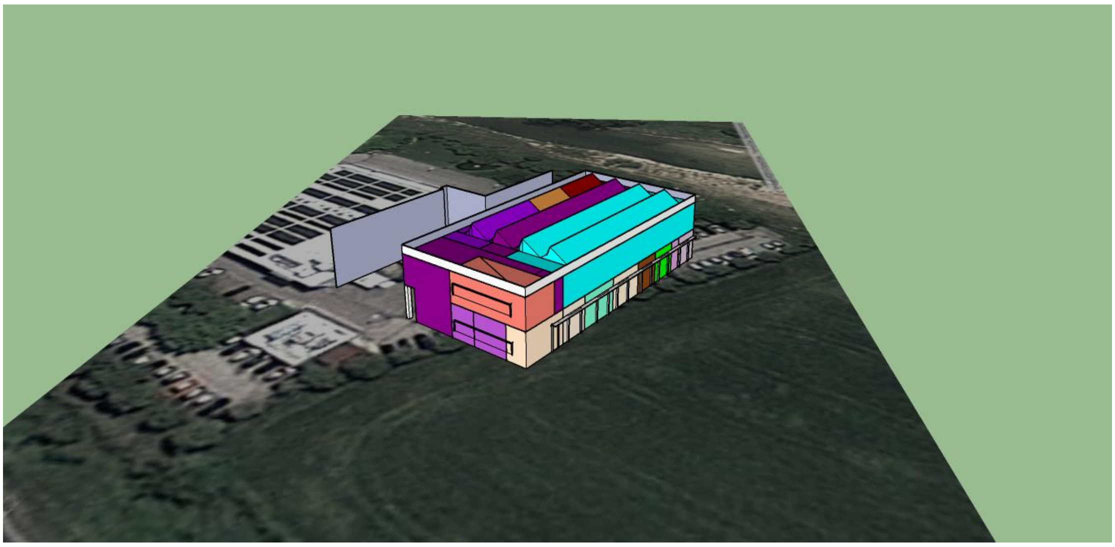


Figure 66: Distinction in thermal zones

Some spaces were unified in one thermal zone as they share similar HVAC activity, as well as similar use and loads. Therefore the 1st and 2nd office of the basement are unified in one thermal zone, as well as the 1st and 2nd laboratorio. The final unification was made for the entrance and the corridor which don't have actual borders dividing them as spaces forming one great unified space.

The thermal zones of the Basement are described below (Figure 78).

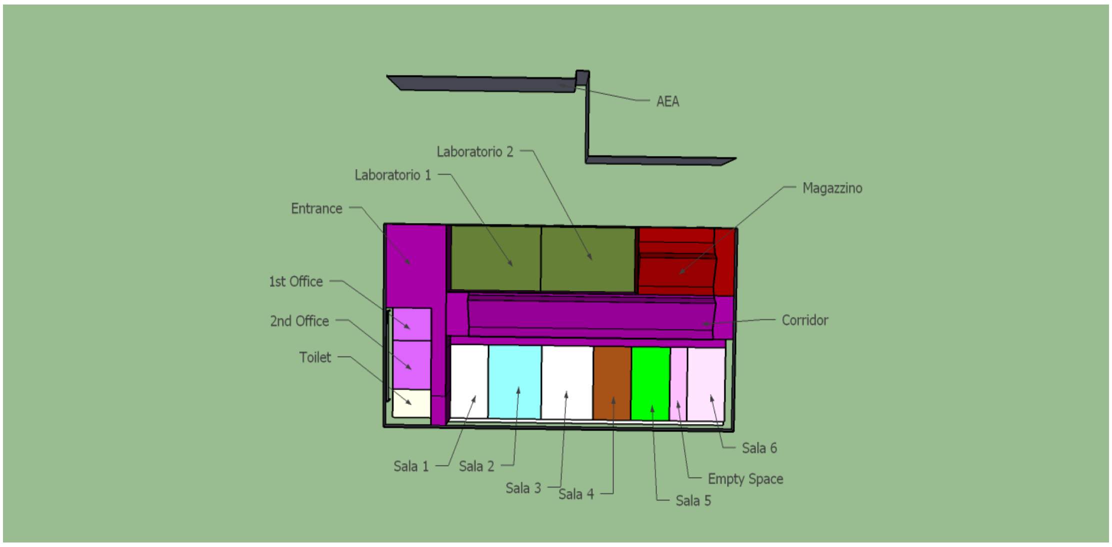


Figure 67: Basement thermal zones

As described before the entrance, the corridor and the magazzino are through to the 2nd floor as well. The second floor is presented in Figure 79.

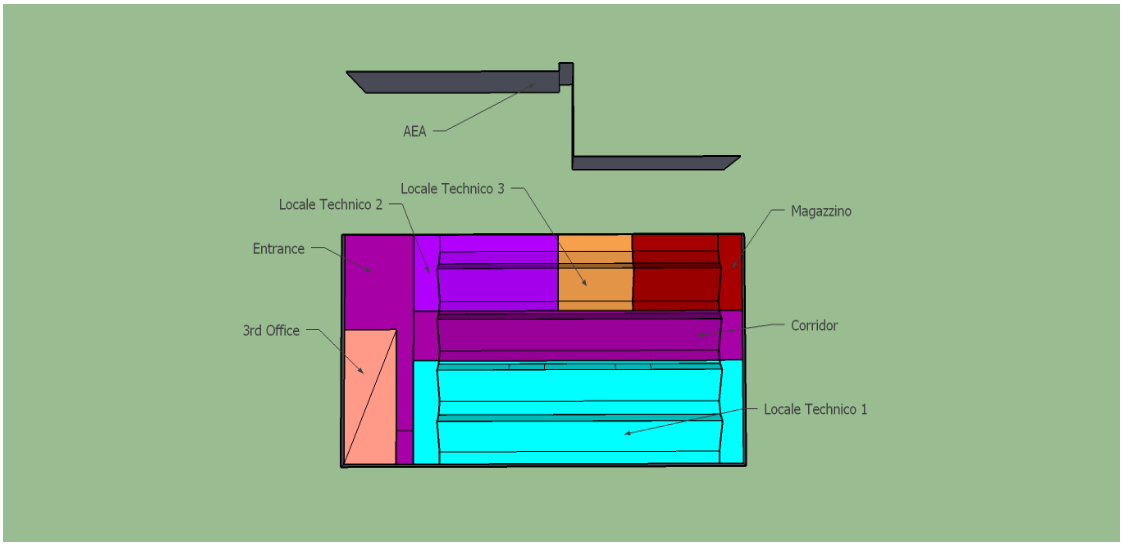


Figure 68: Thermal zones in 2nd floor

The distinction was made using the Open studio platform (Figure 80) that then allows the extraction of the above figures presenting thermal zones with one color each.

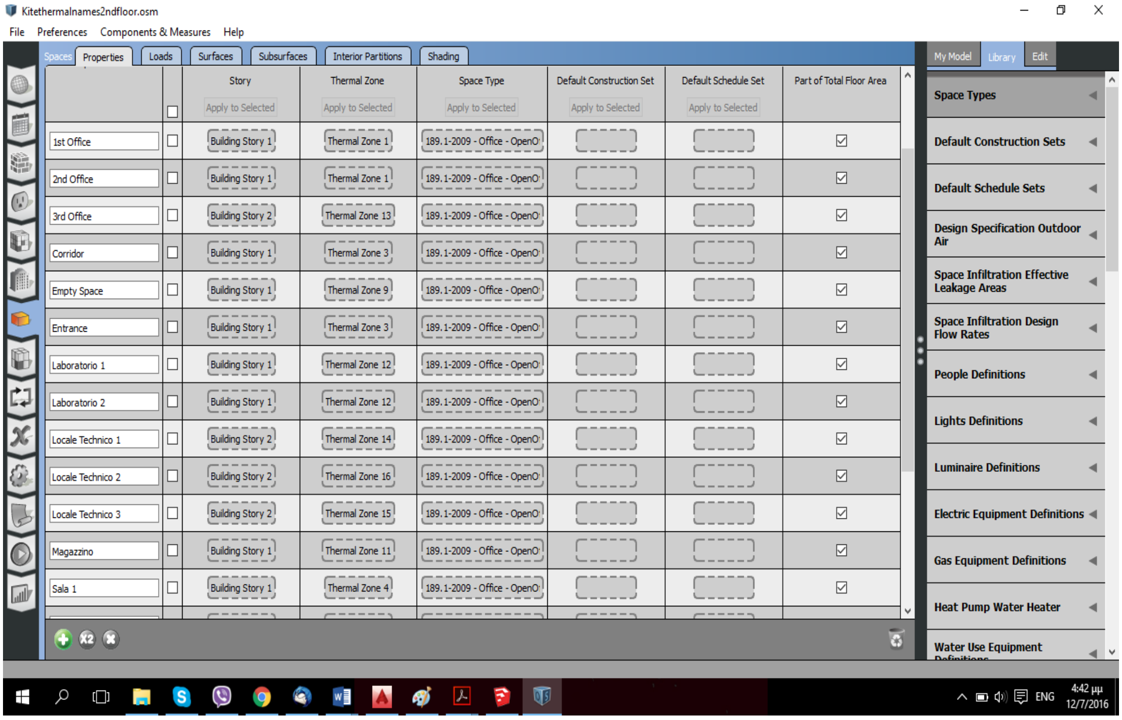


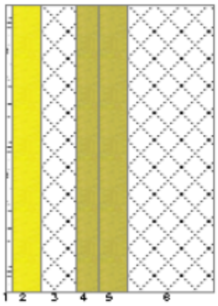
Figure 69: Open studio categorization of building levels and thermal zones

5.2.2.12 Materials and construction

In order to properly simulate the building environment all of the materials characteristics concerning constructions and structure elements must be imported. First the characteristics of each material used in the building were imported. By using the detailed schematics [46] provided (Fig. 81) the different materials such as thickness, conductivity, density and thermal absorptance were determined.

Descrizione della struttura: *Muro esterno prefabbricato - con controparete* **Codice:** *M1*

Trasmittanza termica	***0,225***	W/m^2K
Spessore	***363***	mm
Temperatura esterna (calcolo potenza invernale)	***-6,0***	°C
Permeanza	***1,094***	$10^{-12}kg/sm^2Pa$
Massa superficiale (con intonaci)	***520***	kg/m^2
Massa superficiale (senza intonaci)	***509***	kg/m^2
Trasmittanza periodica	***0,010***	W/m^2K
Fattore attenuazione	***0,043***	-
Sfasamento onda termica	***-11,8***	h



Stratigrafia:

N.	Descrizione strato	s	Cond.	R	M.V.	C.T.	R.V.
-	Resistenza superficiale interna	-	-	0,130	-	-	-
1	Cartongesso in lastre	12,50	0,250	0,050	900	1,00	10
2	Pannello TP 238 - Lana di vetro	50,00	0,032	1,563	32	1,03	3000
3	C.l.s. armato (2% acciaio)	60,00	2,500	0,024	2400	1,00	130
4	Polistirolo EPS 80	40,00	0,035	1,143	37	1,25	60
5	Polistirolo EPS 80	50,00	0,035	1,429	37	1,25	60
6	C.l.s. armato (2% acciaio)	150,00	2,500	0,060	2400	1,00	130
-	Resistenza superficiale esterna	-	-	0,047	-	-	-

Figure 70: Schematics used for the materials and building elements construction.

After inserting each characteristic the materials tab took the following form (Fig.82):

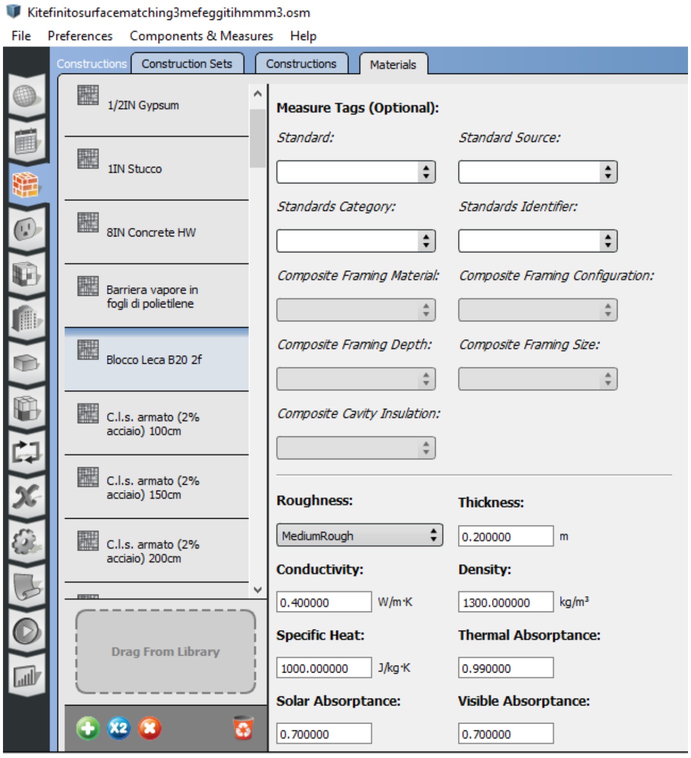


Figure 71: Open studio materials tab

The materials created for walls were:

- Cartogensso in lastre
- Panello TP 238-Lana di vetro
- C.I.s. armato (2% acciaio) of different thickness
- Polistirolo EPS 80
- Ultracoustic R
- Intonato di calce e gesso
- Blocco Leca B20 2f
- Par G3 Touch

Respectively, materials for floors are:

- Legno di abete flusso perpend. Alle fibre
- Intercarpedine non ventilate Av<500mm2/m
- Plyofoam C-500-XPS
- Barriera vapore in fogli di polietilene
- Tessuto non tessuto
- Ghaia grossa senza argilla (um. 5%)
- Masseto ripartitore in calcestruzzo con rete

- Polistirene espanso, estruso con pelle
- Piastrelle in ceramica (piastrelle)
- C.l.s. di argilla espansa pareti interne a struttura aperta (um 4%)

Equally materials for roofs are described below:

- Impermeabilizzazione con bitumen
- Solaio prefabbricato alveolare Poker –H21
- EPS 120
- EPS 80 con grafite

The next step was merging of the materials into walls, floors and roofs. In the constructions tab each element was defined combining the materials (Fig.83):

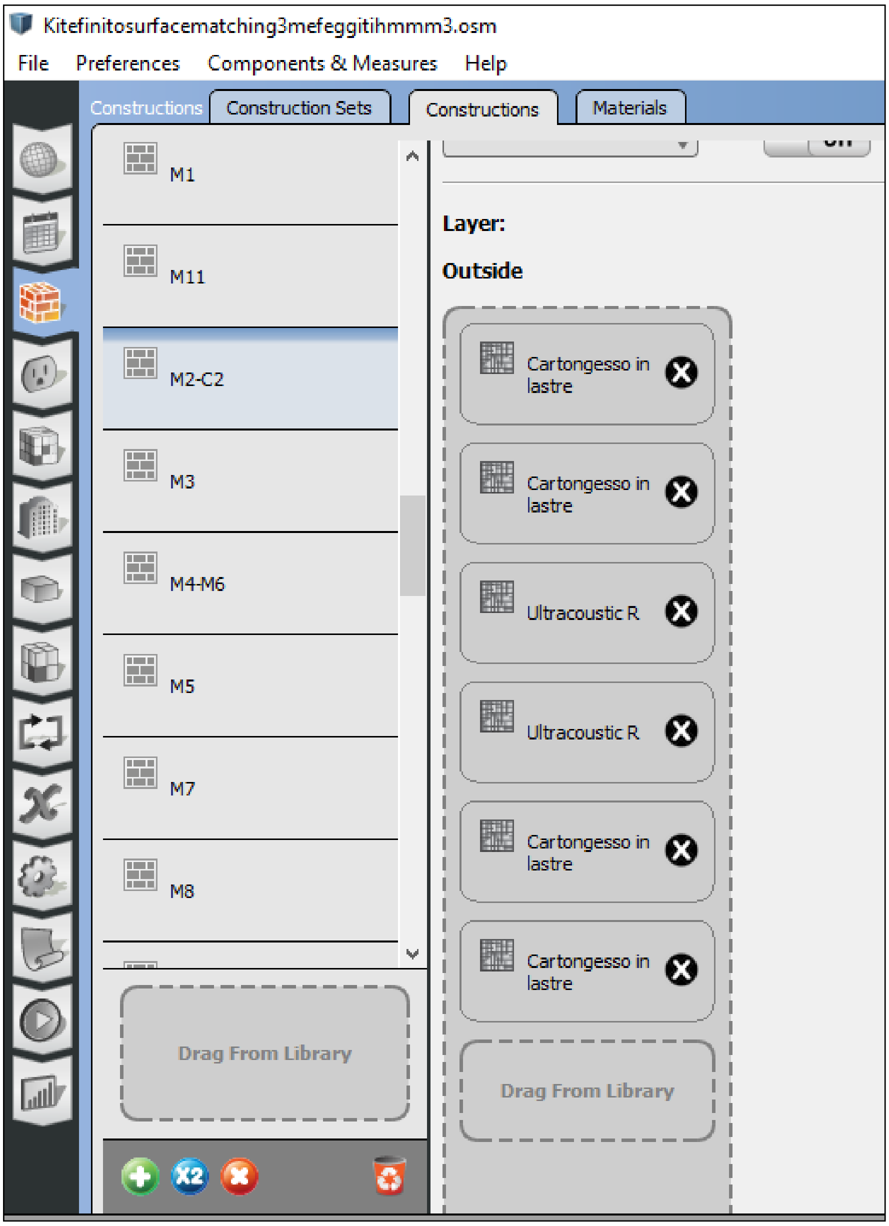


Figure 72: Different type of walls

Each of these elements consists of different layers of materials representing the real layout of the constructions. Inserting properly the above values is crucial to the heat flux transfer between thermal zones or the exterior environment.

Furthermore, the opaque and non-opaque elements such as windows, glass doors, doors, etc. were constructed using once again the schematics of each element and inserting the U-factor accordingly (Fig. 84).

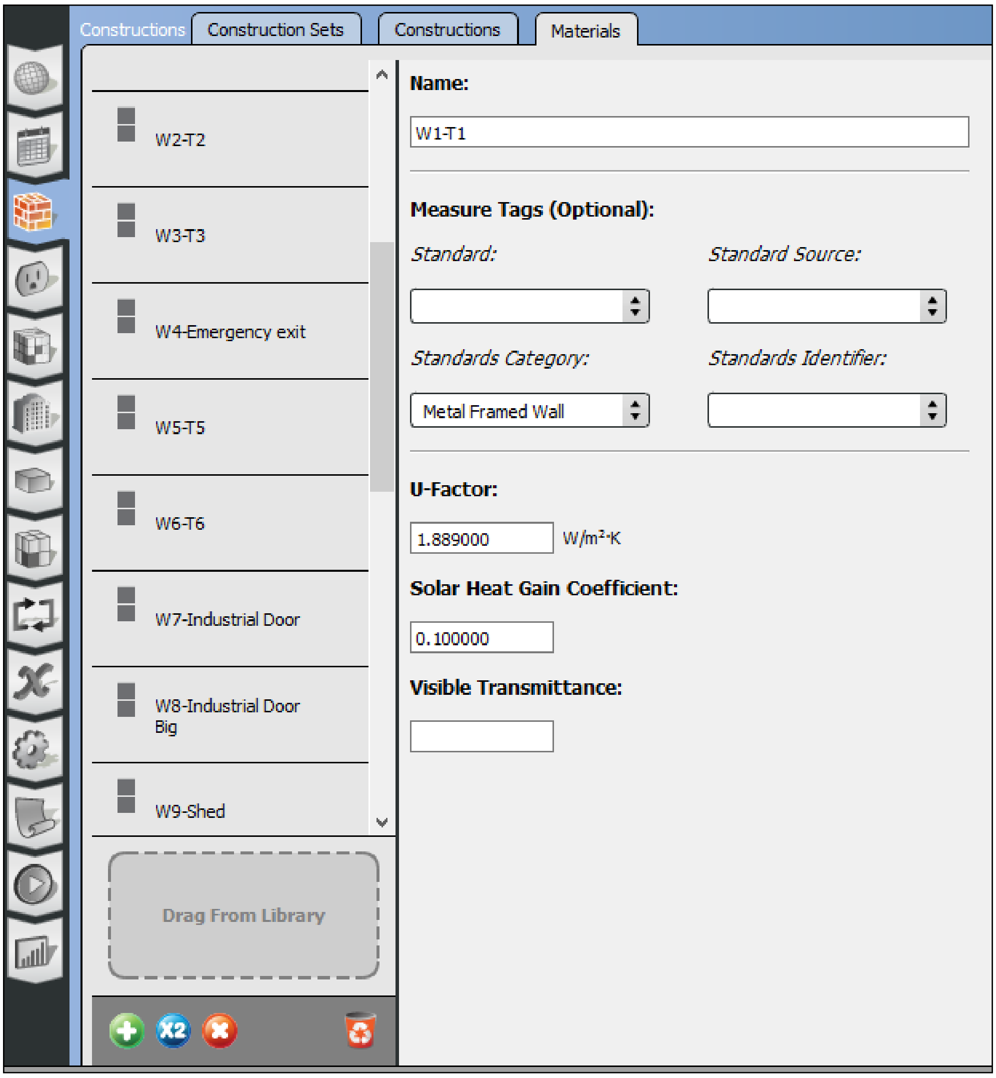


Figure 73: Opaque and non-opaque elements.

Finally, for each different space type constructions sets were composed and linked to each building element. The final form is presented below (Fig. 85).

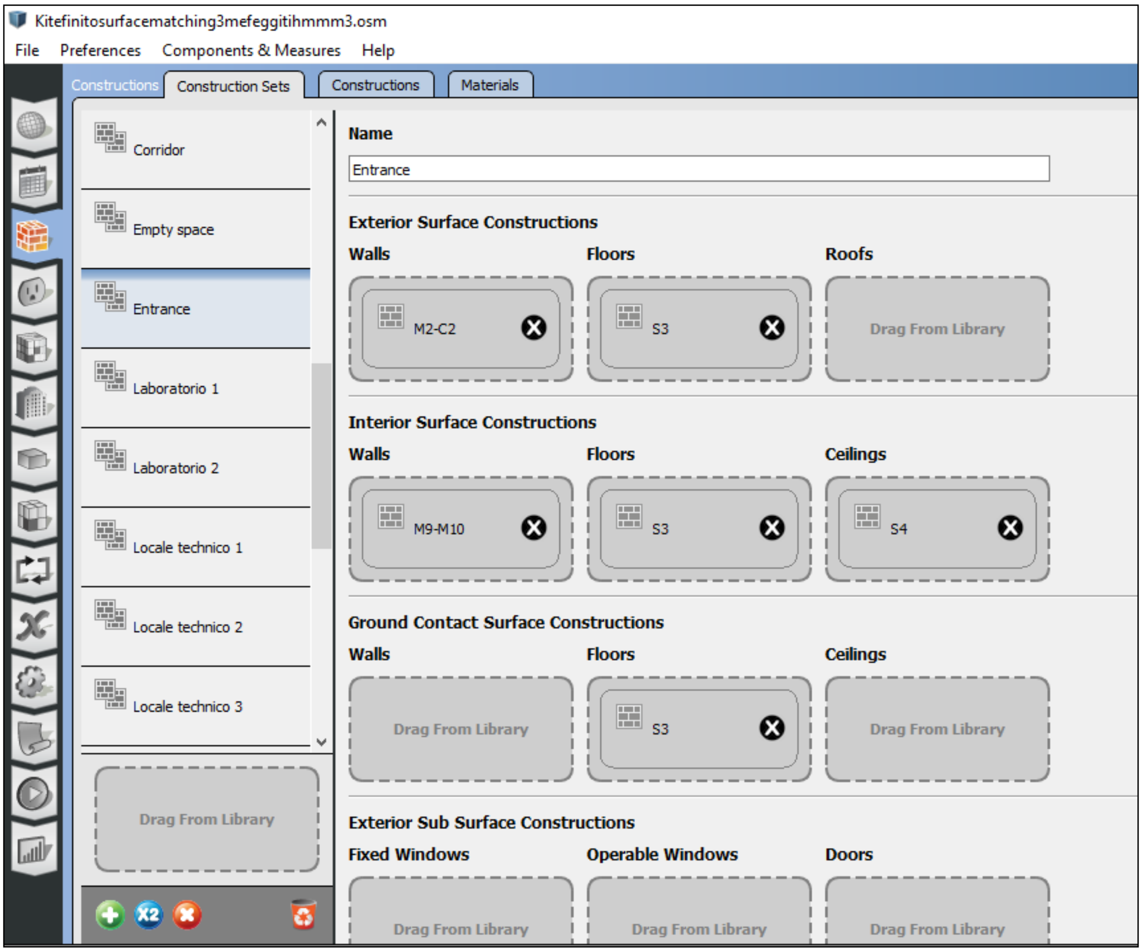


Figure 74: Final form of constructions sets.

Contouring the 3D model by construction type results in the following image (Fig.86).

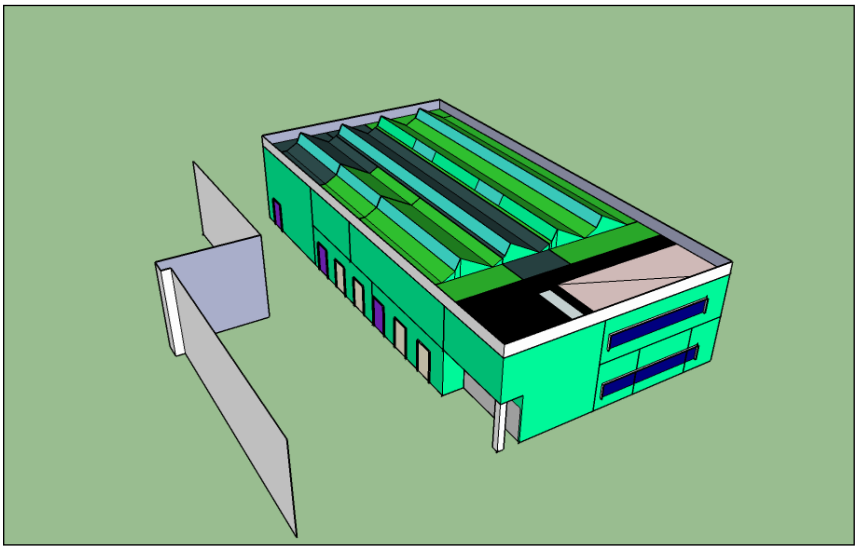


Figure 75: Contour based on materials-construction.

5.2.2.13 Importing weather file

In order to properly simulate the thermal and general behavior of the building the proper weather file was created. Using the Elements [47] platform data from the MyLeaf platform was integrated with the corresponding from the nearest national weather station (Figure 87).

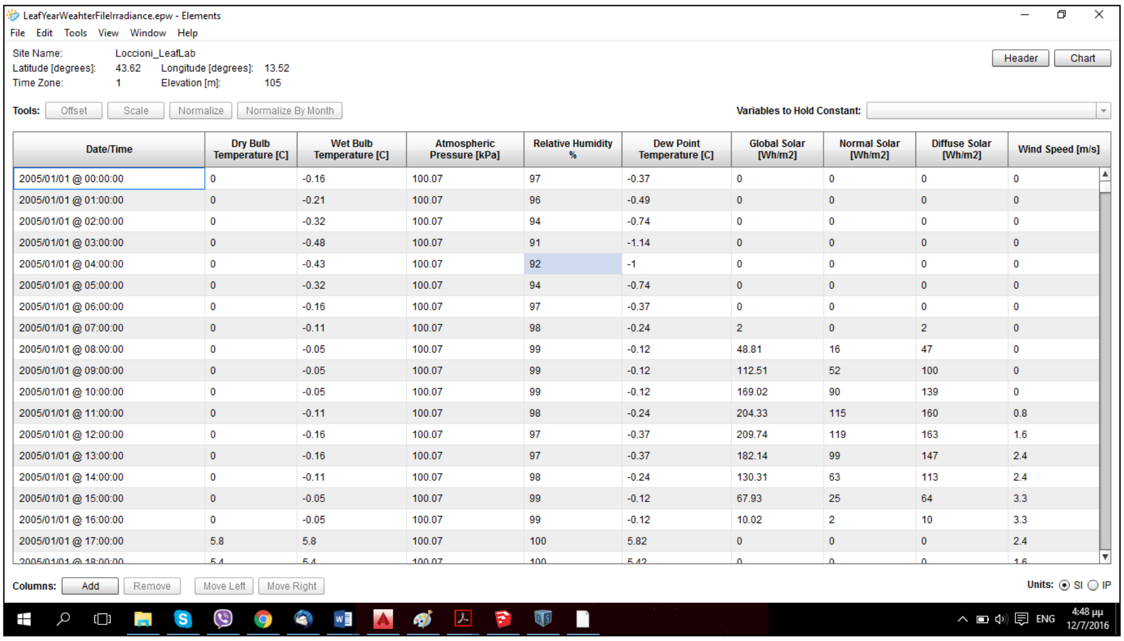


Figure 76: Elements integration of weather data files

The result was a single weather file containing all the necessary data, imported to the Open studio platform (Figure 88).

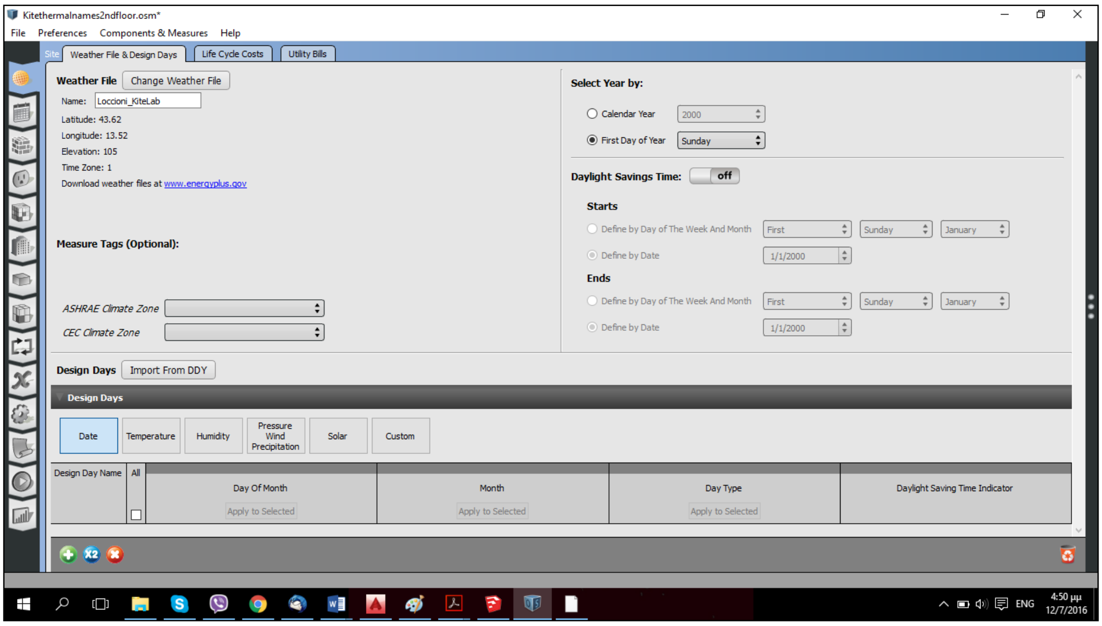


Figure 77: Importing the weather file

5.2.2.14 Internal loads

In every simulation of this kind it is necessary to fully compose an internal loads-gains profile. In each space and thermal zone apply different kind and level of activity, equipment, lighting and number of personnel was defined.

Regarding the personnel working and moving in each space, as also taking into account the size of the space 4 different types of anthropogenic internal gains (Figure 89) were created:

- Big workload spaces
- Little spaces-Big workload spaces
- Little spaces-Little workload spaces
- Unoccupied rooms

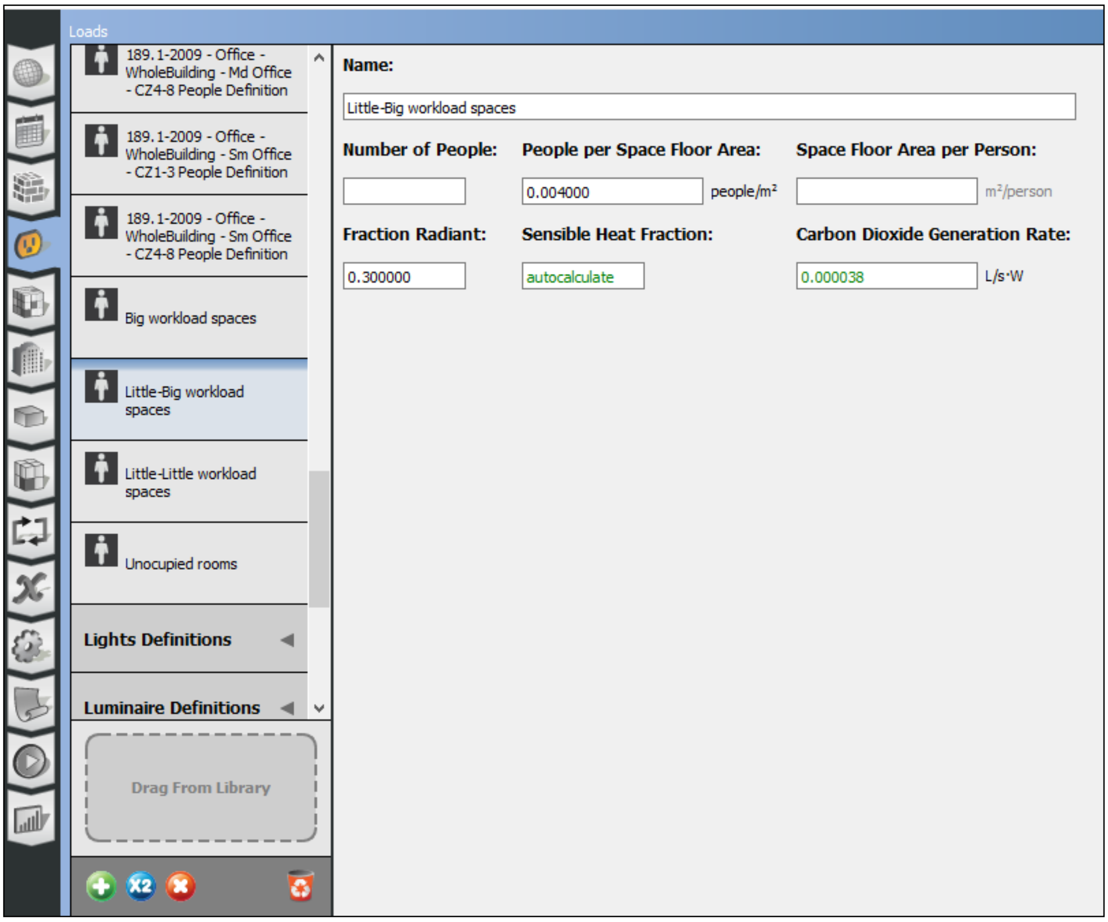


Figure 78 Importing internal loads people definitions.

According to each of the above definitions the proper people's activity values were entered. Similarly for lighting detailed schematics of the lights installed in each floor (Fig.90) were used.

Figure 79: Schematics of lights (blue-yellow) installed in each space.

4 categories of different lights definition depending on the size of the space and the amount of lights were used:

- Small space-Small lights
- Small space-Medium lights
- Large space-Medium lights
- Large space-Large lights

Regarding equipment a similar approach was used to import information from different documents and in situ observations. For the equipment of the 2 laboratories and the 3 offices a standard case of 15 and 5 desktop computers along with the correspondent monitors respectively was taken into consideration. For the equipment of the test rooms separate data was provided [48]. Specifically for test room 1, table 14 includes relevant information:

Table 14: Information regarding equipment

	Aria compressa (P= 6 bar)	**Acqua raffreddamento (P=3bar)**	**Azoto**	**Aspirazione per i banchi**	**Potenza elettrica richiesta**
Banco Sistema Iniezione Completo Sala test 1	200 Nlt/min	200 lt/min @ 12 °C - Delta Temperatura 5°C	10 Nl/min @ 6 bar	1000 Nm^3/hr@400 Pa	Banco = 80kW Chiller = 40 KW Camera clim. = 32 KW

Equivalent data were taken into account for all test rooms except for the 6th, which is still under construction.

The Kite Lab building incorporates 3 heat pumps for the heating-cooling demand through the year. All of the heat pumps are water to water so they can be connected with the nearby river and the water thermal storage. 2 of the heat pumps are of type AIRMEC NXP and connected with the air handling unit for heating and cooling demands. The 3rd one is of type AIRMEC WRL and is used to serve the conditioning of the offices. All of the heat pumps have winter and summer control modes. As described, certain set points are in use for the winter-summer operation of the building. Specifically, the set point for winter is at 20 ^{o}C and for summer is at 25 ^{o}C. These set points are used for every space of the building except for test room 6. As constructions are still in progress set points are changed to meet the necessary working conditions.

5.2.2.15 Conclusions and innovativeness of approach

Integrated energy design is a modern approach concerning the overall design and construction of a building. While it concerns different phases of the construction and the design of a new building it can be applied also in older ones as part of renovation-refurbishment plans [51].

In the case of KITE building the construction has followed many principles of IED. It is already a NZEB building incorporating increased insulation, natural lighting, advanced HVAC systems and renewable energy sources for covering energy demands as part of a self-sustained micro-grid.

The construction, materials and equipment used suggest a highly energy efficient building. The building is brand new and constructions are still under way, while the smart metering systems are properly calibrated and recording since April of 2016. However, no sufficient data was available for completing and validating the 3D model.

Nevertheless, it is a fact that the work that was completed until now composes a very thorough and detailed image of the actual building, so it can be used in the future with small calibrations and after validation with proper yearly data. Moreover, the basic principle that this research was conducted was to be part of a complete IED. Following the general guidelines of the European Union regarding the further advancement of NZEB or ZEB buildings, approaches such as this can play significant role in the future [52].

As described in previous sections a certain directive for a successful IED is yet to be determined. Although it is a cost effective and very resourceful tool most of the studies suggest preliminary measures, mostly about a new building or a to-be-refurbished one.

In this retrospective the present project contributes to this later case. The Kite Lab building was designed and constructed in order to be part of an already existing micro-grid using the latest technologies strengthening the energy self-sufficient state of it. Nevertheless, further optimization can be made after the finish of the works in order to conserve more energy and lower cost.

Following an IED means that there is comprehensive information regarding the building materials, structural components, HVAC systems, equipment, etc. it is much easier to complete a white box 3D model. As described before, the information that could be exported by such simulations is of great value and accuracy. Therefore, further investigation about the buildings behavior and control can be made.

In conclusion, the above approach can be part of a more complete and successful IED procedure. The knowledge that can be extracted from 3D models of this kind cannot be easily replaced by other means of calculations. Moreover, a set of that kind of simulations regarding other buildings of the micro-grid can be combined for later use.

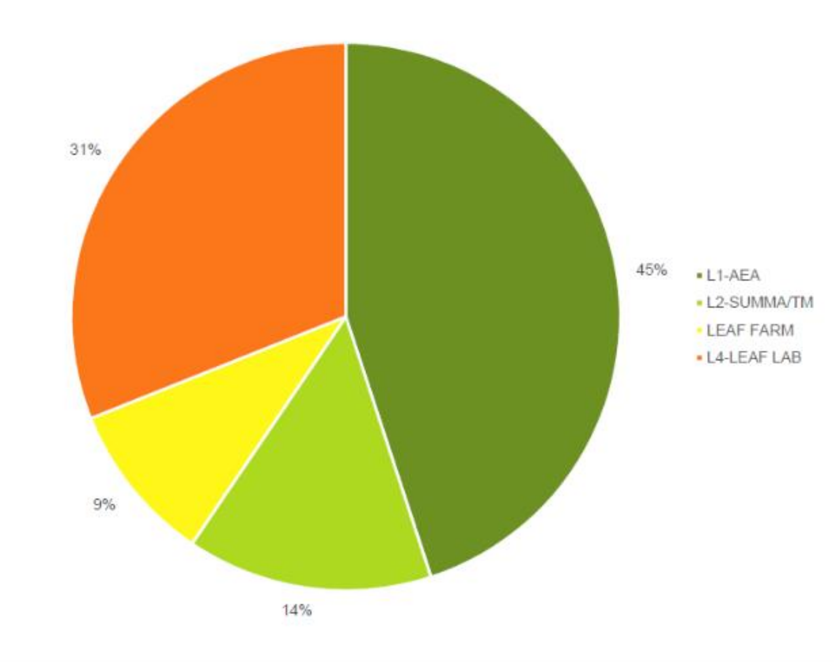
5.2.3 AEA building

5.2.3.1 Introduction

The current report presents the modeling process, the validation, the energy performance and optimization of AEA building of Loccioni Company.

Like the Internet, the Smart Grid consists of controls, computers, automation, new technologies, smart buildings and equipment working together, but in this case these technologies will work with the electrical grid to respond digitally to the quickly changing energy demands of the users. Therefore, smart grids create an exceptional opportunity for the support of the development of smart zero energy buildings and communities and offer the step towards the Internet of Things for the Energy and Building Industry

In Figure 92, the annual consumption of AEA Building for 2014 is depicted.



Area funzionale	Energia utilizzata [kWh]	% sul totale
L1 - AEA	558747	45%
L2 – SUMMA/TM	179956	14%
LEAF FARM	117827	9%
L4 – LEAF LAB	385880	31%
	1.242.410	**100%**

Figure 80: Annual consumption of Loccioni's buildings for 2014

5.2.3.2 Methodology

The main steps of the methodology are briefly described below:

- Data collection, analysis and processing
- Division of the building structure into various thermal zones
- Surface matching
- Building 3D design using Open Studio SketchUp Plugin
- Open studio - Import of the physical and thermal characteristics of building structural elements (walls, ceilings, floors, openings).
- Validation
- Energy performance, cost and internal thermal comfort optimization

5.2.3.3 Data collection, analysis and processing

The architectural drawings were used for the 3D design of the building envelope and merging the several spaces into thermal zones properly.

Moreover, data concerning the physical and thermal characteristics of the external and internal walls, the roof, the ground floor and the ceiling, alongside with similar information about the external windows characteristics was exploited.

5.2.3.4 Building 3D design using Open Studio SketchUp Plugin

In order to implement the 3D design of the AEA building, the dimensions of the different views (north, east, south, west) of each space as provided in AutoCAD drawings were used. First there the opaque elements of the building envelope (walls, roofs, basements) were designed and then the openings (windows, doors) were drawn (Fig.93-97).

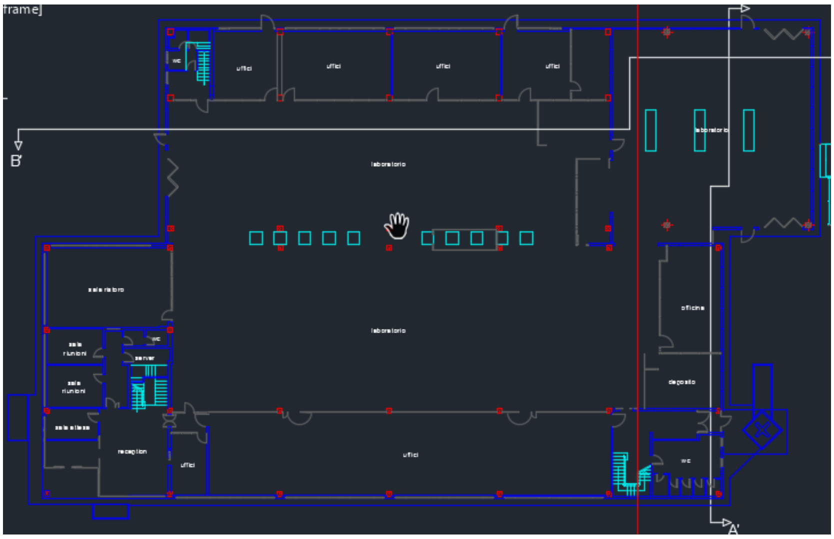


Figure 81: Top view of the first floor of AEA Building

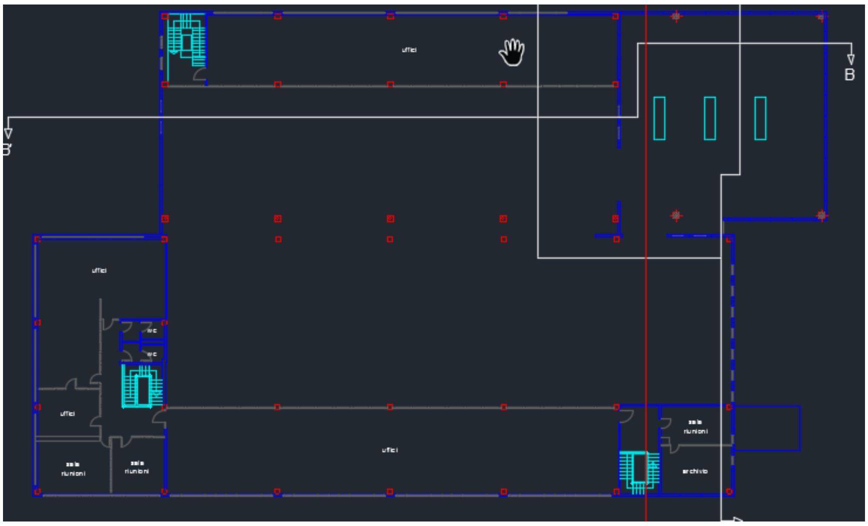


Figure 82: Top view of the second floor of AEA Building

Figure 83: East side view of two storey AEA Building

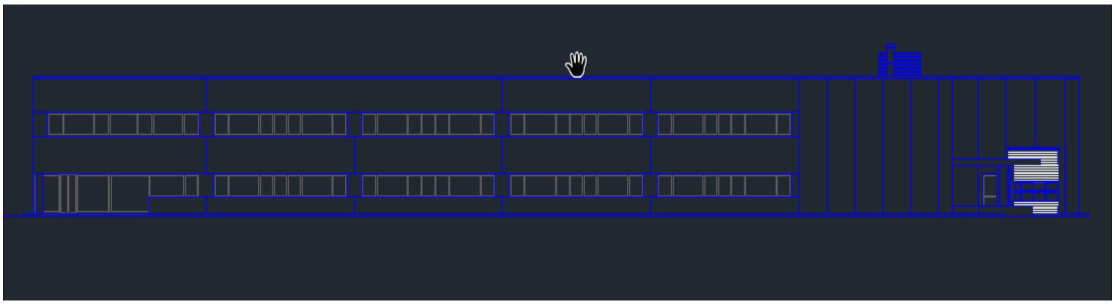


Figure 84: Front side view of two storey AEA Building

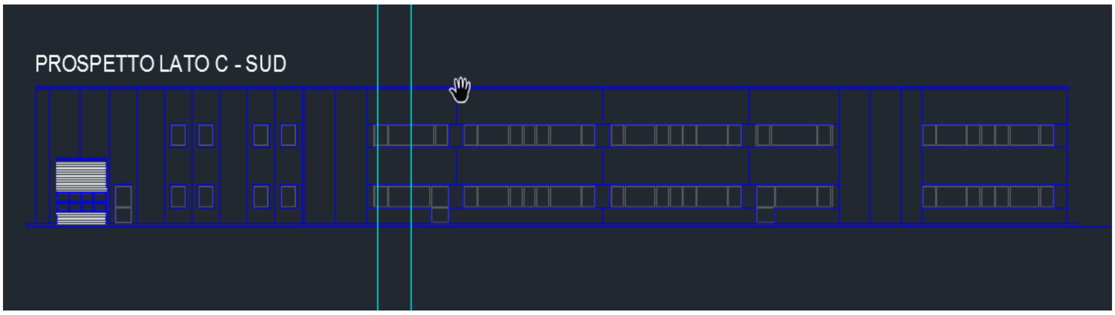


Figure 85: Back side view of two storey AEA Building

The final 3D design of the AEA Building using Open Studio SketchUp Plugin is presented in Figures 98-102:

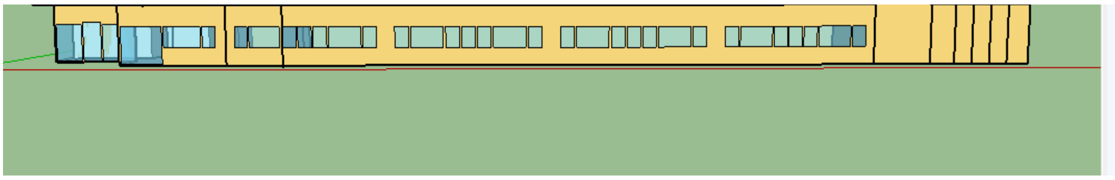


Figure 86: Top view of the first floor of AEA Building

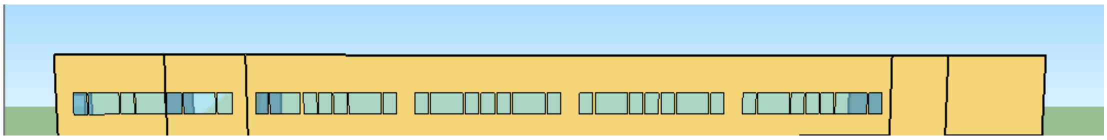


Figure 87: Top view of the second floor of AEA Building

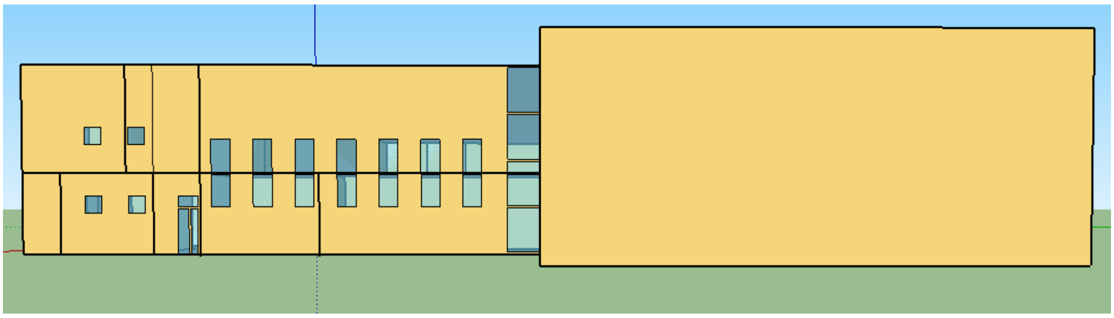


Figure 88: East side view of two storey AEA Building

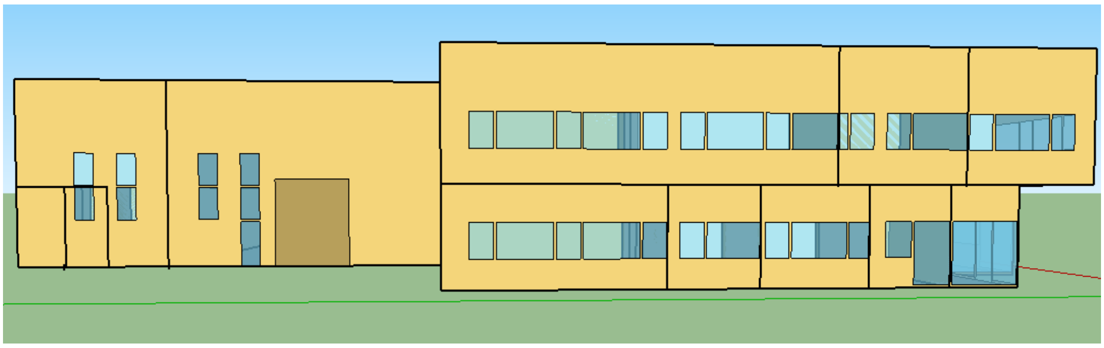


Figure 89: West side view of two storey AEA Building

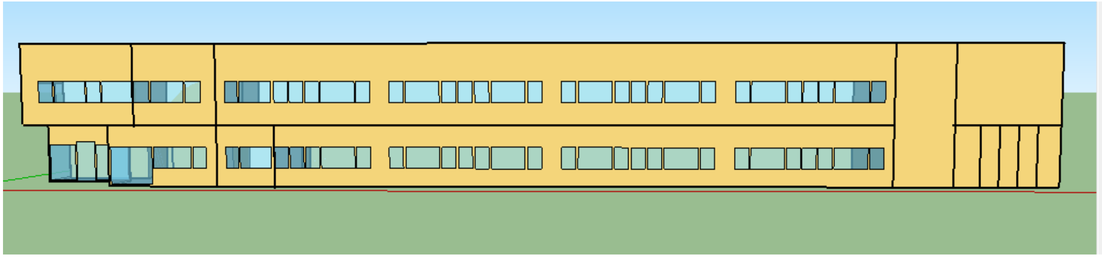


Figure 90: Front side view of two storey AEA Building

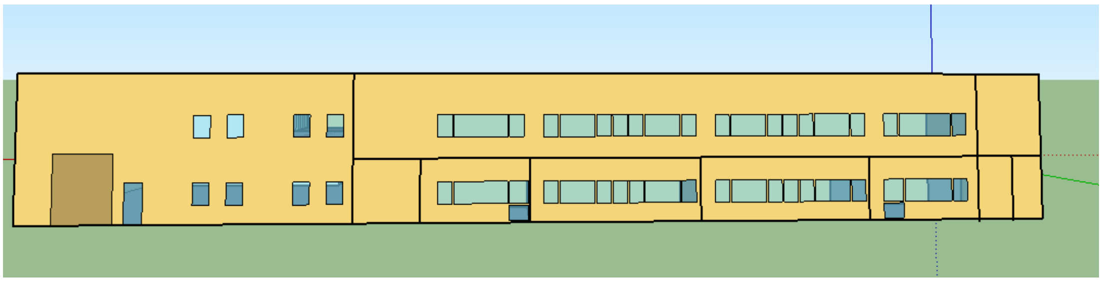


Figure 91: Back side view of two storey AEA Building

5.2.3.5 Division of the building structure in terms of the thermal zones

The thermal zones are divided in terms of the use, the orientation, the schedule and the construction materials of each space. The use of these criteria was chosen as having a central role in the thermal behavior of the various building zones.

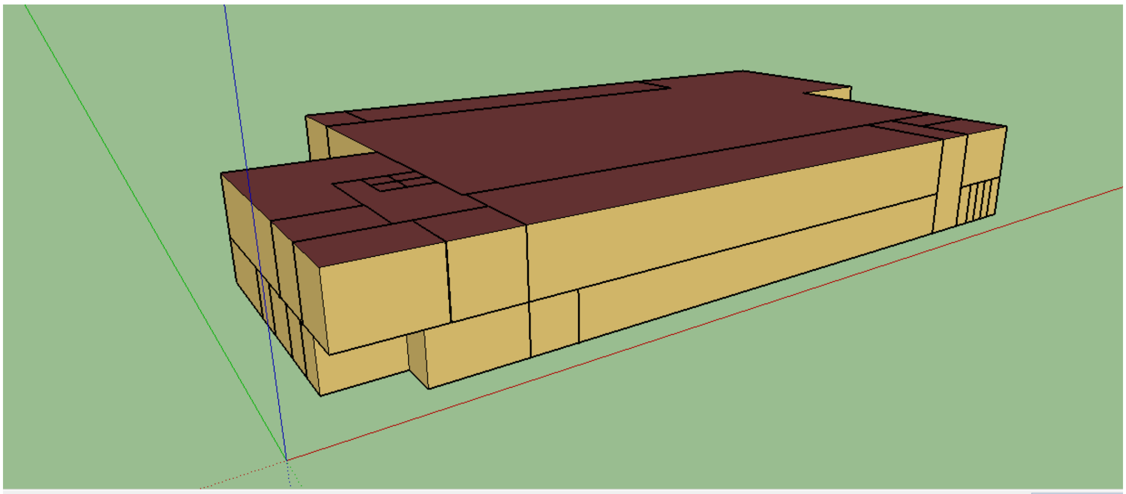


Figure 92: First phase of Leaf Lab 3D modelling

Some spaces were considered one thermal zone for simplicity reasons and in order to avoid having very small thermal zones. This was applied only on spaces that have very similar use, and they are adjacent and/or connected via sliding doors.

In Figures 105-106 the division of AEA building into different thermal zones is presented.

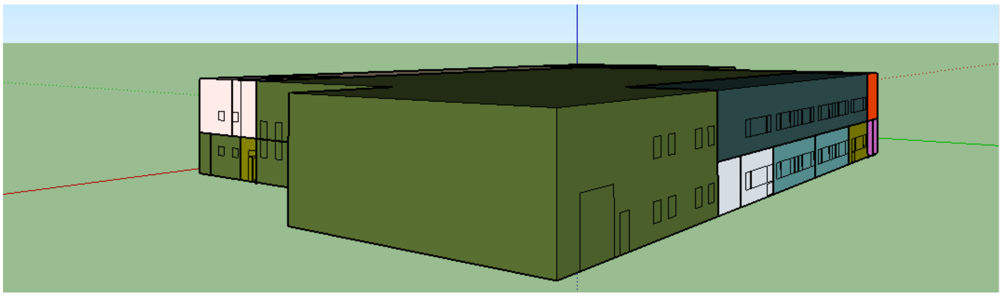


Figure 93: Southeast view of AEA Building divided into thermal zones

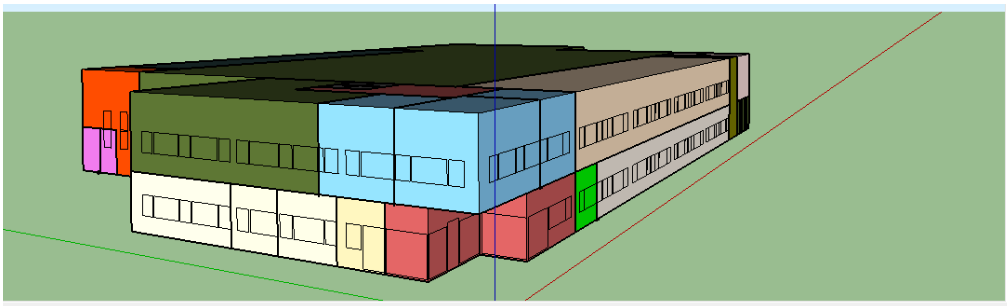


Figure 94: Northwest view of AEA Building divided into thermal zones

5.2.3.6 Surface matching

One very important step in the modelling process is surface matching. Through this procedure external surfaces in contact with outside air are coloured blue whereas the surfaces common between two spaces are coloured green. This is a vital step for the model to perform correctly (Figures 107-108).

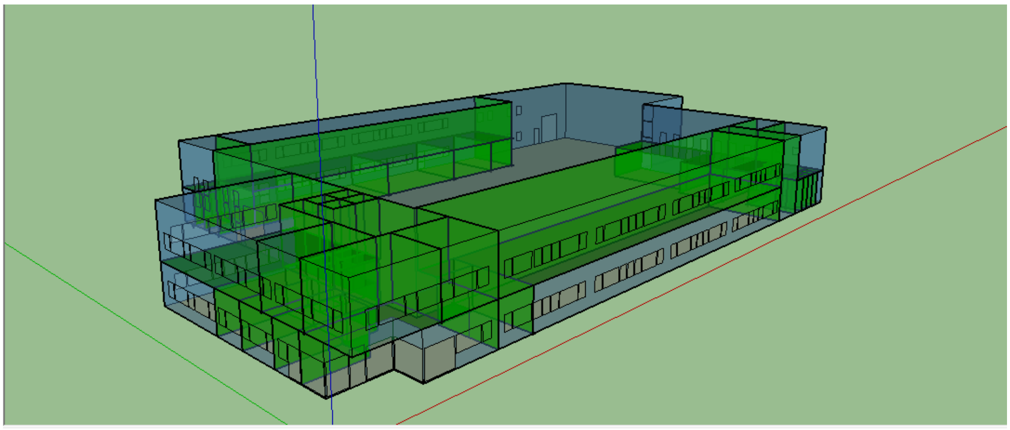


Figure 95: Surface matching for interior of AEA Building

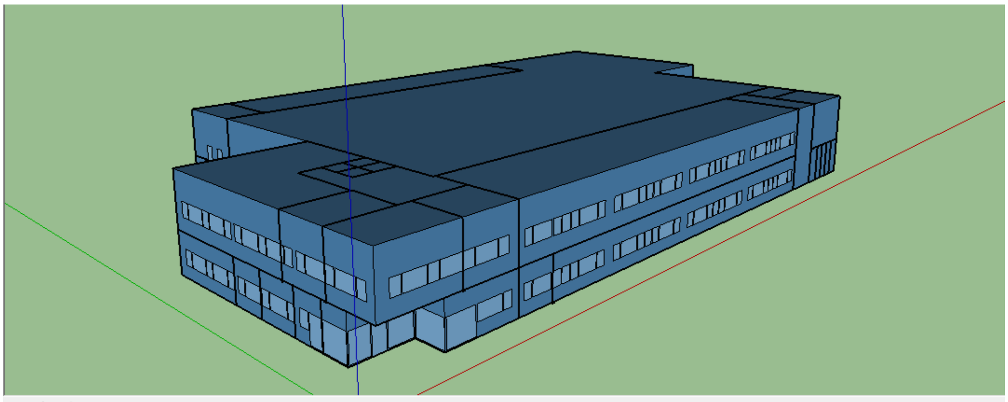


Figure 96: Surface matching for exterior of AEA Building

5.2.3.7 Open studio - Import of the physical and thermal characteristics of building structural elements (walls, ceilings, floors, openings)

Via open studio various data is inserted. This data includes weather conditions, simulation period, construction materials of each building element (wall, ceiling, floor and roof), technical characteristics of the electrical equipment and artificial lighting, lighting schedule, and the schedule of activity and occupancy.

5.2.3.7.1 Data on construction of the building envelope

One of the main steps of modelling the building in Open Studio refers to the constructions i.e. walls, ceilings, floors, roofs which consists of several different layers of materials. The technical properties of the materials that form the building structure elements are imported and assigned to the different construction elements. Then construction sets are created and assigned to each construction. A simple example is presented in Figure 109:

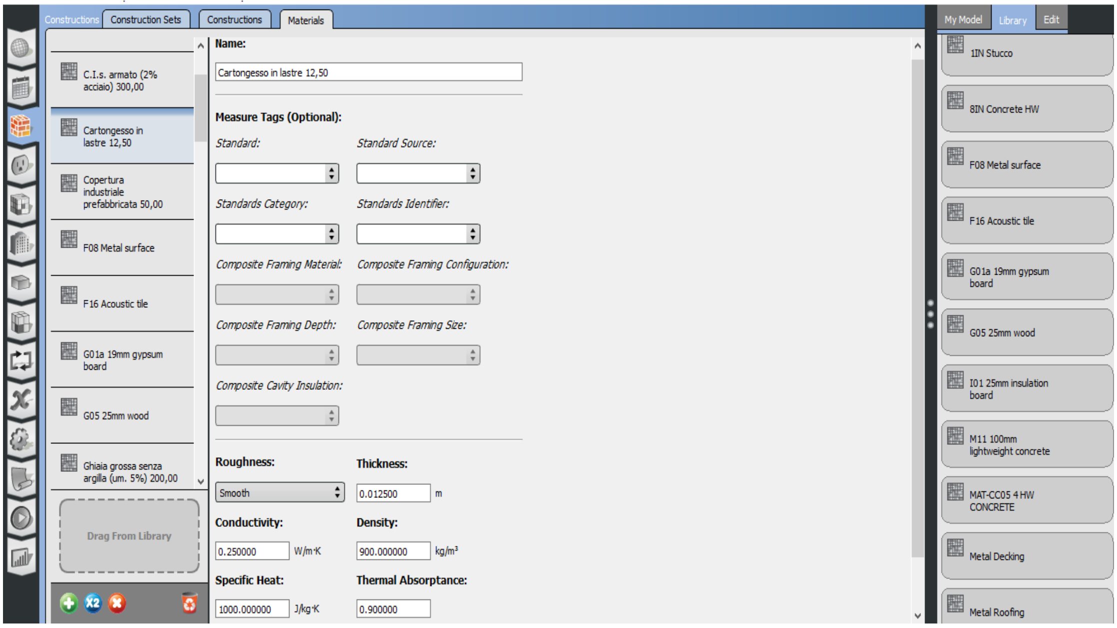


Figure 97: Cartongesso in Lastre physical and thermal values

All data concerning the thickness, conductivity, density, specific heat and thermal absorbance of the different materials were obtained from records such as in tables 15-16 available in Annex 3.

Table 15: Physical and thermal values of expanded polystyrene

N.	Descrizione strato	s	Cond.	R	M.V.	C.T.	R.V.
2	**Polistirene espanso, estruso con pelle**	***50,00***	***0,035***	***1,429***	***35***	***1,25***	***300***

Table 16: Measurement units of the physical and thermal values used

S	Spessore	mm
Cond.	Conduttività termica, comprensiva di eventuale maggiorazione	W/mK
R	Resistenza termica	m^2K/W
M.V.	Massa volumica	kg/m^3
C.T.	Capacità termica specifica	kJ/kgK
R.V.	Fattore di resistenza alla diffusione del vapore in capo asciutto	-

Next is a list of construction materials used in the building model:

- Expanded Polystyrene
- Expanded Polystyrene 2

- Expanded Polystyrene 3
- Expanded Polystyrene for non-thermal walls
- Expanded Polystyrene for underground walls
- Attic air gap
- Attic expanded polystyrene
- Attic prefabricated
- Attic reinforced concrete
- Attic wooden fiber
- Basement floor concrete
- Basement floor rock fragments
- Ceramic tiles
- Fabric layer
- Floor industrial concrete
- Floor industrial expanded polystyrene
- Floor expanded polystyrene
- Fiber wood
- Fabric layer
- Hollow Cores Slab
- Net with concrete
- Polyvinyl – chloride layer
- Plasterboard sheets
- Plasterboard sheets for non-thermal spaces
- Reinforced concrete
- Reinforced concrete 2
- Reinforced concrete 3
- Reinforced concrete for basement walls
- Thin concrete
- Vapor barrier for polythene
- Waterproof Bitumen

An equivalent list of materials was also imported for the construction of the glazing and other opaque elements of the building envelope.

5.2.3.7.2 Construction Types

As a next step every material was inserted in terms of layers into a specific construction type. The different construction types are the following:

- Attic ceiling
- Basement ceiling
- Basement floor
- Basement walls
- Ceiling
- External door
- External glass wall
- External wall
- External window
- Floor
- Ground floor
- Ground industrial floor
- Industrial door
- Internal glass wall
- Non thermal external wall
- Roof
- Roof windows
- Skylight

An example of a construction type in Open Studio is presented in Fig.110:

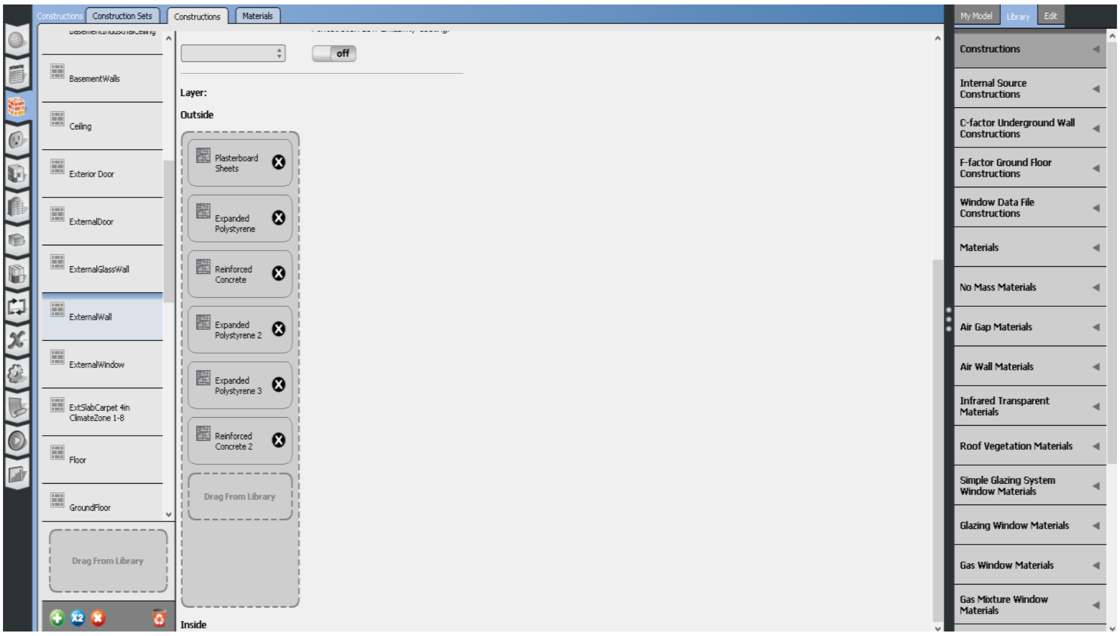


Figure 98: External wall construction type example

5.2.3.7.3 Construction Sets

The last step in the construction group of fields is the unification of the construction types in specific construction sets, depending on the similarity of materials used in each space. The construction sets created are the following:

- Basement
- Floor 1
- Floor 1 meeting room
- Floor 2
- Floor 2 bridge room
- Industrial
- Kitchen
- Non thermal spaces
- Non thermal spaces south WC1
- Non thermal spaces 2nd floor
- Reception

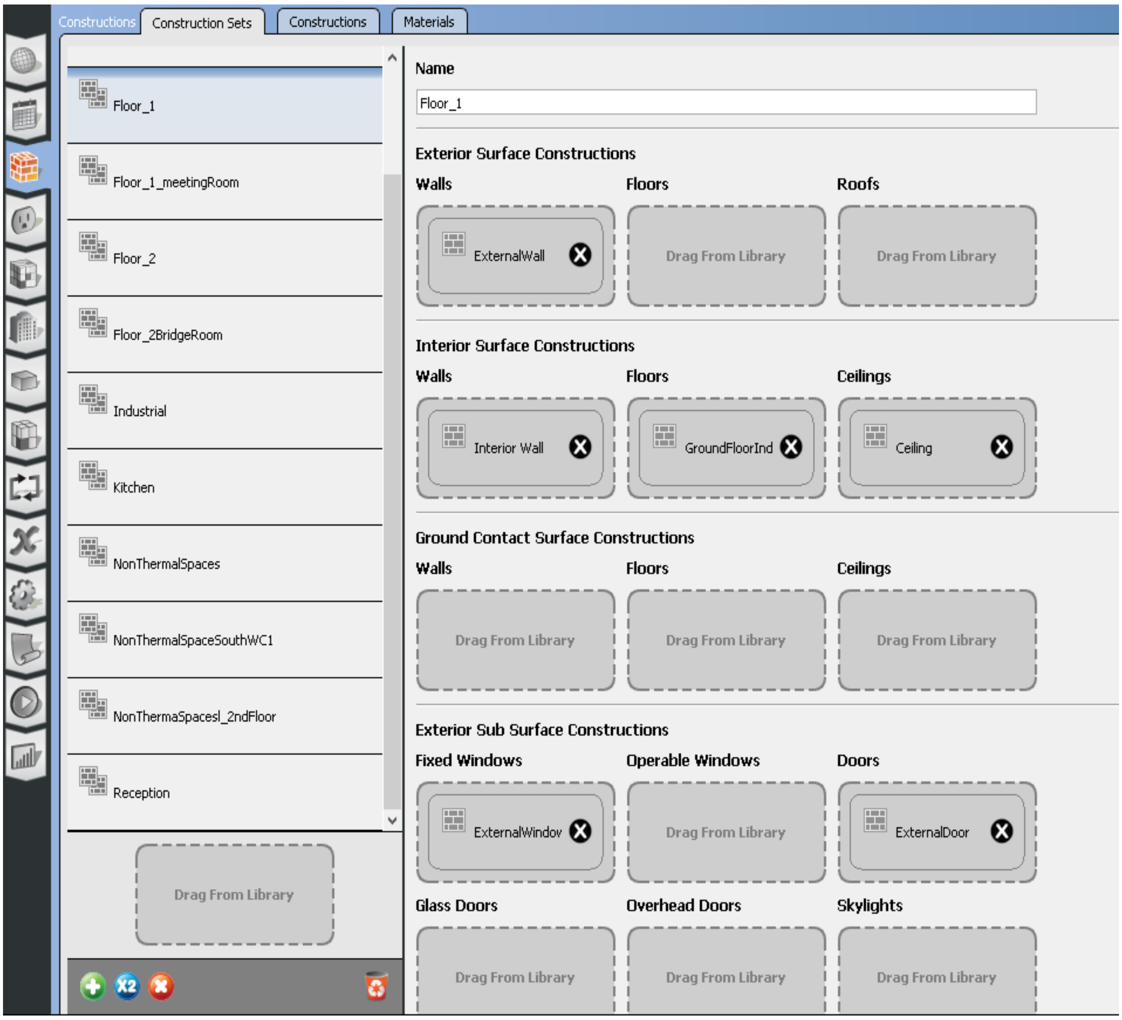


Figure 99: Floor_1 Construction Set example

As shown in the example of figure 112 there are different colours for the exterior walls, ceilings and sub surfaces such as windows.

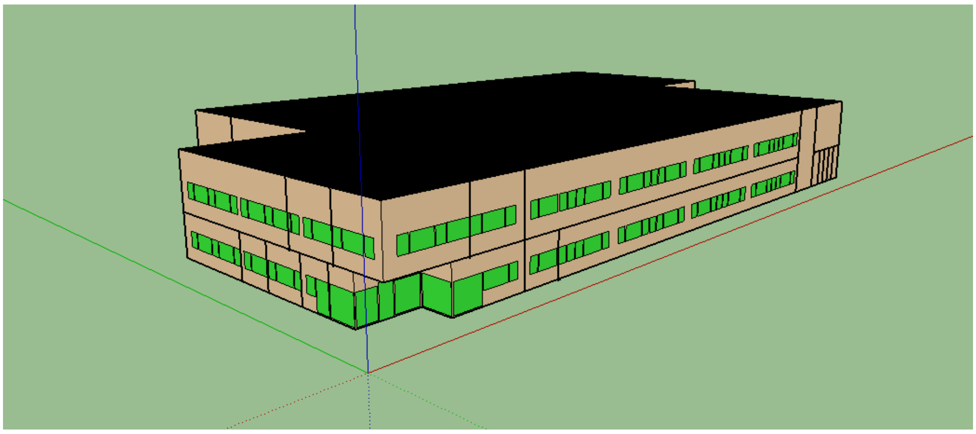


Figure 100: Exterior of AEA Building construction sets

5.2.3.7.4 Space types

After completing the construction sets, space types in terms of similar use and schedule (Figure 113) are created:

- Office
- Kitchen
- Industrial
- Meeting rooms
- Reception
- Others

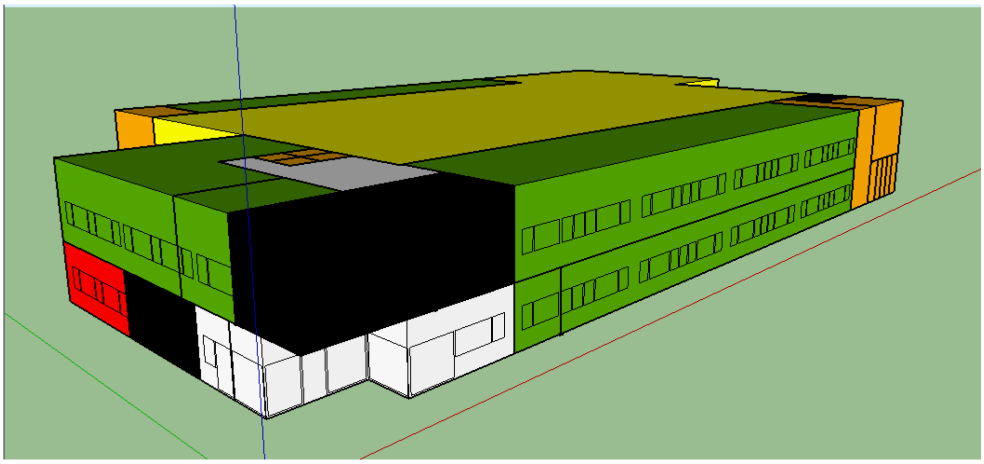


Figure 101: Space types in Open Studio Mode (Green: offices, Yellow: Industrial Use, Red: kitchen, White: Reception and corridors, Black: meeting rooms, Orange: W.C and stairs)

After importing the different schedules, the space types take the form of Fig.114:

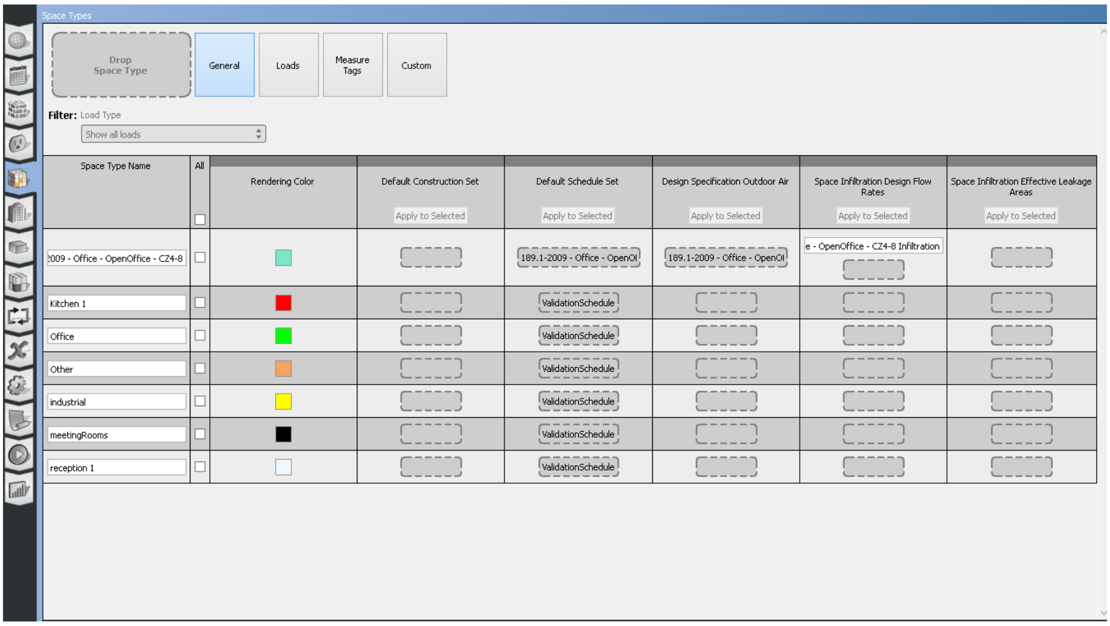


Figure 102: Space types with validation schedule inserted

5.2.3.7.5 Weather files

The next step is to load a weather file of the weather conditions in the province of Ancona as shown in Fig.115.

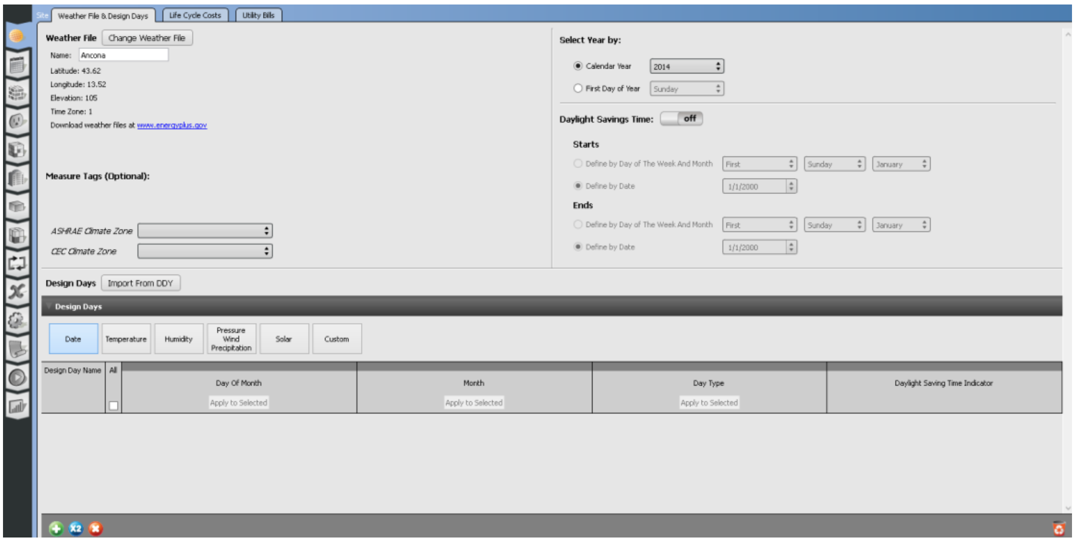


Figure 103: Import a weather file in Open Studio

5.2.3.8 Innovativeness

The value of the project that was undertaken and described in this report is to promote a more accurate and state-of-the-art research on specific energy efficiency measures.

5.2.3.9 Conclusions

Having followed the previous steps, the model for the energy performance of the AEA building is complete. Nevertheless, in order to ensure that the model is robust and reliable the validation process should take place. Through this process the necessary adjustments would be applied to enhance optimization procedure. The scope of the optimization procedure is to suggest measures which will result in the best energy performance of the AEA Building, taking also into account the building's incorporation in Loccioni's micro grid. To name a few a list is provided:

- Use of materials of the newest technology for the construction of the building
- Replacement of the systems for heating, cooling and hot water with the best available technologies (geothermal heat pumps, district heating/cooling systems, absorption/adsorption chillers, hybrid boilers).
- Installation of PV or hybrid renewable energy systems state of the art technology.
- Thermal/Chemical storage

The choice and/or the combination of the above measures would be made, provided that these are the cost effective technically feasible solutions. Optimization takes into account the ratio between investment/installation costs and cost savings. The scope after all is to ensure that the AEA Building would be an nZED Building.

5.2.4 Library building

5.2.4.1 Introduction

The analysis of electrical consumptions of the Library buildings has been conducted within different time frames (days, weeks, months picked during the year); in addition, such an analysis aims to evaluate the impact of innovative solutions as the High Concentrating Photovoltaic systems for combined thermal and electrical production, eventually equipped energy with storage units, or the High Efficiency Solar Cooling, both designed by Idea Srl.

After a first analysis, the installation of a concentrating solar thermal system has been taken into account for driving a double effect absorption chiller system producing heating and cooling to satisfy the thermal needs of a building inside the UoA Campus.

Energy demand for cooling and heating requirements has increased significantly during last years. Global space cooling energy consumption increased by 60% in the period between 2000 and 2010 reaching 4% of global consumption in 2010 [53]. On the other hand heat consumption accounts for more than 50% of the global consumption [54]. Therefore, alternative heating and cooling systems driven by renewable or recovered energy have driven the interest of many researchers. Many researchers [55-58] have carried out experimental and theoretical studies of Solar Heating Cooling (SHC) systems. Work on the use of concentrated energy for polygeneration [59] [60], has drawn significant attention. Absorption heating and cooling systems were studied more than any other systems. These systems have many advantages over other refrigeration systems [61]: Quiet operation, high reliability, long service life, meeting the variable load efficiently, minimum mechanical moving parts, no lubricants needed and no atmosphere-damaging refrigerants. Not many tools are available for accurate dimensioning and evaluating the solar thermal contribution to the total energy requirements. Dynamic simulation tool is used by many researchers [62-64].

Fong et al. [64] made a theoretical comparative study between five different solar cooling systems; Solar electrical compression, solar mechanical, solar absorption, solar adsorption and solid desiccant cooling system. The results show that solar electrical compression alongside solar absorption system have the better performance results. Moreover, the advantages of two-stage systems over other systems are investigated by [65]. It was concluded that the cooling system can work steadily in spite of unsteady solar input, lower generator input and outlet temperature, however, they demand higher temperature heat.

In line with these findings, a solar cooling system has been designed in order to smooth the summer peak of energy demand in one of the case study buildings.

5.2.4.2 The solar cooling plant for the UOA Science Library

Initial design defined the size of a CSP (Concentrating Solar Plant) useful to drive an absorption heating and cooling system to cover completely the cooling energy needs of a building and partially the heating, working in heating mode with the integration of the existent HVAC system.

Maximising the summer peak shaving effect of the UoA electrical load was set as a target. The thermal energy provided annually by the CSP, using an hourly steady-state model that simulated the annual solar energy gain was evaluated. In order to estimate the heating and cooling energy that could be supplied by the double-effect absorption chiller system, a monthly average value of thermal COP was used.

5.2.4.3 Location and description of the building

The building chosen for this analysis is the Library of Science. It is located at the Eastern side of the University Campus close to Hymettus Mountain (Fig.116).

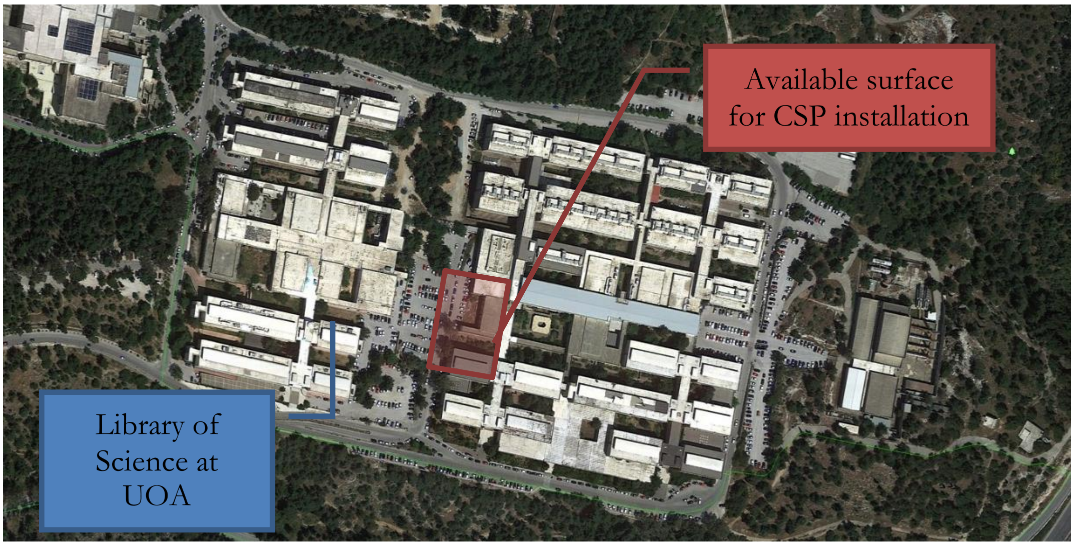


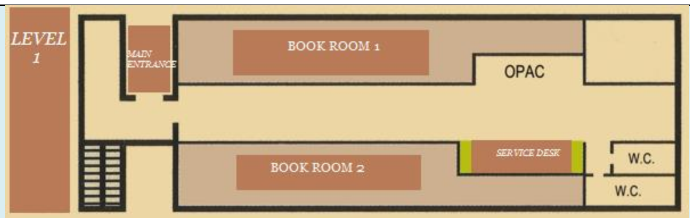
Figure 104: Location of the Library of Science inside the UoA Campus

Figure 105: Street view of the building

The Science Library building is composed by 4 floors, each of which has a useful surface area about of 1580 m^2 and a volume about of 5500 m^3, built in 2009. Overall, the existent centralized HVAC system provide heating, cooling and ventilation for about of 22.000 m^3 of useful volume (Fig.117).

The Science Library hosts (Fig. 118):

- Six Studying Rooms with 550 seats;
- Six Library Rooms;
- Four Group Study Rooms (AOM) of six persons;
- One Computer Room with 24 terminals;
- Seven Rooms with access to the Open Public Access Catalogue (OPAC) of the Athens University Libraries.

		Rooms
1^{st} level		Biology books room
		Geology books room
		Corridors

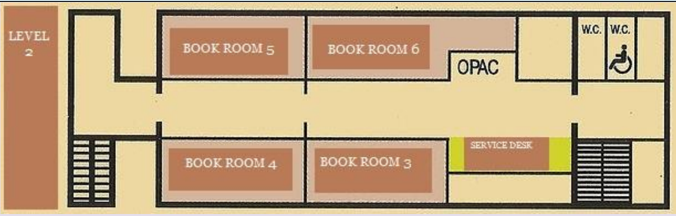
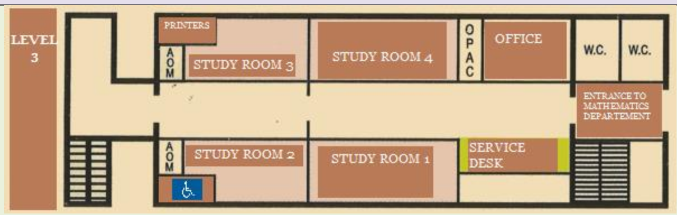
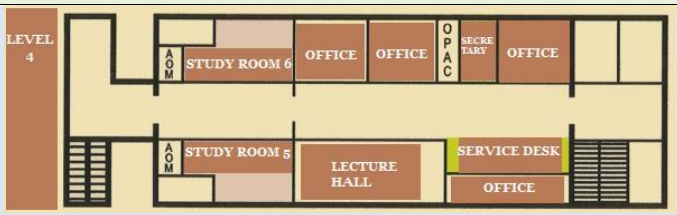
		WC
2nd floor		Chemistry books room
		Physics books room
		Computer Science books room
		Pharmacy books room
		Mathematics books room
		Corridors
		WC
3d floor		Biology study room
		Geology study room
		Computer Science study room
		Mathematics study room
		Corridors
		WC
4th floor		Physics study room
		Pharmacy study room
		Computer room
		Chemistry study room
		Corridors
		WC

Figure 106: List of the rooms divided per floor, with plants

5.2.4.4 HVAC system of the building

The existent centralized HVAC system is modular. It is located on the roof of the building inside a technical central and divided in 7 distribution sub-systems which are able to provide the required ventilation and thermal comfort in different parts of the building. In Table 17, the distribution system, the served rooms and the sizing of each sub-system for winter and summer peak conditions are summarized.

Referring to HVAC system it was not possible to obtain measured data in order to evaluate the electrical energy consumption and the thermal load of the building.

With this data being unavailable sizing of the solar thermal system to cover the heating and cooling energy needs of the building was performed on the estimate of fully covering the summer cooling peak demand of energy including the introduction of a hot thermal storage with an extra daily balancing capacity of 30 %.

Table 17: List of the main features in terms of air flow rate [m^3/h] and thermal power [kW] provided by the 7 distribution sub-system of HVAC system used to size the solar thermal power and absorption chillers system.

HVAC Distrbution Sub-System	Heating		Cooling	
1 Biology books room - Geology books room - Corridors - WC	Air supply (m^3/h)	14326.3	Air supply (m^3/h)	13115.8
	Total heat of equipment (kWth)	46.6	Total heat of equipment (kWth)	61.4
2 Pharmacy books room - Mathematics books room	Air supply (m^3/h)	12101.7	Air supply (m^3/h)	14031.8
	Total heat of equipment (kWth)	42.7	Total heat of equipment (kWth)	70.5
3 Chemistry books room - Computer Science books	Air supply (m^3/h)	10616.2	Air supply (m^3/h)	19648.0
	Total heat of equipment (kWth)	35.3	Total heat of equipment (kWth)	84.2

room - Physics books room				
4 Geology study room - Mathematics study room - Corridors	Air supply (m^3/h)	12298.2	Air supply (m^3/h)	15731.4
	Total heat of equipment (kWth)	64.5	Total heat of equipment (kWth)	114.4
5 Biology study room - Computer Science study room	Air supply (m^3/h)	11977.1	Air supply (m^3/h)	19389.7
	Total heat of equipment (kWth)	58.6	Total heat of equipment (kWth)	121.6
6 Pharmacy study room - Chemistry study room	Air supply (m^3/h)	19745.3	Air supply (m^3/h)	21918.6
	Total heat of equipment (kWth)	84.4	Total heat of equipment (kWth)	133.7
7 Physics study room - Computer room	Air supply (m^3/h)	16820.5	Air supply (m^3/h)	21340.0
	Total heat of equipment (kWth)	73.2	Total heat of equipment (kWth)	127.9
Total Thermal Power at peak condiction	**Heating [kWth]**	**405.3**	**Cooling [kWth]**	**713.7**
Total Ventilation Air Flow rate at peak	Heating [m^3/h]	97885.2	Cooling [m^3/h]	125175.1

5.2.4.5 Proposed Linear Frenel Reflector technology

The proposed solar technology consists in a Linear Fresnel Reflectors composed by 18 mirrors (primary reflective optics) installed by means of glue on a metal frame. At 3.56 m above the mirrors, an absorber tube ASE (Angelantoni Solar Energy) D70 mm in AISI 321, covered by a borosilicate glass (D125mm) and insulated by vacuum, is installed by means of flanges welded on each side of the tube. The length of each LFR module is about of 4 m. The width of each primary mirror is 32 cm, so each module has a primary reflective surface of 21,5 m^2. Globally the LFR module cover an area of 34 m^2.

A secondary optic in metal assembled with Alanod Al silvered film of 0,5mm is used to recover the light beams on the upper surface of the absorber tubes.

We supposed to use as HTF (Heat Transfer Fluid) a diathermic oil, able to operate at more than 250°C, without pressurization and in safety condition. Figure 119 represents a 3D rendering of 8 modules of LFR Solar field installed on the roof of the building.

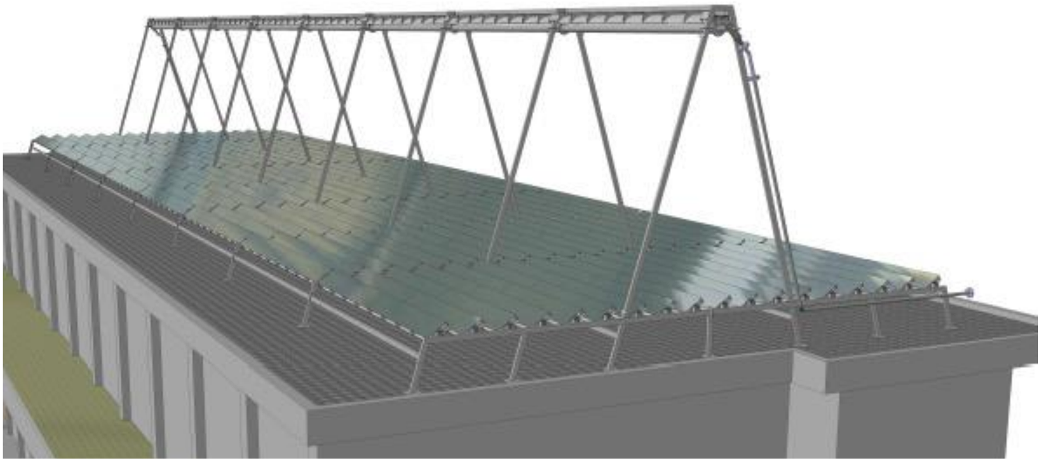


Figure 107: 3D rendering of 8 modules of LFR Solar field installed on a roof of a building

In order to cover the summer peak cooling demand of the building, the LFR solar field is composed by 45 modules, divided in three parallel rows in North South configuration, with about 1,004 m^2 of total collecting surface.

Figure 108: Possible positioning of 45 LFR modules as a shadowing cover of a parking area inside the UoA Campus, on the west side of Library of Science.

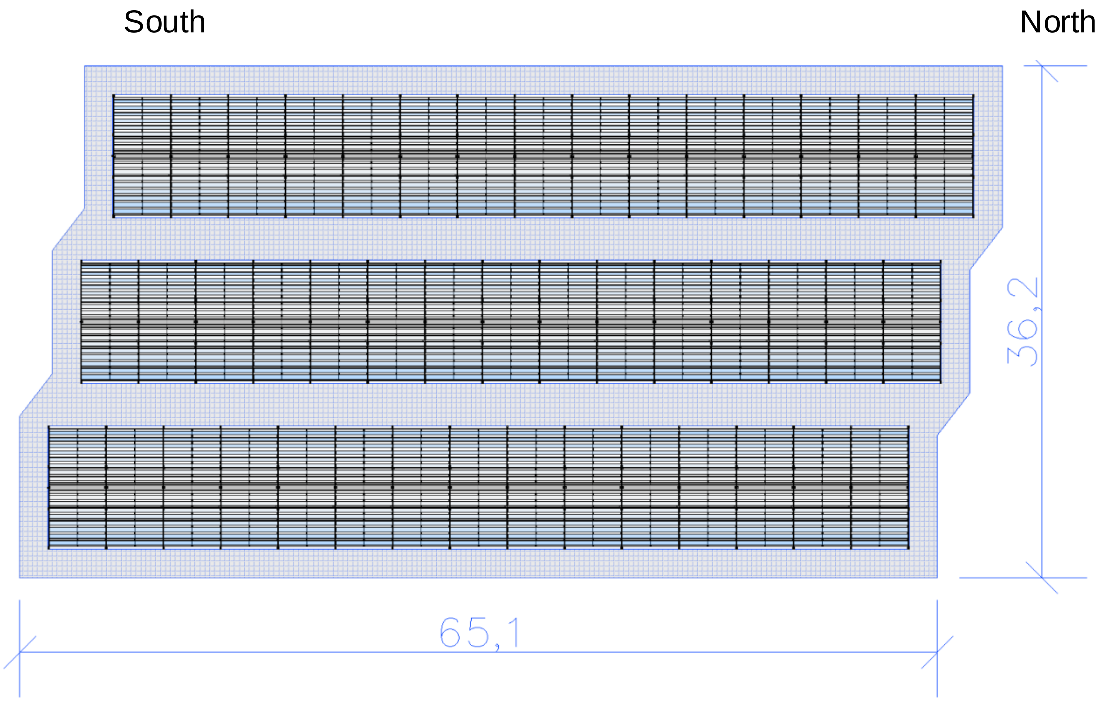


Figure 109: Width and Length of the LFR Solar, built as a covered parking area

Table 18: Main geometrical features of the LFR solar field

Module Type	**LFR1832**
Focal Length [m]	3.5
Module Length [m]	4

Mirror Width [m]	0.31
N. mirrors x module	18
Primary Reflective area [m^2]	22.32
Absorber's Diameter [HCEOI 12] [m]	0.066
Optical efficiency	0.6

Rows in parallel configuration	
Number of modules	15
Total collector area [m^2]	334.8
Total length [m]	60
Number of rows	3
Total mirror surface of solar power plant [m^2]	1004.4

Figure 120 represents the possible positioning of 45 LFR modules as a shadowing cover of a parking area inside the UoA Campus, on the west side of Library of Science and Figure 121 the width and length of the LFR Solar, built as a covered parking area, while in Table 18 the main geometrical features of the LFR solar field are presented.

5.2.5 NUS building

5.2.5.1 Introduction

The work performed during the secondment at the National University of Singapore of Dr. Margarita Assimakopoulos in the framework of the SMARTGEMS project involves the selection of 3 types of rooms (situated in the NUS campus) with different use and different occupancy patterns of a specific campus building which has a BMS installed in order to assess energy performance and thermal behaviour of the buildings and provide guidelines for achieving zero energy balance.

The work was divided into three tasks:

1. To provide the data collected from the selected areas for overall analysis and to introduce suitable analysis methods. This task requires analysing the

data collected from the different rooms and integrate those sections of analysis in identifying the potential savings they might achieve.

2. To integrate the identification of possible Energy Conservation Opportunities where applicable in order to achieve zero energy concept. This task requires to identify any Energy Conservation Opportunities through the data collected from the rooms under investigation.

3. To collect and analyse data from the tools integrated in the demo buildings. Data collected from the tools will be included in the database and the impact on the energy performance and the thermal behaviour of the demo buildings will be reported.

5.2.5.2 Description of the NUS building

The building studied is an institutional building located in Singapore. It contains mainly offices, classrooms and a library space. The offices are open plan, accommodating a large number of staff and researchers each. The library is utilised by students and contains a few permanent staff members. The climate of Singapore is tropical with high temperature and relative humidity throughout the year, so only cooling is required. Windows in air conditioned spaces remain shut at all times during operating hours. The air conditioning system consists of multiple Air Handling Units (AHUs) and Fan Coil Units (FCUs), each serving separate areas. Some of the AHUs and FCUs are of the Single Coil Twin Fan System (SCTF), which decouples the fresh and recirculated air streams until they are mixed immediately prior to reaching the air conditioned zone. The fresh air stream is regulated according to ventilation and indoor air quality requirements, based on readings from CO_2 concentration sensors in the return air grilles, while the recirculated air stream is regulated according to the cooling load, based on readings from temperature sensors. The plant consists of three chillers, of which one is always on standby for extreme load conditions. Each chiller has its own dedicated set of pumps and cooling tower. Architectural plans, material properties, plant specifications and operating conditions were obtained from the building owner in the form of vendor documents, drawings and previous audit findings. Daily energy consumption data for lighting, equipment and HVAC subsystems and hourly CO_2 concentration data was obtained from the building BEMS. The areas selected were an office, a computer room and a lecture theatre due to their different occupancy patterns. Occupancy per office and for the Lecture Theatre by students were provided by the building administration and by observation.

5.2.5.3 Measurement equipment

Measurements were obtained by sensor kits which contained four different types of sensors measuring CO_2 concentration, temperature, relative humidity and illuminance. Table 19 shows the sensors used as well as their technical specifications.

Table 19: Technical specifications of the sensors

Environmental parameter	Sensor type	Range
Temperature (°C)	Sensirion SHT75	-40 to 123.8 °C
RH (%)	Sensirion SHT75	0 to 100 %
CO_2 (ppm)	K-30, CO2 Meter Inc	0 to 5000 ppm
Illuminance (lux)	ROHM, B17xx	0 to 65.000 lux

One sensor is placed in the executive office, two in the computer room and three in the lecture theatre. Greater interest was shown in rooms with frequent fluctuation in occupancy such as the lecture theater and the computer room. Figures 122, 123 and 124 depict the floor plans of the buildings were the rooms under investigation are situated and also show the location of the sensors.
Data is available at 1 minute sampling intervals.

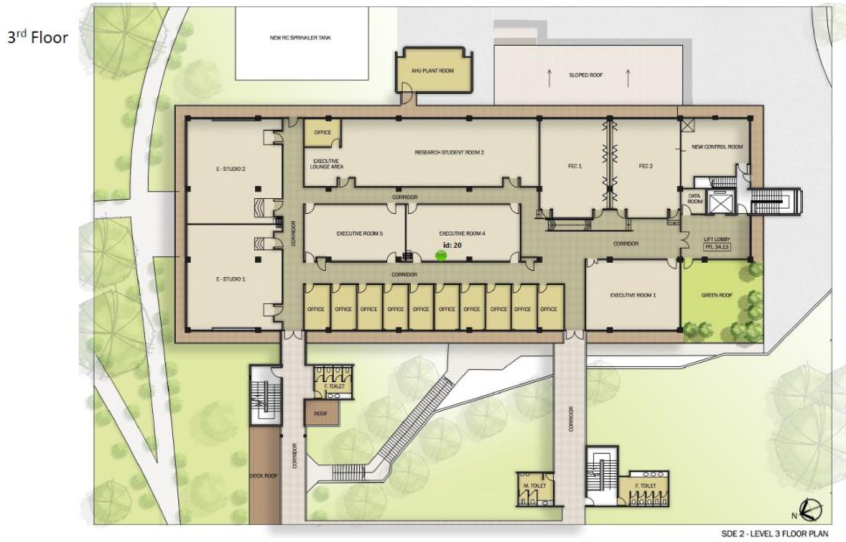


Figure 110: Floor plan of the location of the executive office and the sensor placed

Figure 111: Floor plan of the location of the computer room and the sensor placed

Figure 112: Floor plan of the location of the lecture theatre and the sensor placed

Energy meters have also been installed in the selected rooms and provide data for electrical consumption from lighting, equipment and air-conditioning. In the case of the lecture theatre, the electrical consumption of the FCU is also monitored separately.

7. Conclusions

The recast Directive on the energy performance of buildings (EPBD) stipulates that by 2020 all new buildings constructed within the European Union after 2020 should reach nearly zero energy levels. This means that in less than one decade, all new buildings will demonstrate very high energy performance and their reduced or very low energy needs will be significantly covered by renewable energy sources. In parallel, Member States shall draw up national action plans for increasing the number of nearly zero-energy buildings (NZEB). These national action plans shall include policies and measures to stimulate the transformation of existing buildings which are refurbished into nearly zero-energy buildings. In addition, by 2015 all new buildings and buildings undergoing major renovation should have minimum levels of energy from renewable sources. The implementation of these policy goals requires a major transformation in the building sector during the next few years.

The design of NZEB requires an interdisciplinary approach. Reducing the energy demand in the design phase demands specifications of the different designers and engineers such as architects, building physics or façade designers. For this reason, the introduction of a design team is compulsory for the design of NZEBs.

In order to achieve the high performance goals which constitute not only a requirement but an obligation the building design phase is of particular importance.

To this end the present work focuses on the design phase providing guidelines for integrated design towards smart / zero buildings and smart grids.

IED is a valuable assisting approach to reduce the complexity of the design process, to ensure the implementation of defined, to identify pros and cons of alternative variants of design concepts and to allow decision makers to decide based on transparent facts. Only if IED is applied from the very beginning of the design phase we can assume that a cost-effective solution for NZEB can be identified, because only at the early design phases changes of the general design concept can be implemented at low cost. Therefore, the application of IED is part of the best way towards the intended NZEB at low cost.

- **Implementation of research work:** Research work has been implemented and skills have been developed through secondments from academia to industry and vice versa in the field of integrated design for buildings. For the production of this Deliverable seven researchers were actively involved according to Table 1.
- **Structure of research work:**

In order to provide a holistic approach the following structure was implemented:

- Integrated design concept is analysed providing the principles of ID process and defining decision making protocols. Client's and Tenant's brief is presented including capital cost, delivery risk, operational cost and building unsuitability risk reduction. The scope of services and remuneration models are also investigated. The importance of certification and consultancy aspects is highlighted providing also quality assurance aspects and evaluation of the design quality criteria.
- Within the frame of the secondments hosted in the University of Athens site visit at best practice example NZEB buildings which follow the integrated design concept from the design to the construction and operation, integrating at the same time smart technologies have been carried out. The buildings are documented and their ID characteristics are presented providing also recommendations for smart grid integration.

The activities included sites visits, meeting with the building responsible and assessment of the performance of 4 best practice buildings in Greece:

- A.N. Tombazis and Associates Architects Office Building
- Apivita Commercial & Industrial S.A.
- Stavros Niarchos Foundation Cultural Center
- Karelas Office Park

- 5 Case building were fully assessed during the secondments and the methodology that was developed included the audit and analysis of the building's existing situation, with parameters as Site details and Location, Time, Daylight data and Simulation Weather file data. Except of the above-mentioned, the Layout drawings is described as well as the Activity, Construction, Openings, Lighting, HVAC and Generation data.

The buildings under investigation are

- SUMMA building, Ancona, Italy
- KITE lab, Ancona, Italy
- AEA building, Ancona, Italy
- Library building, University of Athens, Greece
- NUS building, Singapore

To enhance the prospects of building's connection into the smart grid an overall integration design objective is required, thus appropriate simulation models has been developed to estimate and establish the best case scenario concerning the energy consumption.

The correlation of measured and simulated values has also been examined in order to assess the performance and implementation of smart technologies at the buildings.

Fields of innovation related to this work include:

- Analysis of Integrated Design methodology vs conventional procedures
- Application of detailed white box models based on physical knowledge of the system and thermal balance equations vs black box and grey box models that use only measured input/output data and statistical estimation method as well as a priori knowledge on the system. White box models were also used because of the accuracy, the calculation speed and it's usage for optimization and control.
- Evaluation and application of innovative solutions and High Concentrating solar thermal system for combined thermal and electrical production to drive a double effect absorption chiller system producing heating and cooling to satisfy the thermal needs.

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9. Annexes

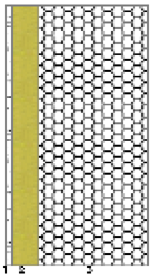
This section includes the hardcopies of the technical characteristics of various elements as provided by the manager of the buildings. More specifically they correspond to the thermophysical characteristics of the building components, such as the external walls and roof, as well as, the specifications of several kind of openings [12-13]. Moreover, the specifications of the electrical equipment used both in warehouse and offices [15-37] are provided, and also the sunpath diagram of the building. All the necessary technical characteristics of the PVs and the Invertors [14], used for the renewable electricity production are provided. Information on Energy data and categorization of internal gains is also provided. Sketchup extractions and CFD temperature contours are depicted.

9.1 Annex 1-Summa Building

Building Components characteristics

Descrizione della struttura: *Parete esterna - isolata* **Codice:** *M1*

Trasmittanza termica	*0,452*	W/m^2K
Spessore	*263*	mm
Temperatura esterna (calcolo potenza invernale)	*-6,0*	°C
Permeanza	*12,403*	$10^{-12}kg/sm^2Pa$
Massa superficiale (con intonaci)	*293*	kg/m^2
Massa superficiale (senza intonaci)	*282*	kg/m^2
Trasmittanza periodica	*0,101*	W/m^2K
Fattore attenuazione	*0,224*	-
Sfasamento onda termica	*-9,5*	h



Stratigrafia:

N.	Descrizione strato	s	Cond.	R	M.V.	C.T.	R.V.
-	Resistenza superficiale interna	-	-	0,130	-	-	-
1	Cartongesso in lastre	12,50	0,250	0,050	900	1,00	10
2	Polistirene espanso, estruso con pelle	50,00	0,035	1,429	35	1,25	300
3	Tamponamento Italprefabbricati	200,00	0,360	0,556	1400	0,88	5
-	Resistenza superficiale esterna	-	-	0,047	-	-	-

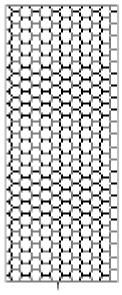
Legenda simboli

s	Spessore	mm
Cond.	Conduttività termica, comprensiva di eventuali coefficienti correttivi	W/mK
R	Resistenza termica	m^2K/W
M.V.	Massa volumica	kg/m^3
C.T.	Capacità termica specifica	kJ/kgK
R.V.	Fattore di resistenza alla diffusione del vapore in capo asciutto	-

-

Descrizione della struttura: *Parete esterna - non isolata* **Codice:** *M2*

Trasmittanza termica	*1,365*	W/m²K
Spessore	*200*	mm
Temperatura esterna (calcolo potenza invernale)	*-6,0*	°C
Permeanza	*200,000*	10^{-12}kg/sm²Pa
Massa superficiale (con intonaci)	*280*	kg/m²
Massa superficiale (senza intonaci)	*280*	kg/m²
Trasmittanza periodica	*0,632*	W/m²K
Fattore attenuazione	*0,463*	-
Sfasamento onda termica	*-7,4*	h



Stratigrafia:

N.	Descrizione strato	s	Cond.	R	M.V.	C.T.	R.V.
-	Resistenza superficiale interna	-	-	*0,130*	-	-	-
1	Tamponamento Italprefabbricati	*200,00*	*0,360*	*0,556*	*1400*	*0,88*	*5*
-	Resistenza superficiale esterna	-	-	*0,047*	-	-	-

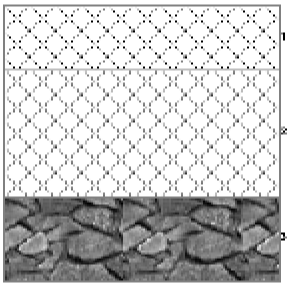
Legenda simboli

s	Spessore	mm
Cond.	Conduttività termica, comprensiva di eventuali coefficienti correttivi	W/mK
R	Resistenza termica	m²K/W
M.V.	Massa volumica	kg/m³
C.T.	Capacità termica specifica	kJ/kgK
R.V.	Fattore di resistenza alla diffusione del vapore in capo asciutto	-

R.V. Fattore di resistenza alla diffusione del vapore in capo asciutto -

Descrizione della struttura: *Pavimento industriale* **Codice:** *P1*

Trasmittanza termica	1,674	W/m²K
Trasmittanza controterra	0,252	W/m²K
Spessore	650	mm
Temperatura esterna (calcolo potenza invernale)	-6,0	°C
Permeanza	3,960	10^{-12}kg/sm²Pa
Massa superficiale (con intonaci)	1390	kg/m²
Massa superficiale (senza intonaci)	1390	kg/m²
Trasmittanza periodica	0,087	W/m²K
Fattore attenuazione	0,344	-
Sfasamento onda termica	-15,7	h



Stratigrafia:

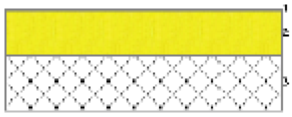
N.	Descrizione strato	s	Cond.	R	M.V.	C.T.	R.V.
-	Resistenza superficiale interna	-	-	0,170	-	-	-
1	Massetto ripartitore in calcestruzzo con rete	150,00	1,490	0,101	2200	0,88	70
2	C.l.s. armato (2% acciaio)	300,00	2,500	0,120	2400	1,00	130
3	Ghiaia grossa senza argilla (um. 5%)	200,00	1,200	0,167	1700	0,84	5
-	Resistenza superficiale esterna	-	-	0,040	-	-	-

Legenda simboli

s	Spessore	mm
Cond.	Conduttività termica, comprensiva di eventuali coefficienti correttivi	W/mK
R	Resistenza termica	m²K/W
M.V.	Massa volumica	kg/m³
C.T.	Capacità termica specifica	kJ/kgK
R.V.	Fattore di resistenza alla diffusione del vapore in capo asciutto	-

Descrizione della struttura: *Copertura a copponi prefabbricati (Ondal)* **Codice:** *S2*

Trasmittanza termica	***0,436***	W/m²K
Spessore	***185***	mm
Temperatura esterna (calcolo potenza invernale)	***-6,0***	°C
Permeanza	***0,004***	10^{-12}kg/sm²Pa
Massa superficiale (con intonaci)	***287***	kg/m²
Massa superficiale (senza intonaci)	***287***	kg/m²
Trasmittanza periodica	***0,201***	W/m²K
Fattore attenuazione	***0,462***	-
Sfasamento onda termica	***-5,5***	h



Stratigrafia:

N.	Descrizione strato	s	Cond.	R	M.V.	C.T.	R.V.
-	Resistenza superficiale esterna	-	-	0,047	-	-	-
1	Acciaio	5,00	52,000	0,000	7800	0,45	9999999
2	Fibra di vetro - Pannello rigido	80,00	0,038	2,105	100	0,84	1
3	C.l.s. armato (2% acciaio)	100,00	2,500	0,040	2400	1,00	130
-	Resistenza superficiale interna	-	-	0,100	-	-	-

Legenda simboli

s	Spessore	mm
Cond.	Conduttività termica, comprensiva di eventuali coefficienti correttivi	W/mK
R	Resistenza termica	m²K/W
M.V.	Massa volumica	kg/m³
C.T.	Capacità termica specifica	kJ/kgK
R.V.	Fattore di resistenza alla diffusione del vapore in capo asciutto	-

6. PRINCIPALI RISULTATI DEI CALCOLI

Edificio:	*Insediamento direzionale produttivo*

a) *Involucro edilizio e ricambi d'aria*

Caratteristiche termiche dei componenti opachi dell'involucro edilizio

Cod.	Descrizione	Trasmittanza U [W/m²K]	Trasmittanza media [W/m²K]
S2	*Copertura a copponi prefabbricati (Ondal)*	*0,436*	*0,436*
M1	*Parete esterna - isolata*	*0,452*	*0,503*
M2	*Parete esterna - non isolata*	*1,365*	*1,395*
P1	*Pavimento industriale*	*0,252*	*0,252*

Caratteristiche termiche dei divisori opachi e delle strutture dei locali non climatizzati

Cod.	Descrizione	Trasmittanza U [W/m²K]	Trasmittanza media [W/m²K]

Caratteristiche di massa superficiale Ms e trasmittanza periodica YIE dei componenti opachi

Cod.	Descrizione	Ms [kg/m²]	YIE [W/m²K]
S2	*Copertura a copponi prefabbricati (Ondal)*	*287*	*0,201*
M1	*Parete esterna - isolata*	*282*	*0,101*
M2	*Parete esterna - non isolata*	*280*	*0,632*

Caratteristiche termiche dei componenti finestrati

Cod.	Descrizione	Trasmittanza infisso U_w [W/m²K]	Trasmittanza vetro U_g [W/m²K]
W1	*Modulo finestra continua*	*2,347*	*2,763*
W2	*Ingresso nord*	*2,401*	*2,763*
W3	*Finestra singola 100x85*	*2,372*	*2,763*
W4	*Uscita di sicurezza 180x250*	*2,383*	*2,763*
W5	*Uscita di sicurezza 115x250*	*2,362*	*2,763*
W6	*Lucernai*	*3,285*	*5,079*
W8	*Portone industriale*	*3,309*	*5,468*

Valutazione dell'efficacia dei sistemi schermanti delle superfici vetrate

Gli infissi sono dotati di opportuni sistemi di schermatura solare.

Attenuazione dei ponti termici (provvedimenti e calcoli)

Non si è intervenuti sulla struttura dell'edificio.

Numero di ricambi d'aria (media nelle 24 ore) – specificare per le diverse zone

N.	Descrizione	Valore di progetto [vol/h]	Valore medio 24 ore [vol/h]
1	*Uffici*	*1,63*	*1,63*
1	*Laboratori*	*0,50*	*0,50*

Portata d'aria di ricambio (solo nei casi di ventilazione meccanica controllata)

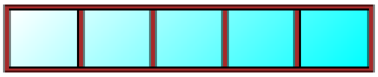
Q.tà	Portata G [m³/h]	Portata G_R [m³/h]	η_T [%]
1	*6340,0*	*6340,0*	*0,5*
1	*1406,0*	*0,0*	*0,0*

Descrizione della finestra: ***Modulo finestra continua*** **Codice:** ***W1***

Caratteristiche del serramento

Tipologia di serramento		*Singolo*	
Classe di permeabilità		*Classe 3 secondo Norma UNI EN 12207*	
Trasmittanza termica	U_w	*2,347*	W/m²K
Trasmittanza solo vetro	U_g	*2,763*	W/m²K

Dati per il calcolo degli apporti solari



Emissività	ε	*0,837*	-
Fattore tendaggi (invernale)	$f_{c\ inv}$	*0,80*	-
Fattore tendaggi (estivo)	$f_{c\ est}$	*0,80*	-
Fattore di trasmittanza solare	$g_{gl,n}$	*0,750*	-

Caratteristiche delle chiusure oscuranti

Resistenza termica chiusure	*0,16*	m²K/W
f shut	*0,6*	-

Dimensioni del serramento

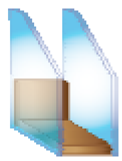
Larghezza	*800,0*	cm
Altezza	*145,0*	cm

Caratteristiche del telaio

Trasmittanza termica del telaio	U_f	*2,50*	W/m²K
K distanziale	K_d	*0,08*	W/mK
Area totale	A_w	*11,600*	m²
Area vetro	A_g	*9,250*	m²
Area telaio	A_f	*2,350*	m²
Fattore di forma	F_f	*0,80*	-
Perimetro vetro	L_g	*27,300*	m
Perimetro telaio	L_f	*18,900*	m

Stratigrafia del pacchetto vetrato

Descrizione strato	s	λ	R
Resistenza superficiale interna	-	-	*0,130*
Primo vetro	*6,0*	*1,00*	*0,006*
Intercapedine	-	-	*0,173*
Secondo vetro	*6,0*	*1,00*	*0,006*
Resistenza superficiale esterna	-	-	*0,047*



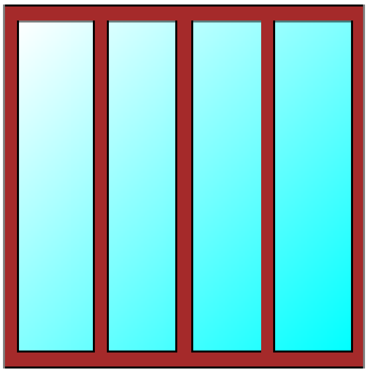
Legenda simboli

s	Spessore	mm
λ	Conduttività termica	W/mK
R	Resistenza termica	m²K/W

Descrizione della finestra: ***Ingresso nord*** **Codice:** ***W2***

Caratteristiche del serramento

Tipologia di serramento		*Singolo*	
Classe di permeabilità		*Classe 3 secondo Norma UNI EN 12207*	
Trasmittanza termica	U_w	*2,401*	W/m²K
Trasmittanza solo vetro	U_g	*2,763*	W/m²K



Dati per il calcolo degli apporti solari

Emissività	ε	*0,837*	-
Fattore tendaggi (invernale)	$f_{c\ inv}$	*0,80*	-
Fattore tendaggi (estivo)	$f_{c\ est}$	*0,80*	-
Fattore di trasmittanza solare	$g_{gl,n}$	*0,750*	-

Caratteristiche delle chiusure oscuranti

Resistenza termica chiusure	*0,16*	m²K/W
f shut	*0,6*	-

Dimensioni del serramento

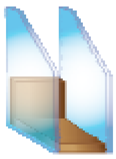
Larghezza	*255,0*	cm
Altezza	*250,0*	cm

Caratteristiche del telaio

Trasmittanza termica del telaio	U_f	*2,50*	W/m²K
K distanziale	K_d	*0,08*	W/mK
Area totale	A_w	*6,375*	m²
Area vetro	A_g	*4,715*	m²
Area telaio	A_f	*1,660*	m²
Fattore di forma	F_f	*0,74*	-
Perimetro vetro	L_g	*22,500*	m
Perimetro telaio	L_f	*10,100*	m

Stratigrafia del pacchetto vetrato

Descrizione strato	s	λ	R
Resistenza superficiale interna	-	-	*0,130*
Primo vetro	*6,0*	*1,00*	*0,006*
Intercapedine	-	-	*0,173*
Secondo vetro	*6,0*	*1,00*	*0,006*
Resistenza superficiale esterna	-	-	*0,047*



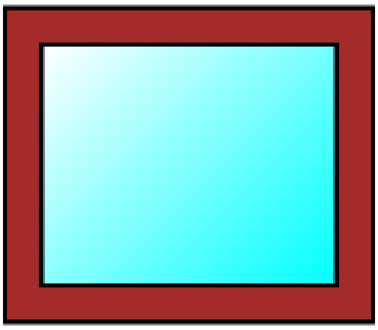
Legenda simboli

s	Spessore	mm
λ	Conduttività termica	W/mK
R	Resistenza termica	m²K/W

Descrizione della finestra: *Finestra singola 100x85* **Codice:** *W3*

Caratteristiche del serramento

Tipologia di serramento		*Singolo*	
Classe di permeabilità		*Classe 3 secondo Norma UNI EN 12207*	
Trasmittanza termica	U_w	*2,372*	W/m^2K
Trasmittanza solo vetro	U_g	*2,763*	W/m^2K



Dati per il calcolo degli apporti solari

Emissività	ε	*0,837*	-
Fattore tendaggi (invernale)	$f_{c\ inv}$	*0,80*	-
Fattore tendaggi (estivo)	$f_{c\ est}$	*0,80*	-
Fattore di trasmittanza solare	$g_{gl,n}$	*0,750*	-

Caratteristiche delle chiusure oscuranti

Resistenza termica chiusure	*0,16*	m^2K/W
f shut	*0,6*	-

Dimensioni del serramento

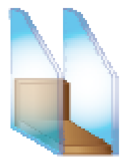
Larghezza	*100,0*	cm
Altezza	*85,0*	cm

Caratteristiche del telaio

Trasmittanza termica del telaio	U_f	*2,50*	W/m^2K
K distanziale	K_d	*0,08*	W/mK
Area totale	A_w	*0,850*	m^2
Area vetro	A_g	*0,520*	m^2
Area telaio	A_f	*0,330*	m^2
Fattore di forma	F_f	*0,61*	-
Perimetro vetro	L_g	*2,900*	m
Perimetro telaio	L_f	*3,700*	m

Stratigrafia del pacchetto vetrato

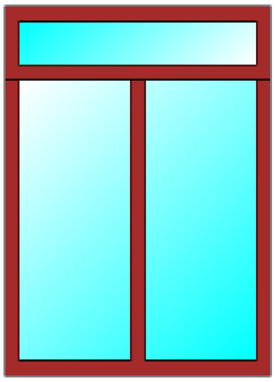
Descrizione strato	s	λ	R
Resistenza superficiale interna	-	-	*0,130*
Primo vetro	*6,0*	*1,00*	*0,006*
Intercapedine	-	-	*0,173*
Secondo vetro	*6,0*	*1,00*	*0,006*
Resistenza superficiale esterna	-	-	*0,047*



Legenda simboli

s	Spessore	mm
λ	Conduttività termica	W/mK
R	Resistenza termica	m^2K/W

Descrizione della finestra: *Uscita di sicurezza 180x250* **Codice:** *W4*



Caratteristiche del serramento

Tipologia di serramento		*Singolo*	
Classe di permeabilità		*Classe 3 secondo Norma UNI EN 12207*	
Trasmittanza termica	U_w	*2,383*	W/m²K
Trasmittanza solo vetro	U_g	*2,763*	W/m²K

Dati per il calcolo degli apporti solari

Emissività	ε	*0,837*	-
Fattore tendaggi (invernale)	$f_{c\ inv}$	*1,00*	-
Fattore tendaggi (estivo)	$f_{c\ est}$	*1,00*	-
Fattore di trasmittanza solare	$g_{gl,n}$	*0,750*	-

Caratteristiche delle chiusure oscuranti

Resistenza termica chiusure	*0,16*	m²K/W
f shut	*0,6*	-

Dimensioni del serramento

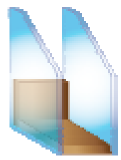
Larghezza	*180,0*	cm
Altezza	*200,0*	cm
Altezza sopraluce	*50,0*	cm

Caratteristiche del telaio

Trasmittanza termica del telaio	U_f	*2,50*	W/m²K
K distanziale	K_d	*0,08*	W/mK
Area totale	A_w	*4,500*	m²
Area vetro	A_g	*3,330*	m²
Area telaio	A_f	*1,170*	m²
Fattore di forma	F_f	*0,74*	-
Perimetro vetro	L_g	*14,400*	m
Perimetro telaio	L_f	*8,600*	m

Stratigrafia del pacchetto vetrato

Descrizione strato	s	λ	R
Resistenza superficiale interna	-	-	*0,130*
Primo vetro	*6,0*	*1,00*	*0,006*
Intercapedine	-	-	*0,173*
Secondo vetro	*6,0*	*1,00*	*0,006*
Resistenza superficiale esterna	-	-	*0,047*



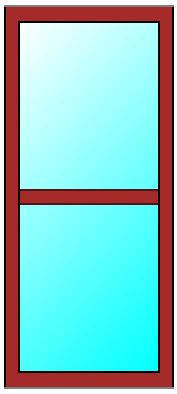
Legenda simboli

s	Spessore	mm
λ	Conduttività termica	W/mK
R	Resistenza termica	m²K/W

Descrizione della finestra: *Uscita di sicurezza 115x250* **Codice:** *W5*

Caratteristiche del serramento

Tipologia di serramento		*Singolo*	
Classe di permeabilità		*Classe 3 secondo Norma UNI EN 12207*	
Trasmittanza termica	U_w	*2,362*	W/m²K
Trasmittanza solo vetro	U_g	*2,763*	W/m²K



Dati per il calcolo degli apporti solari

Emissività	ε	*0,837*	-
Fattore tendaggi (invernale)	$f_{c\ inv}$	*1,00*	-
Fattore tendaggi (estivo)	$f_{c\ est}$	*1,00*	-
Fattore di trasmittanza solare	$g_{gl,n}$	*0,750*	-

Caratteristiche delle chiusure oscuranti

Resistenza termica chiusure	*0,16*	m²K/W
f shut	*0,6*	-

Dimensioni del serramento

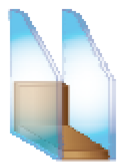
Larghezza	*115,0*	cm
Altezza	*250,0*	cm

Caratteristiche del telaio

Trasmittanza termica del telaio	U_f	*2,50*	W/m²K
K distanziale	K_d	*0,08*	W/mK
Area totale	A_w	*2,875*	m²
Area vetro	A_g	*2,090*	m²
Area telaio	A_f	*0,785*	m²
Fattore di forma	F_f	*0,73*	-
Perimetro vetro	L_g	*8,200*	m
Perimetro telaio	L_f	*7,300*	m

Stratigrafia del pacchetto vetrato

Descrizione strato	s	λ	R
Resistenza superficiale interna	-	-	*0,130*
Primo vetro	*6,0*	*1,00*	*0,006*
Intercapedine	-	-	*0,173*
Secondo vetro	*6,0*	*1,00*	*0,006*
Resistenza superficiale esterna	-	-	*0,047*



Legenda simboli

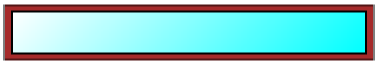
s	Spessore	mm
λ	Conduttività termica	W/mK
R	Resistenza termica	m²K/W

Descrizione della finestra: *Lucernai* **Codice:** *W6*

Caratteristiche del serramento

Tipologia di serramento		*Singolo*	
Classe di permeabilità		*Classe 3 secondo Norma UNI EN 12207*	
Trasmittanza termica	U_w	*3,285*	W/m²K
Trasmittanza solo vetro	U_g	*5,079*	W/m²K

Dati per il calcolo degli apporti solari



Emissività	ε	*0,837*	-
Fattore tendaggi (invernale)	$f_{c\ inv}$	*1,00*	-
Fattore tendaggi (estivo)	$f_{c\ est}$	*1,00*	-
Fattore di trasmittanza solare	$g_{gl,n}$	*0,750*	-

Caratteristiche delle chiusure oscuranti

Resistenza termica chiusure	*0,16*	m²K/W
f shut	*0,6*	-

Dimensioni del serramento

Larghezza	*520,0*	cm
Altezza	*80,0*	cm

Caratteristiche del telaio

Trasmittanza termica del telaio	U_f	*2,50*	W/m²K
K distanziale	K_d	*0,00*	W/mK
Area totale	A_w	*4,160*	m²
Area vetro	A_g	*3,000*	m²
Area telaio	A_f	*1,160*	m²
Fattore di forma	F_f	*0,72*	-
Perimetro vetro	L_g	*11,200*	m
Perimetro telaio	L_f	*12,000*	m

Stratigrafia del pacchetto vetrato

Descrizione strato	s	λ	R
Resistenza superficiale interna	-	-	*0,100*
Primo vetro	*10,0*	*0,20*	*0,050*
Resistenza superficiale esterna	-	-	*0,047*

Legenda simboli

s	Spessore	mm
λ	Conduttività termica	W/mK
R	Resistenza termica	m²K/W

Descrizione della finestra: *Portone industriale* **Codice:** *W8*

Caratteristiche del serramento

Tipologia di serramento		*Singolo*	
Classe di permeabilità		*Senza classificazione*	
Trasmittanza termica	U_w	*3,309*	W/m^2K
Trasmittanza solo vetro	U_g	*5,468*	W/m^2K

Dati per il calcolo degli apporti solari

Emissività	ε	*0,837*	-
Fattore tendaggi (invernale)	$f_{c\ inv}$	*0,00*	-
Fattore tendaggi (estivo)	$f_{c\ est}$	*0,00*	-
Fattore di trasmittanza solare	$g_{gl,n}$	*0,850*	-

Caratteristiche delle chiusure oscuranti

Resistenza termica chiusure		*0,16*	m^2K/W
f shut		*0,6*	-

Dimensioni del serramento

Larghezza	*200,0*	cm
Altezza	*200,0*	cm

Caratteristiche del telaio

Trasmittanza termica del telaio	U_f	*4,40*	W/m^2K
K distanziale	K_d	*0,00*	W/mK
Area totale	A_w	*4,000*	m^2
Area vetro	A_g	*0,000*	m^2
Area telaio	A_f	*4,000*	m^2
Fattore di forma	F_f	*0,00*	-
Perimetro vetro	L_g	*3,600*	m
Perimetro telaio	L_f	*8,000*	m

Stratigrafia del pacchetto vetrato

Descrizione strato	s	λ	R
Resistenza superficiale interna	-	-	*0,130*
Primo vetro	*6,0*	*1,00*	*0,006*
Resistenza superficiale esterna	-	-	*0,047*

Legenda simboli

s	Spessore	mm
λ	Conduttività termica	W/mK
R	Resistenza termica	m^2K/W

Caratteristiche del modulo

Trasmittanza termica del modulo	U	*3,509*	W/m^2K

Ponte termico del serramento

Ponte termico associato	*Z1*	*P.T. serramenti, porte e finestre*	
Trasmittanza termica lineica	Ψ	*0,100*	W/mK
Lunghezza perimetrale		*8,00*	m

Electrical equipment characteristics

Caratteristiche tipiche

Test	Metodo	Unità	D 32	D 68	D 100	D 150	D 220
Grado di viscosità ISO	-	-	32	68	100	150	220
Densità @ 15°C	ISO 12185/ ASTM D4052	kg/m³	870	880	890	890	890
Viscosità @ 40°C	ISO 3104/ ASTM D445	mm²/s (cSt)	34	68	100	150	220
Viscosità @ 100°C	ISO 3104/ ASTM D445	mm²/s (cSt)	5,4	8,7	11,1	14,5	19,2
Indice di viscosità	ISO 2909/ ASTM 2270	-	102	99	98	98	98
Punto di scorrimento	ISO 3016/ ASTM D97	°C/°F	-15/5	-12/10	-12/10	-12/10	-9 /15
Punto di infiammabilità, COC	ISO 2592/ ASTM D92	°C/°F	206/403	232/450	232/450	232/450	249/480
Test antiruggine Procedura A (acqua distillata) Procedura B (nebbia salina)	ISO 7210/ ASTM D665B	-	Passato	Passato	Passato	Passato	Passato
Corrosione del rame (3 ore @ 100°C)	ISO 2160/ ASTM D130	-	1b	1b	1b	1b	1b
Valore di Brugger	DIN 51347	N/mm²	-	44	-	-	-
Prova di usura delle 4 sfere (1 ora, 40 kg, 1800 rpm, 75°C/167°F) - Diametro impronta	ASTM D2266	mm	0,3	0,3	0,3	0,3	0,32
Prova EP delle 4 sfere - Carico di saldatura	ASTM D2783	kg	170	180	180	190	200
Stick slip ratio	(Cincinnati Lamb)	-	0,74	0,74	0,74	0,74	0,74
Specifiche Cincinnati Lamb	-	-	P-53	P-47	-	-	P-50

Informazioni aggiuntive

Magnaglide D risponde ai requisiti di:

- Cincinati Lamb (Milacron) P - 47, P - 50 e P - 53 (a seconda del grado di viscosità),
- DIN 51502 - CGLP,
- DIN 51524 Parte II (Luglio 2004) - che include il test di filtrazione ISO 13357 - 1/- 2,
- Adatto come olio idraulico per le attrezzature Muller Weingarten.

Stoccaggio

Per evitare il deterioramento del prodotto si consiglia di mantenere gli imballaggi sigillati. Evitare qualsiasi infiltrazione di acqua e preservare dal gelo. Mantenere in un luogo fresco ed asciutto, al riparo dal sole diretto, preferibilmente in ambienti chiusi. Per ulteriori dettagli è consigliabile fare riferimento alla scheda di sicurezza del prodotto.

Castrol Industrial, Divisione di BP Italia spa, via A. Checov, 50/2 – 20151 Milano
Tel: 02 33446.1 – Fax: 02 33446300
www.castrol.com/industrial

9 AKZ SERIES

Specifications

AKZ149
AKZ329
AKZ439

AKZ 9 SERIES

Specifications and range of use

Oil Cooling Unit horsepower (HP)	0.5						1.2						1.5					
Model name	AKZ149						AKZ329						AKZ439					
	Standard	−B	−C	−H	−T *9	Different voltage specifications *3	Standard	−B	−C	−H	−T *9	Different voltage specifications *3	Standard	−B	−C	−H	−T *9	Different voltage specifications *3
Cooling capacity (50/60Hz)*1 kW	1.3/1.4						2.8/3.2						3.8/4.3					
Heater kW	–			1	–		–			1	–		–			1	–	
Supply power*2	3-Phase AC 200/200-220V 50/60Hz					*3	3-Phase AC 200/200-220V 50/60Hz					*3	3-Phase AC 200/200-220V 50/60Hz					*3
Circuit voltage – Main circuit*3	3-Phase AC 200/200-220V 50/60Hz																	
Circuit voltage – Operating circuit	DC12/24V																	
Max. power consumption / Max. consumption current – 200V 50Hz	0.90kW/3.9A			1.29kW/4.1A	0.90kW/3.9A	*10	1.36kW/4.9A			1.49kW/4.8A	1.36kW/4.9A	*10	1.80kW/6.6A					*10
Max. power consumption / Max. consumption current – 200V 60Hz	0.91kW/3.6A			1.32kW/4.2A	0.91kW/3.6A		1.43kW/4.8A			1.61kW/5.2A	1.43kW/4.8A		1.88kW/6.4A					
Max. power consumption / Max. consumption current – 220V 60Hz	0.91kW/3.5A			1.43kW/4.2A	0.91kW/3.5A		1.43kW/4.6A			1.72kW/5.0A	1.43kW/4.6A		1.88kW/6.1A					
Transformer capacity	–					2.6kVA	–					2.6kVA	–					2.6kVA
Exterior color	Ivory white																	
Outside dimensions (H×W×D) mm	650×360×440			950×360×440	810×360×535	950×360×440	775×360×440			1075×360×440	965×360×535	1075×360×440	875×360×440			1175×360×440	1065×360×535	1175×360×440
Compressor (Totally enclosed DC swing type)	Equivalent to 0.4kW						Equivalent to 0.75kW						Equivalent to 1.1kW					
Evaporator	Shell-end coil type																	
Condenser	Cross-fin coil type																	
Propeller fan – Motor	φ250, 54W						φ300, 54W											
Oil pump – Motor	0.4kW×4P																	
Oil pump – Theoretical discharge rate L/min	12/14.4						24/28.8											
Oil pump – Open pressure MPa	0.5						0.6											
Temperature adjust (Selectable) – Synchronization type – Standard	Room temperature or machine temperature *4 (Set to "Room temperature: Mode 3" by default)																	
Temperature adjust (Selectable) – Synchronization type – Object to be controlled	Inlet oil temperature or outlet oil temperature (Set to "Inlet oil temperature" by default)																	
Temperature adjust (Selectable) – Synchronization type – Synchronization range K	−9.9~+9.9 against the standard temperature (Set at 0.0 by default)																	
Temperature adjust (Selectable) – Fixed type – Object to be controlled	Inlet oil temperature or outlet oil temperature																	
Temperature adjust (Selectable) – Fixed type – Range ℃	5~50																	
Refrigerant control	Compressor revolutions by inverter + Opening of electric expansion valve																	
Refrigerant (New refrigerant R410A)*5 Filling amount kg	0.49						0.72						0.98					
Protection equipment	A set of overcurrent relay (motor for pump), reverse-phase protection equipment, restart prevention timer, low room-temperature protection thermostat, high room-temperature protection thermostat, low oil-temperature protection thermostat, relief valve for pump, discharge tube temperature thermostat, condenser temperature thermostat, refrigerant leak detector, and inverter protection equipment. High-pressure switch (−C type only), compressor protection thermostat (−C type only), overheat prevention temperature thermostat (−H type only), boil-dry protection switch (−H type only), no-fuse breaker (−B type only)																	
Operating range – Room temperature ℃	5~45																	
Operating range – Inlet oil temperature ℃	5~50																	
Operating range – Oil viscosity mm^2/s	1.4~200 (ISO VG2~32)																	
Operating range – Product external pressure loss – Discharge side	0.5MPa or less																	
Operating range – Product external pressure loss – Suction side	−30.7kPa or less																	
Usable oil	Lubricant, hydraulic oil of mineral oil (Not usable for hydraulic oil of ester phosphate, water, water-soluble liquid, drugs, food products, fuel, cutting liquid, grinding liquid, etc.)																	
Connecting tube – Oil inlet	Rc3/4																	
Connecting tube – Oil outlet	Rc3/4			Rc1 1/4	Rc3/4					Rc1 1/4	Rc3/4					Rc1 1/4	Rc3/4	
Connecting tube – Oil drain	Rc1/4 (Plugged)																	
Noise value (Value measured at 1m height in front, value equivalent as measured in anechoic chamber) dB(A)	62												65					
Transport vibration performance*7	Up down $14.7m/S^2$ ×2.5 hr (7.5~100Hz sweep / 5 min.)																	
Ingress protection*8	IP2X																	
Mass kg	51			78	68	87	56			83	73	92	64			91	81	100
Molded-case circuit breaker (Rated current) A	–	10	–				–	10	–				–	10	–			
Oil tank (Capacity) L	–				15	–	–				20	–	–				20	–
Items to be prepared by customer*8 – Molded-case circuit breaker (Rated current) A	10 (Required for types other than −B type)																	

DART VMC 1000
Centro di lavoro verticale Verticale

VENDUTA!

DART VMC 1000 Centro di lavoro verticale

MODELLO: VMC 1000	TAVOLA	CAPACITÀ	MANDRINO	MAGAZZINO UTENSILI
C.N.C: FANUC 18M	**Dimensioni tavola** 1100x470 mm	**Corsa asse x longitudinale** 1016 mm	**Attacco mandrino** BT40 ISO	**Stazioni portautensili** 24 nr.
ANNO: 1996		**Corsa asse y trasversale** 500 mm	**Velocità di rotazione** 8000 giri/min.	
Note: Cambio utensile ad ombrello, luce di lavoro esterna ed interna.		**Corsa asse z verticale** 570 mm	**Potenza motore** 7.5 Kw	

Crespi Gianluigi
Macchine Utensili
via del Ponte, 25
21052 Busto Arsizio (Va)
tel - fax 0331 634358
cell. 348 7158993
www.crespigianluigi.it
info@crespigianluigi.it

Cat.

CENTRO DI LAVORAZIONE VERTICALE
VERTIVAL MACHINING CENTER

REMA CONTROL

Mod.: **LEONARD RCL 2.4**

Matr.: 3704001 *Anno/ Year:* 2004

Cnc: FANUC 21iM

Note: Trasp. trucioli, refr. attraverso il mandrino 20 bar, tavola girevole SCOTTI continua DIAM. 350mm completa di controsupporto.
Chip conveyor, coolant through the spindle 20 bar, Scotti continuous rotary table complete counterbearing Ø 320mm

€

Caratteristiche tecniche	*Technical Data*		
Tavola	**Table**		
Dimensioni tavola	Table dimensions	mm	2600 X 800
Numero pallet	Number table	n°	2 800 X 800
Capacità di lavoro	**Working Area**		
Corsa asse X longitudinale	Longitudinal X-travel	mm	2400
Corsa asse Y trasversale	Cross Y-travel	mm	800
Corsa asse Z verticale	Vertical Z-travel	mm	650
Rapidi X-Y-Z	Axis rapid X-Y-Z	m/min	40
Mandrino	**Spindle**		
Attacco mandrino	Spindle taper	ISO	40
Velocità di rotazione	Spindle speed	giri/min	8000
Potenza motore	Engine power	Kw	18,5/22
Magazzino utensili	**Tools magazine**		
Stazioni portautensili	Tool holder	n°	30

INTEGREX 200-IV

PRODUCT: INTEGREX

Machine Specifications

Specification		Bed Length -
Capacity	Maximum Machining Diameter	660 mm / 26.000 in
	Maximum Machining Length	995 mm / 39.170 in
Main Spindle	Chuck Size	8 in
	Maximum Speed	5000 rpm
	Motor Output (30 minute rating)	22 kw / 30.0 hp
Milling Spindle	B-Axis Travel	225°
	Magazine Capacity	20
	Maximum Speed	20000 rpm
	Motor Output (20 ED Rating)	6 kw / 8 hp
Feed Axes	Travel (X Axis)	580 mm / 22.83 in
	Travel (Y Axis)	160 mm / 6.30 in
	Travel (Z Axis)	1046 mm / 41.14 in

VTC-300C

PROCESS: VERTICAL

MACHINE DESCRIPTION:

The VERTICAL TRAVELING COLUMN (VTC) 300C Vertical Machining Center features a powerful 40 Taper spindle, full traveling column design and fixed table for machining of extremely long and heavy workpieces. Or with a table center partition the machine work envelop can be transformed into two separate work areas that allow the machine to be in cycle in one work area, while a part is being set up in the other work area. The machine also delivers fast rapid traverse rates to reduce non-cut times.

MACHINE CHARACTERISTICS:

- Long fixed table design
- Optional table partition available
- Standard 12,000-rpm CAT 40-taper spindle
- 1,181 ipm rapid traverse rate
- 24-tool (48 optional) storage capacity
- Automatic tool changer
- Maximum table load of 3,300 lbs.

MACHINE SPECIFICATIONS

Specification		Values
Capacity	Table Right/Left	78.740 in / 2000 mm
	Table Longitudinal	30.000 in / 760 mm
Spindle	Spindle Taper	40
	Maximum Speed	12000 rpm
	Motor Output (30 minute rating)	15.0 hp / 11 kw
Magazine	Number of Tools	24
Feed Axes	Travel (X Axis)	65.35 in / 1660 mm
	Travel (Y Axis)	30.00 in / 760 mm
	Travel (Z Axis)	26.00 in / 660 mm

SP12

HOME > PRODOTTI > MACCHINE DI SERIE > SP12

Scheda Prodotto

Caratteristiche

Compatta

- Filtro a cartuccia autopulente integrato 10m2 (certificazione BIA)
- Sistema di separazione e recupero graniglia ad alta efficienza
- Dispositivo di sparo in pressione 7 lt
- Dispositivo di regolazione flusso graniglia
- Dimensioni camera di lavoro LxPxH mm: 1200 x 1000 x 850
- Dimensioni esterne LxPxH mm: 1590 x 1025 x 1700

Accessori opzionali

- Tavola girevole fissa manuale
- Componentistica e/o Carpenteria in Acciaio INOX
- Tavola girevole fissa automatica
- Tavola girevole mobile manuale
- Supporto esterno per Tavola estraibile
- Gruppo buratto
- Separatore Magnetico
- Rivestimento interno antiusura

La SP12 è una macchina manuale dalle dimensioni contenute, dotata del sistema di sparo in pressione che permette potenze di lavoro e velocità di produzione fino a 3 volte superiori al sistema classico in depressione. La SP12 è perfettamente integrata con il sistema di recupero e di filtrazione delle polveri esauste. Il layout contenuto e pulito la rende collocabile anche negli spazi più ridotti.

Pallinatrice sabbiatrice manuale: NORBLAST Modello: SD12

Costruzione:	NORBLAST
Modello:	SD12
Matricola:	3995
Anno di costruzione:	2005
Completa di filtro e cartuccia con sistema automatico di pulizia:	12 mm
Dimensioni utili di lavoro:	1150 x 950 x h 830 mm
Pressione di lavoro:	1 ÷ 8 bar
Carico massimo applicabile:	150 kg
Motore aspirazione:	0,14 KW
Aspirazione:	160 m³/h
Prevalenza:	330 Pa
Cartuccia filtrante:	10 m²
Materiale cartuccia filtrante poliestere	
Peso:	200 kg
Dimensioni d'ingombro:	1590 x 1095 x h 1700 mm

DYSON AIRBLADE DB AB14 HAND DRYER

50% quieter
Acoustically re-engineered to reduce noise.
Hygienic. Fast. Costs less to run.
5 years guarantee.

Available in 2 colors:
- **Grey**
- **White**

REFERENCE: AB14-W

Send to a friend

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Activation	automatic
Material(s)	White ABS polycarbonate
Electrical Specifications	220V - 240V / 50Hz&60Hz / 1600W
Motor type	Dyson digital motor V4 – brushless DC Motor
RPMs	90,000
Motor watts	1600W
Warranty	5 years parts, 1 year labour guarantee
Air velocity	430 mph
Filtration	Bacteria removal 99.9%
Dimensions	H 661 x W 303 x D 247 mm

Xerox WorkCentre 7245 - multifunction printer (color)

Part Number: 7245V_FX

2 Related Models -

GENERAL /

Copier Type	digital
Printing Technology	Laser - color
Monthly Duty Cycle (max)	135000 impressions
Electronic Auditron	1000 accounts
Manufacturer	Xerox

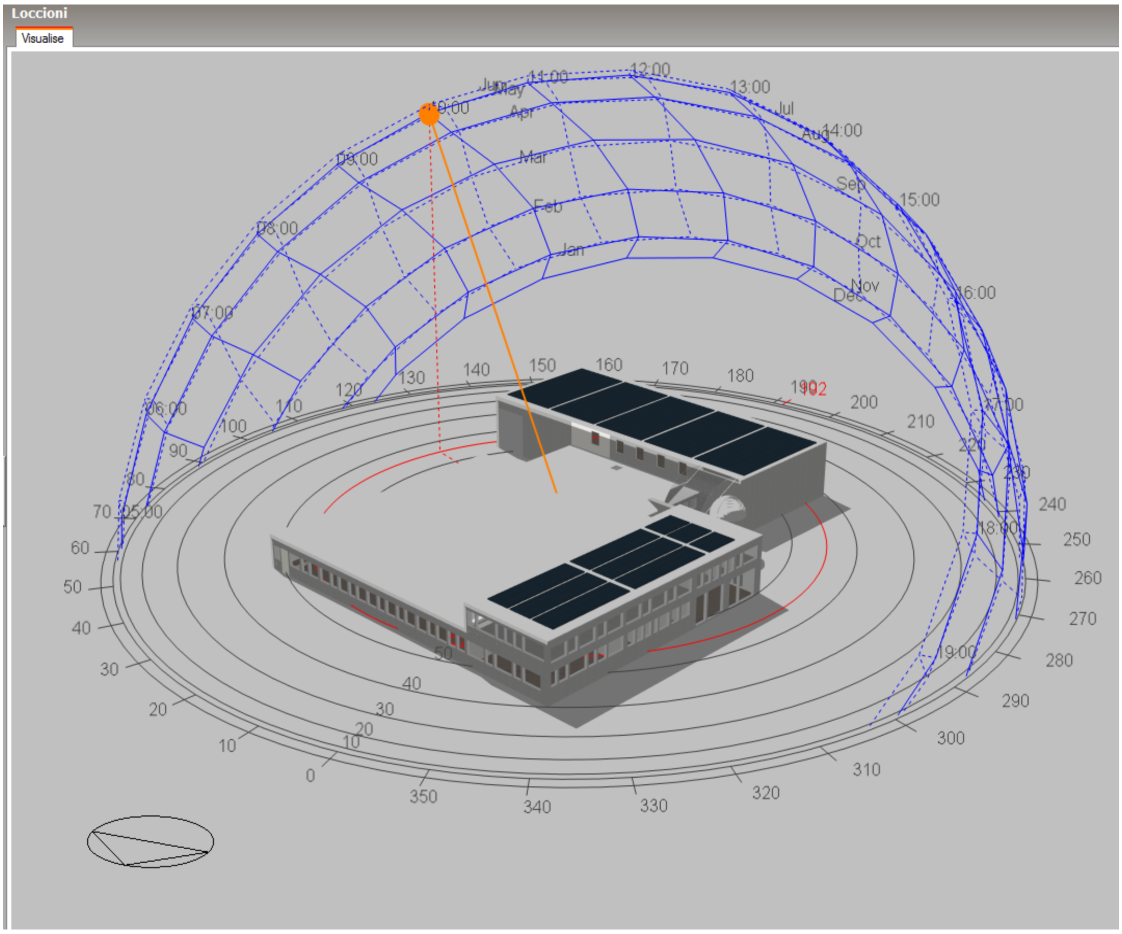
MEMORY /

Standard Memory	768 MB
Hard Disk Drive	40 GB

POWER /

Power Consumption Sleep	80 Watt
Power Consumption Standby	277 Watt
Power Consumption Operational	1012 Watt

Building's sunpath diagram



PV systems and Inverter characteristics

3.5 Parametri modulo fotovoltaico SL-001-182 ; 182 Wp

(installato su tetto stabilimento AEA, SUMMA-AD)

DATI GENERALI	
Codice	SL-001-182
Marca	SOLYNDRA
Modello	182 Wp
Tipo materiale	Cella Cilindrica in CIGS
CARATTERISTICHE ELETTRICHE IN CONDIZIONI STC	
Potenza di picco [W]	182
Imp [A]	2.46
Isc [A]	2.76
Efficienza [%]	9.26
Vmp [V]	73.9
Voc [V]	96.7
ALTRE CARATTERISTICHE ELETTRICHE	
Coeff. Termico Voc [%/°C]	-0.24
Coeff. Termico Isc [%/°C]	-0.02
Coefficiente di temperatura α (P_{mpp})	-0,26%/°C
NOCT [°C]	41.7
Vmax [V]	1000.00
CARATTERISTICHE MECCANICHE	
Lunghezza [mm]	1820
Larghezza [mm]	1080

3.6 Parametri modulo fotovoltaico HS-115 - 115 Wp

(installato su tetto stabilimento SUMMA-ex TM)

DATI GENERALI	
Codice	HS 115 - 115 Wp
Marca	HELIOSPHERA
Modello	115 Wp
Tipo materiale	Film Sottile
CARATTERISTICHE ELETTRICHE IN CONDIZIONI STC	
Potenza di picco [W]	115
Imp [A]	1.12
Isc [A]	1.42
Efficienza [%]	8.04
Vmp [V]	102.7
Voc [V]	130
ALTRE CARATTERISTICHE ELETTRICHE	
Coeff. Termico Voc [%/°C]	-0.37
Coeff. Termico Isc [%/°C]	0.05
Coefficiente di temperatura α (P_{mpp})	-0,32%/°C
NOCT [°C]	--
Vmax [V]	1000.00
CARATTERISTICHE MECCANICHE	
Lunghezza [mm]	1300
Larghezza [mm]	1100
Spessore [mm]	6.4
Peso [kg]	25
Numero celle	--
CERTIFICAZIONI	
Certificazione IEC EN	61646 Ed 2 0
Certificazione Classe II	NO
Altre certificazioni	IEC 61730
GARANZIE	
Garanzia prodotto	5 anni
Garanzia prestazioni	20 anni

3.7 Parametri Inverter REFUSOL 016K

(installato per tetto stabilimento AEA, SUMMA-AD)

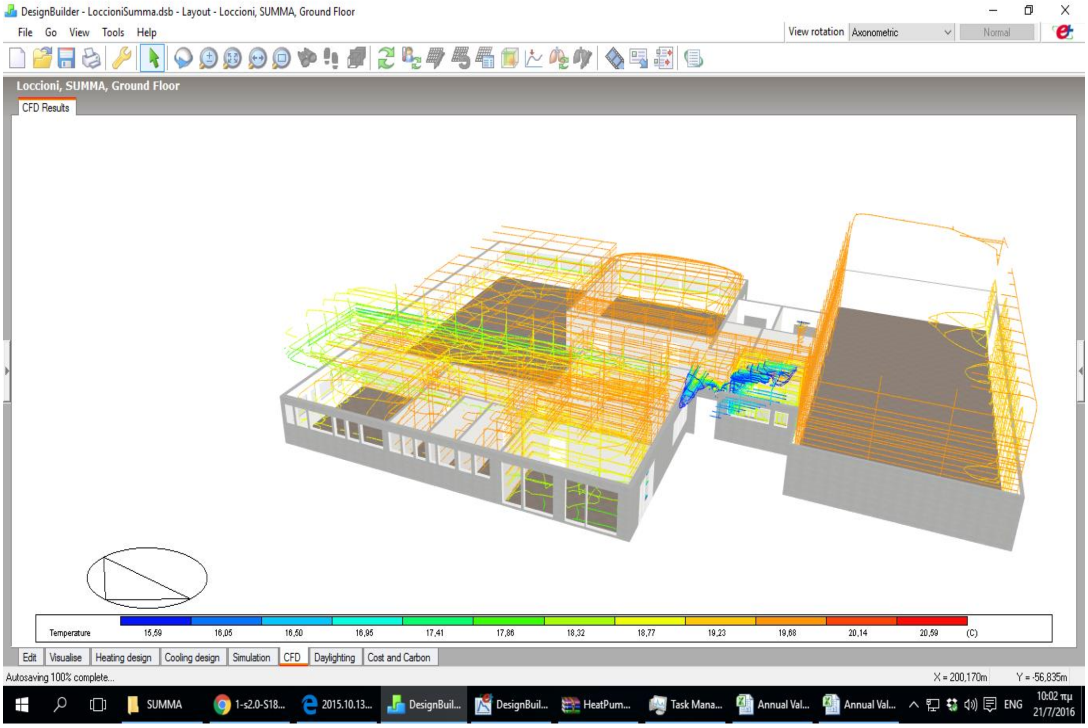
DATI GENERALI	
Marca	REFUSOL
Modello	016 K
Tipo fase	Trifase
PARAMETRI ELETTRICI IN INGRESSO	
VMppt min [V]	525
VMppt max [V]	800
Imax [A]	32
Vmax [V]	1000
Max potenza FV [W]	18.1 kWp
PARAMETRI ELETTRICI IN USCITA	
Potenza nominale [W]	16.5 kW
Tensione nominale [V]	400 Vac
Efficienza massima [%]	$\eta = 98$
Efficienza europea [%]	$\eta_{EU} = 97.7$
Frequenza [Hz]	50/60
Distorsione arm. [%]	< 2.5
CARATTERISTICHE MECCANICHE	
Dimensioni L x H x P [mm]	535 x 601 x 277
Peso [kg]	39
Grado di protezione	IP65
CERTIFICAZIONI	
Certificazione per collegamente alla rete elettrica	
Altre certificazioni	IEC 61643-21
GARANZIE	
Garanzia prodotto	5 anni (data fabbricazione)
Estensione garanzia (+ manutenzione)	Fino a 210 anni
NOTE	
Note	Inverter SENZA trasformatore;

3.8 Parametri Inverter 25 BT (SIAC)

(installato per tetto stabilimento SUMMA-ex TM)

DATI GENERALI	
Marca	SIAC
Modello	25 BT
Tipo fase	Trifase
PARAMETRI ELETTRICI IN INGRESSO	
VMppt min [V]	330
VMppt max [V]	700
Imax [A]	85
Vmax [V]	780
Max potenza FV [W]	27 kWp
PARAMETRI ELETTRICI IN USCITA	
Potenza nominale [W]	22.5 kW
Tensione nominale [V]	400 Vac
Efficienza massima [%]	$\eta = 94.4$
Efficienza europea [%]	$\eta_{EU} = 93$
Frequenza [Hz]	50
Distorsione arm. [%]	< 3
CARATTERISTICHE MECCANICHE	
Dimensioni L x H x P [mm]	550 x 850 x 1055
Peso [kg]	330
Grado di protezione	IP21
CERTIFICAZIONI	
Certificazione per collegamente alla rete elettrica	Conforme alla "Guida per le connessioni alla rete elettrica di Enel Distribuzione" Ed. 1.1 – Dicembre 2009 Appartiene all'elenco dei dispositivi collegabili alla rete BT di Enel Distribuzione
Altre certificazioni	DK 5940, CEI 11-20
GARANZIE	
Garanzia prodotto	2 anni (data fabbricazione)
Estensione garanzia (+ manutenzione)	Fino a 5 o 10 anni

CFD internal Temperature Contour



9.2 Annex 2-KITE lab

My Leaf energy Data

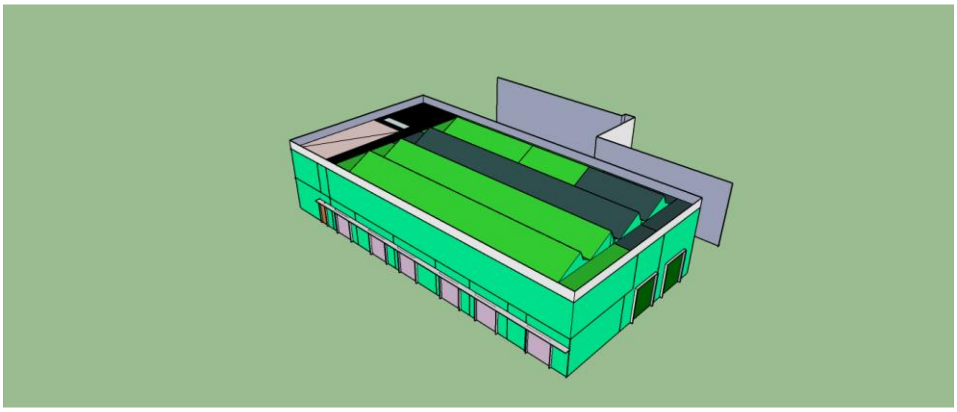
		Contatore	Kite Lab	Sala 1	Sala 2	Sala 3	Sala 4	Sala 5	Lab 1	Lab 2	Condizionamento	Fotovoltaico
	Date	Value	Value	Value	Value	Value	Value	Value	Value	Value	Value	Value
	01/09/2015 00:00:00	197,2	0	0	0	0	0	0	0	0	0	8,216666667
Sep 15	01/10/2015 00:00:00	4140,07	0	0	0	0	0	0	0	0	0	5,750097222
Oct 15	01/11/2015 00:00:00	2599,45	0	0	0	0	0	0	0	0	0	3,493884409
Nov 15	01/12/2015 00:00:00	2565,59	0	0	0	0	0	0	0	0	0	3,563319444
Dec 15	01/01/2016 00:00:00	2485,42	0	0	0	0	0	0	0	0	0	3,34061828
Jan 16	01/02/2016 00:00:00	2107,54	0	0	0	0	0	0	0	0	0	2,832715054
Feb 16	01/03/2016 00:00:00	2132,71	0	0	0	0	0	0	0	0	0	3,064238506
Mar 16	01/04/2016 00:00:00	3410,45	0	0	0	0	0	0	0	0	0	4,583938172
April 16	01/05/2016 00:00:00	4609,26	8,546794	0,000549346	0,001178	0,001281	0,000724	0,000896	0,092227	0,00239225	15,80142647	6,40175
May 16	01/06/2016 00:00:00	5447,15	7,064586	0,000521414	0,001081	0,001578	0,00244	0,000849	0,291874	0,001615791	15,60453401	7,321438172
Jun 16	01/07/2016 00:00:00	5254,13	8,87865	0,000554081	0,001101	0,001435	0,001118	0,001109	0,178107	0,001323327	17,95564998	7,297402778
Jul 16	01/08/2016 00:00:00	6052,23	20,68834	0,000813378	0,00151	0,001894	0,00106	0,001417	0,626073	0,000350252	30,23516057	8,134717742
Aug 16	31/08/2016 00:00:00	5729,32	20,16621	0,000688767	0,00138	0,001816	0,000986	0,001205	0,245619	0	32,55349631	7,957388889
	Sum	46533,32	65,34457	0,003126986	0,006251	0,008005	0,006328	0,005475	1,4339	0,005681621	112,1502673	63,74150867
			6153,692	0,395529412	0,848235	0,922622	0,521345	0,644941	66,4038	1,722420168	11377,02706	4609,26
			5256,052	0,387932121	0,804447	1,173766	1,81536	0,631523	217,1546	1,202148687	11609,7733	5447,15
			6392,628	0,398938004	0,79253	1,033547	0,80529	0,79828	128,2369	0,952795797	12928,06799	5254,13
			15392,12	0,605153345	1,123553	1,409249	0,788365	1,054329	465,7981	0,260587563	22494,95947	6052,23
			15003,66	0,512442536	1,026928	1,351049	0,733451	0,896366	182,7403	0	24219,80125	5920,297333
		kwh	48198,15	2,299995417	4,595692	5,890233	4,663811	4,025439	1060,334	4,137952215	82629,62906	27283,06733
Total	131913,7267	kwh										

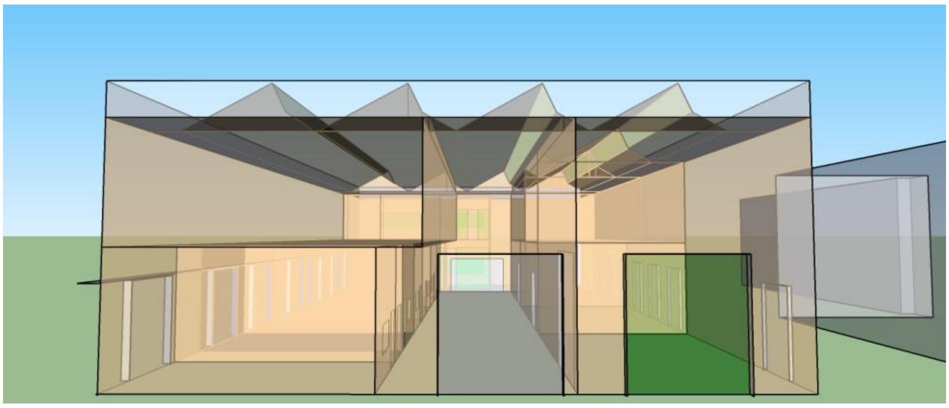
Categorization of internal gains

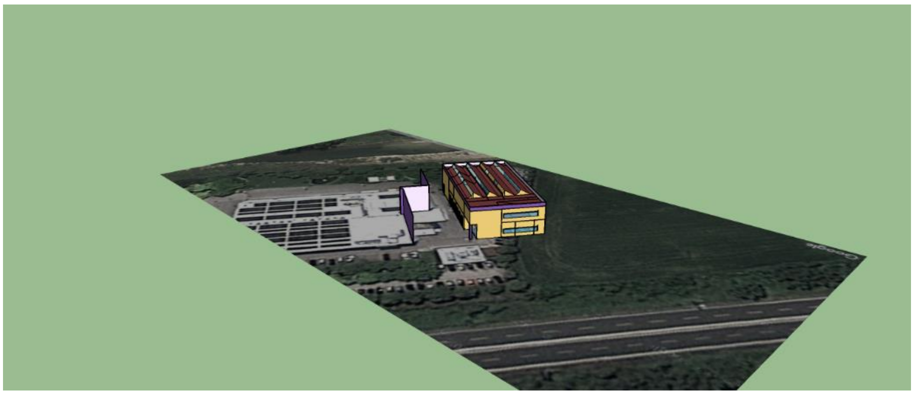
Space	E (m2)	People	Lights (W)	Equipment (W)	Human Activity	Lights	Size
Entrance	82,3	5	656		B	M	L
1st Office	25,6	6	164		B	S	S
2nd Office	35	7	164		B	S	S
Toilet	26,9	2	200		LL	S	S
Lab 1	94,7	10	648	50	B	M	L
Lab 2	94,7	10	648	50	B	M	L
Sala 1	46,3	2	481	152	LL	M	S
Sala 2	65	3	648	73	LL	M	S
Sala 3	63,3	3	648	35	LL	M	S
Sala 4	46,4	2	481	125	LL	M	S
Sala 5	47,3	2	348	125	LL	M	S
Sala 6	46,3	0	348	150	N	M	S
Empty	21,2	0	162		N	S	S
3rd Office	81,2	8	574		B	M	S

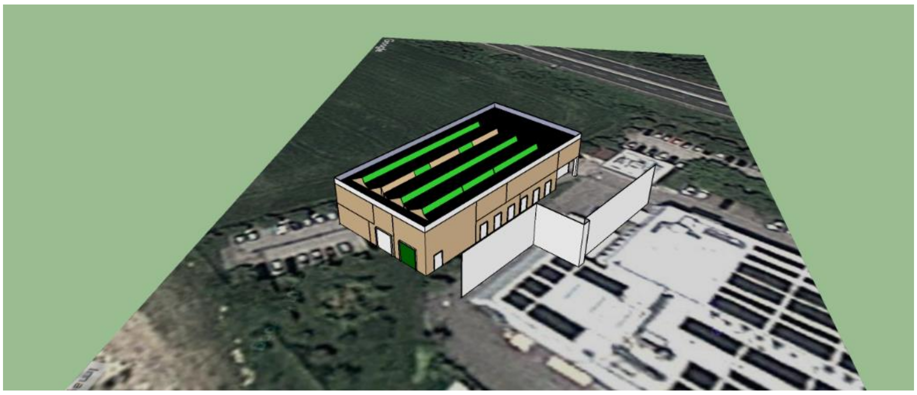
Magazzino	97	4	560	15	LL	M	L
Corridor	245,5	4	1506		LB	L	L
Technico 1	392,8	1	1944		LB	L	L
Technico 2	127,82	0	405		N	M	L
Technico 3	66	0	405		N	M	L

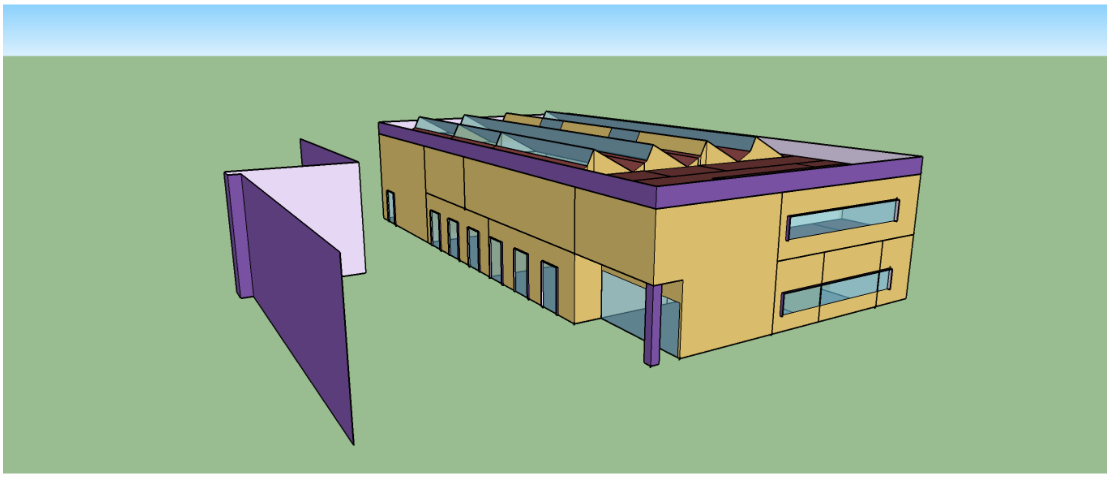
Sketchup extractions

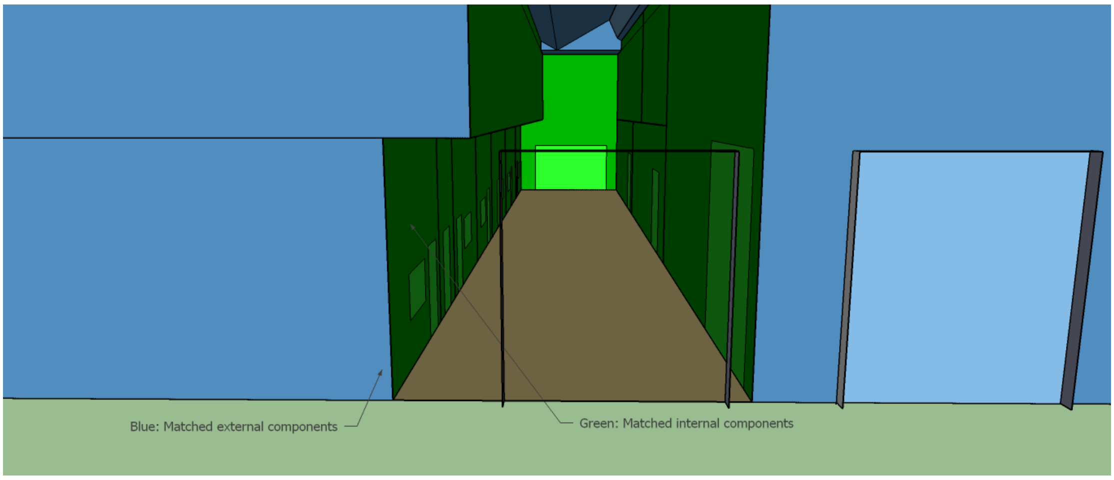


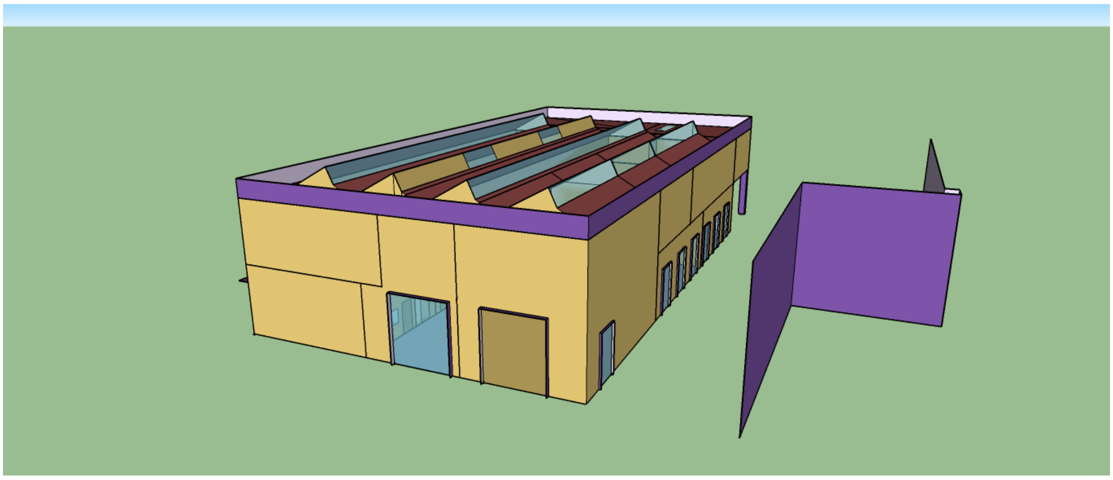


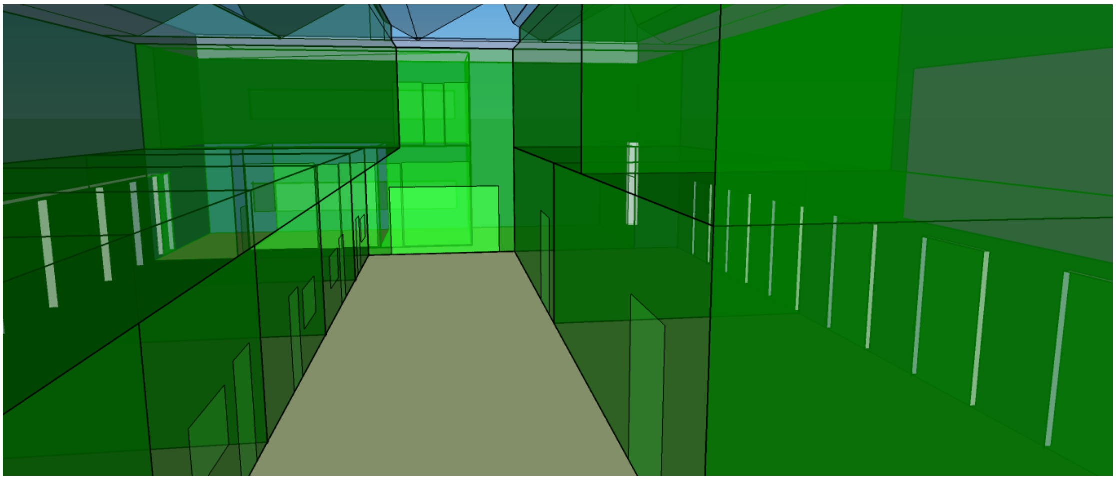


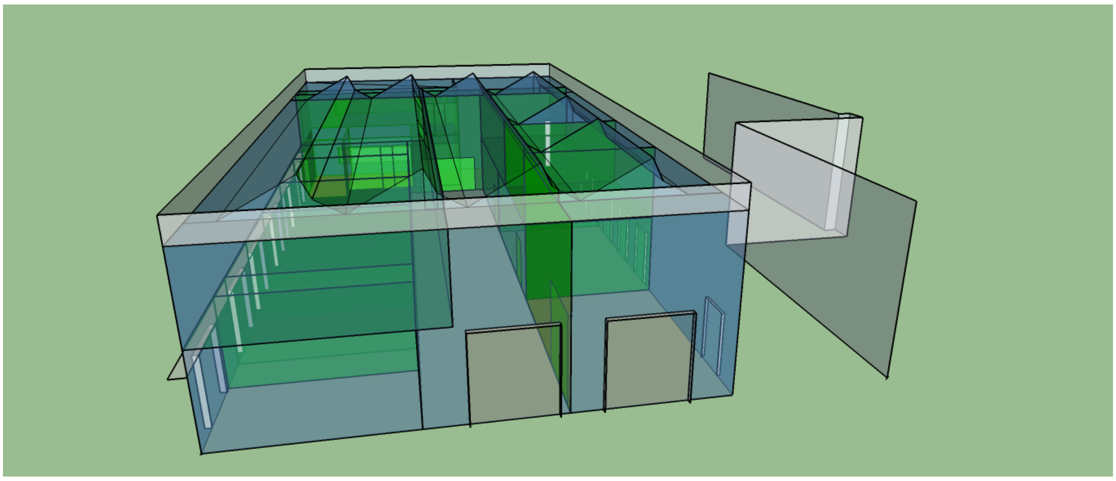


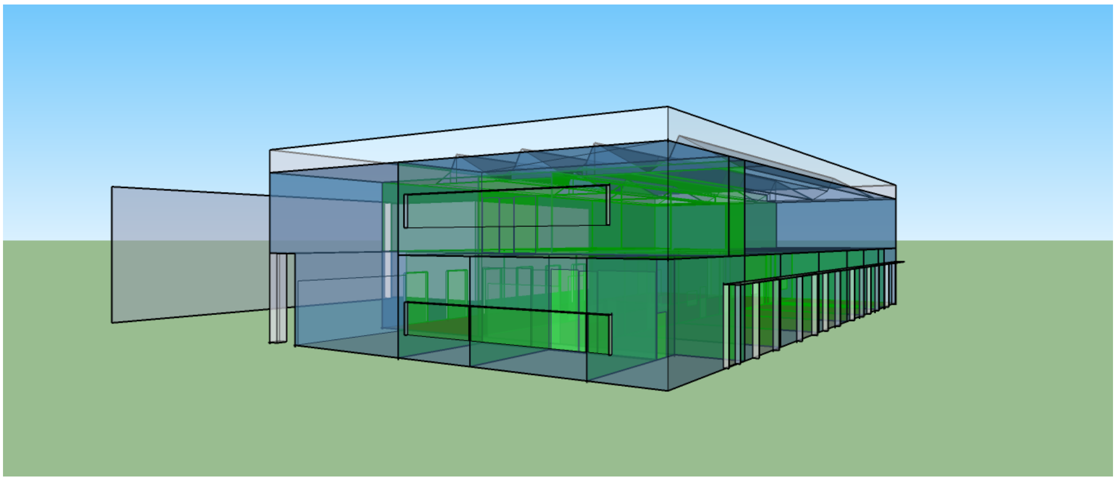


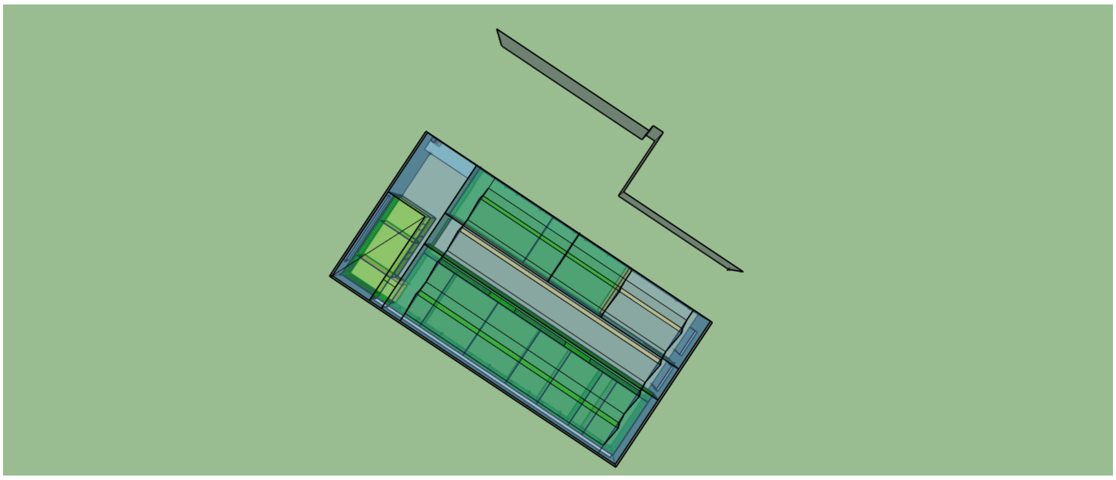

Blue: Matched external components
Green: Matched internal components

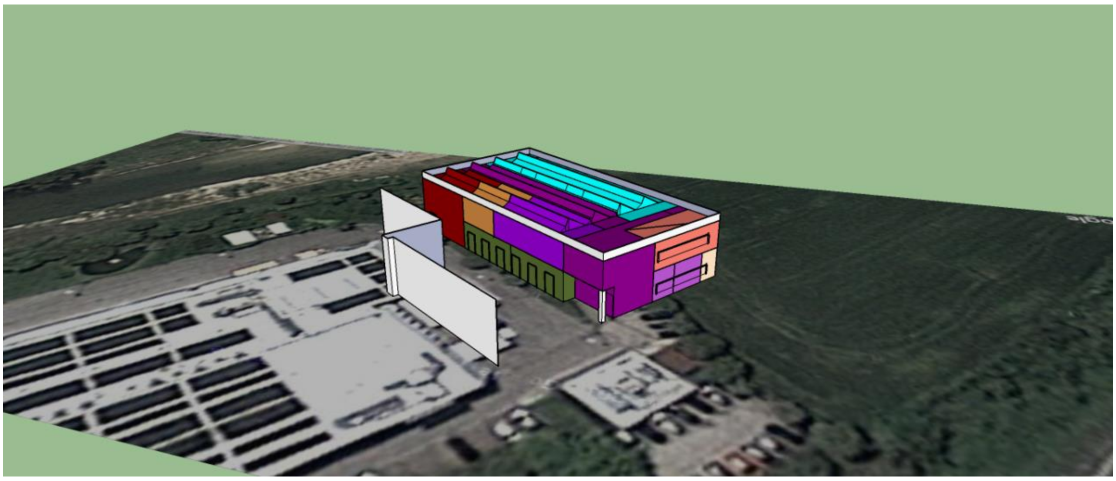


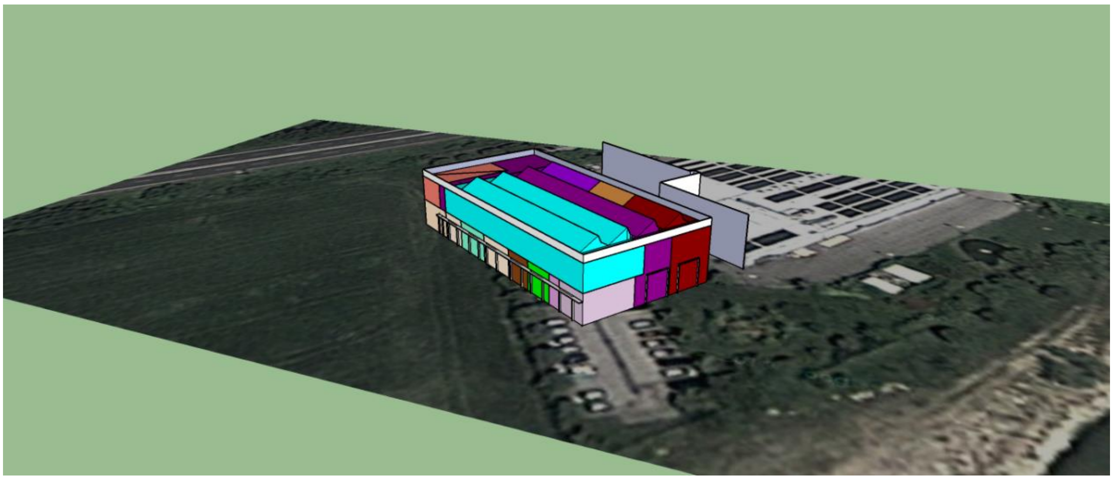


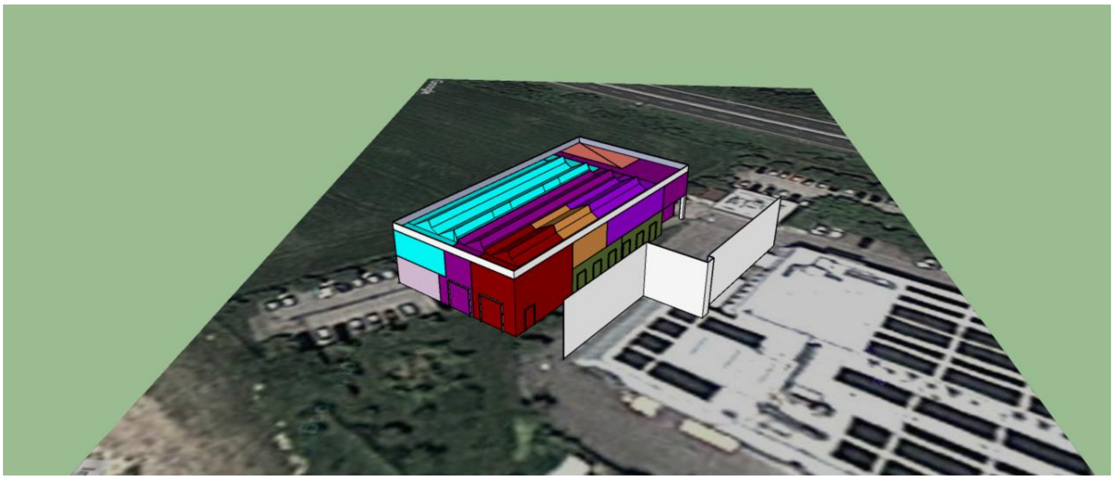


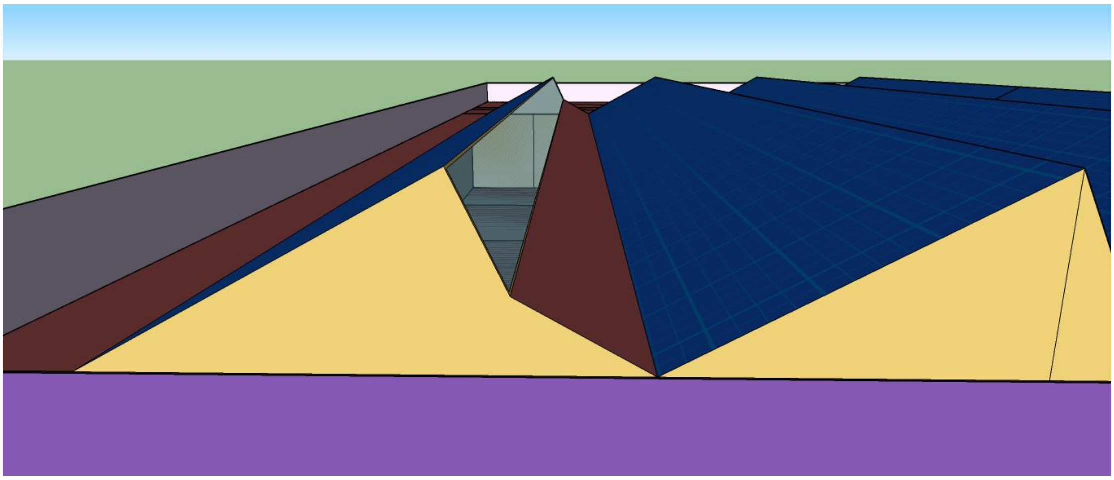


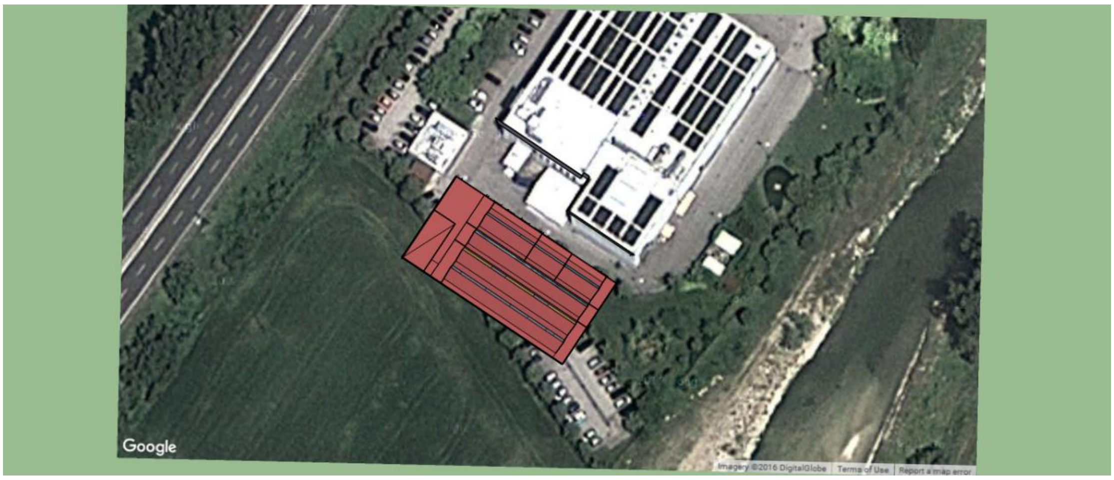











Google

9.3 Annex 3-AEA building

Characteristics of Walls

CARATTERISTICHE TERMICHE E IGROMETRICHE DEI COMPONENTI OPACHI
secondo UNI TS 11300-1 - UNI EN ISO 6946 - UNI EN ISO 13370

Descrizione della struttura: ***Parete esterna - isolata*** **Codice:** ***M1***

Trasmittanza termica	***0,452***	W/m²K
Spessore	***263***	mm
Temperatura esterna (calcolo potenza invernale)	***-6,0***	°C
Permeanza	***12,403***	10^{-12}kg/sm²Pa
Massa superficiale (con intonaci)	***293***	kg/m²
Massa superficiale (senza intonaci)	***282***	kg/m²
Trasmittanza periodica	***0,101***	W/m²K
Fattore attenuazione	***0,224***	-
Sfasamento onda termica	***-9,5***	h

Stratigrafia:

N.	Descrizione strato	s	Cond.	R	M.V.	C.T.	R.V.
-	Resistenza superficiale interna	-	-	0,130	-	-	-
1	Cartongesso in lastre	12,50	0,250	0,050	900	1,00	10
2	Polistirene espanso, estruso con pelle	50,00	0,035	1,429	35	1,25	300
3	Tamponamento Italprefabbricati	200,00	0,360	0,556	1400	0,88	5
-	Resistenza superficiale esterna	-	-	0,047	-	-	-

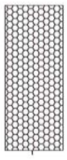
Legenda simboli

s	Spessore	mm
Cond.	Conduttività termica, comprensiva di eventuale maggiorazione	W/mK
R	Resistenza termica	m²K/W
M.V.	Massa volumica	kg/m³
C.T.	Capacità termica specifica	kJ/kgK
R.V.	Fattore di resistenza alla diffusione del vapore in capo asciutto	-

CARATTERISTICHE TERMICHE E IGROMETRICHE DEI COMPONENTI OPACHI
secondo UNI TS 11300-1 - UNI EN ISO 6946 - UNI EN ISO 13370

Descrizione della struttura: ***Parete esterna - non isolata*** **Codice:** ***M2***

Trasmittanza termica	***1,365***	W/m²K
Spessore	***200***	mm
Temperatura esterna (calcolo potenza invernale)	***-6,0***	°C
Permeanza	***200,00 0***	10^{-12}kg/sm²Pa
Massa superficiale (con intonaci)	***280***	kg/m²
Massa superficiale (senza intonaci)	***280***	kg/m²
Trasmittanza periodica	***0,632***	W/m²K
Fattore attenuazione	***0,463***	-
Sfasamento onda termica	***-7,4***	h



Stratigrafia:

N.	Descrizione strato	s	Cond.	R	M.V.	C.T.	R.V.
-	Resistenza superficiale interna	-	-	0,130	-	-	-
1	Tamponamento Italprefabbricati	200,00	0,360	0,556	1400	0,88	5
-	Resistenza superficiale esterna	-	-	0,047	-	-	-

Legenda simboli

s	Spessore	mm
Cond.	Conduttività termica, comprensiva di eventuale maggiorazione	W/mK
R	Resistenza termica	m²K/W
M.V.	Massa volumica	kg/m³
C.T.	Capacità termica specifica	kJ/kgK
R.V.	Fattore di resistenza alla diffusione del vapore in capo asciutto	-

CARATTERISTICHE TERMICHE E IGROMETRICHE DEI COMPONENTI OPACHI
secondo UNI TS 11300-1 - UNI EN ISO 6946 - UNI EN ISO 13370

Descrizione della struttura: ***Pavimento industriale*** **Codice:** ***P1***

Trasmittanza termica	***1,674***	W/m^2K
Trasmittanza controterra	***0,166***	W/m^2K
Spessore	***650***	mm
Temperatura esterna (calcolo potenza invernale)	***-6,0***	°C
Permeanza	***3,960***	$10^{-12}kg/sm^2Pa$
Massa superficiale (con intonaci)	***1390***	kg/m^2
Massa superficiale (senza intonaci)	***1390***	kg/m^2
Trasmittanza periodica	***0,087***	W/m^2K
Fattore attenuazione	***0,524***	-
Sfasamento onda termica	***-15,7***	h

Stratigrafia:

N.	Descrizione strato	s	Cond.	R	M.V.	C.T.	R.V.
-	Resistenza superficiale interna	-	-	*0,170*	-	-	-
1	Massetto ripartitore in calcestruzzo con rete	*150,00*	*1,490*	*0,101*	*2200*	*0,88*	*70*
2	C.l.s. armato (2% acciaio)	*300,00*	*2,500*	*0,120*	*2400*	*1,00*	*130*
3	Ghiaia grossa senza argilla (um. 5%)	*200,00*	*1,200*	*0,167*	*1700*	*0,84*	*5*
-	Resistenza superficiale esterna	-	-	*0,040*	-	-	-

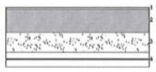
Legenda simboli

s	Spessore	mm
Cond.	Conduttività termica, comprensiva di eventuale maggiorazione	W/mK
R	Resistenza termica	m^2K/W
M.V.	Massa volumica	kg/m^3
C.T.	Capacità termica specifica	kJ/kgK
R.V.	Fattore di resistenza alla diffusione del vapore in capo asciutto	-

CARATTERISTICHE TERMICHE E IGROMETRICHE DEI COMPONENTI OPACHI
secondo UNI TS 11300-1 - UNI EN ISO 6946 - UNI EN ISO 13370

Descrizione della struttura: ***Copertura*** **Codice:** ***S1***

Trasmittanza termica	***0,272***	W/m^2K
Spessore	***205***	mm
Temperatura esterna (calcolo potenza invernale)	***-6,0***	°C
Permeanza	***0,728***	$10^{-12}kg/sm^2Pa$
Massa superficiale (con intonaci)	***90***	kg/m^2
Massa superficiale (senza intonaci)	***90***	kg/m^2
Trasmittanza periodica	***0,183***	W/m^2K
Fattore attenuazione	***0,672***	-
Sfasamento onda termica	***-5,6***	h



Stratigrafia:

N.	Descrizione strato	s	Cond.	R	M.V.	C.T.	R.V.
-	Resistenza superficiale esterna	-	-	*0,047*	-	-	-
1	Impermeabilizzazione con bitume	*5,00*	*0,170*	*0,029*	*1200*	*1,00*	*50000*
2	Polistirene espanso, estruso con pelle	*80,00*	*0,035*	*2,286*	*35*	*1,25*	*300*
3	sottofondo alleggerito	*70,00*	*0,061*	*1,148*	*450*	*0,85*	*7*
4	Copertura industriale prefabbricata	*50,00*	*0,800*	*0,063*	*1000*	*0,84*	*6*
-	Resistenza superficiale interna	-	-	*0,100*	-	-	-

Legenda simboli

s	Spessore	mm
Cond.	Conduttività termica, comprensiva di eventuale maggiorazione	W/mK
R	Resistenza termica	m^2K/W
M.V.	Massa volumica	kg/m^3
C.T.	Capacità termica specifica	kJ/kgK
R.V.	Fattore di resistenza alla diffusione del vapore in capo asciutto	-

Characteristics of Windows and Doors

CARATTERISTICHE TERMICHE DEI COMPONENTI FINESTRATI
secondo UNI TS 11300-1 - UNI EN ISO 6946 - UNI EN ISO 10077

Descrizione della finestra: ***Modulo finestra continua*** — **Codice:** ***W1***

Caratteristiche del serramento

Tipologia di serramento		*Singolo*	
Classe di permeabilità		*Classe 3 secondo Norma UNI EN 12207*	
Trasmittanza termica	U_w	*2,339*	W/m²K
Trasmittanza solo vetro	U_g	*2,763*	W/m²K

Dati per il calcolo degli apporti solari

Emissività	ε	*0,837*	-
Fattore tendaggi (invernale)	$f_{c\,inv}$	*0,80*	-
Fattore tendaggi (estivo)	$f_{c\,est}$	*0,80*	-
Fattore di trasmittanza solare	$g_{gl,n}$	*0,750*	-

Caratteristiche delle chiusure oscuranti

Resistenza termica chiusure	*0,16*	m²K/W
f shut	*0,6*	-

Dimensioni del serramento

Larghezza	*550,0*	cm
Altezza	*150,0*	cm

Caratteristiche del telaio

Trasmittanza termica del telaio	U_f	*2,50*	W/m²K
K distanziale	K_d	*0,08*	W/mK
Area totale	A_w	*8,250*	m²
Area vetro	A_g	*6,630*	m²
Area telaio	A_f	*1,620*	m²
Fattore di forma	F_f	*0,80*	-
Perimetro vetro	L_g	*18,000*	m
Perimetro telaio	L_f	*14,000*	m

Stratigrafia del pacchetto vetrato

Descrizione strato	s	λ	R
Resistenza superficiale interna	-	-	*0,130*
Primo vetro	*6,0*	*1,00*	*0,006*
Intercapedine	-	-	*0,173*
Secondo vetro	*6,0*	*1,00*	*0,006*
Resistenza superficiale esterna	-	-	*0,047*

Legenda simboli

s	Spessore	mm
λ	Conduttività termica	W/mK
R	Resistenza termica	m²K/W

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SERPILLI Engineering
Via Grandi, 45h - 60131 Ancona (AN)

Caratteristiche del modulo

Trasmittanza termica del modulo	U	*2,509*	W/m²K

Ponte termico del serramento

Ponte termico associato	*Z1*	*P.T. serramenti, porte e finestre*	
Trasmittanza termica lineica	Ψ	*0,100*	W/mK
Lunghezza perimetrale		*14,00*	m

CARATTERISTICHE TERMICHE DEI COMPONENTI FINESTRATI
secondo UNI TS 11300-1 - UNI EN ISO 6946 - UNI EN ISO 10077

Descrizione della finestra: ***Vetrata ingresso*** **Codice:** ***W2***

Caratteristiche del serramento

Tipologia di serramento		***Singolo***	
Classe di permeabilità		***Classe 3 secondo Norma UNI EN 12207***	
Trasmittanza termica	U_w	***2,317***	W/m²K
Trasmittanza solo vetro	U_g	***2,763***	W/m²K

Dati per il calcolo degli apporti solari

Emissività	ε	***0,837***	-
Fattore tendaggi (invernale)	$f_{c\,inv}$	***0,80***	-
Fattore tendaggi (estivo)	$f_{c\,est}$	***0,80***	-
Fattore di trasmittanza solare	$g_{gl,n}$	***0,750***	-

Caratteristiche delle chiusure oscuranti

Resistenza termica chiusure	***0,16***	m²K/W
f shut	***0,6***	-

Dimensioni del serramento

Larghezza	***831,0***	cm
Altezza	***250,0***	cm

Caratteristiche del telaio

Trasmittanza termica del telaio	U_f	***2,50***	W/m²K
K distanziale	K_d	***0,08***	W/mK
Area totale	A_w	***20,775***	m²
Area vetro	A_g	***17,618***	m²
Area telaio	A_f	***3,157***	m²
Fattore di forma	F_f	***0,85***	-
Perimetro vetro	L_g	***33,720***	m
Perimetro telaio	L_f	***21,620***	m

Stratigrafia del pacchetto vetrato

Descrizione strato	s	λ	R
Resistenza superficiale interna	-	-	***0,130***
Primo vetro	***6,0***	***1,00***	***0,006***
Intercapedine	-	-	***0,173***
Secondo vetro	***6,0***	***1,00***	***0,006***
Resistenza superficiale esterna	-	-	***0,047***

Legenda simboli

s	Spessore	mm
λ	Conduttività termica	W/mK
R	Resistenza termica	m²K/W

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Caratteristiche del modulo

Trasmittanza termica del modulo	U	***2,421***	W/m²K

Ponte termico del serramento

Ponte termico associato	***Z1***	***P.T. serramenti, porte e finestre***	
Trasmittanza termica lineica	Ψ	***0,100***	W/mK
Lunghezza perimetrale		***21,62***	m

CARATTERISTICHE TERMICHE DEI COMPONENTI FINESTRATI
secondo UNI TS 11300-1 - UNI EN ISO 6946 - UNI EN ISO 10077

Descrizione della finestra: ***Finestra singola 120x150*** **Codice:** ***W3***

Caratteristiche del serramento

Tipologia di serramento		*Singolo*	
Classe di permeabilità		*Classe 3 secondo Norma UNI EN 12207*	
Trasmittanza termica	U_w	*2,345*	W/m²K
Trasmittanza solo vetro	U_g	*2,763*	W/m²K

Dati per il calcolo degli apporti solari

Emissività	ε	*0,837*	-
Fattore tendaggi (invernale)	$f_{c\,inv}$	*0,80*	-
Fattore tendaggi (estivo)	$f_{c\,est}$	*0,80*	-
Fattore di trasmittanza solare	$g_{gl,n}$	*0,750*	-

Caratteristiche delle chiusure oscuranti

Resistenza termica chiusure	*0,16*	m²K/W
f shut	*0,6*	-

Dimensioni del serramento

Larghezza	*120,0*	cm
Altezza	*150,0*	cm

Caratteristiche del telaio

Trasmittanza termica del telaio	U_f	*2,50*	W/m²K
K distanziale	K_d	*0,08*	W/mK
Area totale	A_w	*1,800*	m²
Area vetro	A_g	*1,300*	m²
Area telaio	A_f	*0,500*	m²
Fattore di forma	F_f	*0,72*	-
Perimetro vetro	L_g	*4,600*	m
Perimetro telaio	L_f	*5,400*	m

Stratigrafia del pacchetto vetrato

Descrizione strato	s	λ	R
Resistenza superficiale interna	-	-	*0,130*
Primo vetro	*6,0*	*1,00*	*0,006*
Intercapedine	-	-	*0,173*
Secondo vetro	*6,0*	*1,00*	*0,006*
Resistenza superficiale esterna	-	-	*0,047*

Legenda simboli

s	Spessore	mm
λ	Conduttività termica	W/mK
R	Resistenza termica	m²K/W

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Caratteristiche del modulo

Trasmittanza termica del modulo	U	***2,645***	W/m^2K

Ponte termico del serramento

Ponte termico associato	***Z1***	***P.T. serramenti, porte e finestre***	
Trasmittanza termica lineica	Ψ	***0,100***	W/mK
Lunghezza perimetrale		***5,40***	m

CARATTERISTICHE TERMICHE DEI COMPONENTI FINESTRATI
secondo UNI TS 11300-1 - UNI EN ISO 6946 - UNI EN ISO 10077

Descrizione della finestra: ***Uscita di sicurezza 135x250*** **Codice:** ***W4***

Caratteristiche del serramento

Tipologia di serramento	***Singolo***		
Classe di permeabilità	***Classe 3 secondo Norma UNI EN 12207***		
Trasmittanza termica	U_w	***2,356***	W/m^2K
Trasmittanza solo vetro	U_g	***2,763***	W/m^2K

Dati per il calcolo degli apporti solari

Emissività	ε	***0,837***	-
Fattore tendaggi (invernale)	$f_{c\ inv}$	***1,00***	-
Fattore tendaggi (estivo)	$f_{c\ est}$	***1,00***	-
Fattore di trasmittanza solare	$g_{gl,n}$	***0,750***	-

Caratteristiche delle chiusure oscuranti

Resistenza termica chiusure	***0,16***	m^2K/W
f shut	***0,6***	-

Dimensioni del serramento

Larghezza	***135,0***	cm
Altezza	***250,0***	cm

Caratteristiche del telaio

Trasmittanza termica del telaio	U_f	***2,50***	W/m^2K
K distanziale	K_d	***0,08***	W/mK
Area totale	A_w	***3,375***	m^2
Area vetro	A_g	***2,530***	m^2
Area telaio	A_f	***0,845***	m^2
Fattore di forma	F_f	***0,75***	-
Perimetro vetro	L_g	***9,000***	m
Perimetro telaio	L_f	***7,700***	m

Stratigrafia del pacchetto vetrato

Descrizione strato	s	λ	R
Resistenza superficiale interna	-	-	***0,130***
Primo vetro	***6,0***	***1,00***	***0,006***
Intercapedine	-	-	***0,173***
Secondo vetro	***6,0***	***1,00***	***0,006***
Resistenza superficiale esterna	-	-	***0,047***

Legenda simboli

s	Spessore	mm
λ	Conduttività termica	W/mK
R	Resistenza termica	m^2K/W

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Caratteristiche del modulo

Trasmittanza termica del modulo	U	***2,584***	W/m^2K

Ponte termico del serramento

Ponte termico associato	***Z1***	***P.T. serramenti, porte e finestre***	
Trasmittanza termica lineica	Ψ	***0,100***	W/mK
Lunghezza perimetrale		***7,70***	m

CARATTERISTICHE TERMICHE DEI COMPONENTI FINESTRATI
secondo UNI TS 11300-1 - UNI EN ISO 6946 - UNI EN ISO 10077

Descrizione della finestra: ***Finestra singola 100x100*** **Codice:** ***W5***

Caratteristiche del serramento

Tipologia di serramento	***Singolo***		
Classe di permeabilità	***Classe 3 secondo Norma UNI EN 12207***		
Trasmittanza termica	U_w	***2,365***	W/m^2K
Trasmittanza solo vetro	U_g	***2,763***	W/m^2K

Dati per il calcolo degli apporti solari

Emissività	ε	***0,837***	-
Fattore tendaggi (invernale)	$f_{c\ inv}$	***0,80***	-
Fattore tendaggi (estivo)	$f_{c\ est}$	***0,80***	-
Fattore di trasmittanza solare	$g_{gl,n}$	***0,750***	-

Caratteristiche delle chiusure oscuranti

Resistenza termica chiusure	***0,16***	m^2K/W
f shut	***0,6***	-

Dimensioni del serramento

Larghezza	***100,0***	cm
Altezza	***100,0***	cm

Caratteristiche del telaio

Trasmittanza termica del telaio	U_f	***2,50***	W/m^2K
K distanziale	K_d	***0,08***	W/mK
Area totale	A_w	***1,000***	m^2
Area vetro	A_g	***0,640***	m^2
Area telaio	A_f	***0,360***	m^2
Fattore di forma	F_f	***0,64***	-
Perimetro vetro	L_g	***3,200***	m
Perimetro telaio	L_f	***4,000***	m

Stratigrafia del pacchetto vetrato

Descrizione strato	s	λ	R
Resistenza superficiale interna	-	-	***0,130***
Primo vetro	***6,0***	***1,00***	***0,006***
Intercapedine	-	-	***0,173***
Secondo vetro	***6,0***	***1,00***	***0,006***
Resistenza superficiale esterna	-	-	***0,047***

Legenda simboli

s	Spessore	mm
λ	Conduttività termica	W/mK
R	Resistenza termica	m^2K/W

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Caratteristiche del modulo

Trasmittanza termica del modulo	U	***2,765***	W/m^2K

Ponte termico del serramento

Ponte termico associato	***Z1***	***P.T. serramenti, porte e finestre***	
Trasmittanza termica lineica	Ψ	***0,100***	W/mK
Lunghezza perimetrale		***4,00***	m

CARATTERISTICHE TERMICHE DEI COMPONENTI FINESTRATI
secondo UNI TS 11300-1 - UNI EN ISO 6946 - UNI EN ISO 10077

Descrizione della finestra: ***Finestra singola 110x320*** **Codice:** ***W6***

Caratteristiche del serramento

Tipologia di serramento		***Singolo***	
Classe di permeabilità		***Classe 3 secondo Norma UNI EN 12207***	
Trasmittanza termica	U_w	***2,355***	W/m²K
Trasmittanza solo vetro	U_g	***2,763***	W/m²K

Dati per il calcolo degli apporti solari

Emissività	ε	***0,837***	-
Fattore tendaggi (invernale)	$f_{c\,inv}$	***0,80***	-
Fattore tendaggi (estivo)	$f_{c\,est}$	***0,80***	-
Fattore di trasmittanza solare	$g_{gl,n}$	***0,750***	-

Caratteristiche delle chiusure oscuranti

Resistenza termica chiusure	***0,16***	m²K/W
f shut	***0,6***	-

Dimensioni del serramento

Larghezza	***110,0***	cm
Altezza	***320,0***	cm

Caratteristiche del telaio

Trasmittanza termica del telaio	U_f	***2,50***	W/m²K
K distanziale	K_d	***0,08***	W/mK
Area totale	A_w	***3,520***	m²
Area vetro	A_g	***2,610***	m²
Area telaio	A_f	***0,910***	m²
Fattore di forma	F_f	***0,74***	-
Perimetro vetro	L_g	***9,400***	m
Perimetro telaio	L_f	***8,600***	m

Stratigrafia del pacchetto vetrato

Descrizione strato	s	λ	R
Resistenza superficiale interna	-	-	*0,130*
Primo vetro	*6,0*	*1,00*	*0,006*
Intercapedine	-	-	*0,173*
Secondo vetro	*6,0*	*1,00*	*0,006*
Resistenza superficiale esterna	-	-	*0,047*

Legenda simboli

s	Spessore	mm
λ	Conduttività termica	W/mK
R	Resistenza termica	m²K/W

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Caratteristiche del modulo

Trasmittanza termica del modulo	U	***2,599***	W/m²K

Ponte termico del serramento

Ponte termico associato	***Z1***	***P.T. serramenti, porte e finestre***	
Trasmittanza termica lineica	Ψ	***0,100***	W/mK
Lunghezza perimetrale		***8,60***	m

CARATTERISTICHE TERMICHE DEI COMPONENTI FINESTRATI
secondo UNI TS 11300-1 - UNI EN ISO 6946 - UNI EN ISO 10077

Descrizione della finestra: ***Vetrata Magazzino 165x860*** **Codice:** ***W7***

Caratteristiche del serramento

Tipologia di serramento		***Singolo***	
Classe di permeabilità		***Classe 3 secondo Norma UNI EN 12207***	
Trasmittanza termica	U_w	***2,331***	W/m²K
Trasmittanza solo vetro	U_g	***2,763***	W/m²K

Dati per il calcolo degli apporti solari

Emissività	ε	***0,837***	-
Fattore tendaggi (invernale)	$f_{c\,inv}$	***0,80***	-
Fattore tendaggi (estivo)	$f_{c\,est}$	***0,80***	-
Fattore di trasmittanza solare	$g_{gl,n}$	***0,750***	-

Caratteristiche delle chiusure oscuranti

Resistenza termica chiusure	***0,16***	m²K/W
f shut	***0,6***	-

Dimensioni del serramento

Larghezza	***165,0***	cm
Altezza	***860,0***	cm

Caratteristiche del telaio

Trasmittanza termica del telaio	U_f	***2,50***	W/m²K
K distanziale	K_d	***0,08***	W/mK
Area totale	A_w	***14,190***	m²
Area vetro	A_g	***11,745***	m²
Area telaio	A_f	***2,445***	m²
Fattore di forma	F_f	***0,83***	-
Perimetro vetro	L_g	***27,800***	m
Perimetro telaio	L_f	***20,500***	m

Stratigrafia del pacchetto vetrato

Descrizione strato	s	λ	R
Resistenza superficiale interna	-	-	*0,130*
Primo vetro	*6,0*	*1,00*	*0,006*
Intercapedine	-	-	*0,173*
Secondo vetro	*6,0*	*1,00*	*0,006*
Resistenza superficiale esterna	-	-	*0,047*

Legenda simboli

s	Spessore	mm
λ	Conduttività termica	W/mK
R	Resistenza termica	m²K/W

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Caratteristiche del modulo

Trasmittanza termica del modulo	U	***2,476***	W/m²K

Ponte termico del serramento

Ponte termico associato	***Z1***	***P.T. serramenti, porte e finestre***	
Trasmittanza termica lineica	Ψ	***0,100***	W/mK
Lunghezza perimetrale		***20,50***	m

CARATTERISTICHE TERMICHE DEI COMPONENTI FINESTRATI
secondo UNI TS 11300-1 - UNI EN ISO 6946 - UNI EN ISO 10077

Descrizione della finestra: ***Portone industriale*** — **Codice:** ***W8***

Caratteristiche del serramento

Tipologia di serramento		*Singolo*	
Classe di permeabilità		*Senza classificazione*	
Trasmittanza termica	U_w	*3,309*	W/m²K
Trasmittanza solo vetro	U_g	*5,468*	W/m²K

Dati per il calcolo degli apporti solari

Emissività	ε	*0,837*	-
Fattore tendaggi (invernale)	$f_{c\ inv}$	*0,00*	-
Fattore tendaggi (estivo)	$f_{c\ est}$	*0,00*	-
Fattore di trasmittanza solare	$g_{gl,n}$	*0,850*	-

Caratteristiche delle chiusure oscuranti

Resistenza termica chiusure	*0,16*	m²K/W
f shut	*0,6*	-

Dimensioni del serramento

Larghezza	*200,0*	cm
Altezza	*200,0*	cm

Caratteristiche del telaio

Trasmittanza termica del telaio	U_f	*4,40*	W/m²K
K distanziale	K_d	*0,00*	W/mK
Area totale	A_w	*4,000*	m²
Area vetro	A_g	*0,000*	m²
Area telaio	A_f	*4,000*	m²
Fattore di forma	F_f	*0,00*	-
Perimetro vetro	L_g	*3,600*	m
Perimetro telaio	L_f	*8,000*	m

Stratigrafia del pacchetto vetrato

Descrizione strato	s	λ	R
Resistenza superficiale interna	-	-	*0,130*
Primo vetro	*6,0*	*1,00*	*0,006*
Resistenza superficiale esterna	-	-	*0,047*

Legenda simboli

s	Spessore	mm
λ	Conduttività termica	W/mK
R	Resistenza termica	m²K/W

Caratteristiche del modulo

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Trasmittanza termica del modulo	U	*3,509*	W/m²K

Ponte termico del serramento

Ponte termico associato	*Z1*	*P.T. serramenti, porte e finestre*	
Trasmittanza termica lineica	Ψ	*0,100*	W/mK
Lunghezza perimetrale		*8,00*	m

CARATTERISTICHE TERMICHE DEI COMPONENTI FINESTRATI
secondo UNI TS 11300-1 - UNI EN ISO 6946 - UNI EN ISO 10077

Descrizione della finestra: ***Ingresso ovest 195x280*** — **Codice:** ***W9***

Caratteristiche del serramento

Tipologia di serramento		***Singolo***	
Classe di permeabilità		***Classe 3 secondo Norma UNI EN 12207***	
Trasmittanza termica	U_w	***2,402***	W/m^2K
Trasmittanza solo vetro	U_g	***2,763***	W/m^2K

Dati per il calcolo degli apporti solari

Emissività	ε	***0,837***	-
Fattore tendaggi (invernale)	$f_{c\,inv}$	***1,00***	-
Fattore tendaggi (estivo)	$f_{c\,est}$	***1,00***	-
Fattore di trasmittanza solare	$g_{gl,n}$	***0,750***	-

Caratteristiche delle chiusure oscuranti

Resistenza termica chiusure	***0,16***	m^2K/W
f shut	***0,6***	-

Dimensioni del serramento

Larghezza	***195,0***	cm
Altezza	***210,0***	cm
Altezza sopraluce	***70,0***	cm

Caratteristiche del telaio

Trasmittanza termica del telaio	U_f	***2,50***	W/m^2K
K distanziale	K_d	***0,08***	W/mK
Area totale	A_w	***5,460***	m^2
Area vetro	A_g	***3,975***	m^2
Area telaio	A_f	***1,485***	m^2
Fattore di forma	F_f	***0,73***	-
Perimetro vetro	L_g	***19,600***	m
Perimetro telaio	L_f	***9,500***	m

Stratigrafia del pacchetto vetrato

Descrizione strato	s	λ	R
Resistenza superficiale interna	-	-	***0,130***
Primo vetro	***6,0***	***1,00***	***0,006***
Intercapedine	-	-	***0,173***
Secondo vetro	***6,0***	***1,00***	***0,006***
Resistenza superficiale esterna	-	-	***0,047***

Legenda simboli

s	Spessore	mm
λ	Conduttività termica	W/mK

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R	Resistenza termica	m^2K/W

Caratteristiche del modulo

Trasmittanza termica del modulo	U	***2,576***	W/m^2K

Ponte termico del serramento

Ponte termico associato	***Z1***	***P.T. serramenti, porte e finestre***	
Trasmittanza termica lineica	Ψ	***0,100***	W/mK
Lunghezza perimetrale		***9,50***	m

CARATTERISTICHE TERMICHE DEI COMPONENTI FINESTRATI
secondo UNI TS 11300-1 - UNI EN ISO 6946 - UNI EN ISO 10077

Descrizione della finestra: ***Finestra singola 110x120*** **Codice:** ***W10***

Caratteristiche del serramento

Tipologia di serramento		***Singolo***	
Classe di permeabilità		***Classe 3 secondo Norma UNI EN 12207***	
Trasmittanza termica	U_w	***2,355***	W/m²K
Trasmittanza solo vetro	U_g	***2,763***	W/m²K

Dati per il calcolo degli apporti solari

Emissività	ε	***0,837***	-
Fattore tendaggi (invernale)	$f_{c\,inv}$	***0,80***	-
Fattore tendaggi (estivo)	$f_{c\,est}$	***0,80***	-
Fattore di trasmittanza solare	$g_{gl,n}$	***0,750***	-

Caratteristiche delle chiusure oscuranti

Resistenza termica chiusure	***0,16***	m²K/W
f shut	***0,6***	-

Dimensioni del serramento

Larghezza	***110,0***	cm
Altezza	***120,0***	cm

Caratteristiche del telaio

Trasmittanza termica del telaio	U_f	***2,50***	W/m²K
K distanziale	K_d	***0,08***	W/mK
Area totale	A_w	***1,320***	m²
Area vetro	A_g	***0,900***	m²
Area telaio	A_f	***0,420***	m²
Fattore di forma	F_f	***0,68***	-
Perimetro vetro	L_g	***3,800***	m
Perimetro telaio	L_f	***4,600***	m

Stratigrafia del pacchetto vetrato

Descrizione strato	s	λ	R
Resistenza superficiale interna	-	-	*0,130*
Primo vetro	*6,0*	*1,00*	*0,006*
Intercapedine	-	-	*0,173*
Secondo vetro	*6,0*	*1,00*	*0,006*
Resistenza superficiale esterna	-	-	*0,047*

Legenda simboli

s	Spessore	mm
λ	Conduttività termica	W/mK
R	Resistenza termica	m²K/W

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Caratteristiche del modulo

Trasmittanza termica del modulo	U	***2,704***	W/m²K

Ponte termico del serramento

Ponte termico associato	***Z1***	***P.T. serramenti, porte e finestre***	
Trasmittanza termica lineica	Ψ	***0,100***	W/mK
Lunghezza perimetrale		***4,60***	m