Politecnico di Torino

Master's Degree in Green Building Engineering
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Pre-Assessment LEED applied to Students Residences and an Industrial Warehouse

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Abstract

This thesis faces the application of LEED protocol into two different case studios: one is made up of two buildings used as Students Residences located in *Torino*, while the second is an Industrial Warehouse located in *Mantova*.

The thesis represents one of the most actual themes, for relevance, since the LEED protocol is an instrument to design and actuate measures to improve sustainability in buildings. Sustainability that has becoming relevant in construction sector, due to its negative impact on climate changes (that can led to dangerous consequences for human's life on earth). The work follows, also, the principles of Sustainable Development Goals, where some of the target to be reached by 2030 are considered in credits of the protocol.

The choice of the two case studios is to apply the same general rating system but a different sub-case due to a building function difference. Indeed, for the Students Residences the rating system is Building Design + Construction for New Construction while the Industrial Warehouse follow the Building Design + Construction for Warehouse and Distribution. The version applied in this thesis is LEED v4 even if the new version, LEED v4.1, is already available. By now there is the possibility to change the requirements of the old version with the new one even just for few credits; that's why for the Open Space credit all the alternatives (v4 and v4.1) are considered due to limited space in the Students Residences.

The work has been developed by analysing, for each case studio, some credits of the first three categories of the LEED protocol: Location and Transportation (LT), Sustainable Site (SS) and Water Efficiency (WE). The different location, function, dimension and the different choices conducted by the owners of the two projects, make it interesting to understand how the certification process can change due to different targets that the property want to reach.

In the end, it is possible to compare the different intermediate results, based on technical choices applied in the two projects, necessary to obtain a certain number of points that will be fundamental for the overall process of certification. The importance of a coordination figure such as the LEED AP is also considered based on different way and methods to develop the two projects. Another highlighted aspect is that, different rating systems conduct to different requirements for the same credit. The next passages will require more design information concerning the buildings to analyse the energy efficiency, material characteristics and indoor wellbeing of the occupants that are considered in the other categories of the protocol.

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1. Greenhouse effect and climate changes

In the last few years, it became evident a people's consciousness concerning environmental themes such as: global warming and climate changes. In the next few years, one of the most important battles will be to counteract these phenomena, so all the Nations should collaborate. A European Environment Agency research has highlighted that the mean global temperature has increased of about 0,8 °C in the last 150 years and every decade is considered the warmest ever recorded. The effects are now tangible and scientifically recognized: increasing temperature of the atmosphere and oceans, melting of snow and glaciers, that produce the sea level rise; extreme meteorological events, with very hot periods alternating with strong and unexpected precipitations. All these events have a negative influence on ecosystems, man's life and all the resources useful for its continuation.

Many scientific communities' studies show that humans and their activities are responsible for all these changes from the second half of the XX century. The rising of global population was connected to an increase in demand for food, wood, energy; more land and water were used for agriculture, more industrial production contributed to increasing the greenhouse gases emissions.

The greenhouse effect is a natural and essential phenomenon for life on Earth, but it can grow due to human activities that release carbonic anhydride and methane considered two of the most impactful gases: these gases let the sunray enter in the atmosphere and trap them, causing global warming.

Main causes are:

1. Fossil fuel combustion for electric energy production, transport systems, industrial productions that produce carbon dioxide and nitrous oxide;
2. Deforestation: trees are fundamental to absorb the carbon dioxide, but also when they are cut, they released the CO_2 stored, increasing the greenhouse effect;
3. Intensive farming: sheep and cows produce methane during digestion;
4. Fluorinated gases, that are inside some products used by humans and whose effect is 23.000 times worse than CO_2.

If the population won't take any actions to reduce these effects, the temperature will rise causing irreversible changes with serious consequences on future human's life on Earth. For these reasons, the European Union after the Kyoto's protocol (valid from 2008 to 2012) is trying to reduce the emissions of about 55%, respect to 1990 level, before 2030, promoting initiatives for implementation of renewable sources using wind, solar radiation, hydropower etc.

1.1 CO_2 emissions for materials production

The production of materials, objects, substances are the most responsible factors for CO_2 emissions. Two of the most relevant materials used in the construction sector are cement and steel, despite the problem of sustainability of these materials. In Italy, there are some examples of structures entirely made of concrete such as "Salone del Palazzo delle Esposizioni" in Turin or "Palazzetto dello Sport" in Rome. Research established that about 450 kg of cement per person are produced every year and if cement was a country, it would have been the third for CO_2 production in the world, after China and United States. Obviously, cement is not the only material involved in the construction sector, also the steel is widely used and the production of these two materials are responsible of about 33% of the total annual emissions. It is estimated that one ton of steel produces 1.8 tons of CO_2 while for the cement the ratio is 1:1, even if its recycle mechanism is much more complex. In order to reduce the CO_2 impact of these materials, the process of production should be implemented with usage of electrical energy, coming from renewable sources and without the fossil fuel combustion. Some tests have been done on new systems to change the cement production and use the CO_2 for other purposes, such as Calix, that is an implant capable of capturing almost pure CO_2 released from limestone. *"The system is unique in that the heat of the exhaust gases is transferred to the limestone via a special steel vessel. In this way, the reactor is heated indirectly, with the gas never coming into contact with it. The CO_2 released from the limestone can therefore be separated in an almost pure form."* Therefore, the problem is to think about what we can do with the CO_2 that derives from this process. There are some researches about that topic, such as the creation of a system that use this carbon dioxide for the production of synthetic fuels such as methane or systems that simply store CO_2 without using it for other production chain. It is also called CCUS "Carbon Capture Utilisation and Storage", where the CO_2 reaches some exhausted fields or old coal mine where it can be stored. With the needing to target the carbon neutrality, projects for 30 new implants were announced in 2017, increasing the CO_2 capture until 130 Mt per year. In Italy Eni would realise a CO_2 storage in a field of natural exhausted gases along Ravenna's coast, but for now just feasibility studies have been conducted with all the doubt of environmental association that would not consider this process as it doesn't respect the circular economy principles.

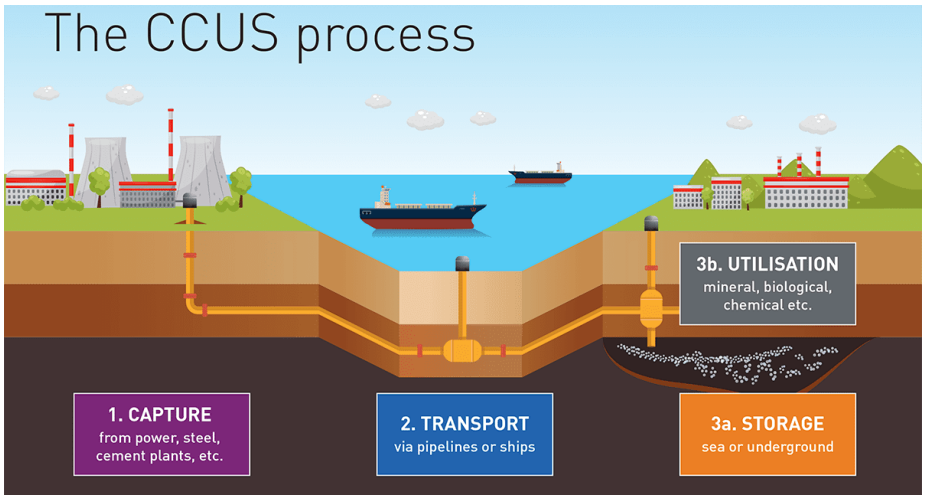


Figure 1: CCUS "Carbon Capture Utilisation and Storage" functioning scheme
Source: https://www.iogp.org/blog/news/developing-low-carbon-technologies/

1.2 Buildings influence on emissions and energy consumes

Construction sector is one of the most relevant for the economy of each Nation in the world thanks to the big support chain: in Italy it employs about 2 million of people in 600.000 different industries, with a GDP of 4,9% (data related to 2021).

Beside the positive aspects, the construction sector is responsible for the highest carbon dioxide emissions and a high energy consumption. Reading the "2021 Global status report for buildings and construction" made by the Global Alliance (GlobalABC), it is clear that the construction sector is responsible of 36% of energy consumption and 37% of emissions; taking into account:

- direct emissions: emitted by the structure;
- indirect emissions: that derives form heating and electric power generation

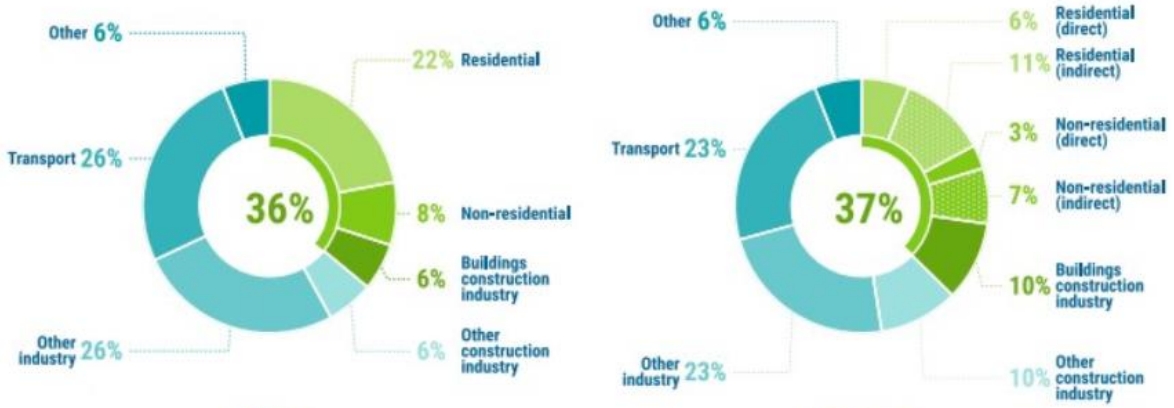


Figure 2: Buildings and construction's share of global energy and energy-related CO2emissions,2020
Source: Global status report for buildings and constructions 2021

The increasing of emissions is also due to the excessive usage of coal, oil and natural gas for heating: the sector is responsible for 55% of global energy consumption.

The target is both to reduce the need of resources with new construction systems and using as much renewable energy as possible.

In the future there will be a rise in demand, almost double before 2050, of residential spaces and new facilities for the Countries in a rapid economic and demographic growth, while in already developed countries, will be fundamental the energy efficiency improvement on existing buildings. For these reasons, one of the phases target will be to control as better as possible the construction and refurbishment, in order to not create worse environmental conditions.

In this potentially dangerous scenario, fundamental could be:

- Political choices, that with public funding can "push" the market into a green transition, reducing the energy consumption of the buildings; an Italian example is the Superbonus 110%;
- Promote the application of sustainability certificates for new constructions and renovations.

Green Certifications represent, among others, the efficiency of a building, but also help the owners and investors to distinguish their structure on the market. These are focused on nearly zero emission parameters and a particular attention on the energy consumption. Some examples could be: BREEAM, LEED, Passivehouse and GreenStar; the last one, created by the Green Building Council Australia, impose that to get the maximum rating, from 2020 the buildings must be totally electrical, without the usage of fossil: 100% of energy must be from renewable sources.

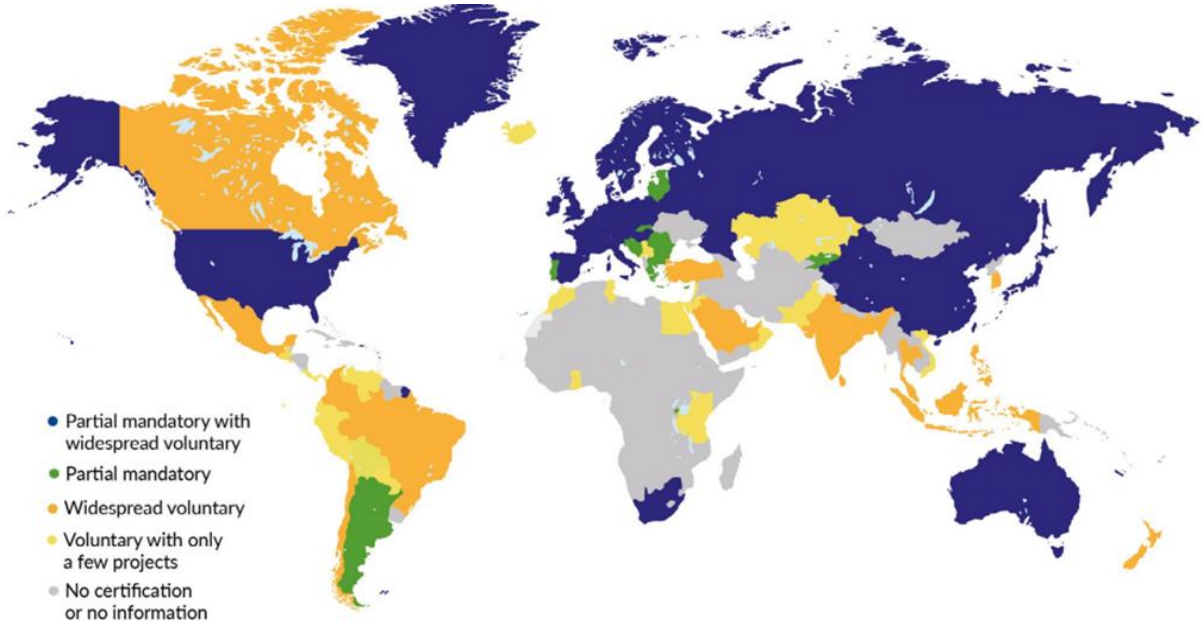


Figure 3: World plan about diffusion of green certifications
Source: Global status report for buildings and constructions 2021

These certifications are expanding all over the world, indeed, a GlobalABC research highlighted that they are used in a mandatory or partial mandatory way in 75% Nations, as it is possible to see from Figure 3.

The widespread environmental awareness made it possible to establish that before 2030 all new structures must be carbon neutral and it will be valid also for existing building before 2050. It is possible to define *carbon neutral*, "a building with nearly zero energy consumption and annual emissions, where the energy consumption and carbon emissions are compensated by using renewable sources, principally generated in situ".

A decarbonization index was also created in order to verify the distances from catching the target of 2050.

The index is made of two elements that are characterised by specific indicators (Figure 4):

1. Actions:
    - Investments to improve energy efficiency;
    - Green Certificate;
    - National laws to get the targets;
    - Building model codes to reduce consumptions.
2. Impact:
    - Energy consumption in kWh/mq;
    - Percentage of renewable sources usage on total demand.

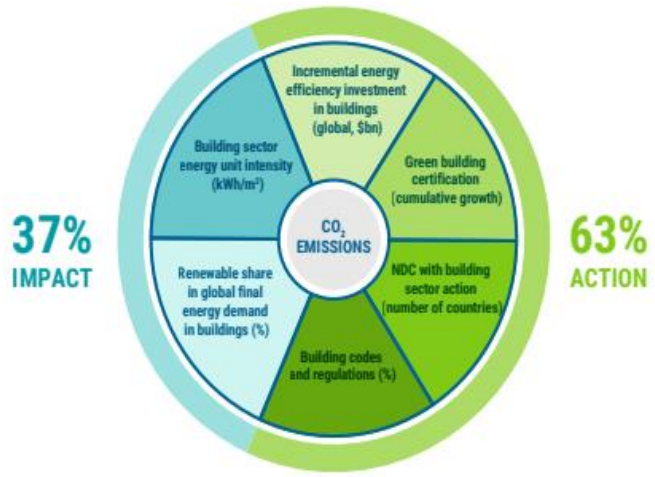


Figure 4: Chart about composition of the Global Buildings Climate Tracker
Source: Global status report for buildings and constructions 2021

Looking at the path (Figure 5), it is possible to see that the goal of 2050 is far at the moment: the graph also shows an inversion of the trend from 2017 to 2018 due to a reduction of the action component (decarbonization index).

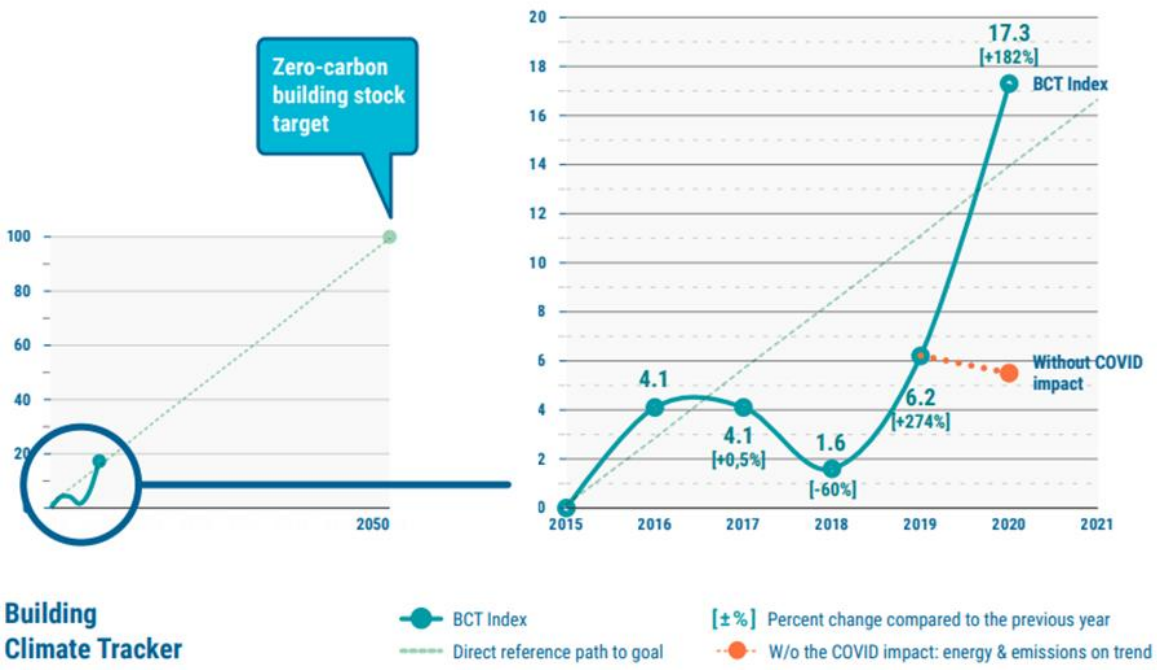


Figure 5: Actual and reference path to a zero-carbon building stock target in 2050
Source: Global status report for buildings and constructions 2021

The report of 2021 is based on the data of 2020, where it is possible to appreciate a "jump" with a +182%. The data are now above the reference path, but this is a "false" improvement: in 2020 all the world was stopped by the Covid emergency that "blocked" the new construction with empty site, most of the people worked from home with a considerable reduction of consumes of electricity, heating and cooling systems ecc. The studies estimate that without Covid-19, the trend would have been negative again, and this is a clear sign that, without important actions, the goal won't be reached.

1.3 Sustainable Development Goals (SDGs)

The Sustainable Development Goals are 17 targets, connected to each other, that are part of the 2030 Agenda for the Sustainable Developments. These goals have been established by the United Nations to highlight the subtle link between human welfare and nature. The document was approved by the General Assembly of UN on 25 September 2015 and it is made up of 169 targets to reach before 2030 and it substituted the old one called: "Millennium Development Goals" signed in the 2000 with a duration of 15 years. The sustainable goals are related to different themes in the environment, social and economic sector such as: poverty, food, right to health and education, work, climate changes, urbanisation and energy consumption.

The complete number and type of thematic analysed are presented below, in the well-known Image of Figure 6.

Figure 6: 17 Development Goals by Agenda 2030
Source: https://sdgs.un.org/goals

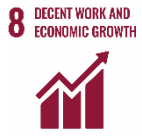
All the 193 Members of the UN agreed with the Agenda 2030 and they are trying to create political measures to get the goals, with the possibility of presenting a voluntary annual national report on the goals progresses.

The 2030 Agenda is based on the concept of 5P:

1. Peace: promote just in societies and inclusivity;
2. People: trying to eliminate hunger and poverty and guarantee dignity and equality;
3. Prosperity: ensure prosperous life and in harmony with nature;
4. Planet: protect natural resources for future generations;
5. Partnership: enforce the agenda with global cooperation.

In the Agenda's goals, the role of construction can be easily reconducted to 7 targets:

- It considers a wider usage of renewable energy for the general consumption. It needs better performances of the building envelope in order to reduce the energy demand that should be covered by renewable sources, giving the possibility to access to new technologies also to less developed countries.



- The Green Building sector can promote an economic growth with availability of new type of jobs.

- New technologies could have a positive influence on production processes but also for the construction of new infrastructures and buildings resilient to climate changes.

● The goal expects the easiness of access to healthier and more sustainable houses.

● It tries to ensure an efficient and conscious usage of resources by the population, as well as a circular policy for recycle and re-use the waste.

● This is one of the most complex goals, because it tries to limit the harmful emissions such as CO_2 for which the construction sector is responsible of about 39% all over the world.

● It encourages the creation of movements and international associations for the application and diffusion of sustainable principles, also in the construction sector, such as LEED Certification promoted by World Green Building Council.

In order to understand the progress made to reach the 17 Sustainable Development Goals, on 3 February 2016, the ASviS (Italian Alliance for Sustainable development) was created by Unipolis Foundation and TorVergata Rome University. The reason is to increase the importance of the 2030 Agenda and to create a goal monitoring system; then they try to establish a possible national strategy to reach them and to stimulate the transformation of industries and public institutions in the direction of sustainability.

The report for the sustainable development drafted by the ASviS in 2021, with data related to 2020, highlights an enormous difficulty in the annual improvements, that are the basis to reach the goal of 2030. In 2020 just three goals improved: clean energy (Goal 7), climate action (Goal 8) and peace and justice (Goal 16). Three goals stay stable: food and agriculture (Goal 2), clean water (Goal 6) and innovations (Goal 9); while the other get worse.

Comparing the Italian situation with other nations of the European Union, our criticalities are tangible, indeed, Italy has 10 indicators below the European average. The actuation of PNRR ("*Piano Nazionale di Ripresa e Resilienza*") could help a lot in reaching the targets. Moreover, the ASviS suggest to:

- update the PNIEC ("*Piano Nazionale Integrato per l'Energia e il Clima*") to bring it in line with the European standard that expect an emissions reduction of about 55% before 2030;

- eliminate public funding for fossil fuels;
- create strategies for gender equality and to reduce youth unemployment;
- improve basis of research and studies for the future of the environment.

1.4 Green Buildings and Life Cycle Assessment (LCA)

Sustainable architecture (or Green Buildings) can be defined as a construction methodology that includes a wide approach to all the different disciplines that are in the area of interest of the construction process, starting from the early phase of design and, for this reason, called "sustainable by design". The fundamental characteristics of green buildings are:

- reduction of the environmental impact of the area where the project is located;
- high energy efficiency;
- care about the inhabitant's health;
- high quality spaces for users;
- material durable, respectful of nature, re-usable and Km0;
- recycle and recover of wastes produced by buildings life cycle.

Green buildings are necessary to face the problem of climate changes, but also: to be respectful of nature and people's quality of life, to use less resources for new construction, less money for the building operation and maintenance, less energy consumption. In the last years, the interest on sustainability and environment themes has increased and the old idea that a green building is necessary just for market purposes, changed; indeed, by now, there is an institutional pressing by authority to reduce the impact of new constructions.

One of the most important aspects of a Green Building is the choice of materials that should be natural, with a low environmental impact during its life cycle, without inner presence of pollutants and with a low carbon footprint. Fundamental is the design phase where the usage of the Life Cycle methodology is recommended: "The LCA assesses the environmental footprint of a product or service among its entire lifecycle; the calculation considers the extraction of materials to produce a goods, its production, transportation, usage and end life".

On this purpose, after the design of many possible solutions with different materials, the method lets the designer evaluate their impact, in order to choose the best alternatives to reduce the negative effects on the ecosystem.

Figure 7: LCA "Life Cycle Assessment" phases
Source: https://www.greenplanner.it/life-cycle-assessment/

Otherwise, a detailed application of LCA is extremely complex and expensive for the typology of information and data needed; for this reason, ongoing researches are developing simplified methods to facilitate the access to public databases that store these information.

1.5 World Green Building Council and Green Building Council Italy

In 1993 the U.S. Green Building Council was founded by Rick Fedrizzi, David Gottfried and Mike Italiano to promote sustainability in the building sector. The same path had been followed by other Nations, that's why David Gottfried created a council to help the establishment of other GBCs, that became the World Green Building Council. In 1999 the founding meeting took place and, after three years, Australia, Brazil, Canada, India, Japan, Mexico, Spain and the United States were part of it. Nowadays, the WGBC spreads a lot, with a global network of about 70 GBC all over the world.

The U.S. Green Building Council was also the promotor of a certification system called LEED, that now it is widely used with projects registered in more than 140 Countries. LEED protocols are, by now, accepted universally and used to certify buildings designed, built and managed in a sustainable and efficient way.

The foundation of the Italian GBC dates to 28 January 2008 thanks to the Technological District of Trentino and other 47 partners, with the headquarter located in Rovereto. Its creation occurred in a region, Trentino, that has always been careful about environmental initiatives, as evidenced by the existence of the technological district for energy and environment called "Habitech".

The GBC Italy shares the same goal of the WGBC, such as:

- Spread the culture of the sustainable design, implementing market choices;
- Educate people and institutions on the impact that constructions have on human's life;
- Implement a sustainable architecture community.

The Italian Green Building Council is opened on admissions of companies, professionals' firms, public and private entities. The principal activity is to adapt the LEED rating system to the Italian construction reality; indeed, they have created the first case of localisation of LEED, approved by the U.S. GBC, that connect the certification principles to Italian norms. The new protocol is called GBC Historical Building and it was conceived to renovate, in a sustainable way, the consistency of the Italian historical patrimony.

Among other things, the GBC Italy works to implement technicians' knowledge to innovate the Italian construction technique using "green" principles, a theme that is at the centre of cultural and political debate.

2. LEED Certification

The LEED, "Leadership in Energy and Environmental Design", is a voluntary certification protocol made in the United States by the no-profit association of the U.S. Green Building Council, that developed and published a first version in 1998.

From the historical point of view, there was a specific event that leads to a higher attention on sustainability of construction sector and environment, with particular caution to consumption themes.

Indeed, in 1973, the Kippur War began with Egypt and Syria opposing Israel. During the conflict, anti-American nations with Arab countries decided to double the costs and reduce or to stop the oil export in America, that was an ally of Israel. That's caused an oil crisis, so the Americans focused on: independency by fossil fuels, energy consumptions, environment and construction. Years later it is possible to see a similar scenario due to the war between Russia and Ukraine, with an increasing price of fuels in Europe that now is trying to find a solution for an energy independency from Russia.

Nowadays, the buildings certificated LEED are recognized all over the world for their capability of matching the sustainable architecture principles in reducing consumption that permits to save money during the building's life cycle, minimizing danger emission for the environment and guaranteeing healthy and comfortable spaces for occupants.

The possible levels of certification are four:

- Certified (40-49 points);
- Silver (50-59 points);
- Gold (60-79 points);
- Platinum (80-110 points).

Figure 8: Certification levels and related score
Source: https://www.gbcitalia.org/leed

The kind of target included in the certification are:

- preservation of water sources;
- preservation of biodiversity and ecosystems;
- promote materials sustainability and re-use;
- ensure a better life's quality;
- improve human's heath;
- enhance a green economy;
- fight against climate changes.

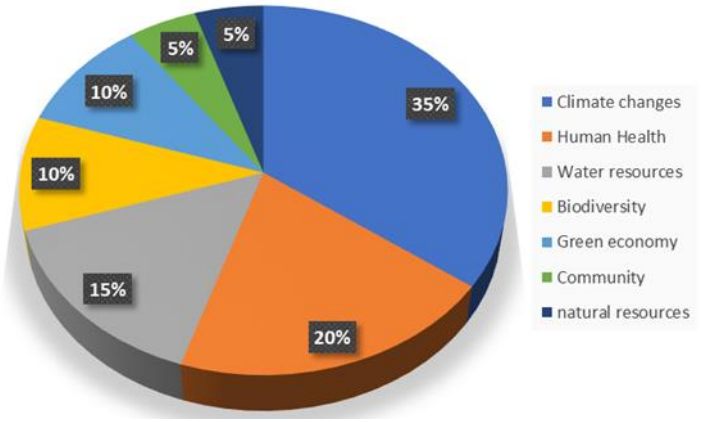


Figure 9: Pie chart of percentage about relevance of thematic given by points
Source: https://www.usgbc.org/

From these targets made by the U.S. Green Building Council, it is clear that the certification system is not focused on just a specific theme, but in general aspects related to the site and the building. In the previous graph there is a percentage that shows the relevance given by credits to each principal theme (Figure 9).

2.1 Rating Systems: LEED v.4 vs V2009

The protocol is continuously updated, one of the main differences between the version 2009 and v.4 is the presence, in the second one, of five new macro-categories (Figure 10). Depending on the project that is going to be certified, a first choice should be done respect to the different rating systems now available:

1) *Building Design + Construction (BD+C),* that is used for new construction or building under major renovation. A further selection should be done depending on:
    - *New Construction:* for new construction or major renovation with envelope and HVAC improvement included;

- *Core & Shell:* exterior shell of new construction, or major renovation, or for mechanical, electrical and plumbing plants but not with an interior complete scheme;
- *Retail:* buildings used for selling products such as shops, bars etc.
- *Schools:* places dedicated to educational purpose*;*
- *Data Centers:* places to store high density computer equipment, such as servers;
- *Hospitality:* buildings for short-term accommodation like hotels, motels etc;
- *Healthcare:* places for long-term care or hospitals that works 24/7;
- *Warehouses and Distribution Centers:* buildings in which are stored products, materials etc;
- *Homes and Multifamily Lowrise:* used for building up to 3 stories single or multi-family;
- *Homes and Multifamily Midrise:* for multifamily residential buldings from 4 to 8 stories.

2) *Interior Design and Construction (ID+C):* used in project that require an internal layout definition and spaces design. It is valid like the previous for Retail and Hospitality, but also for *Commercial Interiors* that are for spaces that differs from the other two functions;
3) *Building operation + Maintenance (O+M):* for building used at least for one year and still fully operative. It is valid for Retail, Schools, Hospitality, Data Centers, Warehouses and Distribution Centers but also for *Existing Buildings* that do not comply in the other categories;
4) *Neighbourhood Development (ND):* used to create sustainable district, they can be new or nearby other buildings completed in the last three years. Can be divided into:
    - *Plan:* for project under early design or under construction;
    - *Built Project:* for already developed projects.
5) *Homes*: used to design of residential buildings of any kinds. It can be Single Homes or Multifamily Lowrise and Midrise.

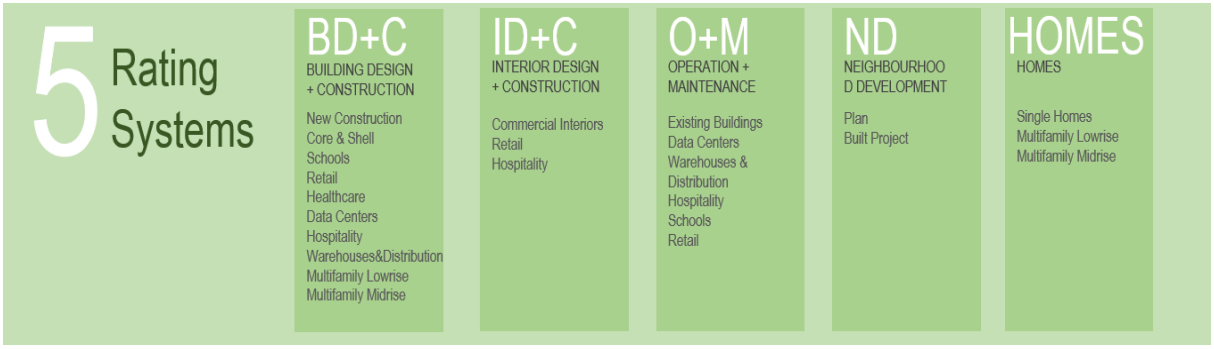
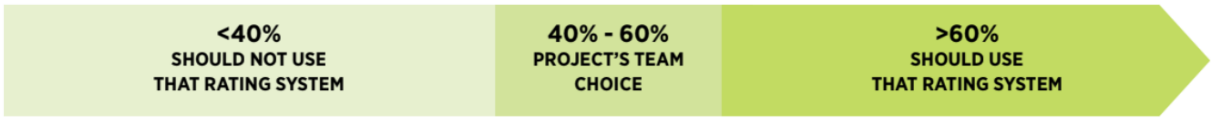


Figure 10: Rating Systems available in LEED v.4

In the update version of LEED (v4.1) there is another rating system called *Cities and Communities*, with a sub-choice between *Plan and Design* or already *Existing* cities and communities.

Since a project can involve different functions, there is a specific rule called "40/60" that helps the team in correctly choosing the rating system. The evaluation considers the percentage, based on square meter of the project, that refers to a rating system. There are three possibilities:

1) If the percentage of that function inserted in a project is less than 40%, its relative rating system is not considered;
2) If the percentage is higher than 60%, its relative rating system has been chosen;
3) If the percentage is in between, it is up to the team to decide.



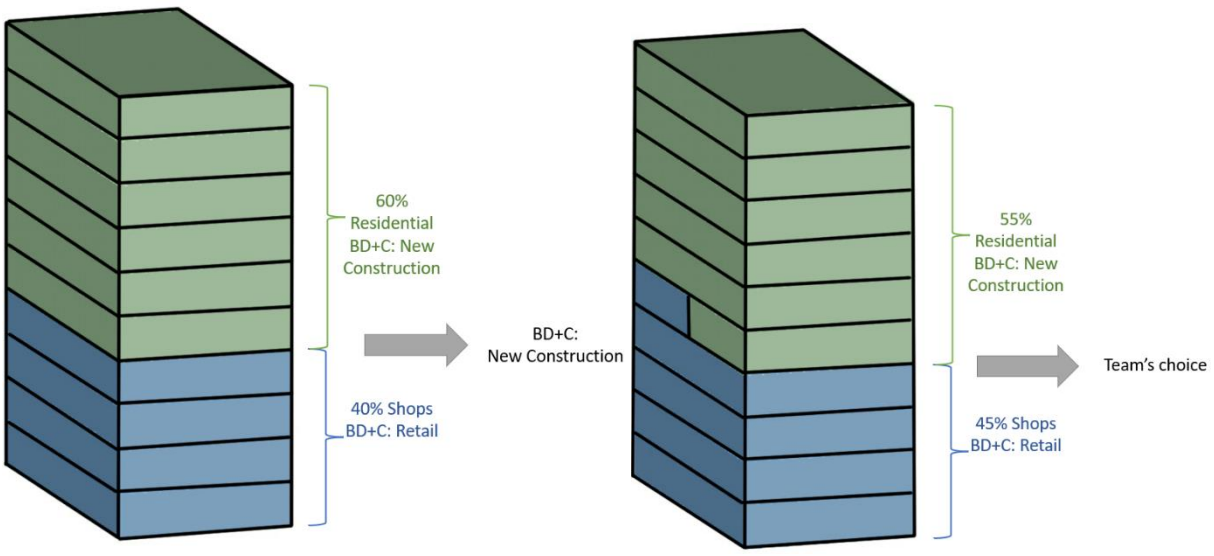


Figure 11: Explanation with schemes of the rating system choice

2.2 Minimum Program Requirements (MPR) and Pre-requisite

The project to be evaluated must match some minimum requirements imposed by the protocol. There are two types of minimum requirements, the first are valid for each type of project and it is fundamental to understand if it is possible to think about an evaluation of the considered structure.

The MPR are:

- the structure must be on a permanent land, because some credits are related to position of the project in the existing environment or calculation about solar exposition etc. For example, it is not possible to certify a mobile home;
- the LEED boundary of the project should be reasonable in order to not take advantages by neglecting or adding some areas. An example can be to include inside the boundary an existing public garden to obtain *Open Space* credits;
- the project must have a minimum gross floor area that for new buildings for example is about 93 m^2 and for neighbourhood certification is maximum 2 buildings and about 607 hectares (1500 acres);

The other pre-requirements are typical of each credit, but they are necessary to obtain the certification. In other word for a certain category, it is possible to not reach any credits, but in any case, it is necessary to respect the prerequisite.

For this reason, once the general minimum requirements are satisfied, the team must ensure to respect the existing prerequisite of each credit category and, after that, there is a study to understand what credits and how it is possible to obtain them proceeding with the certification process.

2.3 LEED Credit Categories and Scorecard

In order to certify a building, an analysis of reachable credits should be done; credits are divided into nine different categories, the number of requirements for each category can vary, and also the credits that it is possible to obtain for each requirement can be different. As told previously, in LEED v4 the categories are nine, four more than the old version of 2009 (Integrative Process, Location and Transportation, Innovation and Regional Priority).

- ***Integrative Process****:* the credit leads the member of the team to collaborate with each other in order to achieve a better result from an environmental and energy performance point of view, but also human's wellbeing. The process of construction should be integrated since the early stage of design; the credits try to "push" the team in continuous contact with all members in order to find together some cost-effective solutions. The different disciplines involved in a standard construction project work together with synergy in order to reduce further problems typical of construction sites and that usually increase time and costs due to some changes or interaction problems between different sectors.

- ***Location and Transportation****:* the credits involved in this category reward the construction in places already developed and anthropized to not waste other money and land for new connections such as street network, bicycle networks, services, utilities like electricity, water, gas etc. It encourages places well connected with public transport in order to reduce the use of cars diminishing the greenhouse gases emissions, or presence of bicycle networks creating parking for bicycle in building's open spaces.

- ***Sustainable Sites****:* the category focuses its attention on the environment around the building, trying to protect the ecosystem and protecting biodiversity. The credits reward the reduction of the heat island effect without the usage of dark materials, or reduction of light pollution to the public streets. It promotes a minimum area of open spaces that must be vegetated to reduce also, the runoff effect during rainy days.

• ***Water Efficiency****:* the category uses the "efficiency first" approach to reduce water wasting looking at water indoor and outdoor use and its metering. Fundamental in this part is the occupancy calculation to estimate water consumption but also the possibility to install systems that recover rainy water for non-potable uses.

• ***Energy and Atmosphere****:* the credits involved in this part of the protocol are assessed to reduce the usage of oil, coal and natural gases because they are responsible of greenhouse gases emissions but also, they are non-renewable. The high performances could be obtained with some technical systems like high-efficient HVAC systems but also with integration of on-site renewable energy production with photovoltaic panels (for example) but also with studies on the orientation of the building to take benefits from solar light and heat.

• ***Materials and Resources****:* the credits give the priority to the usage of materials respectful of the environment with particular attention on performance of materials and the resources necessary to their production. In this part a LCA (Life Cycle Assessment) calculation is involved to consider not just the resources used for a material production, but all the involved processes, from extraction of resources to produce it until its end of life.

• ***Indoor Environmental Quality****:* in Green Buildings also the quality of life and people's comfort inside the structure is fundamental; for these reasons credits in this part encourage the design team to implement some measures for thermal, acoustic and visual comfort.

• ***Innovation****:* the protocol can't be updated to all new technologies that's why it gives the possibilities to use them even if they are not considered in other credits, but the team must provide all the necessary documentation. Other points are assigned for exemplary performances (usually with stricter limits) and the presence of a LEED AP that coordinates the process.

• ***Regional Priority***: the credit encourages the team to follow some necessities that are important for the environment and public health; obviously the team must provide documentation to certify that they are helping public institutions to reach a specific target.

The number of points that is possible to obtain for each credit differs from one category to another, but also there is a different distribution of points depending on the rating system that it is selected considering the characteristics of the projects.

The following image represents the Scorecard for LEED BD+C New Construction that is the one used for the projects of our case studio. This table, given in an Excel format by LEED Online, is the starting point of the process of certification. For a Pre-Assessment, the LEED AP (professional figure responsible of the process) can study the early design of the building and select what kind of credits can be easily obtained and the ones more complicated. Obviously, there is an evaluation of what is the owner target and the monetary budget needed to satisfy some credits requests. In this way it is possible to coordinate the different responsible of the construction sectors in what it is necessary to change or implement in the project design.

LEED v4 for BD+C: New Construction and Major Renovation
Project Checklist

Project Name:
Date:

Y	?	N			
			Credit	Integrative Process	1

0	0	0	**Location and Transportation**		16
			Credit	LEED for Neighborhood Development Location	16
			Credit	Sensitive Land Protection	1
			Credit	High Priority Site	2
			Credit	Surrounding Density and Diverse Uses	5
			Credit	Access to Quality Transit	5
			Credit	Bicycle Facilities	1
			Credit	Reduced Parking Footprint	1
			Credit	Green Vehicles	1

0	0	0	**Sustainable Sites**		10
Y			Prereq	Construction Activity Pollution Prevention	Required
			Credit	Site Assessment	1
			Credit	Site Development - Protect or Restore Habitat	2
			Credit	Open Space	1
			Credit	Rainwater Management	3
			Credit	Heat Island Reduction	2
			Credit	Light Pollution Reduction	1

0	0	0	**Water Efficiency**		11
Y			Prereq	Outdoor Water Use Reduction	Required
Y			Prereq	Indoor Water Use Reduction	Required
Y			Prereq	Building-Level Water Metering	Required
			Credit	Outdoor Water Use Reduction	2
			Credit	Indoor Water Use Reduction	6
			Credit	Cooling Tower Water Use	2
			Credit	Water Metering	1

0	0	0	**Energy and Atmosphere**		33
Y			Prereq	Fundamental Commissioning and Verification	Required
Y			Prereq	Minimum Energy Performance	Required
Y			Prereq	Building-Level Energy Metering	Required
Y			Prereq	Fundamental Refrigerant Management	Required
			Credit	Enhanced Commissioning	6
			Credit	Optimize Energy Performance	18
			Credit	Advanced Energy Metering	1
			Credit	Demand Response	2
			Credit	Renewable Energy Production	3
			Credit	Enhanced Refrigerant Management	1
			Credit	Green Power and Carbon Offsets	2

0	0	0	**Materials and Resources**		13
Y			Prereq	Storage and Collection of Recyclables	Required
Y			Prereq	Construction and Demolition Waste Management Planning	Required
			Credit	Building Life-Cycle Impact Reduction	5
			Credit	Building Product Disclosure and Optimization - Environmental Product Declarations	2
			Credit	Building Product Disclosure and Optimization - Sourcing of Raw Materials	2
			Credit	Building Product Disclosure and Optimization - Material Ingredients	2
			Credit	Construction and Demolition Waste Management	2

0	0	0	**Indoor Environmental Quality**		16
Y			Prereq	Minimum Indoor Air Quality Performance	Required
Y			Prereq	Environmental Tobacco Smoke Control	Required
			Credit	Enhanced Indoor Air Quality Strategies	2
			Credit	Low-Emitting Materials	3
			Credit	Construction Indoor Air Quality Management Plan	1
			Credit	Indoor Air Quality Assessment	2
			Credit	Thermal Comfort	1
			Credit	Interior Lighting	2
			Credit	Daylight	3
			Credit	Quality Views	1
			Credit	Acoustic Performance	1

0	0	0	**Innovation**		6
			Credit	Innovation	5
			Credit	LEED Accredited Professional	1

0	0	0	**Regional Priority**		4
			Credit	Regional Priority: Specific Credit	1
			Credit	Regional Priority: Specific Credit	1
			Credit	Regional Priority: Specific Credit	1
			Credit	Regional Priority: Specific Credit	1

0	0	0	**TOTALS**	**Possible Points: 110**

Certified: 40 to 49 points, **Silver:** 50 to 59 points, **Gold:** 60 to 79 points, **Platinum:** 80 to 110

Figure 12: Scorecard LEED v4 for BD+C: New Construction
Source: https://www.usgbc.org/

The widespread application of the LEED protocol also induced the formation of new professional figures such as:

- ***LEED AP (Accredited Professional),*** is someone that has followed a course and has passed the relative exam. It is a figure that knows the certification procedure and its updates; it manages and coordinates the design and construction phase to reach the requisite necessary for a credit;
- ***Commissioning Authority,*** it is the referent for the client, it must pass an exam and be in a professional register. It controls all the choices and verify that the design complies the client need. It is fundamental to have this figure since the beginning in order to speed up the process and to have an effective confrontation during the different project phases. This figure can be also supported by the ***Commissioning Agent*** that works with the authority to verify the correct advancing of the project;
- ***TAB Responsible (Testing, Adjusting, Balancing),*** that controls a three steps process to validate the correspondence of the system with design conditions. It tests all the characteristics of the implants such as air flow or temperature etc, then adjusts them and, in the end, balances the system to reach the desired performance.

2.4 Certification Steps

To certify a building, some steps need to be followed:

1) ***Pre-Assessment***: in this phase the whole project is analysed to understand the feasibility of reaching a certain level of certification by evaluating the Minimum Program Requirements, the pre-requirements of each category and studying the economic and project possibility to obtain some credits.
2) ***Online Registration***: if the owner is satisfied about the possible LEED certification level, the process continues with the registration of the project in "LEED Online" platform by paying a fee to the GBCI. The LEED AP will control and prepare all the further documentation also produced by other team members.
3) ***Application for Design review***: the LEED AP upload on the interface of LEED Online the documentation for design pre-requisite and credits to be evaluated. It is possible to also ask some further explanation in case of project problems.
4) ***Preliminary Design Review and Response***: when all the documents are present, credits can be evaluated by the GBC that gives a preliminary evaluation.

5) ***Final Design Review Decision***: it is a phase where all the design documentation is revised.
6) ***Application for Construction review***: in this phase there is the upload of all the documents needed for credits related to the construction phase;
7) ***Preliminary Construction Review and Response***: after the upload of all the documentation, the revisor provide a preliminary evaluation;
8) ***Final Construction Review Decision***: final phase of evaluation for the construction credits.

There is a table on the LEED manual that specify clearly the credits to submit in design phase and the ones in construction phase. Once all documents are correctly loaded and revised, a LEED Reviewer does a final check and asks for the certification. In the end, the USBC will provide an official certification based on gained points.

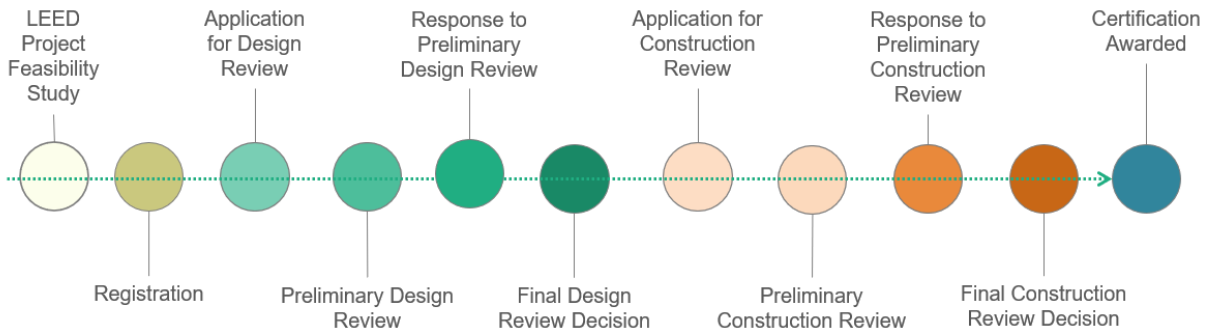


Figure 13: Path for a LEED split review

The already explained passages are part of the so called "Split Review" where the evaluation of pre-requisites and credits are divided into two different moments: design and construction phase. But this is not the only option, indeed, it is possible to follow the path of the "Combined Review", where all the documentation related to both design and construction are evaluated in the end. This is a riskier choice because once the construction is realized, most of the aspects can't change and it is possible to reach a level less than expected or no certification at all if a pre-requisite is not satisfied. On the other hand, the split review gives the possibility to check if a credit is earned or not during the design phase and this leads to possible changes in the project. This is the key concept of the thesis: highlight how the LEED protocol should be used as a tool for the project design, and not just a secondary evaluation of sustainability at the end of the entire process. Potentially, this process makes it feasible to reach the level requested by the client without any surprise, so it is the safest procedure to follow. In some cases, the split

review is not applicable due to an already development stage of a project, for this reason they also create the combined review, with all the difficulties arising therefrom for the LEED AP.

2.5 Benefits related to LEED

Some surveys highlight that people spend 90% of their time in indoor spaces such as: houses, offices and transport methods. For this reason, it is fundamental to create spaces as healthy as possible for occupants. Instead of standard buildings, the ones certificated LEED ensure better performances and characteristics thanks to parameters that are more rigorous with respect to construction civil norms.

Among the main benefits that derives from the certification there are three macro-categories:

1) Reduction of the environmental impact; there are some credits that come from the localization of the site: presence of cycling road, bus stops, underground, services or moreover reclamation of the areas from substances and choices of low-emitting materials;
2) Improvement of performances and reduction in consumption; to increase people's comfort there are credits related to thermal, acoustic and visual well-being with strict requisites. Increasing efficiency, it is possible to limit consumes and save money. Reducing natural sources for the operativity of the building means a minimization of environmental impact as the previous category of benefit.
3) Relevance on market; a LEED certificated building is more attractive for investors, so it is easier to sell or rent with a higher price thanks to a heavy demand.

However, the flip side of the coin is also present and it is due to the costs for getting a certification. Obviously to obtain the LEED certification the owner should consider:

- Costs of professional figures that lead to a LEED Pre-Assessment to verify the feasibility of reaching a specific LEED level, costs to modify the preliminary design with solutions that give credits and for the document preparation;
- Bureaucratic costs imposed by GBC, that are necessary to obtain the certification;
- Costs of particular technical solutions to reach some credits like: raining water management, energy efficiency or ventilation etc.

Other surveys show that during the early design many people are worried about using particular systems or technology for a higher energy efficiency due to their initial costs; the problem is that a short-term investment is mostly evaluated and not the long-term benefits of these technologies. An example of an economic evaluation related to the application of specific sustainable systems in buildings, with particular attention on economic incidence of the certification, it was based on 200 LEED buildings located in America.

The research includes a cost-benefit analysis that tries to understand if it is convenient or not to spend more money to certify a building or to do it with traditional technique. It selects 200 LEED structures with their relative costs of construction given by documentation of U.S. Green Building Council and, at the same time, these costs were than compared with traditional methods. The data consider different correction factors, such as place and year of construction in a statistic way.

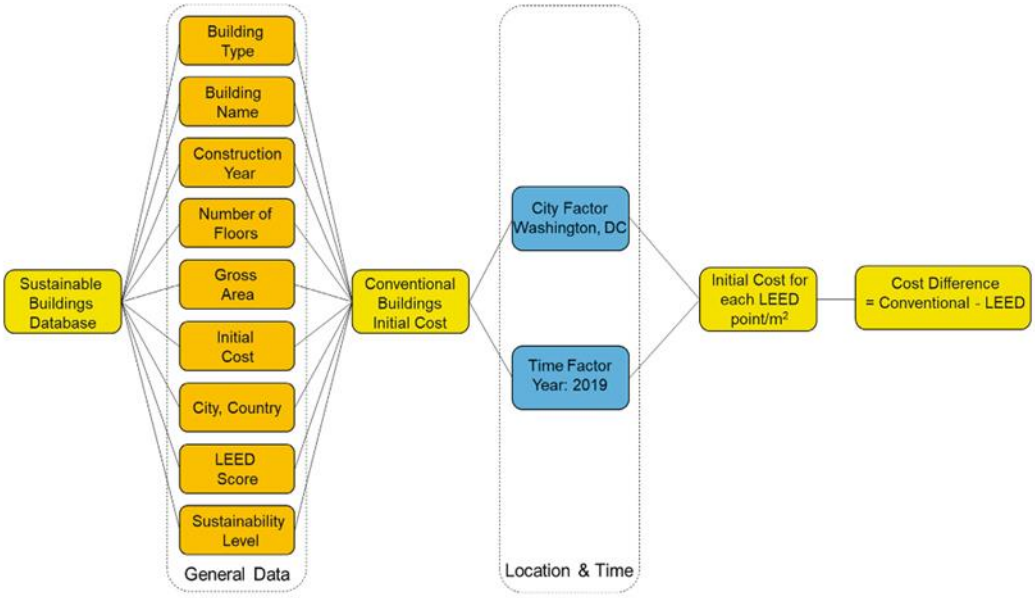


Figure 14: scheme about economic calculation of cost difference for LEED project
Source: Initial cost assessment stochastic model for green buildings based on LEED score, Energy and Buildings, Volume 245, 2021

The analysis also divides the data in different categories depending on:

- the building's function: commercial, educational or residential sector

- the level of certification: Certified, Gold, Silver and Platinum.

Comparing standard initial costs and the LEED ones, the cost premium of LEED score is calculated as in the graph above; data results are summarised in the table below.

Statistics	Green Commercial Buildings				Green Educational Buildings			Green Residential Buildings	
	Certified(CCB)	Silver (SCB)	Gold (GCB)	Platinum (PCB)	Certified(CEB)	Silver (SEB)	Gold (GEB)	Gold (GRB)	Platinum (PRB)
Mean	7.24	9.22	6.28	9.54	12.9	14.65	9.41	5.13	3.90
Median	8.03	5.69	4.77	6.61	8.94	13.43	6.52	4.24	2.53
Mode	9.40	2.57	2.74	0	0	11.44	0	–	1.06
Standard Deviation	4.80	11.83	5.40	9.54	12.90	6.94	9.41	3.58	4.58
Variance	23.03	139.89	29.17	90.96	166.41	48.14	88.52	12.80	20.96
Skewness	−1.14	7.46	3.21	2	2	1.14	2	0.31	5.14
Kurtosis	5.40	181.97	25.71	9	9	5.40	9	1.49	72.75
Coeff. of Variability	0.6628	1.28	0.85	1	1	0.47	1	0.69	1.17
Minimum	∞	1.10	0	0	0	∞	0	1.14	0
Maximum	∞	∞	∞	∞		∞	∞	10.64	∞
5th percentile	−1.7	1.89	1.40	0.49	0.66	5.51	0.48	1.14	0.55
50th percentile	8.03	5.69	4.77	6.61	8.94	13.43	6.52	4.24	2.53
95th percentile	13.51	27.68	16.20	28.57	38.64	27.51	28.19	10.60	11.69

Figure 15: statistical results for cost premium of LEED scores square meter for different building types

Source: Initial cost assessment stochastic model for green buildings based on LEED score, Energy and Buildings, Volume 245, 2021

The best data, considering the "mean" (costs) and the "standard deviation" ("risk"), is recorded for residential sector with a Platinum certification with a 3,90 $/m^2$ for each LEED point; considering that to reach a Platinum, 80 points minimum are required, the increase of construction cost is about 312 $/m^2$ respect to a traditional one.

Considering the costs during the building life cycle, the research underlines that despite the higher initial investments, during the years significant quantity of money are earned thanks to the energy saving making the investments feasible. This kind of economic evaluation should become the starting point of a project, in order to demonstrate to the client the convenience of a long-term investment and also to help the professionals to reach a reasonable level of certification from the cost-effectiveness point of view.

2.6 LEED at present: analysis of data

Applying sustainable principles in design and construction phase could not be easy and that's why during the past few decades, many certification systems have been developed to provide some rules and instruments to designers.

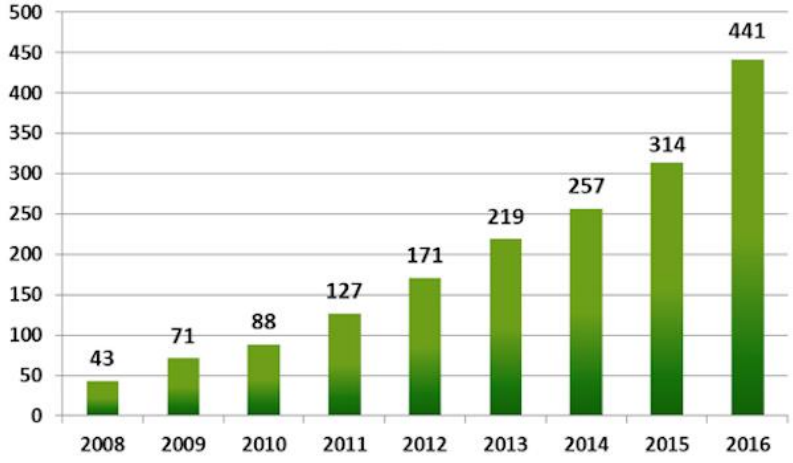


Figure 16: chart of registered project, GBC Italy 2016
Source: http://2016.gbcitalia.org/news/1073?locale=it

As told before, the LEED certification is one of the most used also in Italy, and it registered a rising trend of interests during the years: as shown in Figure 16, the number of registered projects in 2016, is about ten times higher than 2008 (data from GBC Italy).

On the Italian GBC website it is possible to download an Excel file with data related to the number of buildings that are already certified and others that are not yet certified, but already registered as LEED project to be evaluated when the documentation will be complete.

The file provides some information such as: project's location (city, region, address), the LEED rating system adopted, its related points and level of certification, gross surface area. Not all the data for all the projects are available, indeed, some information are reserved and not specified.

Actually (data related to December 2021), in Italy there are 215 certified buildings and 529 registered projects, 88 new ones respect 2016 data. In the pie chart below it is summarised the number of projects for each LEED certification level.

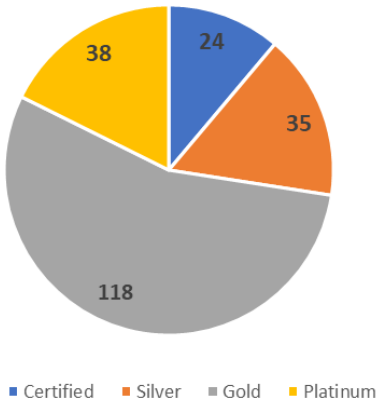


Figure 17: Pie chart of certified projects number for each level

As it is possible to understand, the majority reached the Platinum or Gold level, with 38 and 118 certified buildings respectively, that represent a higher degree of sustainability in the construction processes.

A further investigation has been conducted to understand where these projects are located in the Italian territory. By simply using the file, a graph has been realized to divide the number of buildings in their relative region and considering the certification level obtained (Figure 18). Analysing the chart, it is evident that most of the certified buildings are in North of Italy with just some exceptions such as *Abruzzo*, *Campania*, *Lazio* and *Toscana* in middle Italy, with 40 projects, and *Puglia,* with just 2 examples for the South. In the North, there is *Lombardia* and *Trentino* with 86 and 38 edifices respectively that represent the bigger numbers, but also structures in *Piemonte*, *Friuli* and *Veneto* are present. It should be noted that for 5 cases is not possible to understand where they are located due to a lack of data (Table 1).

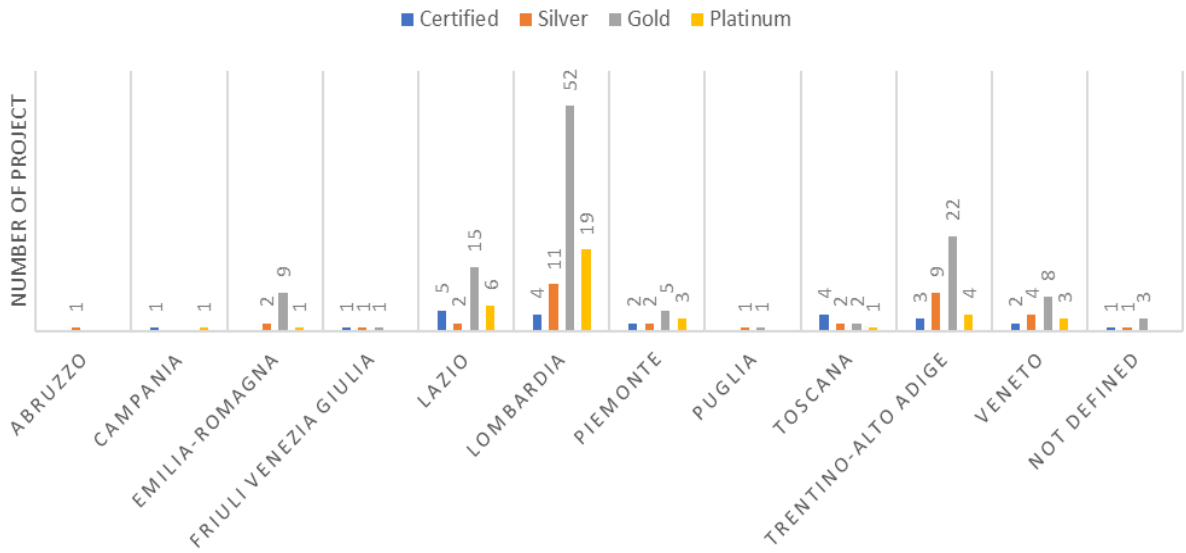


Figure 19: Graph of certified projects number for each level in Italian Regions

Region	Number of Projects	Gross Surface Area [m²]
Abruzzo	1	6.399,00
Campania	2	1.717,00
Emilia-Romagna	12	62.108,00
Friuli Venezia Giulia	3	17.125,00
Lazio	28	250.049,00
Lombardia	86	1.397.110,00
Piemonte	12	491.674,00
Puglia	2	688,00
Toscana	9	7.119,00
Trentino-Alto Adige	38	166.171,00
Veneto	17	678.718,00
Not defined	5	/
Total	215	3.078.878,00

Table 1:Summary table for each Region

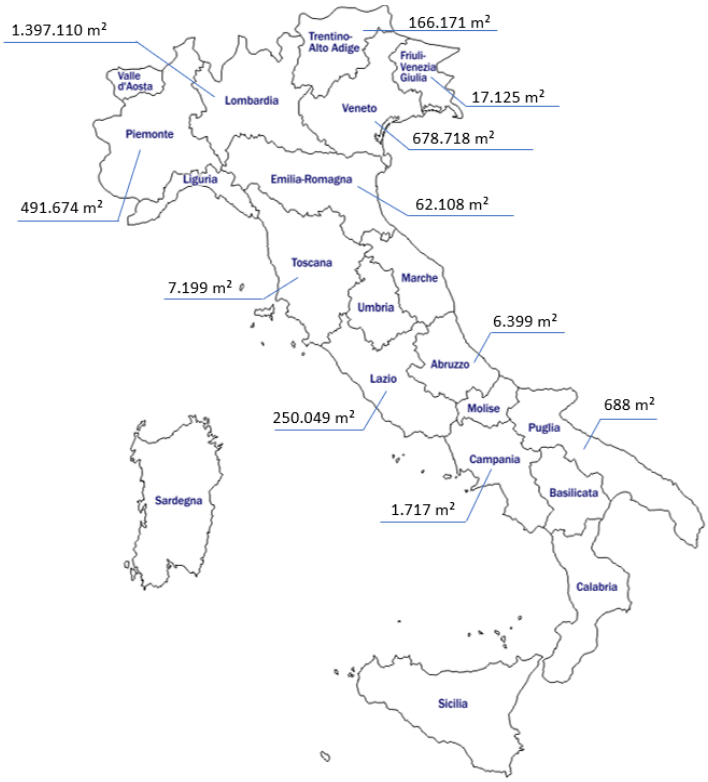


Figure 18: Gross surface floor area of certified projects

In Figure 19 there is the distribution of certified gross surface area of projects for each region. Analysing the data, some discrepancies can be noticed: for example, Piemonte and Veneto have more square meter respect to Lazio or Trentino, even with fewer number of certified projects. There could be two principal explanations: the first is that in some cases, region have not declared the gross surface area for some projects, so the gap could be smaller in reality. The second is that the table considers different projects, certified with different rating systems and this means that for example, a region could have less projects but related to a Neighbourhood rating system that involves bigger areas respect to another one with Retail rating system projects that involve fewer square meters.

2.7 Examples in Turin

The following examples in the city of Turin are considered to evidence the importance of the LEED protocol for the sustainable design of new entire buildings such as the *Intesa San Paolo Skyscraper* but also for intervention on historical building like *Palazzo Novecento*, considering the large amount of Italian historical patrimony and the need to improve the energy efficiency of ancient protected building.

Intesa San Paolo Skyscraper

Intesa San Paolo Skyscraper is one of the most important works realized in Turin and it was the one that obtained a double LEED Platinum certification for the categories of *New Construction* and *Operation and Maintenance*. The building is alimented only with certified renewable sources and 1600 m^2 of photovoltaic panels installed on the south façade (Figure 20); at east and west there are two double-skin façades (Figure 21) that let the sunrays enter in the cavity to mitigate the temperature in winter and, in summer, avoid the overheating with openings.

Figure 20: External view façade of Intesa San Paolo Skyscraper
https://www.mark-up.it/grattacielo-intesa-sanpaolo-doppia-certificazione-leed-platinum/

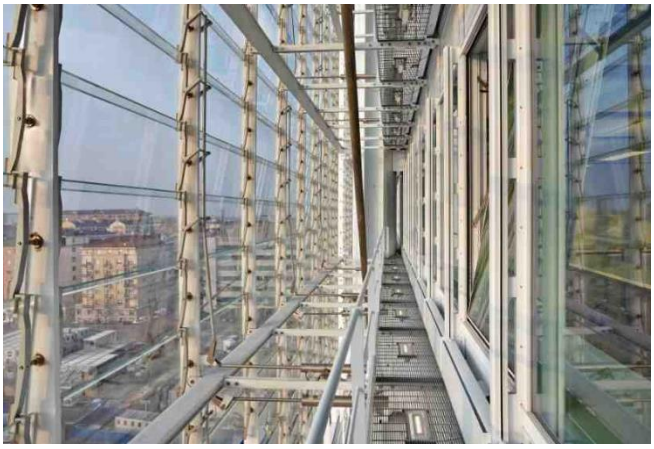


Figure 21: View of the doule-skin façade
Source: https://www.conteco.it/it/torre-intesa-sanpaolo

Systems for rainwater collection and re-usage for non-potable purposes are also present. The lighting system is made up of about 80% led, with a control system capable to adapt the intensity depending on the presence of natural light and number of occupants.

Palazzo Novecento

Palazzo Novecento is another example of LEED Platinum certification in Turin. In this case the work made by designers, engineers and architects represent the first example of certificate in Homes Multifamily Midrise. This is a residential palace with 47 units realized in 1930 and it has an architectural relevance because it is considered an example of the rising Rationalism Movement (Architects: Gino Levi-Montalcini and Giuseppe Pagano).

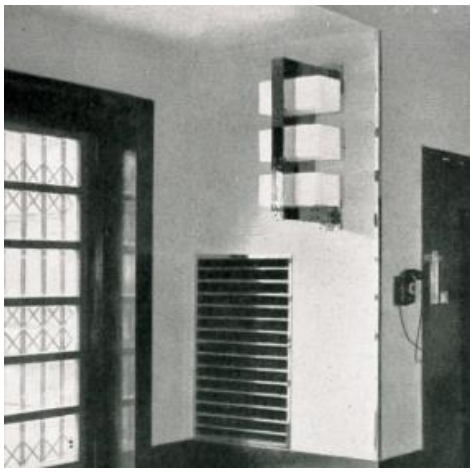


Figure 22: Old image of Palazzo Novecento Hall
Source:http://www.baiettobattiatobianco.com/portfolio_page/palazzo-novecento/

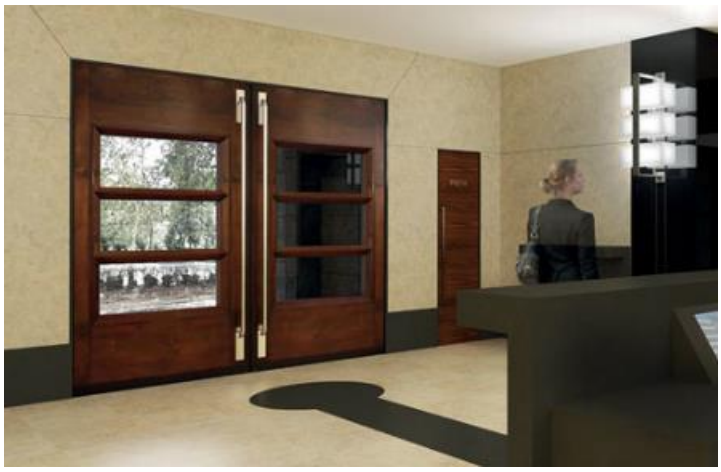


Figure 23: Render of internal hall renovation
Source: https://www.palazzonovecento.com/

The complexity of the intervention is to obtain high energetic and sustainable standards by working on an existing structure that should also maintain its aesthetic characteristics.

The renovation involves the usage of high-performance insulating materials, centralized implant for heating and cooling, a mechanical ventilation system and a photovoltaic system on the roof. The internal design of the houses was realized following the zero emission and recycling principles. It should be also mentioned the attention on some elements of internal design, typical of the buildings, that were modified to be reused in the actual structure, such as the lamps of common spaces, that were adapted to led system without changing the aspects of the first design of places.

3. Case studio: two buildings used as Students Residences

The next chapters of the thesis are going to focus on two different cases studio: the first is located in *Torino* and it is a complex with two different buildings functioning as a students residence; the second one is a high-tech logistic centre for the distribution of products nearby *Mantova*. These two cases studio has been selected to apply the protocol in order to compare them and highlight differences:

- the two buildings due to diverse functions and inevitably different location, one nearby the city centre and the second at 5 km from the city, oblige to apply different Rating System, because even if the industrial one is a New Construction, the related rating system is Warehouse & Distribution Centers. This implies some different wight of points for some credits and/or some different requirements to obtain them.
- The case of the students residence complex is made up of two buildings, the LEED certificate has been considered as one for all the constructions (Group Approach of the protocol). For this reason, in some credit the evaluation is longer due to consideration of worst case between the two.
- The different location, function and dimension of the two projects involved make it interesting to analyse the possible technical choices applicable to reach some credit points.
- There is a diverse management of the projects that make it easier or more complex the process of certification and the coordination activity of the LEED AP.

This comparison lead to further consideration on how can be important to implement protocols, such as LEED, for the usual design and construction of buildings. More specifically, following some guidelines provided by the Green Building Council a comparison between CAM Italian law (*"Criteri Ambientali Minimi"*) and protocol's credits requirements involved in this thesis. This gives the opportunity to understand the possibility of using the LEED protocol as an instrument to also satisfy the criteria of CAM with some integration, where necessary, guaranteeing the quality of the final project.

The first project being studied is part of a requalification plan of a zone located in Turin, not so far away from the city centre; during the years, many projects and ideas have been developed, but they have never led to anything. By now, a new project has been accepted by the public administration and the administrative procedures, to realize this intervention, have already started. Since it is an oncoming project, some specific data or analysis are sensible, this is the

reason why the propriety gives the opportunity to use them without mentioning the name of specific location or companies involved in the project.

The area of interest was built at the end of '800 as a support space for the near railway station. During the years the area has been used as goods yard, repair spaces or train elements storage. After that, the zone has been bombed during the World War II with consequently several damages and now it is in a complete state of decay, that's why a requalification is needed.

Figure 24: Project's area of interest

The land that will be used for the project is part of a bigger area that is almost abandoned from years. The Figure 24 is an orthophoto, where in the red is indicated the land involved in the project.

Inside the area, there are four old and abandoned buildings that are going to be demolished. After the realization of the project, there will be three buildings (Figure 25[1]):

- a five-storey student residence with the main façade on "Corso YY"; [2]
- an eight-storey student residence with the lateral façade on "Via XX",
- a one storey shop area with an underground parking.

As it is possible to understand from the Sheet_01.D the building B on Corso YY is at the end of a little bridge of connection of two city zones and the quote of the ground are different respect to the building A. In the Sheet_01.D it is represented the plan with functions of the fourth floor for the building A that correspond to the second floor on the other one.

[1] Little discrepancies could emerge respect to renders of Sheet_01.D that correspond to a preliminary design
[2] The owner didn't allow to publish the complete location information

In the building A, at fourth floor, there are students' rooms principally. While the second floor of building B correspond to the principal entrance of the residence so there are other functions such as: study rooms, gaming room, gym and a common kitchen (Sheet_02.D).

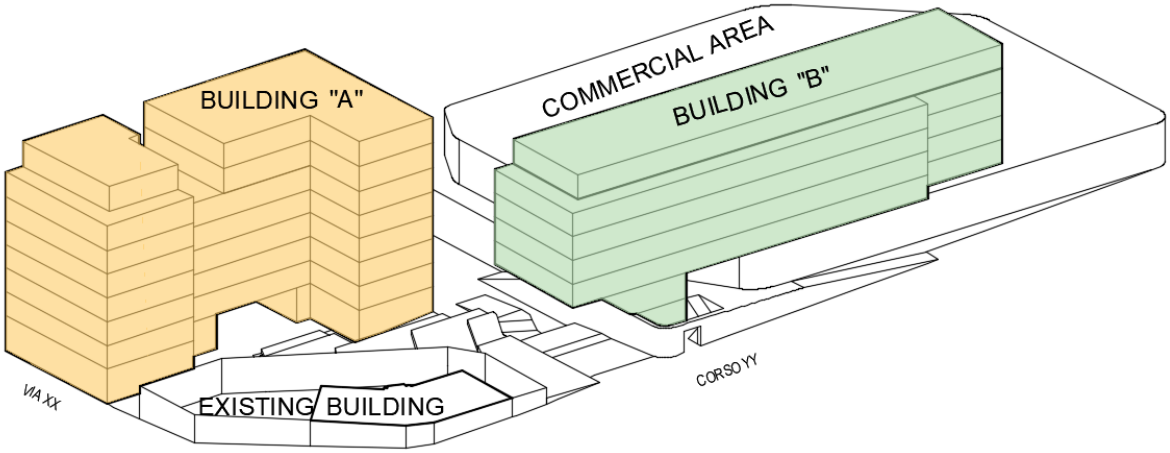


Figure 25: Axonometry of the future development of the area

The client decided to do a Pre-Assessment of the project in order to obtain the LEED Gold level. In this phase the shop area and its relative underground parking are not taking into account, since the client has decided to certificate just the two students residences. As it is visible in Sheet_01.D the LEED boundary is highlighted, considering just the two buildings and the connecting open space in between. This is a precise operation because this evaluation will have some specific consequences on some future credit calculations. Since the state of the project is at design phase, the rating system adopted is LEED BD+C New Construction and the Split Review will be done considering first all the credits connected to the design phase and then the ones related to the construction phase. There are two buildings in the interest area, so, there are two choices:

1) Group Approach: that allows buildings with similar functions, that are in the same location, to be considered as one. That's means a single certification for both the buildings and credits must be verified considering the worst situation between them.
2) Campus Approach: that allows to obtain a certification for each building in the area, checking the credits for each of them, so it requires a higher amount of documentation to be prepared.

The team's choice, in accordance with the client, is to consider the Group Approach.

3.1 Location and Transportation (LT) category

This category of credits, in the used rating system, can reach in total sixteen points. There are two possibilities to obtain them, the first is to build our building into the boundary of a project certified as LEED for Neighbourhood Development; the points earned depend on the type of rating system adopted by the already existing project and its LEED level. The Table 2 represents the distribution of points:

Certification Level	Points BD+C	Points BD+C (Core and Shell)	Points BD+C (Schools)	Points BD+C (Healthcare)
Certified	8	8	8	5
Silver	10	12	10	6
Gold	12	16	12	7
Platinum	16	20	15	9

Table 2: LEED distribution of obtainable points

The second method of evaluation divides the 16 points into different credits, and it is used when our building can't be located into a LEED for Neighbourhood Development project. Since our renovation area is not included in any existing LEED Neighbourhood project, other credits will be evaluated and described better in the next chapters.

- ***Sensitive Land Protection***

The credit intent is to induce the team to develop the project in a non-sensitive land, reducing the environmental impact of the new construction.

There are two option that can be prosecuted, the one considered in this case states that the project must be located on a previously developed land. For definition the protocol considers previously developed, a land: *"altered by paving, construction, and/or land use that would typically have required regulatory permitting to have been initiated (alterations may exist now or in the past). Land that is not previously developed and landscapes altered by current or historical clearing or filling, agricultural or forestry use, or preserved natural area use are considered undeveloped land"*[3].

The considered site was already developed as functional spaces for the trainline that is nearby, there are also some old buildings that are going to be demolished.

[3] LEED glossary: https://usgbc.org/glossary#previously-developed (05/05/2022)

By looking at the PRG of Turin (Figure 26) the area is considered as "urban transformation area": an existing urban area characterized by the presence of unused buildings and where it is possible to proceed with interventions at urban and building scale. So, one point is gained.

Figure 26: PRG of Turin

- ***Surrounding Density and Diverse Uses***

The aim of the credit is to encourage the construction on already developed areas with existing infrastructure, to promote different and greener methods of transportation. The credit gives the possibility to obtain 5 points in total, divided into two different evaluations.

For the ***Surrounding Density*** calculation, the project's LEED boundary should be increased with an offset of about 400 meters. Then the calculation considers the ratio between all the GFA (Gross Floor Area) of each building and the sum of the buildable area of each block. The protocol provides the Table 3 where the first column is used where no distinction between residential and non-residential functions is considered.

Combined Density	Separate Residential and Nonresidential Densities		Points BD+C (except Core and Shell)	Points BD+C (Core and Shell)
Square meters per hectare of buildable land	Residential Density (DU/hectare)	Nonresidential Density (FAR)		
5 050	17.5	0.5	2	2
8 035	30	0.8	3	4

Table 3: LEED points for surrounding density

Figure 27: Buildable areas of each block

Thanks to some files available on the Geoportal of Turin, an AutoCAD file has been realized to select the buildable land area (Figure 27) and the gross floor area of the buildings for each block (Figure 28) that must be multiplied by the existing number of floors. The Figure 28 is just a zoom to represent what has been realized on the AutoCAD file, so the whole representation is at the Annex 02 where just the building used for the calculation are evidenced and numbered.

In such a way to perform the calculation, an Excel file has been done to know if the limit imposed by the protocol, to gain the credit, is reached.

On the Excel table, represented in the Annex 01, there is:

- The identification number of the building;
- The gross floor area;
- The number of floors of the building.

The file upload the calculation of the above-mentioned ratio every time the data of a building are inserted. For this reason, the calculation stopped after 165 buildings and the result obtained is present below in Table 4. The points obtained for the verification of half of this credit are three.

Buildable Land	348.908,00	m^2
GFA	283.169,00	m^2
Buildable Land	34,89	ha
Ratio	8115,86	m^2/ha
LEED limit	8035	m^2/ha

Table 4: Calculation result

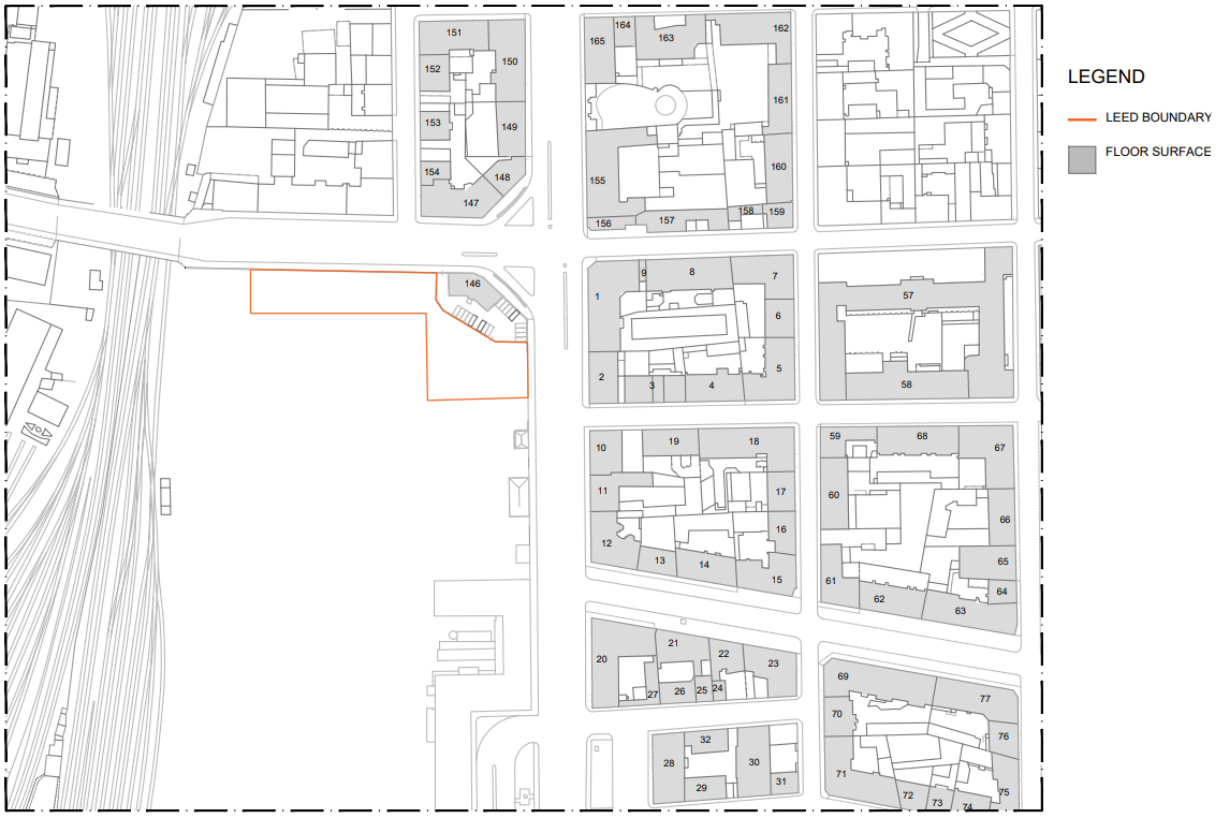


Figure 28: Floor surface of each building

Another check must be done to obtain the other two points of the credit related to ***Diverse Uses.*** The protocol provides a table, to fill, with five categories with some different building functions. It asks to select different functions at maximum 800 m walking distance from the entrance in at least three out of the five categories.

The functions count as one even if there are more, for example, if there are three supermarkets, just one is considered, except for the restaurant where there is the possibility to insert two of them.

In our case studio there are two different buildings, so it is considered the longest distance between the two entrance and the destination. The protocol's table has been modified inserting two columns: "Building" to identify the referring building entrance "A" or "B" and Identification number to associate the name of the service with the number used in the map.

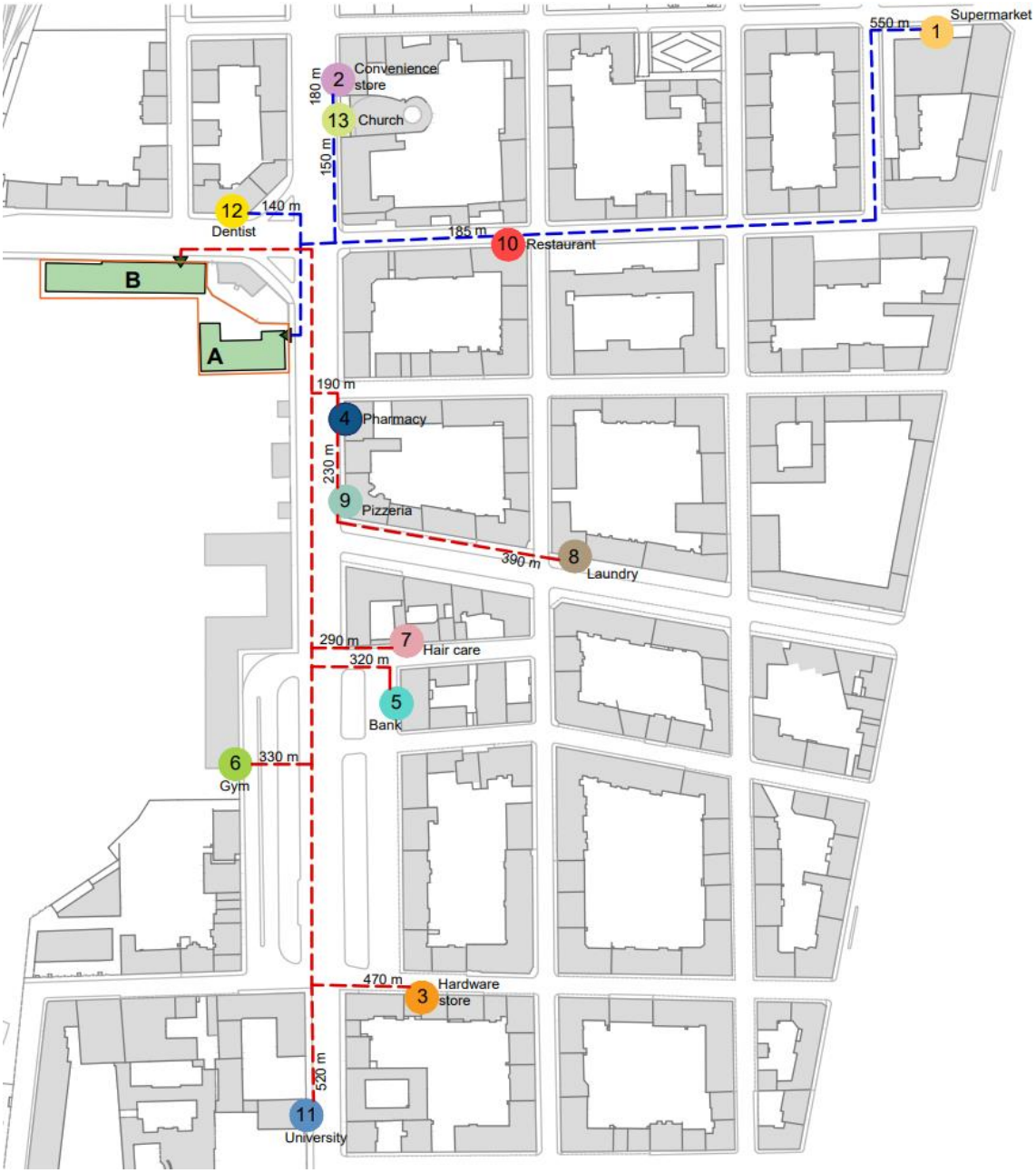


Figure 29: Map of diverse uses

The following image (Figure 29) and Table 5, explain how the distances are considered and what kind of documentation the USBC require to submit the credit review. The research has involved 13 services divided into four categories, so two points are obtained.

Category		Use type	Name	Distance (m)	N. of use	Building	Identification number
1	Food retail	Supermarket	In'S	550	1	A	1
		Grocery with produce section					
2	Community-serving retail	Convenience store	Simpatia CRAI	180	3	A	2
		Farmers market					
		Hardware store	Utinsileria Meccanica Cavallero	470		B	3
		Pharmacy	Farmacia Nizza	190		B	4
		Other retail					
3	Services	Bank	Intesa San Paolo SpA	320	6	B	5
		Family entertainment venue (e.g., theater, sports)					
		Gym, health club, exercise studio	Orange Nizza	330		B	6
		Hair care	Hairstylist Enzo Torino	290		B	7
		Laundry, dry cleaner	Lavasecco	390		B	8
		Restaurant, café, diner (excluding those with only drive-thru service)	Pizza e cozze	230		B	9
			Linea 16	185		A	10
4	Civic and community facilities	Adult or senior care (licensed)			3		
		Child care (licensed)					
		Community or recreation center					
		Cultural arts facility (museum, performing arts)					
		Education facility (e.g., K—12 school, university, adult education center, vocational school, community college)	Università degli studi di Torino-Dipartimento di biotecnologie	520		B	11
		Government ofce that serves public on-site					
		Medical clinic or ofce that treats patients	Polimedical Torino	140		A	12
		Place of worship	Istituto Suore Sacramentine di Bergamo	150		A	13
		Police or fire station					
		Post office					
		Public library					
		Public park					
		Social services center					
5	Community anchor uses (BD+C and ID+C only)	Commercial ofce (100 or more full-time equivalent jobs)					

Table 5: LEED summary table of services

- ***Access to Quality Transit***

The aim of the credit is to locate the new construction in places well connected with the existing public transport system to reduce the usage of cars, motorbike in such a way to guarantee a reduction of pollution and greenhouse gases emission. To perform the calculation, the bus or tramline stop must be at a maximum walking distance of 400 m and 800 m for light or heavy railway stations. There are some other restrictions imposed by the protocol such as:

- the line stop considered must be present in two opposite directions;
- for a certain line just the number of trips in one direction are considered;
- if the same line has more than one stop in the allowable distance, just one can be counted;
- The sum of all the trips of the total number of line stops must overcome some limits in both weekdays and weekend.

In the table 6 there are the different number of trips to obtain up to 5 points.

Weekday Trips	Weekend Trips	Points BD+C (except Core and Shell)	Points BD+C (Core and Shell)
72	40	1	1
144	108	3	3
360	216	5	6

Table 6: Distribution of LEED points respect to public transport trips

The first thing is to verify the presence of bus, tram or underground stops in a range accepted by the protocol. The selected public transport stops are represented in the map below (Figure 30), considering, as previous case, the longest distance from the entrance of building A or B.

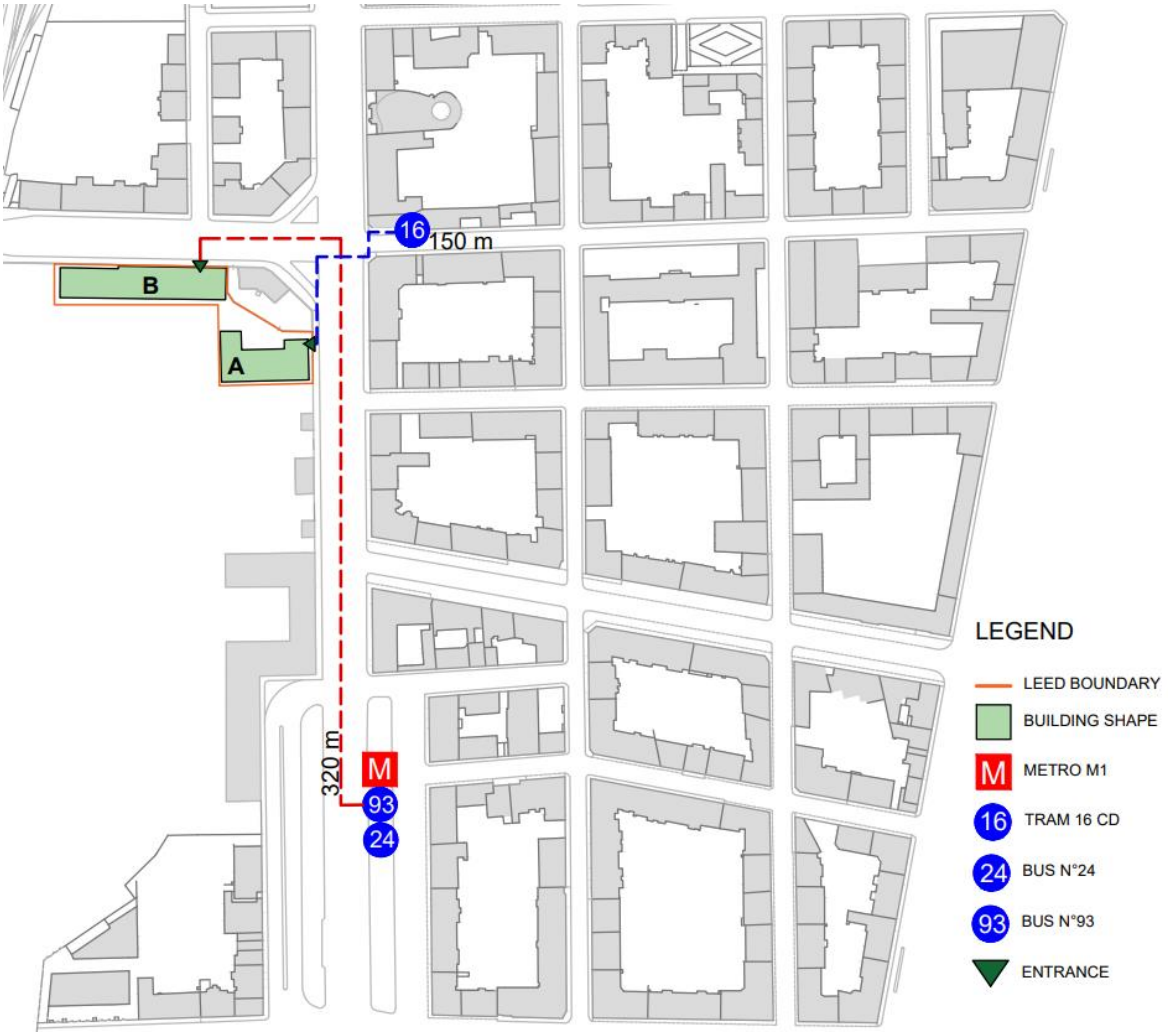


Figure 30: Map of the public transport stops

The evaluation of the number of trips of each line is evaluated with the data provided by the partnership between GTT ("*Gruppo Torinese Trasporti*") and Moovit and the data are collected into the Table 7. Since the protocol also require a minimum limit for the weekend trips, this data is calculated with an average value of the trips during Saturday and Sunday that differs in number. The available public transport is enough to take all the 5 points of the credits.

Unfortunately, other bus stops have a distance a little longer than the limit, so it is impossible to obtain the extra point for the exemplary performance, which impose to double the trips limit.

Line	Weekday trips	Saturday trips	Sunday trips	Weekend trips
M1	343	293	251	272
16 cd	99	86	0	43
93	3	1	0	1
24	7	0	0	0
totale	**452**		**316**	
LEED limit	360		216	

Table 7: Summary table of number of public transport trips

- ***Bicycle Facilities***

The scope of the credit is to reduce the emissions due to the use of motor vehicles and to encourage the physical activity of people. To attempt the credit, the entrance of the building must be at maximum walking distance of 180 m from a bicycle network and using it, people must reach at least ten diverse uses, provided by the protocol's table, with a maximum distance of 4800 m. Other restrictions are present:

- For residential functions, the protocol requires a number of short-term bicycle storage for at least 2,5% of peak visitors (but no less than four for each building) and 30% of regular building occupants (but no less than one for each unit) as long-term storage.
- For commercial functions, such as the offices, it requires a short-term bicycle storage of 2,5% of peak visitors (but no less than four for each building) and a long-term one with 5% of regular building occupants (but at least four spaces per building).

First of all, there is a Municipality's rule: art.82 of the Building Code that impose for a new construction or renovation, to provide the open internal space with bicycle parking considering at least the 1% of the Gross Floor Area of the project. Since the area interested in the project is bigger than the LEED boundary (about 12.855 m^2) to respect the law, about 128,55 m^2 are needed. The plan layout is already provided with this space for bike racks with about 160 m^2 like it is represented in Sheet_01.D whit the building's functions.
In this case the LEED limit is stricter than the public law, because it imposes at least one space for each residential regular occupant. Considering that the two buildings will host 407 rooms, the same number of bikes parking are required. In this case there is a feasibility problem in the design of the outdoor spaces that would be just a parking place with a negative impact on th aesthetic part of the building.

Figure 31: example of possible bike parking solution

To overcome the problem the solution proposed is to leave the outdoor layout as it is, providing a space for cleaning the bike, and install in each room a bike support as in Figure 31.

Category		Use type	Name	Distance (m)	N. of use	Building	Identification number
1	Food retail	Supermarket					
		Grocery with produce section					
2	Community-serving retail	Convenience store	Simpatia Crai	180	3	A	1
		Farmers market					
		Hardware store	Utensilferramenta dal 1913	700		B	2
		Pharmacy	Farmacia Nizza	190		B	3
		Other retail					
3	Services	Bank	BCC Bene Banca	460	5	B	4
		Family entertainment venue (e.g., theater, sports)					
		Gym, health club, exercise studio	Orange Nizza	380		B	5
		Hair care	VG hairlab	290		A	6
		Laundry, dry cleaner					
		Restaurant, café, diner (excluding those with only drive-thru service)	Pizza e cozze	230		B	7
			Da Ciccillo	270		B	8
4	Civic and community facilities	Adult or senior care (licensed)			4		
		Child care (licensed)					
		Community or recreation center					
		Cultural arts facility (museum, performing arts)					
		Education facility (e.g., K—12 school, university, adult education center, vocational school, community college)	Scuola dell'infanzia Stefano Bonacossa	370		A	9
		Government ofce that serves public on-site					
		Medical clinic or ofce that treats patients					
		Place of worship	Istituto Suore Sacramentine di Bergamo	170		B	10
		Police or fire station					
		Post office	Poste Italiane	800		A	11
		Public library					
		Public park	Giardino Sambuy	1300		A	12
		Social services center					
5	Community anchor uses (BD+C and ID+C	Commercial ofce (100 or more full-time equivalent jobs)					

Table 8: Services reachable with bike network

After the evaluation of the number of bike ranks, a further check must be done considering the services available with a maximum distance of 4800 m using the bicycle network.

In the Table 8 twelve services are selected so one points is obtained. The map of the service positions is presented in Sheet_01.L.

- ***High Priority Site***

The intent of the credit is to promote the construction in particular situation like historic constrains or areas to be reclaimed. The credit gives the possibility to choose between three cases:

- project in a historic district (one point);
- follow a Public Institution programme to develop a specific critical area (one point);
- clean the project area from hazardous substances (two points).

The first two possibilities are not suitable for the considered project, for this reason an analysis of hazardous substances on site has been conducted. The research has evidenced the presence of large quantities of ballast, a material widely used for railway networks. During years, ballast particles and steel powder, due to train passages, tend to create a phenomenon called "fouling" that cause the soil pollution.

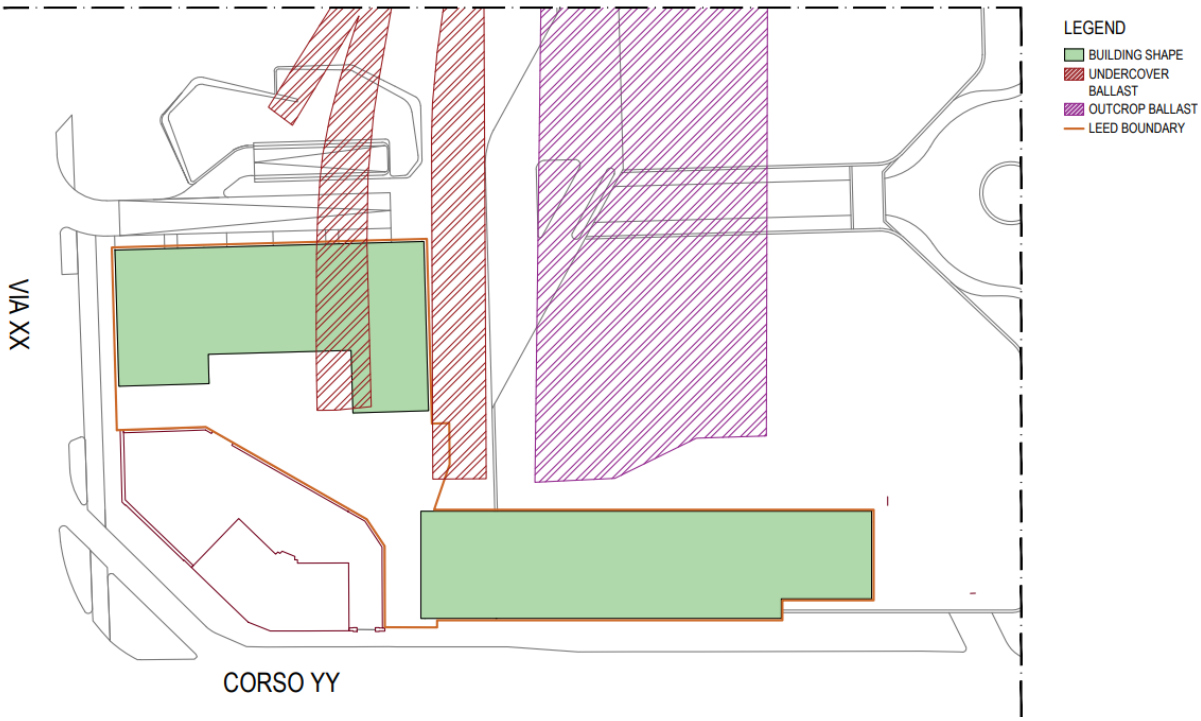


Figure 32: Representation of ballast position in the construction site

In this case the area to certify, corresponding to the LEED boundary, is just a part of the construction site; for this reason, the ballast must be present inside the boundary to obtain the credit. In Figure 32, it is possible to see that on site there is outcrop and undercover ballast and part of them are inside the LEED boundary. In the end, to obtain the two points provided by the protocol, a remediation document must be uploaded on "LEED Online".

3.2 Sustainable Site (SS) Category

The Sustainable Site category of credits focus the project's team attention on using methods that reduce the substances and lighting pollution, heat island effect and the rainwater runoff. It tries to protect and preserve ecosystems and biodiversity that are threatened by deforestation and soil erosion causing extinction of species. The percentage of not absorbed rainfall is also responsible of transportation of pollutants such as: oil, land fertilizers etc that end up inside rivers and sea causing damages to natural species.

- ***Construction Activity Pollution Prevention (Pre-requisite)***

The mandatory pre-requisite requires to create a plan for soil erosion and water sedimentation. The General Contractor is responsible of realizing the plan and appoint a supervisor that periodically goes on site to verify the application of the measures. The inspection can be once a week or a month, in this last case, after a relevant rainfall (more than 6 mm of precipitations), a visit on site is mandatory. The measure considered, depending on the type of construction site, are:

- To compact and cover the excavated ground in order to not disperse it due to rain or wind events;
- The road to access/exit from the site must be realized with compacted material or asphalt, all the vehicle's wheels must be cleaned so the road can't get dirty and the vehicles must be covered to not disperse dust out of site;
- All the manhole covers must be protected with a TNT layer to be replaced after a certain time in function of site operations;
- Use a soil covering layer nearby the area subjected to casting operations.

- ***Environmental Site Assessment (Pre-requisite)***

The intent of this second pre-requisite is to provide the certainty that the project land is free from any contaminants with or without a remediation, to ensure the best condition for human's health.
The materials to upload on "LEED Online" are:

- an analysis of historical sheet and documentation of the site, a site visit to identify the possible presence of contaminants and a summary report about this first operation;

- a further analysis requires some soil tests in order to assess clearly the type and the quantity of involved contaminant;
- the third part is useful to determine how the remediation will be realized considering time, cost and logistic operation to do it.

This pre-requisite relates to the LT Credit called "High-Priority Site" where one possibility to obtain points is to provide documentation of pollutants remediation occurred inside the LEED boundary. For this reason, if the documentation is available for the pre-requisite it ensures to reach the related points in the over mentioned credit and vice versa.

- ***Site Assessment***

The intent of this credit is to collect as much information as possible about the site area, in order to perform better choices for the design of the building. Different professional figures are necessary to realize the required documentation such as:

- a geological report of the site characteristics is done, highlighting the presence of ground made of sandy gravel with pebbles. The site is inside the Class I of geomorphologic dangerousness so there is no particular prescription from the construction point of view;
- a hydrology report to check flood risks in the area. Looking at the documentation available at the *"Difesa del Suolo della Provincia di Torino"*, it is evidenced that the site is not inside the areas subjected to hydrological restrains;
- a climatic general analysis of the site is conducted to understand the solar load during the year and it also helps the choices of building shape and orientation.
- a preliminary vegetation analysis is done to guarantee a project with enough shaded areas, green open spaces appreciable by people and in harmony with the existing environment. The used criteria are: velocity of plants growing, use species that cause no allergies and require less maintenance as possible and resilient to stresses.
- a further analysis on soil is required to find the presence of pollutants to be remediated;
- for the "human use" analysis, information taken from LT credits can be suitable thanks to data related to infrastructures, public transport connections and adjacent building characteristics;
- "human health effects" analyse the presence of existing structure that need particular attention such as hospital where acoustic and pollution problems should be reduced as much as possible. Moreover, positive impacts of sports and open-air activities on human health can be highlighted.

Many documentations have been provided for the different thematic areas so one credit is obtained.

- ***Site Development - Protect or Restore Habitat***

The target of this credit is to preserve undeveloped areas from new construction or at least force the team to protect the already existing green areas, if it exists, and to create a new vegetated space inside the LEED boundary.
The protocol imposes to preserve at least the 40% of existing green areas, if they are present, from construction activities. Then it is possible to choose between two different paths:

- the first is to create a vegetated area of about the 30% of the already soil disturbed surface of the site. In project with a floor area ratio of 1.5 also green roof can be used for the calculation. The ground to be revegetated, must complies some specific characteristics such as: the soil used must have comparable function, can not come from prime farmland or other greenfield. It should also meet some characteristics like organic composition, compaction and infiltration rates, biological and chemical composition respect to the reference soil that is the one already presents in the site (two points);
- the second possibility is to provide a financial support of 4 €/m^2 of total site area, building shape included, to a recognized local or national land conservation organization (one point).

Another possibility is to substitute the limit imposed by the credit of LEED v4 with the one provided by the new version LEED v4.1 where it still imposes to protect the 40% of existing green areas but does not consider anymore the possibility to provide a financial support to organization. It imposes to create a new vegetated area of about 15% of the site area to get one point or 25% to get two points.
Since the LEED boundary is about 3025 m^2, the second option of v4 that consists in a financial support, it will cost about 12.100 € to obtain one point.
Now an evaluation on percentage of LEED boundary area is conducted to understand the feasibility of the credit.

Option 1: 30% of site area (LEED v4)

From the Figure 33, it is possible to notice that even if all the external spaces of the student residences would have been vegetated, it is impossible to respect the limit imposed by the protocol LEED v4.

Figure 33: Possible outdoor vegetation space layout

Indeed, considering the total area of 3025 m^2, the 30% of that is about 907,5 m^2 while the outdoor space is 837 m^2. The summary of the calculation is presented in Table 9 below.

Restore Habitat		
LEED Boundary (LB)	3025	m^2
Green areas to riqualify (30% LEED v4)	907,5	m^2
Outdoor space area	**837**	m^2

Table 9: Calculation summary for LEED v4

Option 2: 25% of site area (LEED v4.1)

The second option is provided by the LEED v4.1 where it requires a minimum restoration of outdoor green spaces of 25% respect to the whole site surface. In this case the 25% of 3025 m^2 is less than the total outdoor space (about 756 m^2). The problem is that in order to comply with the Municipality's bike ranks law, a large part of the common external area is occupied by bicycle parking and for this reason is not possible to pursue the two points given by the credit. In Figure 34 there is the functional indications of how are distributed by project the outdoor spaces and the calculation summary is in Table 10.

Figure 34: Design outdoor spaces distribution

Restore Habitat		
LEED Boundary (LB)	3025	m²
Green areas to riqualify (25% LEED v4.1)	756,25	m²
Outdoor space area	**837**	m²
Project green area	**250**	m²

Table 10: Calculation summary with LEED v4.1 (two points)

Option 3: 15% of site area (LEED v4.1)

The third option consider the possibility of LEED v4.1 to gain one point considering a restore habitat of 15% than the total site area. Also in this case, the percentage of green areas present in the project is not sufficient to match the requirements as resumed in Table 11. Looking at the plan (Fig.34) to reach the point at least half of bicycle spaces should be used but it is not possible as explained in option two.

Restore Habitat		
LEED Boundary (LB)	3025	m²
Green areas to riqualify (15% LEED v4.1)	453,75	m²
Outdoor space area	**837**	m²
Project green area	**250**	m²

Table 11: Calculation summary with LEED v4.1 (one point)

- ***Open Space***

The intent of the credit is to improve, as the restore habitat, the presence of outdoor vegetated spaces to reduce the heat island effect, protect biodiversity and increase rainwater infiltration. Moreover, it promotes open spaces to favours people activities and interactions with themselves

and the surrounding nature with positive benefits such as: stress reduction, creativity and productivity increment.

The credit request is to establish, inside the LEED boundary, outdoor spaces for at least the 30% of the site area. It also requires that the 25% of the outdoor area should be vegetated considering that the grass alone is not accepted by the protocol. If the project has a 1.5 floor-area ratio also green roof can be considered as vegetated open spaces.

The open spaces must have specific characteristics such as:

- pedestrian path and accommodation areas;
- zone with sport furniture to promote physical activities;
- garden with food production for community.

Looking at the actual project the outdoor space is sufficient to satisfy the protocol but not the minimum vegetated area, even if the percentage is considered on the open-air space and not on total site area like in restore habitat. The minimum required is not so far from the green areas by project, but it is not categorized as "quality" space due to the absence of specific characteristics listed before. The analysed data are considered in Table 12 below.

Open Space Credit		
LEED Boundary (LB)	3025	m²
Buildings area	1906	m²
Open Space (OS)	1119	m²
Required Open Space	30%	
Project Open Space	**37%**	
Required Green areas: 25% of Open Space	279,75	m²
Project Green areas	**250**	m²

Table 12: Calculation summary for Open Space Credit

- ***Heat Island Reduction***

The heat island effect is a phenomenon for which higher temperature are registered in cities respect to outlying areas. This is due to buildings, roads and all the anthropic constructions that absorb and re-emit the heat of sunrays increasing the temperature up to five degrees above the usual. The effect is a rise in energy costs for cooling, air pollution, and health related problems due to extreme heat that can cause death of vulnerable people.

The aim of the credit is to limit this phenomenon with two choices: one includes the possibility to place the parking under cover with a shading structure with SRI (Solar Reflectance Index) of at least 39 at installation or under a vegetated ones or systems with energy generation. These

solutions allow to achieve one point and it is not considered in the actual case studio since parking spaces are not realized in the LEED boundary.

The second choice is to provide roof and nonroof surfaces with some specific characteristics. For example, for nonroof:

- provide shades with trees or vegetated structures;
- provide shade with structure integrated with energy production systems such as photovoltaic panels;
- provide shade with structure characterized by a SR (solar reflectance) value of 0.33 at installation;
- use open-grid pavements or pavements with a SR of at least 0.33 at installation.

For roofs it is possible to install a vegetated roof or material with a specific SRI as in Table 13, in function of their inclination.

	Slope	Initial SRI	3-year aged SRI
Low-sloped roof	≤ 2:12	82	64
Steep-sloped roof	> 2:12	39	32

Table 13: Credit requirements for roof

The protocol provides, also, a formula to respect in order to obtain the two points provided by this option of the credit.

$$\frac{\text{Area of Nonroof Measures}}{0.5} + \frac{\text{Area of High-Reflectance Roof}}{0.75} + \frac{\text{Area of Vegetated Roof}}{0.75} \geq \text{Total Site Paving Area} + \text{Total Roof Area}$$

Equation 1: Mandatory equation to respect for LEED credit Heat Island Reduction

Therefore, it is possible to calculate the outdoor areas with specific characteristics of solar reflectance. The areas used came from the roof plan of the two buildings. The actual development of the project is not sufficient to determine specifically the product that will be installed on site, but nowadays, it is not difficult to find products with a certified solar reflectance.

Heat Island Reduction		
Total Site Area	**3.025**	**m²**
ROOF with initial SRI>82	2.037	m²
NON ROOF - Pathways (SR>0,33)	215	m²
NON ROOF - bicycle parking areas (SR > 0,33)	335	m²
NON ROOF - Estimated path in green area(SR > 0,33)	25	m²

Table 14: Areas of project roof and non-roof measures

For this reason, a possible product solution is represented in Sheet_02.L; the areas used are the defined ones, just an estimation of a pedestrian path in the green area is considered (about 10% of total green area: 250 m^2). The Table 15 represents the calculation provided by the protocol's equation with the weighted roof and non-roof areas and the result is positive, so two points are obtained.

PRELIMINARY DESIGN SURFACES		
NON ROOF measures (SR>0,33)	575	m²
ROOF area of high reflectance roof (SRI>82)	2.037	m²
Total Site Paving Area + Total Roof Area	2.612	m²
Weighted sum of non roof and roof measures	2.678	m²
Result	**Positive**	

Table 15:Calculation result of protocol's equation

3.3 Water Efficiency Category (WE)

The water efficiency category focuses the attention on reducing the water usage inside the LEED boundary, for both outdoor and indoor uses and to use non potable and alternative water sources. Some researches highlighted that treat drinking water and transport it to a building is a high energy consuming procedure. It is estimated that about 220 l per person are consumed in Italy (one of the highest values in Europe) where about the 39% is due to bathroom usage. That's why the protocol's credits try to insert peculiarity in design choices to overcome this problem.

- ***Outdoor Water Use Reduction Pre-requisite***

The intent is to reduce the outdoor water consumption by neglecting the irrigation using some plants that don't require irrigation after two years or reducing the irrigation water of at least 30% from baseline case peak month.

To fulfil this pre-requisite, it is possible to use some table related to the geographic area that provide some indication of autochthon green species and the best environment characteristics where they should be used (paying attention on the altitude where they can be considered autochthon). The usage of autochthon species is fundamental to reduce the necessary maintenance, reduce pesticide and water consumption uses for irrigation.

In Table 16 there are an example of usable plants with some data such as:

- Solar Exposition (EP), that considers the best sun exposition for a certain specie;

- Soil Humidity (US), considers the ground condition and the necessity of irrigation;
- Soil Porosity (PS), considers the specie behaviour respect to ground stagnant water;
- Soil Deep (HS), considers if a specie requires high or low deep soils;
- PH Soil Level (pH), plant preferences of acid or basic ground characteristics;
- Root System (RA), considers the specie's root development;
- Dimension (PT), considers the specie possibility to develop its dimension in future;
- Growth (AC), considers the growing velocity of the specie;
- Leaves (FG), considers the type of specie's leaves;
- Longevity (LG), considers the usual specie's lifespan;
- Special Characteristics, highlights typical peculiarity of a specie.

Nome volgare	*Denominazione scientifica*	EP	US	PS	HS	pH	RA	PT [m]	AC	FG	LG [anni]	CARATTERI PARTICOLARI
Abete bianco	*Abies alba*					> 7,5		>30			>100	Tra le conifere più "eleganti". Adatta in ampi spazi. Patisce le potature.
Abete rosso	*Picea abies*					6÷8		>30			>100	Tra le conifere più rustiche. Adatta in ampi spazi. Soggetta a ribaltamenti. Patisce le potature.
Larice	*Larix decidua*					< 6,5		>30			>100	Chioma leggera e luminosa. Oltre 500 m s.l.m.
Pino cembro	*Pinus cembra*					< 6,5		20÷30			>100	Molto "elegante". Chioma verde scuro. Oltre 800 m s.l.m. Crescita lentissima.
Pino silvestre	*Pinus sylvestris*					6÷8		>30			>100	Molto rustica. Adatta in ampi spazi.
Pino uncinato	*Pinus uncinata*					6÷8		10÷20			>100	Relativamente rustica. Oltre 600 m s.l.m.
Pino mugo	*Pinus mugo*					6÷8		AR			>100	Relativamente rustica, adatta anche per siepi e bordure.
Ginepro comune[2]	*Juniperus communis*					6÷8		AR			30÷100	Rustica, con aghi pungenti, adatta anche per siepi e bordure. Si piega facilmente con il peso della neve.
Ginepro prostrato	*Juniperus nana*					6÷8		AR			30÷100	Analoga al ginepro comune, ma con portamento nettamente prostrato. Adatto per coperture.
Tasso	*Taxus baccata*					6÷8		10÷20			>100	Bacche rosse ornamentali gradite dagli uccelli. Altre parti della pianta velenose. Adatto anche per siepi.
Salice rosso	*Salix purpurea*					6÷8		AR			30÷100	Specie adatta per recuperi ambientali e delle fasce riparie. Ornamentale lungo i bordi delle zone umide.

Table 16: Example of autochthon species of Piedmont with information

- ***Indoor Water Use Reduction***

This is a pre-requisite but also a credit, obviously only the first is mandatory. The pre-requisite requires to reduce the indoor water consumption of 20% respect to the baseline of the typical fixtures of a building, indicated in Table 17.

Fixture or fitting	Baseline (IP units)	Baseline (SI units)
Toilet (water closet)*	1.6 gpf	6 lpf
Urinal*	1.0 gpf	3.8 lpf
Public lavatory (restroom) faucet	0.5 gpm at 60 psi** all others except private applications	1.9 lpm at 415 kPa, all others except private applications
Private lavatory faucets	2.2 gpm at 60 psi	8.3 lpm at 415 kPa
Kitchen faucet (excluding faucets used exclusively for filling operations)	2.2 gpm at 60 psi	8.3 lpm at 415 kPa
Showerhead*	2.5 gpm at 80 psi per shower stall	9.5 lpm at 550 kPa per shower stall

Table 17: Baseline value for fixtures

The related credits are obtained with a reduction respect to baseline values and the obtainable points depend on the percentage reduction. The maximum value of points for the credit is 6 with a 50% reduction (Table 18).

Percentage reduction	Points (BD+C)	Points (Schools, Retail, Hospitality, Healthcare)
25%	1	1
30%	2	2
35%	3	3
40%	4	4
45%	5	5
50%	6	–

Table 18: Credit's points respect to reduction percentage

To perform the calculation there is a pre-set Excel file to fulfil, provided by USGBC. In the first page of the file there are choices regardless the unit of measure used between IP and SI, the last one is selected, if the project is part of a LEED Neighbourhood Development.

In the page related to the building some data of occupancy are used. Residential occupancy it is easy to calculate, considering the number of rooms present in the project. While for the employees the data have been provided by the owner of the student residence and for the visitors a 10% of the total occupancy is considered (Table 19).

☑ **The project includes ADA and/or gender-neutral bathrooms**
If the project includes separate gender neutral and/or ADA restrooms without urinals, the LEED default assumption is that 5% of male occupants and 5% of female occupants use these restrooms. Enter 95% into the percent of males expected to use restrooms with urinals below. Alternately, the project team can estimate this percentage based on the project's restroom layout/anticipated usage patterns or weighted fixture counts.

Occupancy Type	Employees (FTE)	Visitors	Retail Customers	Students (K-12)	Residential	Other *(specify)*	Gender Ratio (%)
Total	15	24	0	0	225	0	100%
Male	8	12	0	0	113	0	50%
Female	7	12	0	0	112	0	50%

Table 19: Occupancy values for Residence A

The programme requires a total occupancy divided by different types (residential, employees, visitors, etc.) and then automatically considers the general division between male and female at 50% each. Other data to be inserted is the percentage of urinals in man bathroom and day of operation of the building (Table 20).

Percent of males expected to use restrooms with urinals	95%
Annual days of operation	365

Table 20: Presence of urinals and annual day of operation for Residence A

The other data to be inserted is the design flush rate that in this case is a dual-flush toilet with 2 litres per flush, the low one, and 4 litres per flush, in the full one. The average is calculated then by the Excel file and it is present in Table 21.

Low flush (lpf)	2
Full flush (lpf)	4
LEED weighted average flush rate (lpf)	2,98

Table 21: Design flush for toilet of Residence A

The following operation is to fulfil the table with the type of "Flush" fixtures using the value of design already decided and the file calculate the litres per year that are necessary for the baseline and the design case. The calculation considers the occupancy inserted and values of daily uses (Table 22).

Fixture Information			Flush Rate		
Fixture ID	Fixture Family	Fixture Type	Baseline Flush Rate (lpf)	Design Flush Rate (lpf)	Percent of Occupants (%)
	Toilet (male)		6,00	2,98	100
	Toilet (female)		6,00	2,98	100
	Urinal		3,80	2,5	100
Baseline case annual flush volume (liters/year)					2.572.520,00
Design case annual flush volume (liters/year)					1.282.157,40

Table 22: "Flush Fixture" design information respect baseline of Residence A

The last table considers the flow rate of other typical fixtures present such as: showers, kitchen or bathroom faucets. Also in this case, the calculation considers total daily uses depending on occupancy and default duration of usage (Table 23). The design flow rate used for the fixtures has been reduced respect the baseline value considering some values used by the owner for other properties. The reduction of water consume can be done with some cheap systems called "flow regulators" that can be applied to faucets or showers (Figure 35). The two systems differ a bit from each other, but the functional principle is the same. The regulator fragments the water into little particles and mixes it with air in order to have the same volume sensation of the jet but using less water quantity.

Fixture Information		Duration		Flow Rate		
Fixture ID	Fixture Type	Default (sec)	Non-default (sec) (Optional)	Baseline Flow Rate (lpm)	Design Flow Rate (lpm)	Percent of Occupants (%)
	Public lavatory (restroom) faucet	30		1,90	1,35	100
	Private (residential) lavatory faucet	60		8,30	1,35	100
	Residential kitchen faucet	60		8,30	5,4	100
	Showerhead	300		9,50	7,6	100
	Residential showerhead	480		9,50	7,6	100
Baseline case annual flow volume (liters/year)						12.422.008,50
Design case annual flow volume (liters/year)						7.356.293,95

Table 23: "Flow Fixtures" design information respect to baseline of Residence A

Figure 35: Image of a flow regulator for faucet

The last sheet of the file is a summary of all the calculations with the percentage of water consume reduction (Table 24) that is fundamental to obtain the precise number of points for this credit.

Summary for Design and Construction Rating Systems

Note: All information on this tab is READ-ONLY. To edit, see the previous tab(s).

Refresh Groups

Group Name	Baseline Case (liters/year)			Design Case (liters/year)		
	Annual Flush Volume	Annual Flow Volume	Annual Consumption	Annual Flush Volume	Annual Flow Volume	Annual Consumption
Student Residence A	2.572.520,00	12.422.008,50	14.994.528,50	1.282.157,40	7.356.293,95	8.638.451,35

Annual baseline water consumption (liters/year)	14.994.528,50
Annual design water consumption (liters/year)	8.638.451,35
Percent water use reduction (%)	**42,39%**

Table 24: Summary comparison between baseline and design consumption

For the other building, the Student Residence B, the only data that change are the one related to the occupancy due to a different number of employees and students' room (Table 26). In this case the number of rooms are less than the other one; the number of employees is less than the other residence because the offices to manage the structures are present in the other building. For this reason, the amount of visitors reduced since it is calculated as a percentage of the sum of the previous two occupancies.

Occupancy Type	Employees (FTE)	Visitors	Retail Customers	Students (K-12)	Residential	Other *(specify)*	Gender Ratio (%)
Total	5	19	0	0	182	0	100%
Male	3	10	0	0	91	0	50%
Female	2	9	0	0	91	0	50%

Table 25: Occupancy rate of Residence B

The summary evidenced almost an identical result respect to the other building and it is reported in Table 26. The worst result, between the two buildings, considers a reduction of 42,39% for this reason four points out of six are gained (Table 18). As said before the calculation are based on some flow used usually by the property, but with the same waste reduction systems it is

possible to increase the percentage until 50%. In this case the maximum number of points could be obtained, but it will be an owner's choice.

Summary for Design and Construction Rating Systems

Note: All information on this tab is READ-ONLY. To edit, see the previous tab(s).

Refresh Groups

Group Name	Baseline Case (liters/year)			Design Case (liters/year)		
	Annual Flush Volume	Annual Flow Volume	Annual Consumption	Annual Flush Volume	Annual Flow Volume	Annual Consumption
Students Residence B	2.038.765,90	10.028.166,95	12.066.932,85	1.014.756,21	5.935.206,60	6.949.962,81

Annual baseline water consumption (liters/year)	12.066.932,85
Annual design water consumption (liters/year)	6.949.962,81
Percent water use reduction (%)	**42,40%**

Table 26: Summary comparison of baseline and design water consumption

- ***Building-Level Water Metering pre-requisite***

The protocol requires to install permanently water meters that measure all the potable water consume in and out of the building. It is imposed also to create some monthly and annual summaries and send it to the USBGC for five years after the LEED certification is obtained.

- ***Water Metering***

This is the credit related to the above-mentioned pre-requisite. The credit intent is to create a system of submetering to analyse some specific water implants of the building; in this way it is possible to monitoring the consumes in a more efficient way and some potential waste can be detected and solved. For this reason, the submetering should be applied on the most expensive source of consumes.

The considered credit gives the possibility to obtain one point by installing water meters on at least two subsystems. The six possibilities included are: irrigation, indoor fixtures and fittings, domestic hot water, boiler, reclaimed water, other process water (dishwashers, clothes washers etc.). In accordance with the property, the two selected subsystems are:

- Indoor plumbing fixtures and fittings, a meter system of 80% of systems used in the Indoor Water Use Reduction credit;
- Domestic hot water, that measures the 80% of the installed domestic hot water heating capacity.

4 Case studio: Logistic Industrial Warehouse

The second case studio is about a construction of an industrial warehouse for logistic purposes to stock goods coming from the European market and to address it to local smaller centers. The site is about 5 km from the city of *Mantova* and it is easily accessible by extra-urban road and it is well connected to the highway A22. The site is near the *Valdaro* port that is an important freight yard for the city. The whole area has been subjected to a rapid and huge transformation with the establishment of new industries of transport and logistic sector.

Figure 36: Area of interest of the new warehouse project

The new logistic warehouse and relative offices dedicated to the management of the activities, realized after the demolition of some existing structures, will have a covered surface of about 76.000 m^2 while the gross surface area will be about 150.000 m^2. The accesses to the area will be placed at North, with a gate and guard. The external area will host 582 car parking spaces at North while at East and South, 156 parking for trucks will be placed. The internal roads are made of asphalt and drains channel for rainwater are presents; green areas will be also available around the warehouse. The external spaces will also include some areas for employee aggregation such as football field and pic-nic furniture.

The warehouse will be realized with a structural part in pre-compressed concrete and the vertical partitions will include rock wool panels with metallic support and coloured metallic finishing, after the demolition of the buildings already existing on site. The warehouse will be divided into different compartments with some difference in height, some part will have just the ground floor, while other are up to three floors. Most of the compartments are needed just to store the goods while the offices are concentrated in specific areas.

The roof will be made of Bac-acier system with an 1,5% inclination for water outflow in direction East and West and Thermoplastic polyolefin (TPO) will be used as impermeabilization layer with a very light colour to match the requirement of the heat island reduction. On the roof, openable and fix skylights will be installed.

The LEED rating system to be used in this case is BD+C: for Warehouse and Distribution and the method of verification is always the Split Review. In this case the Scorecard is the same of the previous example (Figure 22) but some requirements in part of the credits change.

4.1 Location and Transportation (LT) Category: Warehouse and Distribution

- ***Sensitive Land Protection***

To persecute the one point of the credit, some criteria must be respected:

- the construction must not be realized on land considered as prime farmland by public regulation. The following criteria is confirmed in Figure 37, where the PTC *("Piano Territoriale di Coordinamento")* states that the land is for production areas, so the agricultural usage is neglected;

Figure 37: PTC for the function definition of the site

- the building must not be on a flood hazard area. Figure 38 represents the PGRA ("*Piano di Gestione Rischio Alluvioni"*). With the map provided by the municipality, it is possible to state that a little area of our LEED boundary is in a location with a very low risk (rare event). For this reason, the location is acceptable;

Figure 38: PGRA for flood risk definition

- The site must not be included in a naturally protected area. For this purpose, the map of protected areas of Mantova has been consulted, indeed, the location indicated in Figure 39 is outside any parks or natural reserves;

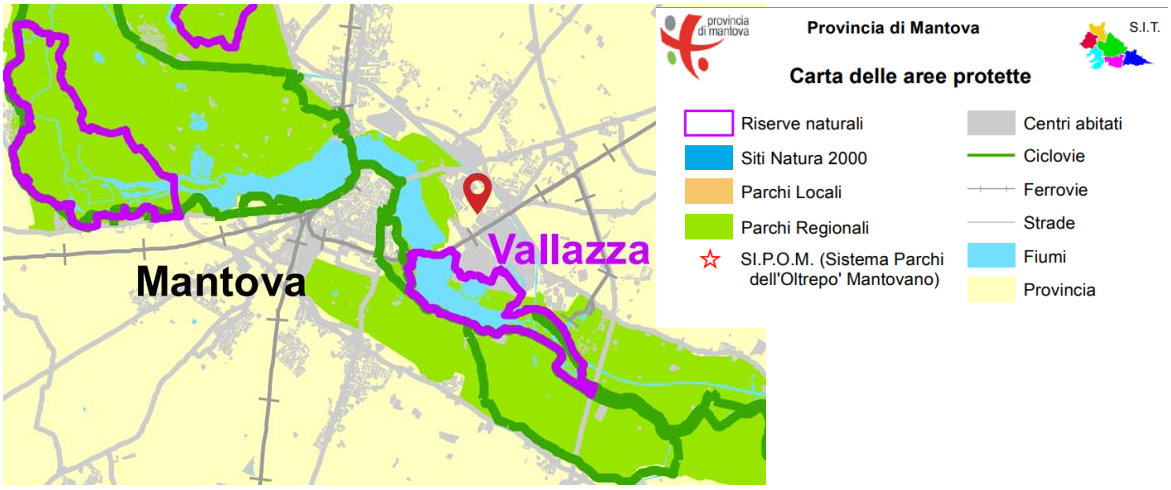


Figure 39: Natural protected land of Mantova

- Site alterations must be at minimum 30,5 m from a water body and 15,5 m from a wetland. In this case the site is near a water body that follow one side of the LEED boundary while there is no wetland where for definition of the protocol it includes swamps and marshes. The limit doesn't consider the distance from the boundary, but exclude green areas or people's pathways.

For this reason, in our case studio the nearest alterations are the trucks parking that have been designed to respect the minimum distance as it is possible to see in Figure 40 where it is represented part of our site and a 30,5 m offset of the river's banks.

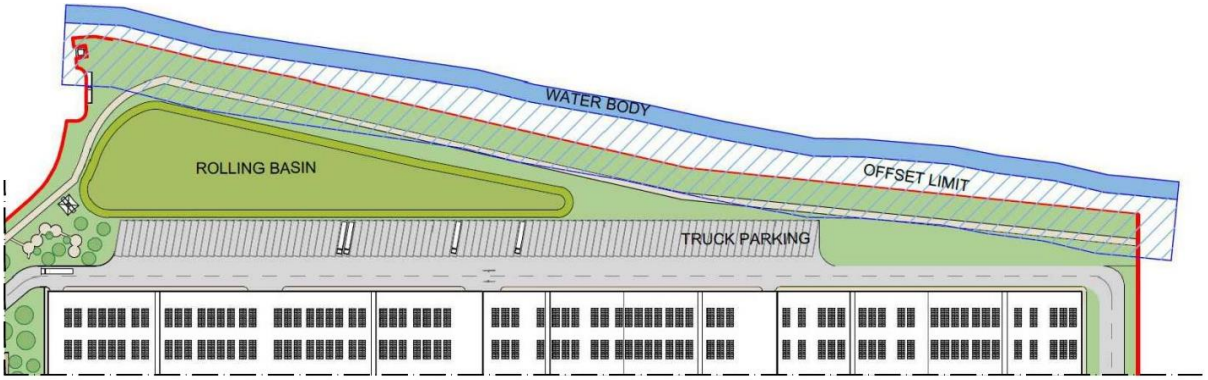


Figure 40: Distance check from water body nearby the site

- ***Surrounding Density and Diverse Uses***

In this case the credit for Warehouse and Distribution requires a different limit respect to the one used for the students' residences. There are two possible options:

1. Build the new building on at least 75% of a previously developed site (2 points). If our site bordering for at least 25% with a previously developed site another point is obtained ("adjacent site").
2. Build on a site that has at least two (1 point) or four (2 points) of the following characteristics:
    - 16 kilometres distance from an airport, seaport, intermodal facility;
    - 1600 metres driving distance from the highway;
    - 1600 metres driving distance from an access of a freight rail line;
    - Site served by an active freight rail spur.

None of the limit imposed by the option two are satisfied in terms of distances.

For the option one the definition of previously developed is considered from the LEED glossary that states: *"altered by paving, construction, and/or land use that would typically have required regulatory permitting to have been initiated. Landscapes altered by current or historical clearing or filling, agricultural or forestry use, or preserved natural area use*

are considered undeveloped land". Our site is altered by some old buildings and an internal road (14,67%), but the minimum percentage is not gained (Figure 41).

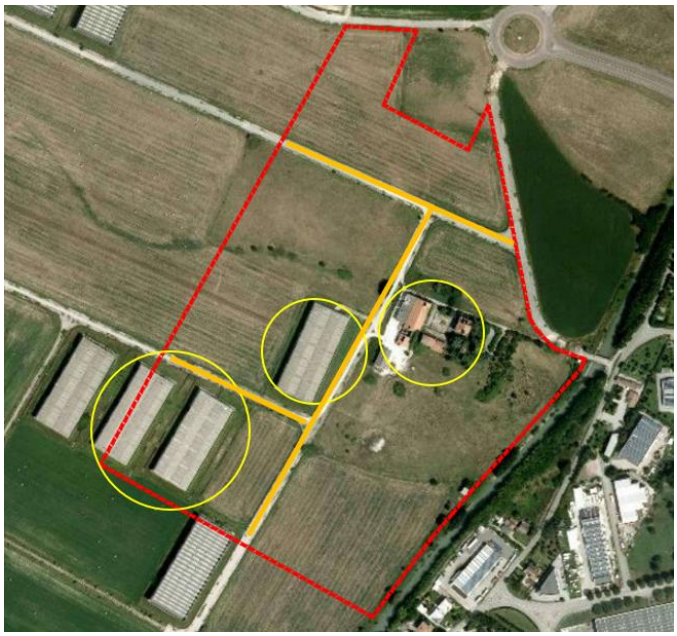


Figure 41: Previously developed areas

- ***Access to Quality Transit***

The considered credit has the same requirements already explained in the previous case studio (Table 6).

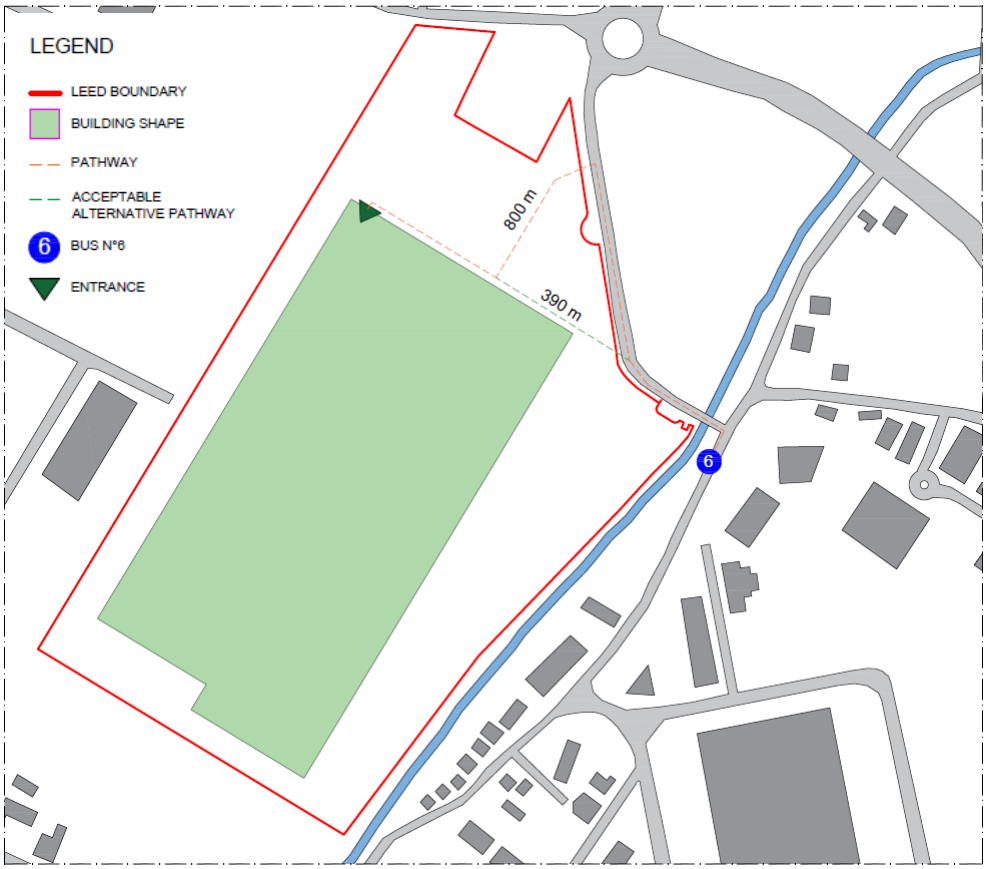


Figure 42: Map of public transport system nearby the site

Since the actual project is an industrial warehouse, obviously built far from the city centre, there is a poor connection with the public transport system. The only bus that stops near the site is the number 6 (*Buscoldo – Formigosa*) and it is not sufficient to satisfy either the minimum trip values (72 weekdays and 40 weekend) to obtain one point. From Figure 42 is possible to see that, even if the trips were sufficient, the external design should have been changed (with a new pedestrian entrance) in order to respect the limit distance of 400 m from the bust stop to the building entrance.

- ***Reduced Parking Footprint***

The aim of the credit is to reduce as much as possible the presence of new parking to stimulate the usage of alternative methods of transportation, to reduce land consumption and the phenomenon of rainwater runoff. The credit gives the possibility to achieve one point; depending on our project there are two possible cases:

- Case 1: if the project has not earned any points for LT category in credit Surrounding Density and Diverse Uses or Access to Quality Transit, a reduction of 40% respect the baseline value must be obtained.

- Case 2: If the project obtained at least one point in one of the two overmentioned credits, the reduction respect to the baseline must be of 60%.

Since no points are obtained in the two credits of LT category, our case is the number one and a reduction of 40% minimum must be reached. Moreover, the protocol specify that all new parking related to the project must be considered even if they are realized outside of the LEED boundary. Parking in public street and inside the project but for inventory vehicles are excluded from the calculation, that's why the camions parking is not considered. The credit imposes to reserve a 5% of spaces for carpooling (orange parking as in Figure 44) that is a method of transport where at least two people use one private vehicle to travel the same rout. Moreover, demonstrate that the amount of parking is less than the Municipality prescription.
As showed in Figure 43, in the project are present 582 parking for offices and warehouse. The first evaluation is needed to check if the square meter of the design car park is less than the limit imposed by the Municipality

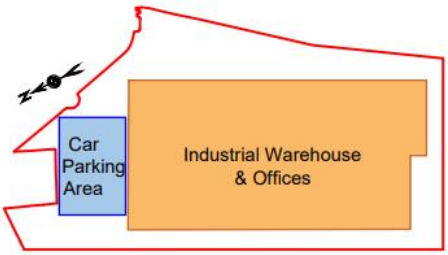


Figure 43: distribution of car parking at the warehouse entrance

The "*Piano Regolatore Generale*" of *Lombardia* states that: in cases of new construction, it is necessary to create some areas for car parking with a ratio of 1 m^2 each 3,3 m^2 of Sl ("Superficie Lorda d'uso") corresponding to the gross area of each floor presents in the project. As present in Table 28, the result is positive, the Municipality area[4] is calculated with the ratio indicated above while the project parking area is obtained multiplying the total number of car parks (from Table 29) for its area (2,5 m x 5,0 m).

Sl	m^2
Ground Floor	129.312
First Floor	35.615
Second Floor	8.134
Total Sl	173.061

Table 27: "Superficie Lorda d'uso" from Revit abacus

Municipality area	Project parking area	unit
52443	7275	m^2

Table 28: Check on Municipality area respect to the project one

[4] It is obtained as follow: (Total Sl)/3,3 m^2

The Table 29 represents the number of parking provided by project and that are necessary for the calculation of the reduction respect to the baseline case.

Number of design parking		
Nr. project office parking	149	nr.
Nr. project warehouse parking	433	nr.
Total number of project parking	582	nr.

Table 29: Designed number of parking space

The protocol provides a table with instructions useful for the calculation of the baseline case depending on the function of the building and its dimension as it is possible to see in Table 30, that reports the two cases related to our project.

Use	Size or condition	Parking spaces
Office Building	2325 to 9300 m²	if y is m² : 4,1-[0,43*(y-2325/6975)] spaces per 100 m²
Warehousing		0,72/100 m²

Table 30: Calculation assumption for baseline provided by the LEED protocol

Starting with the office baseline, using the area of 3500 m^2 in the formula of Table 31, four parking each 100 m^2 are obtained so the result is showed in Table 30.

BASELINE Office		
office area	3500	m²
nr. Parking each 100mq	4,0	nr.
Total number of parking	141	nr.

Table 31: Baseline calculation for the office

The same logic of calculation has been used for the Warehouse baseline value summarized in Table 32.

BASELINE Warehouse		
warehouse area	169561	m²
nr. Parking each 100mq	0,7	nr.
Total number of parking	1221	nr.

Table 32: Baseline calculation for the warehouse

The verification of the credit is summarized in Table 33, where the incidence of the project parking on baseline is obtained with their ratio. The reduction obtained overcome the limit of 40 % imposed by the protocol, so one point is gained.

Credit Verification		
Total number of project parking	582	nr.
Total Baseline	1362	nr.
Incidence nr. Project parking / Baseline	43%	
Total reduction	57%	

Table 33: LEED verification on parking reduction

For this credit is possible to also obtain the exemplary performance by reaching the 60% of reduction, and this can be obtained by reducing the existing car parks from 582 to 545. The credit imposes also to reserve at least the 5% of parking for carpooling; the calculation led to 30 places and they are visible in the Figure 44, that is simply a zoom in of the previous image (Figure 43).

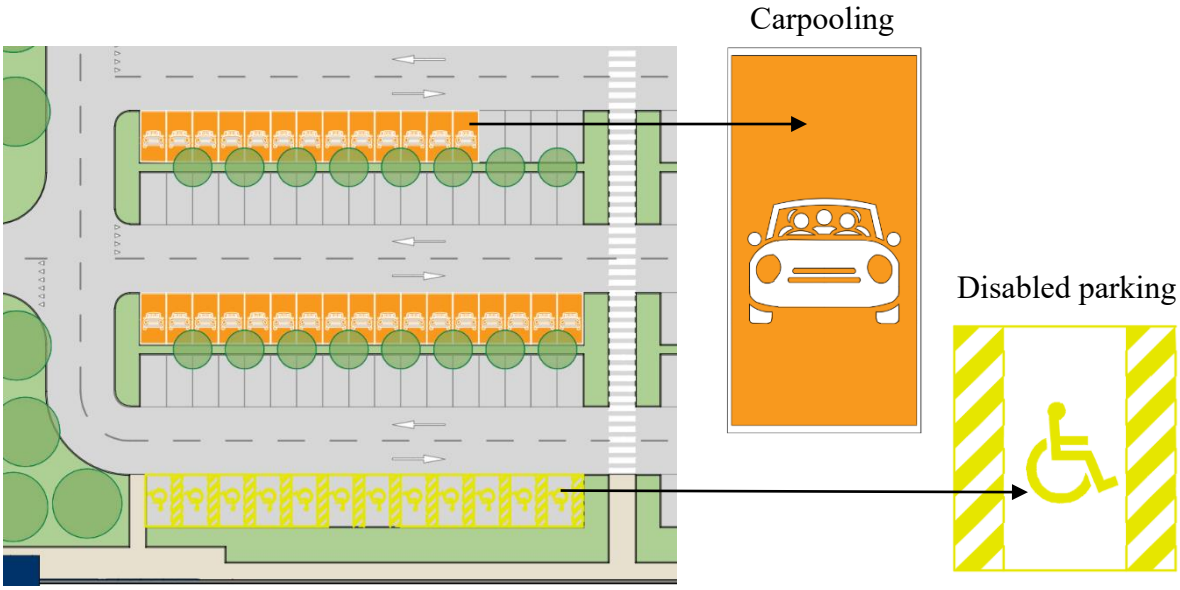


Figure 44: Disposition of preferred parking for carpooling and disabled

- ***Green Vehicles***

The aim of this credit is to provide preferred parking and recharging station for electric vehicles by placing them near the principal entrance of the building. It tries to encourage the usage of green vehicles respect to the one based on fuels derived from petroleum. In our specific case studio, the warehouse rating system gives the possibility to obtain one point persecuting one of the following actions:

- Option 1: provide at least one yard tractor powered by electricity, propane or natural gas with its relative charging or fuel station on site.
- Option 2: provide an electrical connection for at least 50% of all dock door locations.

The solution applied is the second. As a result, one interlocked socket (Figure 45) is installed each two dock door parks as it is visible in Sheet_03.L.

Thanks to these electrical connections at loading dock doors, it is possible for the driver, to stay in-cab in comfort conditions by connecting to the grid power instead of using the fossil fuel engine.

Figure 45: Gewiss interlocked socket

4.2 Sustainable Site (SS) Category: Warehouse and Distribution

As in the previous case, for this category there are two pre-requisite that are mandatory for the certification. The first one called "Construction Activity Pollution Prevention" requires a plan that neglect sedimentation and erosion and it will be realized during the construction phase. For the purposes of this Thesis, just the design credits are considered. The second pre-requisite is: "Environmental Site Assessment"; it requires a remediation investigation and plan of the site, but the inspection didn't evidence the presence of any contaminants, therefore just a relation will be uploaded. Consequently, it neglects the possibility to obtain the points for the LT credit "High Priority Site".

- ***Protect and Restore Habitat***

In this case the requirements of the LEED v4.1 are considered. Summarizing what's already has been explained for the same credit of the previous case studio, it imposes to have at least the 40% of greenfield areas and restore a portion (15% or 25%) of already developed area, by using native plant species.

The definition of greenfield by glossary is: *"area that has not been graded, compacted, cleared, or disturbed and that supports (or could support) open space, habitat, or natural hydrology".* Looking at the Figure 41, inside the LEED boundary there are some disturbed areas due to presence of buildings and the other green land cannot be considered as greenfield as it has been already graded and compacted. Therefore, the following calculation focus just on the percentage of restored areas.

The calculation has been summarised in Table 34 below: the percentage is higher than 25% so two points are obtained.

LEED boundary area	240.304	m²
Previously developed area	35.253	m²
New building area	129.639	m²
Total previously developed area	164.892	m²
Rainwater management area	5976	m²
Net previously developed area	158.916	m²
Project green area	45.338	m²
Percentage of restore habitat	28,53	%

Table 34: Calculation Summary for protect and restore habitat credit

Where:

$$Total\ previously\ developed\ area = Previously\ developed\ area + New\ building\ area$$

$$Net\ previously\ developed\ area = Total\ previously\ developed\ area - Rainwater\ management\ area$$

$$Percentage\ of\ restore\ habitat = \frac{Project\ green\ area}{Net\ previously\ developed\ area} \cdot 100$$

The green areas designed are represented by a coloured hatch in Figure 46.

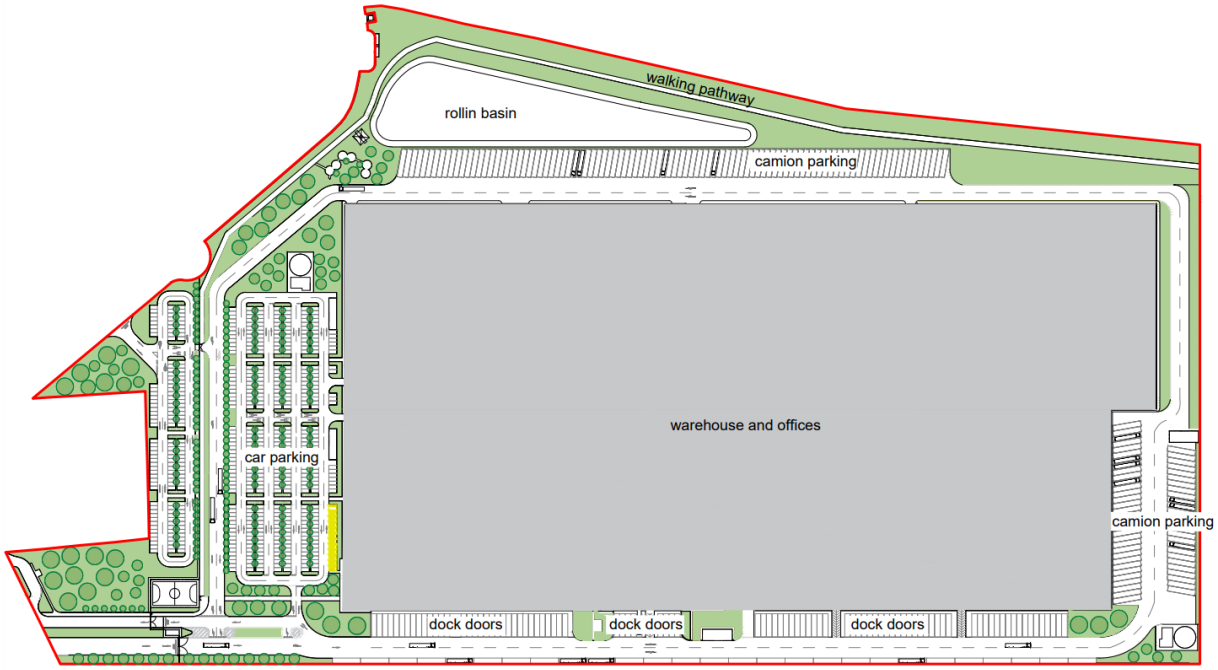


Figure 46: Considered designed green area disposition for the calculation

Figure 47: Representation of actual state of art of the site used for credit evaluation

- ***Open Space***

For the following credit, as previously done in the other case studio, the LEED v4.1 is applied. It requires to have at least 30% of the total site area as "Open Space" and at least the 25% of this value must be vegetated. The Table 35 provide the summary of areas used for the calculation; the result is positive so one point is obtained.

Project Data			Result
LEED boundary area	240.304	m²	
Building area	129.639	m²	
30% of LEED boundary area	72.091	m²	
Open space area	110.665	m²	Positive
25% of LEED boundary area	27.666	m²	
Project Green area	39.241	m²	Positive

Table 35: Calculation summary of Open space credit

The open space must include some "quality areas" where with quality the protocol means some sports areas, recreation zone to increase the social interactions and activities or garden space to cultivate. In the project there is a football court and picnic zone provided with tables connected by a pedestrian-cycle path as showed in Figure 48.

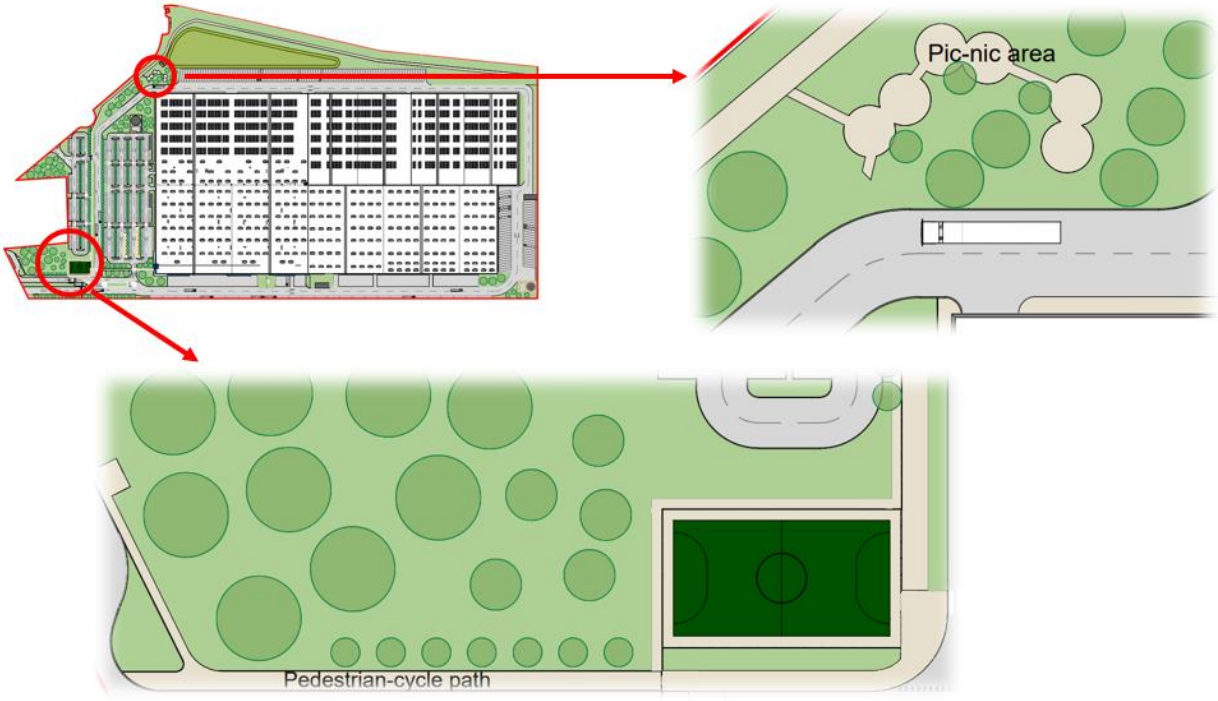


Figure 48: Image representing quality open space for the employees

Heat Island Reduction

The requirements have been already explained for the same credit in the previous case studio, thus, the same relation must be respected (Equation 1). In Sheet.04.L there is the subdivision of the different areas; all the measures to reduce the heat island phenomena are applied in all the surface except for the car viability where there is the asphalt. The imposed characteristics are Solar Reflectance Index (SRI) for the roof and Solar Reflectance (SR) for the pavements and they are indicated in the Table 36 below.

Heat Island Reduction		
Total Site Area	240.304	m²
ROOF - Roof measure (SRI > 82)	129.639	m²
NON ROOF - Asphalted Surfaces	46.795	m²
NON ROOF - Dockdoors Parking (SR > 0,33)	5.876	m²
NON ROOF - Pedestrian Path (SR > 0,33)	4.469	m²
NON ROOF - Car Parking (Open Grid > 50%)	7.284	m²

Table 36: Surfaces measure for different type of function

The summary values and result are present in Table 37; since it satisfies the requirements, two points have been obtained.

Project Surfaces		
NON ROOF measures	17.629	m²
ROOF area of high reflectance roof	129.639	m²
Total Site Paving Area + Total Roof Area	194.063	m²
Weighted sum of non roof and roof measures	208.110	m²
Result	**Positive**	

Table 37: Calculation summary of the applied measures

- ***Rainwater management***

The natural hydrological system of a site is obviously affected by the new construction, the impermeable asphalted surfaces for viability, soil compaction and loss of existing vegetation. The aim of the credit is to apply some strategies that can reduce the phenomena of the surface runoff in order to prevent flooding events.

Concerning the requirements of this credit, it is possible to persecute two options:

- Percentile of Rainfall Events, it requires some low-impact development strategies to retain on site the runoff related to the percentile of regional or local events. The reachable points respect to the percentile is evidenced in Table 38.

All Projects	Zero Lot Line Projects	Points	Points (Healthcare)
80th Percentile	70th Percentile	1	1
85th Percentile	75th Percentile	2	2
90th Percentile	80th Percentile	3	-

Table 38: Reachable LEED points respect to the rainfall percentile

- Natural land cover conditions, it imposes to calculate the project runoff volume of the design condition and the one related to the natural land cover conditions at the existing site state. If the two values are at least equal, three points are gained.

The option one is applied in this case studio considering the 90th percentile: so three points have been obtained.

Thanks to the availability of space, the technical solution reported by the design company is:

- Mixed reservoir system made of concrete main backbones with 800-1200 mm diameter and prefabricated boxes 200x100 mm;
- Permeable Roll in basin along the main backbone with a 7000 m2 of surface and a profundity of 3,83 m;
- Surface drainage network made of prefabricated drains connected to the main backbone with PVC pipes after the water treatment;
- Rain columns of 400 mm diameter that collect the rainwater from the roof and collected in calm wells first.

The whole draining system is composed by a "ring" structure that goes all around the warehouse from which the rainwater from the roof is collected. The water from the asphalted surfaces is conducted in some concrete channels, treated and get into the main backbone of the system that takes all the water inside the roll in basin. The connection between the main backbone and the roll in basin is made up with eight pipes with a diameter of 800 mm. The whole system works entirely by gravity and when the maximum allowable rainwater volume is obtained a valve allow to let the water goes into the public sewerage system.

Considering the large amount of green areas present on site a system to collect and re-use the rainwater from a part of the roof has been designed in order to irrigate the spaces. The system is made up of a tank of 100 m^3 provided with two submersible electric pumps (one as a reserve in case of malfunction).

To perform the calculation the protocol provides a file excel where it is possible to insert the historical data of precipitation of at least the last ten years. In this case the data are taken from the "Mantova Tridolino" station from 1st January 2005 to 17 February 2022, but to use the LEED calculation file, all the precipitation event less than 2,5 mm have to be neglected. The file performs the calculation of the 90th percentile that corresponds to 20,88 mm. In order to calculate the volume of rainwater to be managed on site and the one retained by the strategies applied another excel file is realized following the calculation principle of the "Technical Guidance on Implementing the Stormwater Runoff Requirements for Federal Projects" used in the United State and recognized as one of the computing methods accepted by the protocol. The formulas to be used in this case are:

$$Runoff = Rainfall - Depression\ Storage - Infliltration\ Loss$$

$$Runoff_{site} = \{(Runoff_{roof} \cdot A_{roof}) + (Runoff_{pavement} \cdot A_{pavement}) + (Runoff_{previous} \cdot A_{previous})\}/A_{site}$$

The infiltration is calculated by means of the Horton's equation:

$$F_t = f_{min} + (f_{max} - f_{min}) \cdot e^{-kt}$$

Where:

- F_t is the infiltration rate at time t (mm/h);
- f_{min} is the minimum or saturated infiltration rate (mm/h);
- f_{max} is the maximum or initial infiltration rate (mm/h);
- k is the infiltration rate decay factor (1/h);
- t is the time measured from time runoff first discharged into infiltration area.

Some other data, used for the computation, are the different areas on site and the Depression Storage provided by the guidance (Table 39 and Table 40).

Depression Storage	
Roof	2,54 mm
Pavement	2,54 mm
Pervious	5,08 mm

Table 41: Depression Storage values from the Technical Guidance

Surfaces		
Roof	129639	m²
Viability	57140	m²
Green area	39241	m²
Bioretention	7000	m²
Permeable pavement	7284	m²

Table 40: Site area dived in different surfaces Depression Storage values from the Technical Guidance

	Rainfall [mm]	Depression [mm]	Infiltration [mm]	Runoff [mm]	Volume [m³]	
Roof	20,88	2,54	0	18,34	2377,58	
Viability	20,88	2,54	0	18,34	1047,95	
Green area	20,88	5,08	246,99	0	9692,29	
Bioretention	20,88		246,99	0	1728,96	
Permeable pavement	20,88	2,54	246,99	0	1799,10	
Runoff volume to be retained on site					**3425,53**	**m³**
Runoff volume retained					**3528,06**	**m³**
Runoff sito					**71,44**	**mm**

Table 39: Calculation summary of Runoff volume

The summary of calculation is presented below in Table 41, where the total volume of rainfall to be retained on site is about 3425 m^3 and it was calculated with the sum of the multiplication between the runoff in meter and the area of the relative surface.

The infiltration value is calculated with the Horton's formula in which the parameter depends on the type of soil present on site. The analysis of the site's soil evidenced the presence of a soil type B (Table 42); the calculation evidenced the same infiltration for "Green area", "Permeable pavement" and "Bioretention" (Table 43) since the soil is considered type B everywhere then the volume of rain is obtained by multiplying the infiltration by the area of the considered surface but in the end the "Green area" is not considered in the "Runoff volume retained" since the protocol consider only improvements made with projected infrastructures.

Soil B		
f max	127	mm/h
f min	7,62	mm/h
k	2	1/h

Table 42: Reference value for soil B

t (h)	infiltration rate (mm/h)	infiltration (mm)
0	127,00	0,00
0,5	51,52	44,63
1	23,76	18,82
1,5	13,54	9,33
2	9,79	5,83
2,5	8,40	4,55
3	7,90	4,08
3,5	7,71	3,90
4	7,64	3,84
4,5	7,61	3,81
5	7,61	3,81
5,5	7,60	3,80
6	7,60	3,80
6,5	7,60	3,80
7	7,60	3,80
7,5	7,60	3,80
8	7,60	3,80
8,5	7,60	3,80
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19,5	7,60	3,80
20	7,60	3,80
20,5	7,60	3,80
21	7,60	3,80
21,5	7,60	3,80
22	7,60	3,80
22,5	7,60	3,80
23	7,60	3,80
23,5	7,60	3,80
24	7,60	3,80
Total infiltration [mm]		**246,99**

Table 43: Calculation summary of the total rainfall infiltration

Once the rainfall volume retained on site has been calculated, on the LEED file provided for the credit it is possible to insert the result to perform the required final check. To summarise, the strategy adopted are: the roll in basin, the open grid pavements for car parking and the irrigation tank and the total volume of runoff retained on-site is more than 100% as requested by the protocol (Table 44).

Runoff volume required to be retained onsite (cu m)	3.425,53

Strategies

List all low-impact development (LID) and green infrastructure (GI) strategies used to retain runoff on-site. Include the amount of volume retained per strategy. The combination of strategies listed must retain 100% of the runoff volume listed above.

LID or GI Strategy Description	Runoff Volume Retained (cu m)	Percent Runoff Volume Retained (%)
Roll in basin (Bioretention)	1.728,96	50,47%
Irrigation tank	100,00	2,92%
Parking permeable pavement	1.799,10	52,52%
		0,00%
		0,00%
		0,00%
		0,00%
		0,00%
		0,00%
		0,00%
Total volume of runoff retained on-site	3.628,06	105,91%

Table 44: LEED file for calculation summary

4.3 Water Efficiency Category (WE)

- ***Indoor Water Use Reduction***

The subsequent topic is relative to a mandatory pre-requisite and its relative optional credit. The same requirement of the first case studio must be respected: 20% as mandatory reduction of indoor water consumption respect to baseline value (given by protocol in Table 17) and the possibility to reach at maximum six points with a 50% reduction.

The main difference respect to the other case studio is that there is only one building with two different kinds of activities, so the calculation is made just with one excel file provided by the protocol by simply considering two “groups”: one for the offices and one for the warehouse. The owner of the warehouse provides the occupancy number for both the warehouse and office while the visitors are based on an estimation of about 10% of the usual occupancy.

The data inserted for the occupancy are represented in Table 45, where the gender ratio is for default evaluated as 50% for male and 50% for female.

Occupancy Type	Employees (FTE)	Visitors	Retail Customers	Students (K-12)	Residential	Other *(specify)*	Gender Ratio (%)
Total	272	28	0	0	0	0	100%
Male	136	14	0	0	0	0	50%
Female	136	14	0	0	0	0	50%

Table 45: Occupancy type for warehouse

Since the project consider the presence of ADA bathrooms the percentage of male expected to use urinals are 95% and the annual operational days of utilisation of the building is considered as 365 days. The bathrooms are designed with a dual flush with the following characteristics (Table 46) the LEED weighted average flush rate is used, then, as design value.

Low flush (lpf)	2
Full flush (lpf)	4
LEED weighted average flush rate (lpf)	2,98

Table 46: Flush values used for the project

The computation of the baseline and design case for bathroom flush rate of fixtures are listed below (Table 47).

Fixture Information			**Flush Rate**		Percent of Occupants (%)
Fixture ID	Fixture Family	Fixture Type	Baseline Flush Rate (lpf)	Design Flush Rate (lpf)	
	Toilet (male)	Dual-Flush Water Closet	6,00	2,98	100
	Toilet (female)	Dual-Flush Water Closet	6,00	2,98	100
	Urinal	Low-Flow Urinal	3,80	1	100
Baseline case annual flush volume (liters/year)					1.605.708,00
Design case annual flush volume (liters/year)					711.998,20

Table 47: Flush rate for baseline and design case

The calculation of the baseline and design case for bathroom flow rate are in Table 48.

Fixture Information		**Duration**		**Flow Rate**		Percent of Occupants (%)
Fixture ID	Fixture Type	Default (sec)	Non-default (sec) (Optional)	Baseline Flow Rate (lpm)	Design Flow Rate (lpm)	
	Showerhead	300		9,50	5,5	100
	Public lavatory (restroom) faucet	30		1,90	1,2	100
Baseline case annual flow volume (liters/year)						759.382,50
Design case annual flow volume (liters/year)						454.790,00

Table 48: Flow rate for baseline and design case

The same assumptions of the previous case are valid for the offices but the only thing that change is the occupancy that is like in Table 49.

Occupancy Type	Employees (FTE)	Visitors	Retail Customers	Students (K-12)	Residential	Other *(specify)*	Gender Ratio (%)
Total	130	13	0	0	0	0	100%
Male	65	7	0	0	0	0	50%
Female	65	6	0	0	0	0	50%

Table 49: Occupancy type for offices

The values obtained, for both flush and flow volume for the offices, are represented in the summary calculation table below (Table 50), where it is possible to see the obtained result that is a 50,69% of reduction, so all the six points are gained.

Summary for Design and Construction Rating Systems

Note: All information on this tab is READ-ONLY. To edit, see the previous tab(s).

Refresh Groups

Group Name	Baseline Case (liters/year)			Design Case (liters/year)		
	Annual Flush Volume	Annual Flow Volume	Annual Consumption	Annual Flush Volume	Annual Flow Volume	Annual Consumption
Warehouse	1.596.656,00	759.729,25	2.356.385,25	707.005,00	455.009,00	1.162.014,00
Offices	761.696,60	362.875,70	1.124.572,30	337.223,50	217.321,00	554.544,50

Annual baseline water consumption (liters/year)	3.480.957,55
Annual design water consumption (liters/year)	1.716.558,50
Percent water use reduction (%)	**50,69%**

Table 50: Summary calculation for Indoor Water Use Reduction credit

- ***Outdoor Water Use Reduction***

The indicated theme is treated inside the protocol as a pre-requisite and a credit. The first asks to have no irrigation system or a reduction of water quantity, for irrigation, of at least 30% while the second one allows to obtain two points maximum, depending on the percentage reduction as showed in Table 51.

Percentage reduction from baseline	Points (except Healthcare)	Points (Healthcare)
50%	1	1
100%	2	–

Table 51: Protocol's limits to obtain points

In the case under examination the project considers a water network for irrigation so the evaluation of percentage reduction from the baseline is considered to understand if it is feasible to obtain some points.

The first considerations are based on the baseline calculation of the water required for the landscape area. The summary of the calculation is in Table 52, where the month with the peak ETo value is multiplied by the total green area (45.338 m^2) to obtain the Landscape water baseline.

	Monthly Rainfall (mm)	Monthly ETo (mm)	Watering Demand (mm)
January	50	9	-41
February	56	20	-36
March	61	43	-18
April	89	69	-20
May	94	96	2
June	80	111	31
July	67	127	60
August	77	105	28
September	97	66	-31
October	96	34	-62
November	103	15	-88
December	61	9	-52
Peak watering month			July
Peak watering demand (mm)			60
Peak watering month ETo (mm)			127
Landscape water allowance (l/month)			4.033.722
Landscape water baseline (l/month)			5.762.460

Table 52: Baseline calculation format from protocol's excel file

In this case the monthly Rainfall is taken from the Figure 49 that consider an average value for each month on 20 years base (from 1991 to 2021). While for the monthly ETo calculation, two software developed by the FAO has been used:

- Climawat, that provides the climatic data of the nearest station, in this case *Verona;*
- ETo Calculator, that reads the data exported from Climawat and provides the values of the evapotranspiration coefficient (ETo) in mm/day for each month of the year. A screen of the calculator is below in Figure 50.

	Gennaio	Febbraio	Marzo	Aprile	Maggio	Giugno	Luglio	Agosto	Settembre	Ottobre	Novembre	Dicembre
Medie Temperatura (°C)	3.1	4.8	9	13.3	17.8	22.4	24.7	24.3	19.5	14.6	9	4
Temperatura minima (°C)	-0.1	0.8	4.1	8.2	12.6	17.2	19.6	19.6	15.4	11.1	6	1
Temperatura massima (°C)	7.1	9.3	14.1	18.1	22.6	27.3	29.5	29.1	23.8	18.5	12.5	7.6
Precipitazioni (mm)	50	56	61	89	94	80	67	77	97	96	103	61
Umidità(%)	83%	76%	71%	69%	67%	63%	60%	61%	68%	76%	83%	84%
Giorni di pioggia (g.)	5	5	6	8	8	7	6	7	7	7	7	6
Ore di sole (ore)	5.0	6.2	7.8	9.5	11.4	12.6	12.5	11.5	9.5	6.3	4.8	4.7

Figure 49: Climate average data from 1991 to 2021 taken form https://it.climate-data.org/

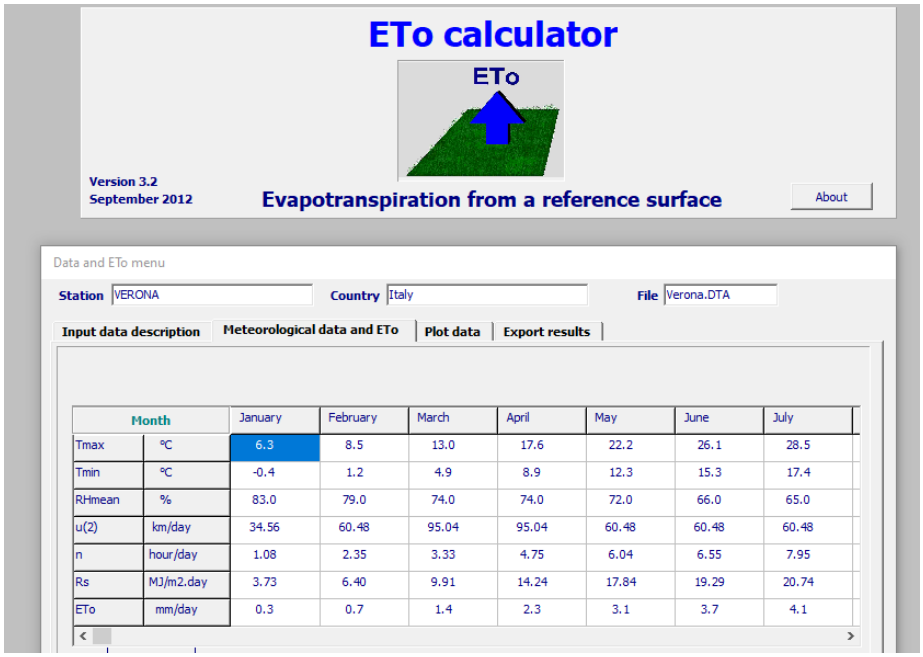


Figure 50: Screen of ETo calculator

The second step is the evaluation of the calculation of the LWR (Landscape Water Requirement) that is based on the month that required more water: July with 67 mm/month as monthly rainfall value. To perform the calculation there is a subdivision of the green areas in different zones depending on the type of irrigation systems indicated by project and represented in Sheet_05.L. The water requirement evidenced in Table 53 are selected considering the typologies of trees species, their size and the type of irrigation.

Zone ID	Hydrozone or Landscape Feature Area (sq m)	Plant Type or Landscape Feature	Water Requirement	Landscape Coefficient (K_L)	Irrigation Type	Distribution Uniformity (DU_{LQ})	LWR_H (l/month)
	10.592	Trees	High	0,9	Rotor	70%	1477433
	4.530	Groundcover	Medium	0,5	Fixed spray	65%	326160
	16.883	Groundcover	Low	0,2	No irrigation	N/A	0
	13.333	Trees	Medium	0,5	Drip (press comp)	90%	693316
							0
							0
							0
							0
							0
							0
Total hydrozone or landscape feature area (sq m)							45.338
Landscape water requirement based on the site's peak watering month (l/month)							2.496.909

Table 53: Landscape water requirement calculation

In the last page of the protocol excel file there is the summary of the calculation already done and the percentage of reduction from the baseline, that is more than 50%, as in Table 54, so one point is gained.

Landscape water baseline (l/month)	5.762.460
Landscape water requirement (LWR) (l/month)	2.496.909
Percentage reduction from baseline (%)	57%

Table 54: Calculation summary for Outdoor Water Use Reduction Credit

- ***Building-Level Water Metering pre-requisite***

As for the previous case studio the protocol requires to install permanently water meters to control total indoor and outdoor water consumption. Monthly and annual report must be sent to the USBGC for five years after the LEED certification is obtained.

- ***Water Metering***

The considered credit gives the possibility to obtain one point by installing water meters on at least two subsystems. The six possibilities included are: irrigation, indoor fixtures and fittings, domestic hot water, boiler, reclaimed water, other process water (dishwashers, clothes washers etc.). In accordance with the property, the two selected subsystems are:

- Indoor plumbing fixtures and fittings, a meter system of 80% of systems used in the Indoor Water Use Reduction credit;
- Irrigation, that measures the water consumption of 80% of vegetated area.

5 Results comparison between the two projects

As previously explained, the two considered projects have a different function, location, dimension, that's why some credits are easier to obtain in one respect to the other. In this chapter, a critical comparison has been realized between the different results of credits, the different methodologies and the key problems related to the projects.

Location and Transportation (LT) category

- ***Sensitive Land Protection credit***

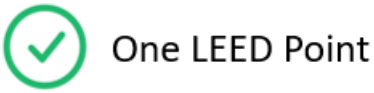
Students Residences

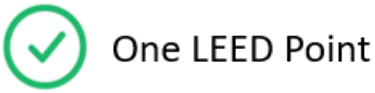
The project must be on a previously developed land. The case in exam is on a land completely altered by existing paving and on the Italian PRG it is considered as a "urban transformation area".

Logistic Centre

Since the project site can be considered as partially previously developed the first option is not persecuted. The second one requires:

- ✓ Not to use a prime farmland;
- ✓ The site must not be on a hazard flood area;
- ✓ The site must not be on a naturally protected area;
- ✓ Site alteration far from water body at least 30,5 m;





The industrial warehouse is far from the city centre and part of its area is at natural state. Even if it is not considered as agricultural purposes, it cannot be categorized as previously developed; for this reason, more documentation is required to evaluate how much the surrounding is going to be altered by the new construction, but in the end both projects obtained one point.

- ***Surrounding Density and Diverse Uses***

Students Residences	Logistic Centre
The previously mentioned credit is divided into two checks: ✓ Evaluation of the population density of the area surrounding the site; ✓ Presence of different services nearby, reachable by walking.	The request for the warehouse, imposed by protocol, are different: - 75 % of the site must be previously developed. OR - The site must be near some facilities such as airport, seaport, highways etc.
 Five LEED Points	 No LEED Points

The credit requires different things from one rating system to the other, that's because the Warehouse rating system considers that an industrial building, usually, is not built nearby the city centre. For this reason, it is almost impossible to obtain points evaluating the population density and services in the surrounding area for the second project, while the first obtained easily all the available five points. The Warehouse rating system focus on using previously developed land or the connection with strategical infrastructures but none of that are satisfied by the project, so no points have been gained.

- ***Access to Quality Transit***

Students Residences	Logistic Centre
The credit requires the presence of a minimum passages of public transport system. The project is located in a central area of the city, so the points are easily accessible.	The location of the project effects negatively on this credit evaluation. The project is far away from the city centre and it is not well connected with the public transport system.
 Five LEED Points	 No LEED Points

- ***Bicycle Facilities***

Students Residences

The credit requires a minimum number of services reachable with an existing bicycle network with a maximum 4800 m. The location is serviced by an existing bicycle network that connects the project to a big city area; the only problem is the possible distribution of spaces that must be ensure as bicycle parking.


One LEED Point

Logistic Centre

Even if the project has lots of available space to be used to create bicycle storage and cabinets, the project's location is not serviced by an existing bicycle network, so it is impossible to persecute the following credit.


No LEED Points

- ***High Priority Site***

Students Residences

One of the credit's options is to demonstrate that the site has been polluted by hazardous substances. In this case the presence of ballast is certified and a soil remediation occurs.


Two LEED Points

Logistic Centre

The soil analysis conducted by specialists has highlighted no presence of any contaminants. Furthermore, the area is not historical and it is not included in any public programme to develop critical area.


No LEED Points

- ***Green Vehicles***

Students Residences

The credit of New Construction rating system requires some recharge station and preferred parking for electric vehicles. In this case, they are mixed with the commercial area, so it is not possible to quantify them.


No LEED Points

Logistic Centre

The credit for Warehouse rating system requires the disposition of electrical connection for half of dock doors location. They are correctly placed in the project.


One LEED Point

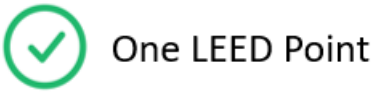
- ***Reduced Parking Footprint***

Students Residences

The open space related to the project is very limited, for this reason the minimum number of parking are designed in the underground parking of the commercial building nearby. Since they are mixed with the other commercial parking is not possible to demonstrate an effective reduction.

Logistic Centre

The project has lots of available open space where there are placed car and truck parking. The credit requires a reduction respect the municipality rules. This is largely respected in the project.



As results, for the first credit category considered, the Student Residences in *Torino* reached 14 points out of 16 thanks principally to a good location of the site that helps to obtain 10 points for the population density and services reachable by foot or bicycle. The opposite situation is evidenced in the second case studio, the logistic centre in *Mantova*, where for the first category, only 3 points out of 16 are obtained.

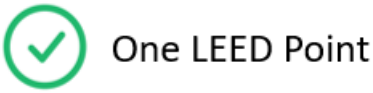
From this simple comparison it is easy to understand the importance of the location of the future construction; this poor quantity of points achieved will obviously have some consequences on future development to obtain the certification. This is because most of these points depends on fixed characteristics of the site, so the leakage of points here, will obviously force the future choices on more technical aspects or layout modifications. The possible risks can be: not enough points to get a certification or a different LEED level from what expected.

Sustainable Site (SS) category

- ***Site Assessment***

Students Residences

The credit involves a series of documentation regarding the site produced by specialists such as geologist.



Logistic Centre

At the actual state of art of the project, there is no sufficient documentation, provided by professional figures, to persecute the credit.

- ***Protect and Restore Habitat***

Students Residences

Different possibility can be persecuted using the LEED v4 or v4.1. The problem is that none of them are feasible due to limited spaces. There are no existing greenfield areas to preserve.

Logistic Centre

LEED v4.1 is used in this case. The site contains a large part of green area not considered as greenfield. A restoration over 25% of already developed area has been done.

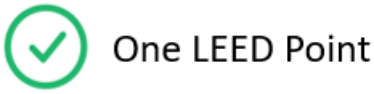
- ***Open space***

Students Residences

It requires a minimum open space in relation of site dimension. A percentage of this open space must be green of quality with sport furniture for example. The required open space is satisfied but the green areas not.

Logistic Centre

Thanks to a big availability of space both requirement on open space and green areas are satisfied. A pic-nic area and a football court has been designed.



- ***Heat Island Reduction***

Students Residences

To respect the limit of the credit, some evaluation on SRI and SR of materials applied for paving and roof must be done. In this case, to satisfy the requirement, the measures must be applied on all the horizontal surfaces.

Logistic Centre

The same limit must be respected in this case studio. Even if there is a portion of asphalted surfaces, the limit is satisfied by using open grid pavements in the area dedicated to car parking.

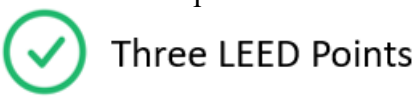
- ***Rainwater management***

Students Residences

The site dimension doesn't allow to create a system as a roll in basin or similar. On the roof there will be no space for a tank since photovoltaic panels will be placed.

Logistic Centre

The project involves the construction of a roll in basin connected with a channel system that collect the water from all the site's zones and the presence of a tank to reuse water for non-potable reasons.



Water Efficiency (WE) Category

- ***Indoor Water Use Reduction***

Students Residences

The project is made up of two separate buildings, for this reason the calculator must be used separately for each structure. The two documents must be provided on LEED online and the worst result is considered.

Logistic Centre

The project is just one building with an area dedicated to offices and another with logistic areas. For this reason, just a calculator is used with two groups considered. In this case, all the data contribute to one reduction percentage to be evaluated.

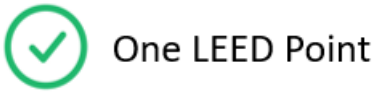
- ***Outdoor Water Use Reduction***

Students Residences

The green areas on site are very limited due to a lack of spaces. For this reason, just the pre-requisite is persecuted where plant species with no irrigation need will be used.

Logistic Centre

It is realized by the calculation of reduction of water requirement for irrigation of green areas respect to a water baseline. The project has a large amount of vegetated area, so the credit is persecuted.



- ***Water Metering***

Students Residences	Logistic Centre
Two sub-systems that controls potential water wastes: indoor plumbing fixtures and fittings and domestic hot water.	Also for this case studio, there are two sub-systems: indoor plumbing fixtures and fittings and irrigation.
 One LEED Point	 One LEED Point

At the actual state of art of LEED evaluation for the two projects, the differences of typology, location and size reflect themselves in totally divergent results. The centrality of the location of Students Residences allows to easily obtain 14 points in the Location and Transportation (LT) category while the Logistic Centre obtained only 3 points. The LT category is one of the key elements for the further development of the project since the majority of the points depend on the existing facilities and infrastructure around the site and just the "Reduce Parking Footprint" and "Green Vehicles" request to modify something in the parking design of the project. These can be considered "easy" or "free" points to get, since they do not require any type of investments and they give the possibility to obtain a good amount of points that can effect positively the certification process. At first glance, the LT category could be accounted as a leak in the certification process because 14 out of 16 points are not related to any kind of design of the structure. On the other hand, the category is fundamental to guide the correct positioning of the building to take advantage of existing infrastructure and connection that avoid the non-necessary usage of cars as method of transportation and to create new roads disturbing undeveloped land. Indeed, it has been established that the related CO_2 emissions to build the new viability and the emission of cars to get in a place contribute to the climate change and it has a negative impact on the environment. The points obtained in the first category are fundamental to understand how much will be the investments that the property has to sustain for technical interventions in order to increase the performances of the building and obtain more points in other categories.

Concerning the Sustainable Site (SS) category the situation is inverted between the two projects. The availability of space that is characteristic of the Logistic Centre permits to get in an easy way the three points related to "Protect and Restore Habitat" and "Open Space". This imposes to create quality green spaces for the wellbeing of occupants but also to increase the presence of vegetated areas that helps to maintain the ecosystem's health and to manage the rainwater.

The Logistic Centre needs to obtain as many points as possible, for this reason, the path of "Rainwater Management" credits has been persecuted. Channels all around the site collect the rainwater from different points and by gravity take them to the drainage basin to let the water infiltrate in the ground and a tank to use water for irrigation or bathroom flush is also present. On the contrary, the Students Residence due to limited portion of site space do not persecute the credit and, also, it doesn't need to force it too much, since it reached many points in the first category and a rainwater management system can be expensive. So, in the end, the Students Residences obtain three points while the Logistic Centre eight.

For the "Water Efficiency" category, both projects persecute the "Water Metering" credit. The "Indoor Water Use Reduction" is also considered in both cases but with stricter parameter for the Logistic Centre that gets more points than the other. Thanks to the availability of large green spaces the Logistic Centre applies strategies to reduce the outdoor water use with particular systems of irrigation. So, in the end it takes three more points respect to the Students Residences.

Category	Credit	Students Residences	Logistic Centre
Location and Transportation	Sensitive Land Protection	1	1
	Surrounding Density and Diverse Uses	5	0
	Access to Quality Transit	5	0
	Bicycle Facilities	1	0
	High Priority Site	2	0
	Reduce Parking Footprint	0	1
	Green Vehicles	0	1
	Total	**14**	**3**
Sustainable Site	Site Assessment	1	0
	Protect and Restore Habitat	0	2
	Open Space	0	1
	Heat Island Reduction	2	2
	Rainwater Management	0	3
	Total	**3**	**8**
Water Efficiency	Outdoor Water Use Reduction	0	1
	Indoor Water Use Reduction	4	6
	Water Metering	1	1
	Total	**5**	**8**
Total		**22**	**19**

Table 55: Summary result table of credits earned in the first three LEED Categories

To summarize, the Logistic Centre obtain in the first three categories 19 points while the Students Residences 22. In both cases the property expectation is a LEED Gold level, so the analysis of the first category provides information to how many other credits must be persecuted

to obtain a certain level. The gap between the projects has been reduced, a little bit, thanks to some technical and design choices that the warehouse's owner approved. This is a clear example of the importance of the project location for a certification that can boost to a higher level or can lead to avoid credits that are more expensive for the owner.

5.1 The figure of the LEED AP in the process of integrated project design

The figure of the LEED Accredited Professional is fundamental in the overall process of certificating a building and it has been accredited by the Green Building Council of United States after an exam. The LEED AP is a figure prepared on green themes with specific competences on the LEED certification and its adjournments. This is the professional figure that coordinates the teamwork along the process by guiding them and proposing modifications to structures characteristics. During the experiences of thesis in AI Studio, an activity of support to the LEED AP, in both projects, had been realized, in order to modify some design aspects and to guide the different disciplines involved in the design process. Some clear examples of modifications or guidelines for the projects are:

Students Residences

- Changes in bicycle parking design, inserting bicycle support inside the students' rooms.
- The specifications on SR and SRI of materials to be used on site for heat island reduction.
- The usage of flow regulator to reduce indoor water consumptions.
- Inserting specific water metering systems in the hydraulic plant.

Logistic Centre

- Imposed distances of negative environmental interventions from the water body.
- Guidelines on numbers of car parking disposition and numbers of carpooling parking.
- Imposed presence of electrical connections on dock doors area.
- Minimum requirements for green areas around the building.
- Creation of quality spaces: picnic area and football court.
- SR and SRI of materials to be used on site for heat island reduction.
- Minimum dimensions of rainwater management systems and in particular modification of the collector system that bring water to the roll in basin. The system was designed with pump that led to a water circulation up to the bioretention area; to comply with a

more sustainable solution required by protocol, a change in its design has been done, creating a system with an inclination that allow to collect and move water with gravity.

- Usage of flow regulator and water metering for water consumption.
- Definition of specific areas to be irrigated and its relative system to satisfy the protocol.

Another important difference between the two projects is the way they are managed which has repercussions on the activities done by the LEED AP.

The Students Residences is a project entirely handled by AI Studio with different areas of competences: architecture, structure, implants etc. For this reason, the indications and the project changes, necessary to comply the protocol requirements, can be easily managed by the LEED AP with a constant check on the design progress by simply talking with member of the project's team. The negative aspect is that the project is realized on AutoCAD, as a result, there is a higher possibility to make some mistakes by make calculation or evaluation on obsolete files. There must be a higher attention of the LEED AP to control all the progress and to receive them.

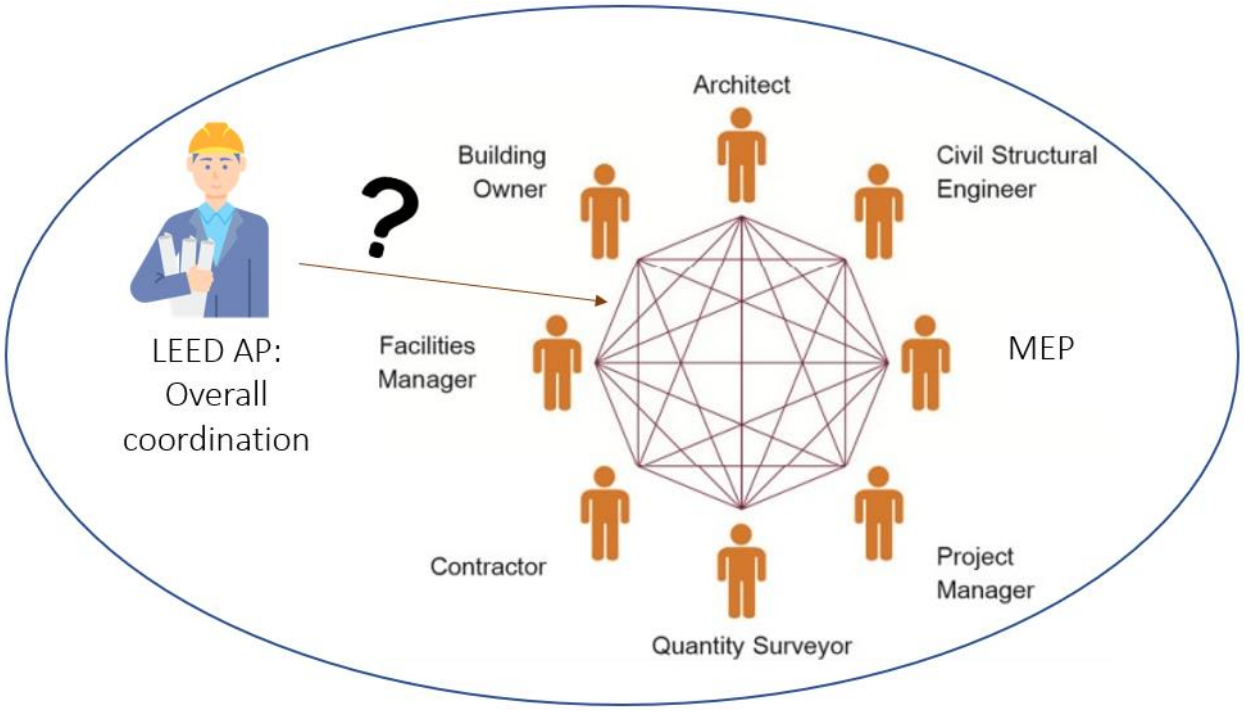


Figure 51: Coordination of LEED AP in a CAD approach project

The Logistic Centre is a bigger project that is not managed by AI Studio, the role is the LEED management of the project that consists of adjusting some aspects to reach the LEED Gold certificate, as owner's desire. In this case the project is divided in different subcontractors that realize their own project, consequently, the guidelines and the control operation is more

complex since many companies are involved. To reduce the problems on clash between different disciplines, the project has been realized on Revit, with a central model where different subcontractors have their own work set in which they upload the project's progress. In this case the possibility to use obsolete files is neglected and it is also easier to make calculation on areas or type of material since abacus with characteristics and quantity can be extracted from the software.

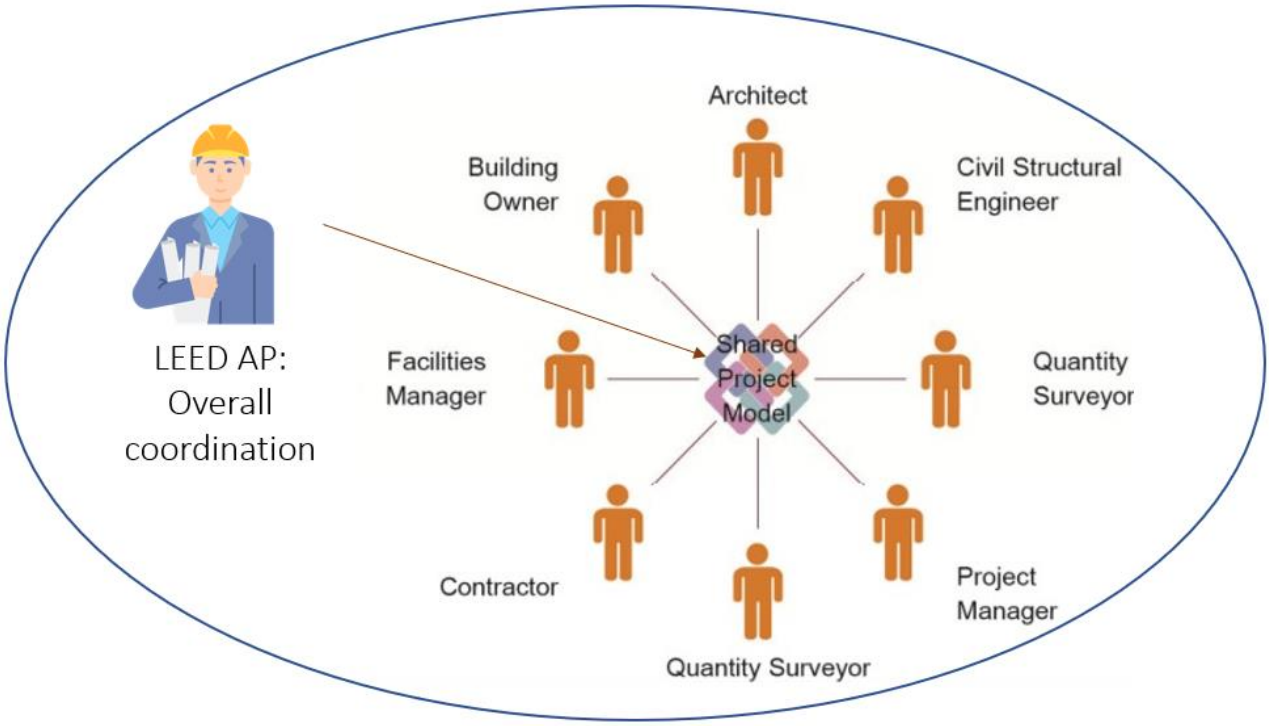


Figure 52: Coordination of LEED AP in a BIM environment project

The presence of multiple companies, that realize only a part of the project, complicates the LEED AP work that has to constantly communicate virtually with them to check that all the guidelines are respected. The other negative aspect is that in the first case, entirely managed by AI Studio, all the sectors involved in the process works with the common target to reach the certification; while in the second case, it is more difficult to convince subcontractors to work with the purpose of getting a green certification, also considering the cost of choices that usually are higher in green project like the two presented in this thesis.

5.2 Comparison between LEED and CAM principles

The Green certifications, such as the LEED, are voluntary process that an owner can decide to persecute to build in a more efficient way guaranteeing the wellbeing of the occupants and being respectful of the environment.

In Italy, for what concerns the public procurement, it is mandatory to follow the CAM ("Criteri Ambientali Minimi") that gives general indications to public entities for a sustainable procurement process in order to find the best design solution for its entire lifecycle but also to rationalise consumption and reducing the public costs. It became effective with Law 221/2015, article 18 and article 34 bearing "Energy and environmental sustainability criteria" of Legislative Decree 50/2016 "Procurement Code". There are 17 categories of supplies and procurements, but in this part, there is a focus on CAM for design and construction, refurbishment and maintenance of public administration buildings. The construction CAM index is represented below in Italian:

The requests made by CAM must be valid and with a possibility to be checked scientifically and, when possible, they should be referred to technical norms. The CAM for constructions includes Minimum Environmental Criteria and Rewarding Criteria; for all of them the structure of the code is:

- Contents and modality to verify the criteria;
- Reference norm, objective, tools, observations;

For each criteria the verification can be done with:

- Documentation that demonstrates the conformity of a product or service;

- Presumed conformity, acceptable instead of direct proof;
- Controls to verify prescriptions;

Although the presence of CAM, with the target to reach at least 50% of green procurement in a limited time, the reality is still far away from what expected, indeed, in 2017 just the 9% of public procurement were green. That' s why it can be interesting to understand the correlation between a Certification Protocol, LEED in this case, and the requirements made by the CAM. This work could be important to use LEED as support for the Italian law. Obviously, there isn't a perfect match between CAM and the credits of different rating systems and only the ones with a quality level at least equal to CAM can be used, in other conditions additions must be provided. For this reason, in the following part, some CAM criteria are considered to find correlations with some of the LEED credits analysed before in the two cases studio.

1.3 "Tutela del suolo e degli habitat" (Soil and Habitat Protection)

CAM The aim is to reduce the soil consumption, its impermeabilization, the lost of habitat and agricultural space.

LEED There is no credit inside the LEED protocol that satisfy all the aspects, but similar prescription can be found in LT Surrounding Density and Diverse Uses, Access to Quality Transit and Bicycle Facilities that refers to presence of services and existing connections that would reduce the creation of new infrastructure on undeveloped land. Also, SS Protect and Restore Habitat can be included since it imposes to preserve and restore green spaces with local type of soil and vegetation.

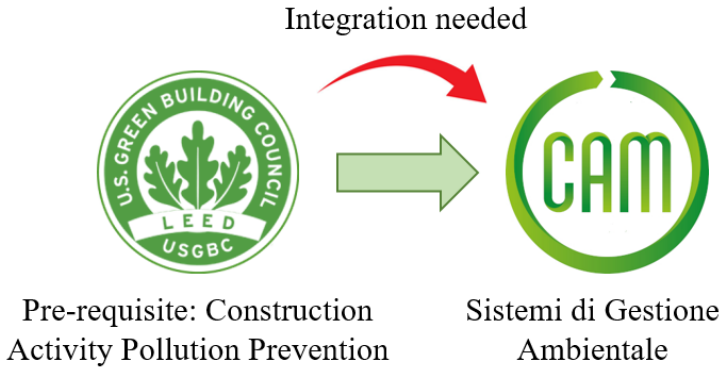
LT Sorrounding Density and Diverse Uses
LT Access to Quality Transit
LT Bicycle Facilities
SS Protect and Restore Habitat

Tutela del Suolo e degli Habitat

2.1.1 “Sistemi di Gestione Ambientale” (Environment management systems)

CAM The aim is to reduce the environmental impact adopting a recognised norms to manage the site.

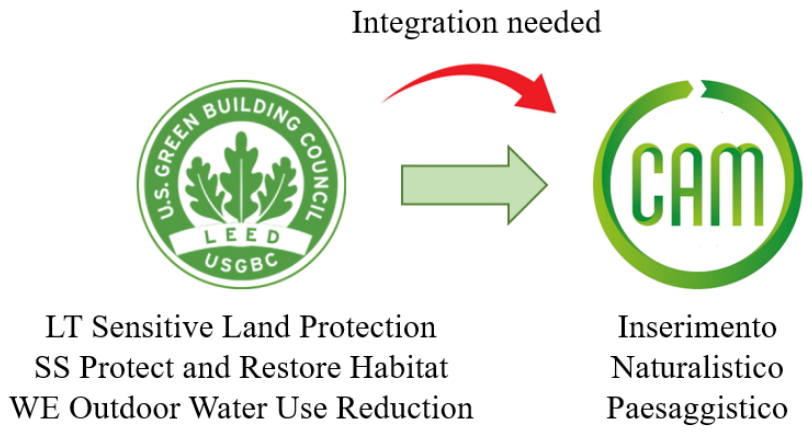
LEED One of the LEED’s pre-requisites is to create a ESC (Erosion and Sedimentation Control) plan which considers: slope of the soil and water drain, quantity of ground disturbed, runoff effect, site conditions that can contribute to dust formation etc. All this aspect can be considered and implemented to became part of a bigger Environmental Plan to complies with CAM if the bidder hasn’t the EMAS registration or the ISO14001.



2.2.1 “Inserimento Naturalistico Paesaggistico” (Natural Landscape Inclusion)

CAM For the construction of new buildings, it is necessary to respect the stricter rules but also to guarantee preservation of habitats, vegetation, landscape. The project must include a connection between indoor and outdoor spaces with specific consideration of plant species to use considering their water need, resistance to pathologies and effects on human health such as allergies and hazardous substances absorbed.

LEED The LEED protocol considers these aspects in the following credit: LT Sensitive Land Protection, SS Protect and Restore Habitat, WE Outdoor Water Use Reduction. The two aspects not considered inside the Vegetation Design are: hazardous substances absorbed and absence of human health problems that must be integrated.

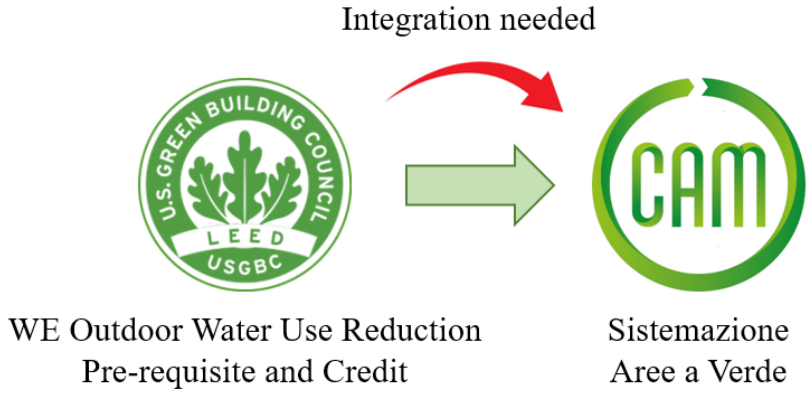


2.2.2 "Sistemazione Aree a Verde" (Vegetation Area Disposition)

CAM The disposition of the green spaces must consider their maintenance in order to be sustainable also from an economic point of view. The species to use should follow these indications:

- Autochthonous species with low allergenic pollen;
- Species with low production of pollen;
- No stinging or thorny species;
- Species with long roots for inclined surfaces;
- No species with thin roots that could create problems in case of meteorological events.

LEED The LEED protocol does not complain a credit with these kind of detail for species choice; it only asks to use local species with low water need for irrigation, and it is evidenced in a pre-requisite and its relative credit. The different quantity of information between LEED and CAM are not negligible for this reason the protocol must integrate information to satisfy the requirements of the Italian law.



2.2.3 “Riduzione del Consumo di Suolo e Mantenimento della Permeabilità dei suoli” (Reduced Soil Consumption and Permeability Preservation)

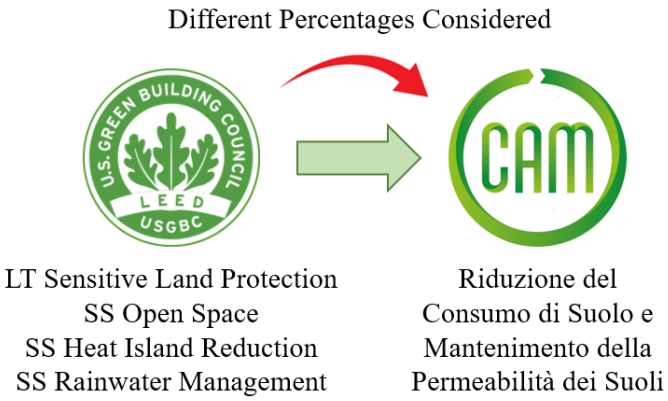
CAM The project must follow some prescriptions:

1. It is not possible to increase volume of buildings in protected areas;
2. At least 60% of the project surface must be permeable;
3. At least 40% of the not built site area and at least 30% of the total site area must be vegetated;
4. Inside the vegetated areas at least 40% must be covered by tree and 20% of bushes using autochthonous species;
5. Draining material for bicycle and pedestrian pathways,
6. It requires a soil removal of 60 cm where excavations are needed. The soil is stored on site and then re-used for green areas.

Point by point connections with LEED credits are evidenced in the table below

CAM	LEED Credit
1.	LT Sensitive Land Protection: it establishes to not built on prestigious areas
2.	SS Open Space and SS Heat Island Reduction requests is similar to the CAM but with different percentage to respect.
3.	SS Open Space but with different percentage.
4.	There is no credit that impose the usage of trees or bushes, so an integration is needed.
5.	SS Rainwater Management and SS Heat Island Reduction have some similar requests.
6.	This aspect is not considered in any credit of the protocol so an integration must be done.

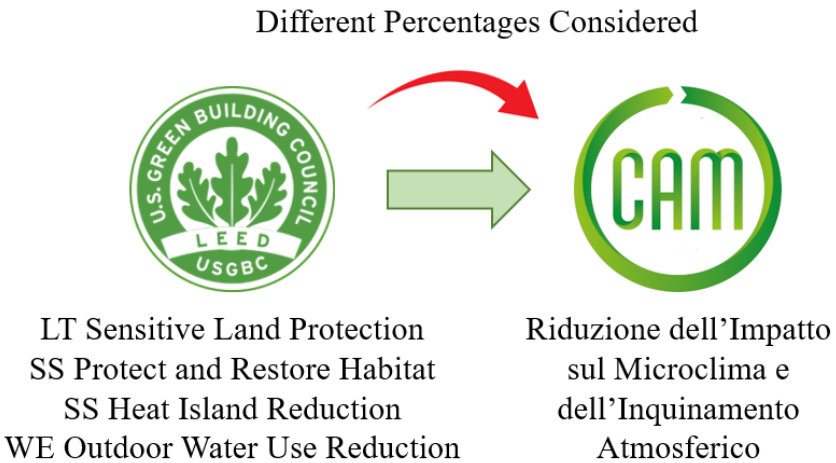
Table 56: Comparison table CAM – LEED for “Reduced Soil Consumption and Permeability Preservation



2.2.6 Riduzione dell'Impatto sul Microclima e dell'Inquinamento Atmosferico ("Impact Reduction on Microclimate and Pollution")

CAM The target is to reduce the effect of emissions and the heat island effect by using green areas, with limited water need, that absorb CO_2 and improve the microclimate. For paving, permeable materials are preferable and also with an SRI of at least 29. For rooftop materials, an SRI equal to 29 if it is inclined (more than 15%) or 76 if its inclination is less than 15%.

LEED Similar requirements are evidenced in LEED credits: LT Sensitive Land Protection, SS Protect and Restore Habitat, WE Outdoor Water Use Reduction and SS Heat Island Reduction paying attention to differences of SRI values.

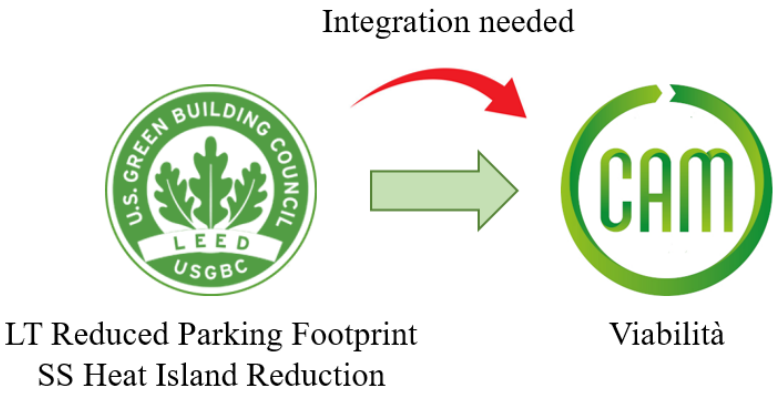


2.2.8.1 "Viabilità" (Viability)

CAM If it is not possible to use green surfaces, the colour must be cold and light or using open-grid pavement. Parking spaces must be shaded by trees for at least 10%, at least

75% of its perimeter must be vegetated. If it is covered by structure, it must involve photovoltaic panels and spaces must consider the number of people that will use the area.

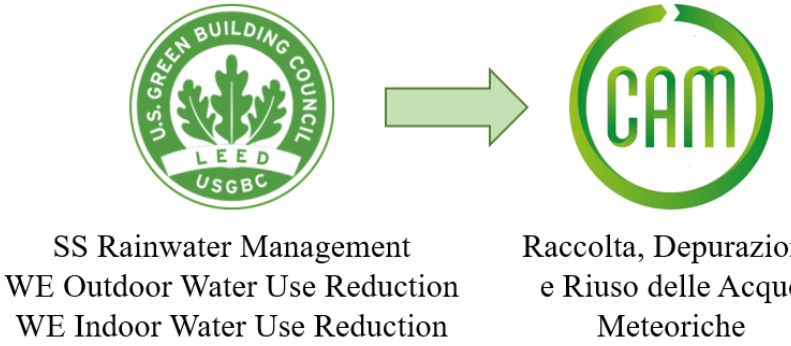
LEED In LEED protocol there is SS Heat Island Reduction that refers to colours of pavement materials; while for the parking spaces there is Reduced Parking Footprint that need integration since it doesn't focus on shadows made by trees or vegetation but only tries to reduce the number of parking spaces respect to the municipal law.



2.2.8.2 "Raccolta, Depurazione e Riuso delle Acque Meteoriche" (Recover and Reuse of the Rainwater)

CAM It requires the creation of a system that recover the rainwater to be treated. The rain coming from not polluted surfaces such as pedestrian path, sidewalks, gardens can be conducted directly in tanks to be stored and used. While the one that comes from parking or street must be treated first.

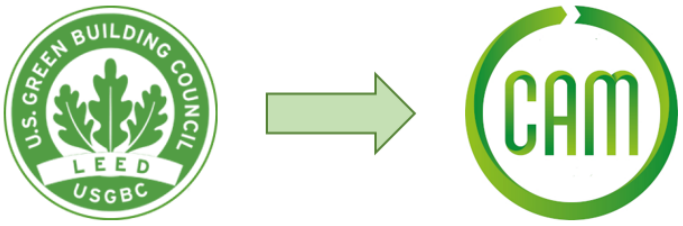
LEED Inside the LEED protocol these aspects are considered in the following credits: SS Rainwater Management, WE Outdoor Water Use Reduction, WE Indoor Water Use Reduction with parameter equivalent to the CAM law.



2.2.8.3 “Rete di Irrigazione delle Aree a Verde Pubblico” (Irrigation Network for Vegetated Areas)

CAM To reduce the water consumption a drip irrigation is considered with an automatic control system that takes energy from renewable sources.

LEED The correspondent LEED credits are: SS Rainwater Management, WE Outdoor Water Use Reduction and EA Renewable Energy Production.



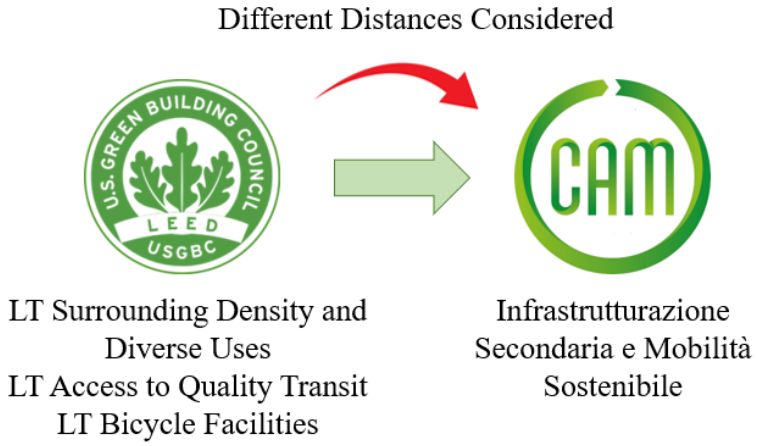
SS Rainwater Management
WE Outdoor Water Use Reduction
EA Renewable Energy Production

Rete di Irrigazione delle Aree a Verde Pubblico

2.2.9 “”Infrastrutturazione Secondaria e Mobilità Sostenibile” (Secondary Infrastructure and Transport Sustainability)

CAM The CAM requires a mix of different functions inside the project, depending on its dimensions. Furthermore, depending on the occupants, there should be: public services at 500 m distance, underground station at 800 m and railway station at 2000 m, bicycle network and bike ranks, public transport system at 500 m distance, pedestrian pathways enriched by vegetation.

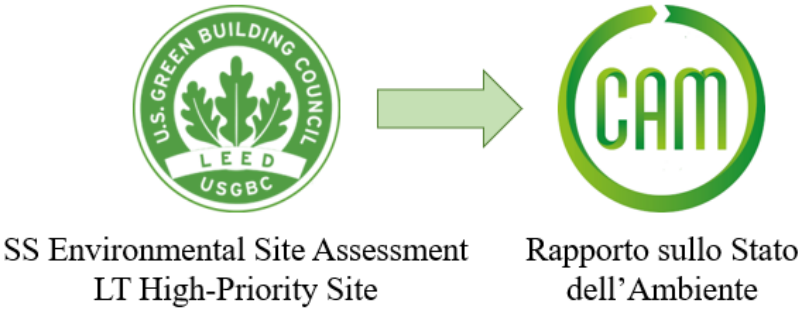
LEED Even if the CAM criteria refers to bigger area such as a headquarter and not a single building, it is possible to find connection with specific LEED credit such as: LT Surrounding Density and Diverse Uses, LT Access to Quality Transit, LT Bicycle Facilities just paying attention in different distances considered.



2.2.10 "Rapporto sullo Stato dell'Ambiente" (Report on Environmental Conditions)

CAM The project must be correlate by a survey of the site conditions such as: chemical, biological, vegetation conditions with related photos and an intervention plan.

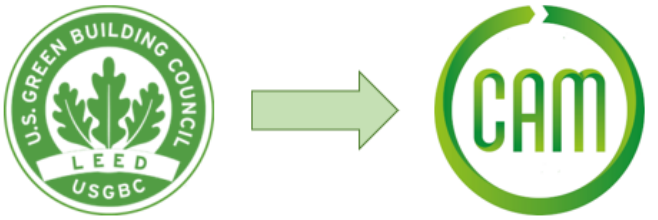
LEED Considering CAM requirements, inside the LEED protocol the equivalent data are collected in SS Environmental Site Assessment and LT High-Priority Site where remediation of polluted site is considered.



2.3.4 "Risparmio Idrico" (Water Waste Reduction)

CAM Its criteria states to recover and re-use rainwater for irrigation or toilet flushes, usage of flux reducer, metering systems. Bathroom must be provided with dual flush (6 and 3 litres), while urinal should work completely without liquid.

LEED In this case the credits of LEED protocol are stricter because they indicate a minimum percentage of reduction for both internal and external use, also taking into consideration the water recovered by systems eventually present on site.



WE Outdoor Water Use Reduction
WE Indoor Water Use Reduction
WE Building-Level Water Metering

Risparmio Idrico

The comparison analysis, between the mandatory Italian law for public procurement (CAM) and the voluntary certification LEED, highlighted that some requirements can be considered equivalent or need just some integration. The further development should be to create a uniformity between documentation needed and requirements by creating new versions of CAM and LEED. The purpose is to use the LEED criteria to design, built and maintenance of a building with an integrative process guided by the protocol and recognized by the CAM law to facilitate its usage. With a correspondence between the two, the application of CAM can be easier and public building can be also registered on LEED Online to obtain the certificate. In this perspective, voluntary certification such ash LEED can be considered as mandatory, in particular cases, such as to reach public financing in projects, that is, for example, what has happening in Holland since 2014 where voluntary certification on real estate gives the possibility to gain tax benefits.

6. Conclusions

The two over mentioned cases studio have been evaluated using the LEED protocol v4. The categories of credits considered are: Location and Transportation (LT), Sustainable Site (SS), Water Efficiency (WE). These categories give the possibility to evaluate the project, preferably at first stages of design, in order to improve sustainable technical choices for the building. Moreover, the credits involved represent some of the goals defined in the Agenda 2030 for the sustainable development subscribed by 193 Countries including Italy. In particular, from the 17 SDGs the ones treated in these credits are: goal 9 “Industry, Innovation and Infrastructure”, goal 11 “Sustainable Cities and Communities”, goal 12 “Responsible Consumption and Production” and goal 13 “Climate Action”.

The thesis has been developed by analysing the different credits for each project obtaining the following results:

- For the Students Residences located in Torino, the Location and Transportation categories reached 14 points out of 16 thanks to its central position in the city, the zone is well-connected with the public transport system and it is dense of services for people. The Sustainable Site categories involve more design and technical choices; in this case the Protect and Restore Habitat and Open Space credit are impossible to obtain due to a limited outdoor space while the Rainwater Management credit is not persecuted due to an owner choice so 3 points out of 10 are obtained. The last category is Water Efficiency where 5 points out of 11 are persecuted, the owner choices do not allow to reach the maximum points for the Indoor Water Use Reduction and the Outdoor one is not persecuted due to limited green spaces. To summarize, the points obtained in the first three categories can be considered a good result for a Gold Level, that is the owner’s request. The only negative aspects highlighted comes from the Location and Transportation Category that obtained a good quantity of points for this reason less sustainable choices, based on the building itself, are considered, at least, in the next two categories.
- For the Industrial Warehouse located in Mantova, the Location and Transportation category only reached 3 point out of 16 due to its location: the periphery of the city. For this reason, the property has been forced to accept some expensive technical choices in order to reach the Gold Level of the certification. Indeed, the Sustainable Site category obtained 8 points out of 10 thanks to the design of outdoor spaces for Protect and Restore Habitat and Open Space and, also, thanks to Rainwater Management credit. In

particular, to prepare the documentation of the Rainwater Management credit, historical rainwater data are collected and the principle of the "Technical Guidance on Implementing the Stormwater Runoff Requirements for federal Projects" is used considering the Horton's formula for the infiltration calculation. In the end 8 points out of 11 are obtained in Water Efficiency category where all the points for Outdoor and Indoor Water Use Reduction credit are gained.

Fundamental for the overall process of certification is the figure of the LEED AP that is in constant contact with the owner and the project team, providing indications and modification necessary to comply with the LEED credit requirements.

In conclusion, the first part of this Pre-Assessment LEED led to obtain 22 points out of 37 for the Students Residences and 19 points for the Industrial Warehouse. This is a good base considering the other categories involved in the process that will be analysed when more information about the design of the two buildings will be available. After the application on LEED Online of all the design and construction credits and their respective review, the two buildings will be certificated LEED.

The two analyses have conducted to, more or less, the same amount of points even if with different requirements and choices induced by lost or earned points in the first category that is centred on project location and can be clearly considered the needle to reach a low or high LEED level certificate in the end of the process.

Index of figures

Index of Tables

Annexes

- Annex 01

Building n°	Floor surface [m²]	Number of floors	Gross Surface [m²]
1	675,00	6,00	4.050,00
2	290,00	6,00	1.740,00
3	315,00	4,00	1.260,00
4	319,00	4,00	1.276,00
5	472,00	6,00	2.832,00
6	215,00	5,00	1.075,00
7	422,00	5,00	2.110,00
8	529,00	4,00	2.116,00
9	28,00	4,00	112,00
10	272,00	5,00	1.360,00
11	296,00	5,00	1.480,00
12	408,00	9,00	3.672,00
13	108,00	9,00	972,00
14	333,00	8,00	2.664,00
15	390,00	9,00	3.510,00
16	208,00	5,00	1.040,00
17	210,00	5,00	1.050,00
18	624,00	6,00	3.744,00
19	288,00	6,00	1.728,00
20	672,00	6,00	4.032,00
21	317,00	8,00	2.536,00
22	214,00	8,00	1.712,00
23	390,00	7,00	2.730,00
24	50,00	6,00	300,00
25	85,00	6,00	510,00
26	149,00	1,00	149,00
27	142,00	2,00	284,00
28	425,00	10,00	4.250,00
29	186,00	1,00	186,00
30	448,00	7,00	3.136,00
31	115,00	1,00	115,00
32	177,00	1,00	177,00
33	335,00	4,00	1.340,00
34	300,00	4,00	1.200,00
35	494,00	10,00	4.940,00
36	263,00	10,00	2.630,00
37	210,00	6,00	1.260,00
38	1.083,00	6,00	6.498,00
39	290,00	5,00	1.450,00
40	446,00	5,00	2.230,00
41	167,00	5,00	835,00
42	159,00	1,00	159,00
43	349,00	10,00	3.490,00
44	59,00	1,00	59,00
45	184,00	5,00	920,00
46	740,00	3,00	2.220,00
47	226,00	5,00	1.130,00
48	228,00	6,00	1.368,00

49	678,00	5,00	3.390,00
50	224,00	5,00	1.120,00
51	200,00	5,00	1.000,00
52	247,00	5,00	1.235,00
53	135,00	5,00	675,00
54	223,00	6,00	1.338,00
55	158,00	3,00	474,00
56	92,00	6,00	552,00
57	2.125,00	4,00	8.500,00
58	700,00	5,00	3.500,00
59	234,00	5,00	1.170,00
60	381,00	5,00	1.905,00
61	341,00	5,00	1.705,00
62	357,00	8,00	2.856,00
63	525,00	7,00	3.675,00
64	129,00	6,00	774,00
65	366,00	6,00	2.196,00
66	289,00	4,00	1.156,00
67	512,00	5,00	2.560,00
68	447,00	6,00	2.682,00
69	693,00	8,00	5.544,00
70	226,00	6,00	1.356,00
71	583,00	6,00	3.498,00
72	157,00	2,00	314,00
73	135,00	6,00	810,00
74	202,00	5,00	1.010,00
75	357,00	5,00	1.785,00
76	188,00	5,00	940,00
77	500,00	6,00	3.000,00
78	1.397,00	6,00	8.382,00
79	210,00	6,00	1.260,00
80	236,00	5,00	1.180,00
81	468,00	4,00	1.872,00
82	437,00	4,00	1.748,00
83	529,00	4,00	2.116,00
84	218,00	4,00	872,00
85	202,00	4,00	808,00
86	229,00	5,00	1.145,00
87	380,00	6,00	2.280,00
88	478,00	4,00	1.912,00
89	270,00	5,00	1.350,00
90	505,00	6,00	3.030,00
91	79,00	3,00	237,00
92	122,00	4,00	488,00
93	220,00	6,00	1.320,00
94	119,00	6,00	714,00
95	191,00	6,00	1.146,00
96	162,00	6,00	972,00
97	953,00	6,00	5.718,00
98	508,00	2,00	1.016,00

99	133,00	2,00	266,00
100	221,00	5,00	1.105,00
101	120,00	5,00	600,00
102	279,00	5,00	1.395,00
103	198,00	6,00	1.188,00
104	209,00	6,00	1.254,00
105	561,00	7,00	3.927,00
106	165,00	5,00	825,00
107	413,00	4,00	1.652,00
108	257,00	2,00	514,00
109	400,00	8,00	3.200,00
110	837,00	1,00	837,00
111	441,00	5,00	2.205,00
112	491,00	5,00	2.455,00
113	387,00	4,00	1.548,00
114	812,00	2,00	1.624,00
115	596,00	2,00	1.192,00
116	376,00	5,00	1.880,00
117	211,00	4,00	844,00
118	262,00	5,00	1.310,00
119	252,00	5,00	1.260,00
120	338,00	5,00	1.690,00
121	455,00	6,00	2.730,00
122	270,00	4,00	1.080,00
123	135,00	2,00	270,00
124	89,00	1,00	89,00
125	28,00	2,00	56,00
126	155,00	3,00	465,00
127	228,00	6,00	1.368,00
128	243,00	1,00	243,00
129	306,00	7,00	2.142,00
130	132,00	5,00	660,00
131	187,00	4,00	748,00
132	233,00	4,00	932,00
133	273,00	4,00	1.092,00
134	378,00	5,00	1.890,00
135	462,00	5,00	2.310,00
136	309,00	5,00	1.545,00
137	269,00	6,00	1.614,00
138	282,00	5,00	1.410,00
139	188,00	4,00	752,00
140	200,00	4,00	800,00
141	37,00	2,00	74,00
142	95,00	4,00	380,00
143	255,00	8,00	2.040,00
144	204,00	7,00	1.428,00
145	551,00	5,00	2.755,00
146	235,00	8,00	1.880,00
147	486,00	7,00	3.402,00
148	197,00	5,00	985,00

149	299,00	5,00	1.495,00
150	520,00	6,00	3.120,00
151	418,00	5,00	2.090,00
152	211,00	6,00	1.266,00
153	166,00	5,00	830,00
154	119,00	5,00	595,00
155	743,00	4,00	2.972,00
156	111,00	5,00	555,00
157	317,00	6,00	1.902,00
158	75,00	4,00	300,00
159	133,00	5,00	665,00
160	361,00	6,00	2.166,00
161	322,00	3,00	966,00
162	505,00	4,00	2.020,00
163	491,00	3,00	1.473,00
164	122,00	5,00	610,00
165	385,00	6,00	2.310,00
TOT		TOT	283.169,00

Buildable Land	348.908,00	m²
GFA	283.169,00	m²
Buildable Land	34,89	ha
Ratio	8115,86	m²/ha
LEED limit	8035	m²/ha

• Annex 02

LEGEND

LEED BOUNDARY

FLOOR SURFACE

LEED BOUNDARY OFFSET

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a.y. 2021/2022

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Co-supervisor: Fasana Sara

Candidate:
Giovanni Donzella

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Master's Thesis in Building Engineering: Green Building
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Students Residences: General explanation of the developing project

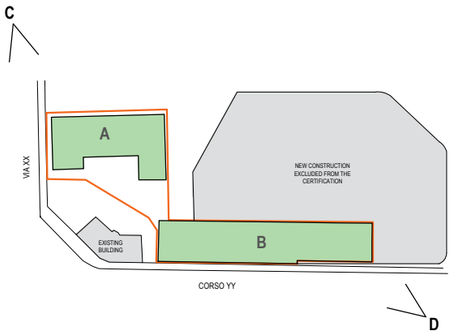
Sheet n°
01.D

FUNCTIONAL PLAN BUILDINGS "A" (FOURTH FLOOR) AND "B" (SECOND FLOOR) SCALE 1:500

LEGEND

- LOUNGE
- GYM
- STUDY ROOM
- OFFICE
- TECHNICAL SPACE
- COMMUNAL KITCHEN
- GAMING
- PARCEL ROOM
- STUDENT ROOM
- HORIZONTAL CONNECTION
- VERTICAL CONNECTION
- GREEN AREA
- BICYCLE PARKING
- LEED BOUNDARY

KEYPLAN



RENDER VIEW FROM THE TOP

RENDER FROM POINT VIEW "C"

RENDER FROM POINT VIEW "D"

PRELIMINARY RENDERS OF POSSIBLE EXTERNAL DESIGN PROVIDED BY AI STUDIO AND AI ENGINEERING

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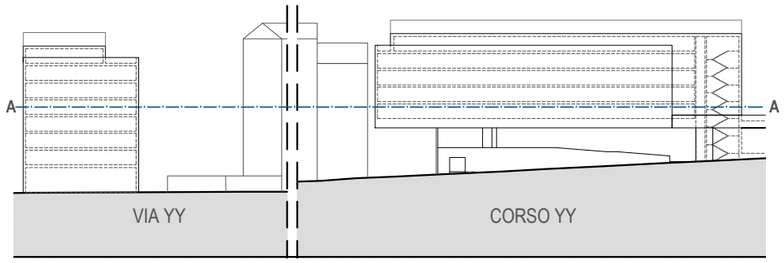
Co-supervisor: Fasana Sara
Candidate:
Giovanni Donzella

Students Residences: possible development of 2th and 4th floor

Sheet n°
02.D

KEYPLAN

SECTION PLAN A-A



SECTION PLAN A-A (4th FLOOR) OF STUDENTS RESIDENCE "A" WITH PROBABLE INTERNAL FIXTURES LAYOUT SCALE 1:200

SECTION PLAN A-A (2th FLOOR) OF STUDENTS RESIDENCE "B" WITH PROBABLE INTERNAL FIXTURES LAYOUT SCALE 1:200

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Industrial Warehouse: General explanation of the developing project

Sheet n°
03.D

GENERAL PLAN OF THE INDUSTRIAL WAREHOUSE

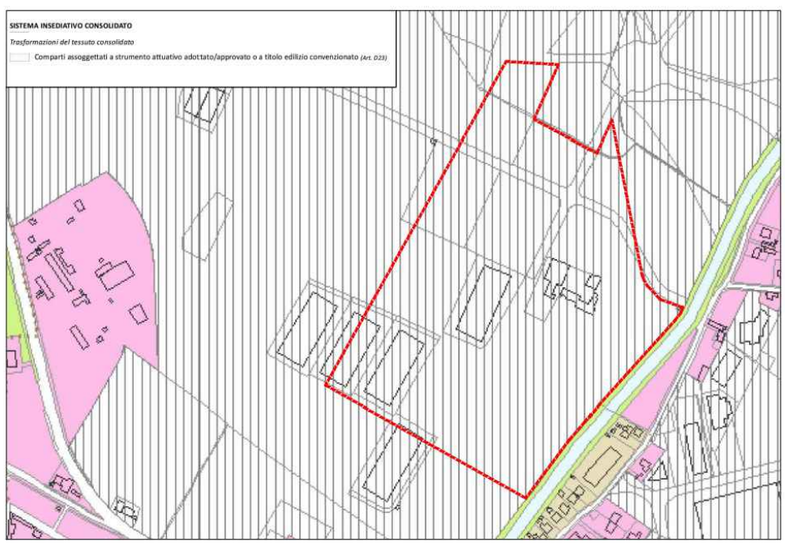
ORTOPHOTO OF THE SITE AREA

LEGEND

1. Truck entrance
2. Visitors entrance
3. Car parking
4. Truck parking
5. Dock doors area
6. Pic-nic area
7. Football court
8. Bioretention area
9. Warehouse and offices

RENDER OF THE EXTERNAL DESIGN OF THE WAREHOUSE FROM VIEW "A"

EXTRACT OF "PGT" OF *MANTOVA* ("*Piano di Governo del Territorio*")



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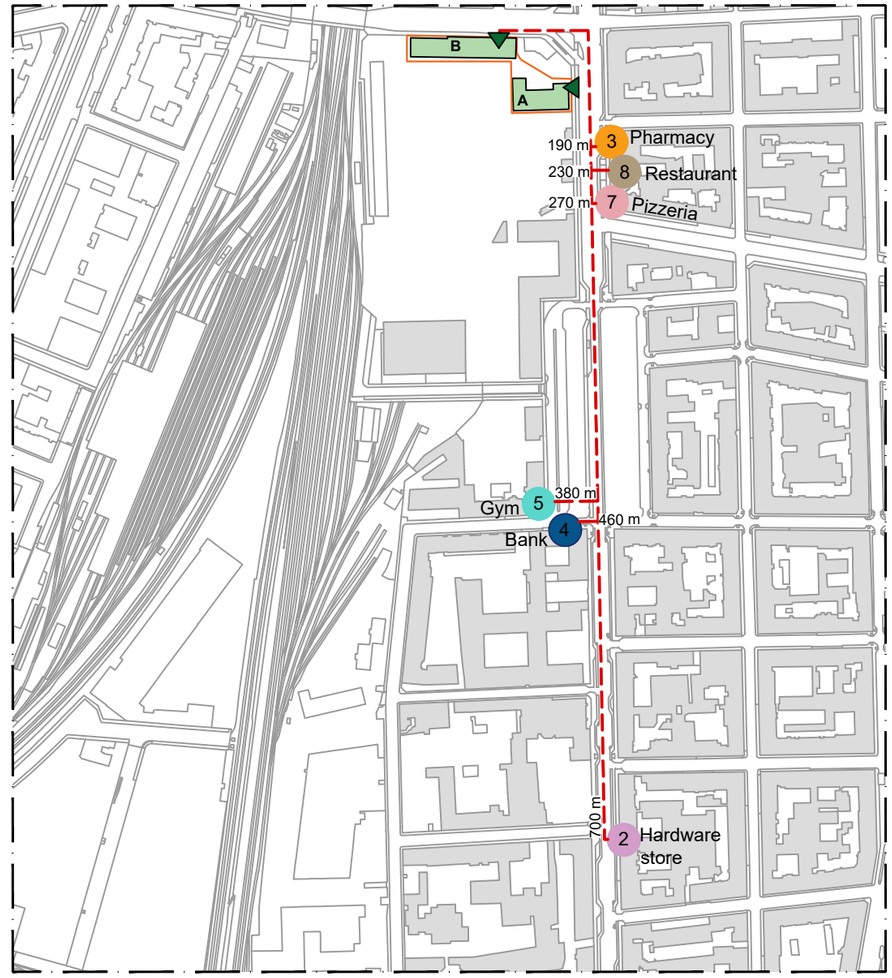
Students Residences: LT category, Bicycle Facilities Credit

Sheet n°
01.L

MAP OF BICYCLE NETWORK CONNECTIONS WITH NEIGHBOURHOOD SERVICES



Category		Use type	Name	Distance (m)	N. of use	Building
1	Food retail	Supermarket				
		Grocery with produce section				
2	Community-serving retail	Convenience store	Simpatia Crai	180	3	A
		Farmers market				
		Hardware store	Utensilferramenta dal 1913	700		B
		Pharmacy	Farmacia Nizza	190		B
		Other retail				
3	Services	Bank	BCC Bene Banca	460	5	B
		Family entertainment venue (e.g., theater, sports)				
		Gym, health club, exercise studio	Orange Nizza	380		B
		Hair care	VG hairlab	290		A
		Laundry, dry cleaner				
		Restaurant, café, diner (excluding those with only drive-thru service)	Pizza e cozze	230		B
			Da Ciccillo	270		B
4	Civic and community facilities	Adult or senior care (licensed)			4	
		Child care (licensed)				
		Community or recreation center				
		Cultural arts facility (museum, performing arts)				
		Education facility (e.g., K—12 school, university, adult education center, vocational school, community college)	Scuola dell'infanzia Stefano Bonacossa	370		A
		Government ofce that serves public on-site				
		Medical clinic or ofce that treats patients				
		Place of worship	Istituto Suore Sacramentine di Bergamo	170		B
		Police or fire station				
		Post office	Poste Italiane	800		A
		Public library				
		Public park	Giardino Sambuy	1300		A
		Social services center				
5	Community anchor uses (BD+C and ID+C only)	Commercial ofce (100 or more full-time equivalent jobs)				

LEGEND

- LEED BOUNDARY
- BIKE PATH FROM BUILDING B
- BIKE PATH FROM BUILDING A
- FLOOR SURFACE
- XX SERVICE IDENTIFICATION NUMBER
- BUILDING ENTRANCE

LOCATION AND TRANSPORTATION CATEGORY

BICYCLE FACILITIES CREDIT

TEN SERVICES REQUIRED IN 4800 m

TWELVE SERVICES IDENTIFIED: ONE POINT GAINED

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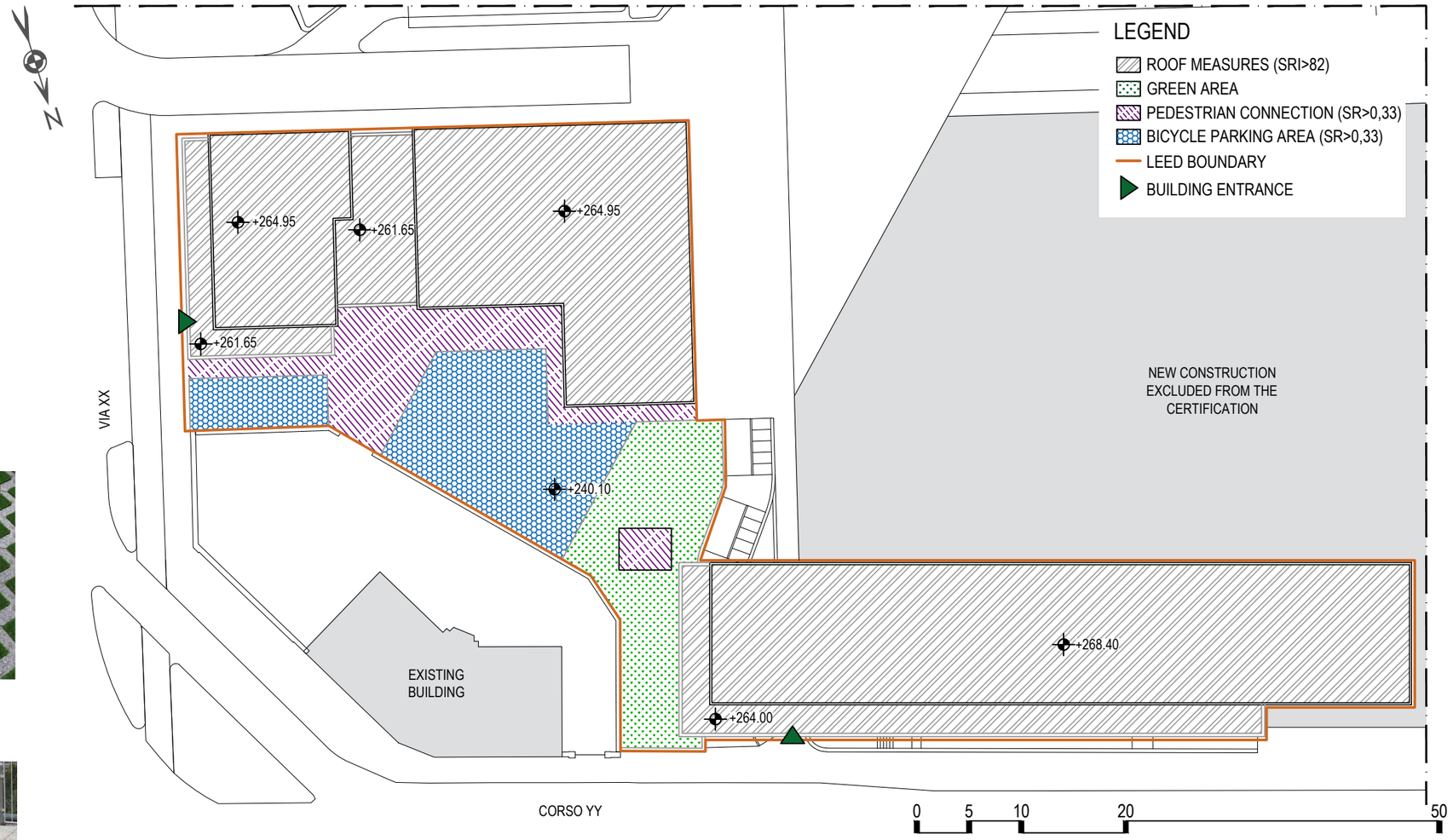
Students Residences: SS category, Heat Island Reduction Credit

Sheet n°
02.L

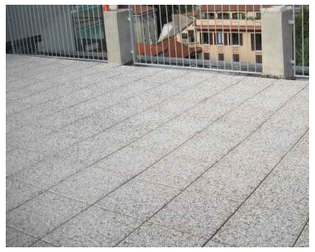
DISTRIBUTION OF ROOF AND NON-ROOF SOLAR REFLECTANCE MEASURES PLAN SCALE 1:500



POSSIBLE PRODUCTS TYPOLOGY AND COLOUR APPLICABLE TO RESPECT PROTOCOL REQUIREMENTS

White self-locking pavement

50% Open-grid pavement



Light-coloured external pavement

PRELIMINARY DESIGN SURFACES		
NON ROOF measures (SR>0,33)	575	m²
ROOF area of high reflectance roof (SRI>82)	2.037	m²
Total Site Paving Area + Total Roof Area	2.612	m²
Weighted sum of non roof and roof measures	2.678	m²
Result	**Positive**	

SUSTAINABLE SITE CATEGORY → **HEAT ISLAND REDUCTION CREDIT**

PROTOCOL'S EQUATION TO SATISFY AND CALCULATIONS SUMMARY

$$\frac{\text{Area of Nonroof Measures}}{0.5} + \frac{\text{Area of High-Reflectance Roof}}{0.75} + \frac{\text{Area of Vegetated Roof}}{0.75} \geq \text{Total Site Paving Area} + \text{Total Roof Area}$$

→ **2** **POSITIVE RESULT FROM CALCULATION: TWO POINTS GAINED**

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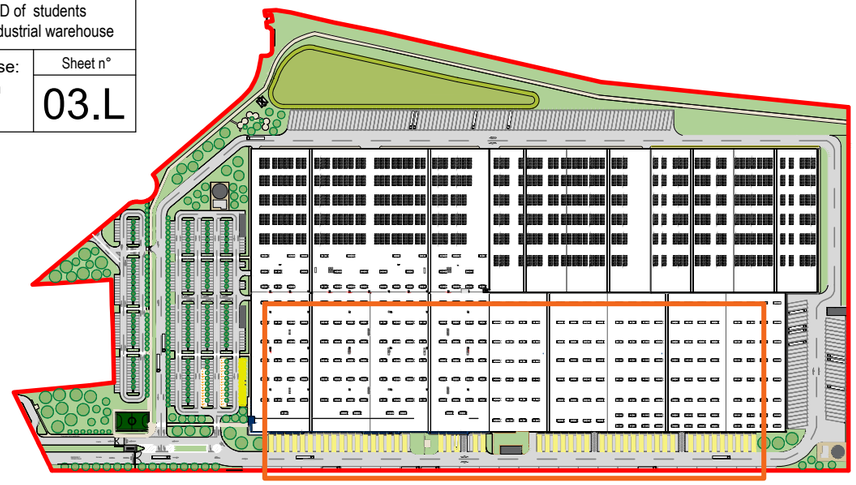
Industrial Warehouse:
LT category, Green Vehicles Credit

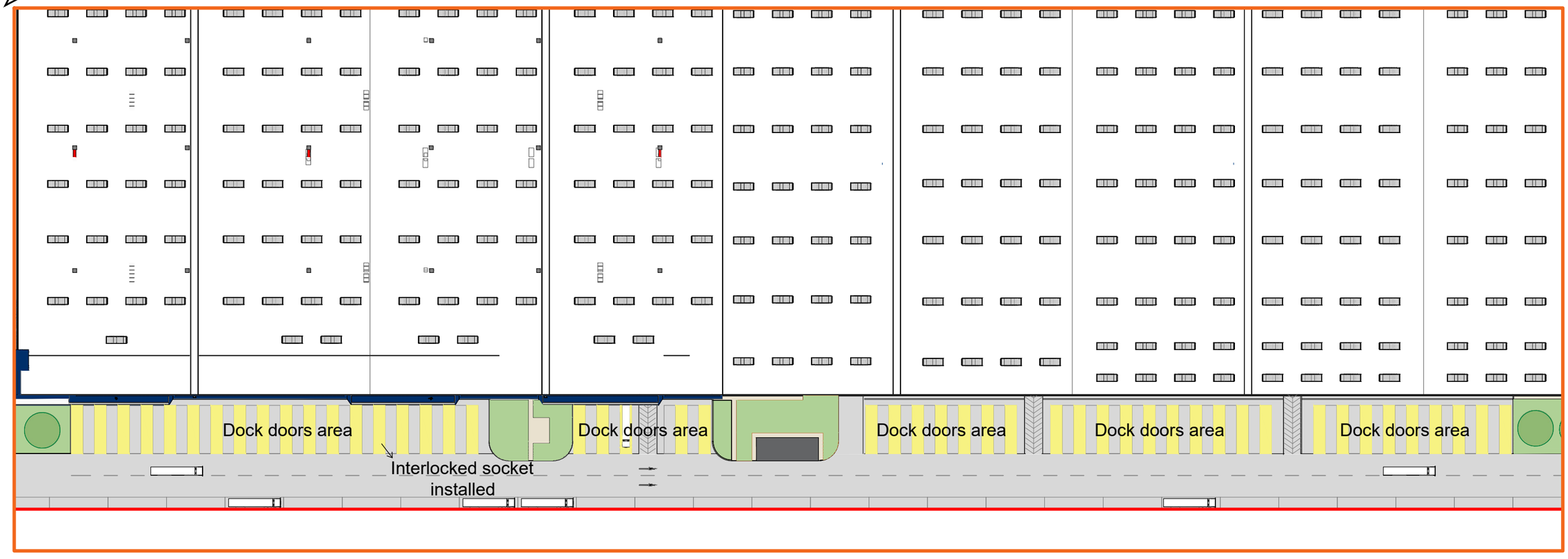
Sheet n°
03.L

KEY PLAN



EXAMPLE OF APPLICATION

ZOOM IN THE AREA OF THE DOCK DOORS WHERE THE INTERLOCKED SOCKETS WILL BE INSTALLED



0 13 26 39 52 65

LOCATION AND TRANSPORTATION CATEGORY → **GREEN VEHICLES CREDIT** →

→ **AT LEAST 50% OF DOCK DOORS PARKING MUST HAVE AN INTERLOCKED SOCKET** → **1** **50 OUT OF 94 DOCK DOORS PARKING ARE PROVIDED WITH INTERLOCKED SOCKET: ONE POINT IS GAINED**

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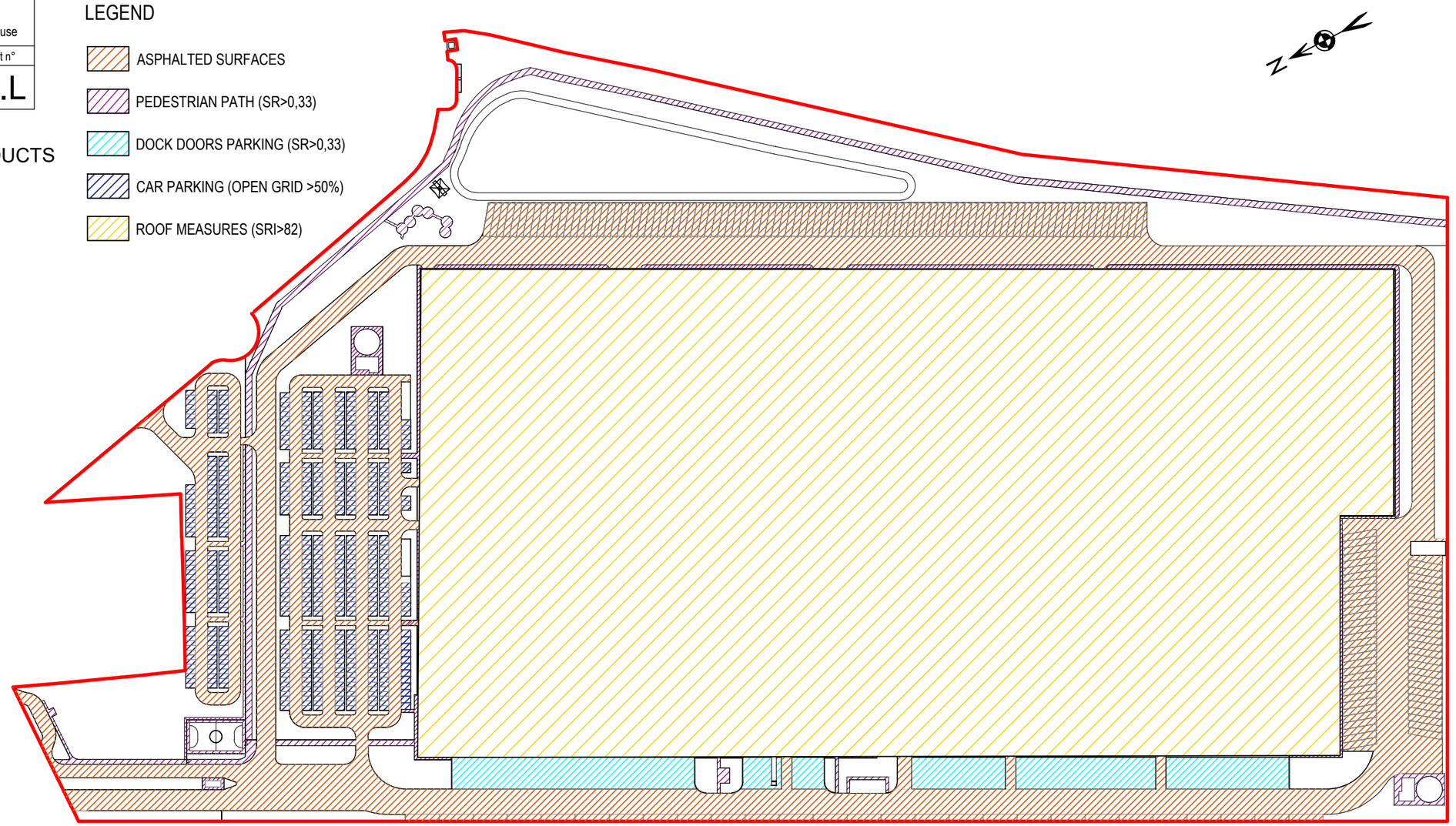
Industrial Warehouse: SS category, Heat Island Reduction Credit

Sheet n°
04.L

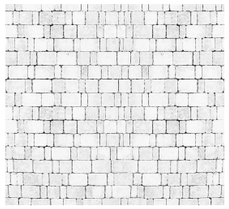
DISTRIBUTION OF ROOF AND NON-ROOF MEASURES AGAINST HEAT ISLAND EFFECT

LEGEND

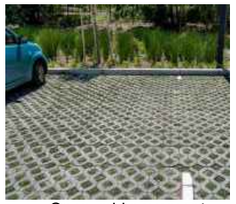
- ASPHALTED SURFACES
- PEDESTRIAN PATH (SR>0,33)
- DOCK DOORS PARKING (SR>0,33)
- CAR PARKING (OPEN GRID >50%)
- ROOF MEASURES (SRI>82)



EXAMPLE OF APPLICABLE PRODUCTS



White self-locking pavement



Open-grid pavement

Light-coloured self locking pavements

TPO membrane

Project Surfaces		
NON ROOF measures	17.629	m²
ROOF area of high reflectance roof	129.639	m²
Total Site Paving Area + Total Roof Area	194.063	m²
Weighted sum of non roof and roof measures	208.110	m²
Result	**Positive**	

SUSTAINABLE SITE CATEGORY → **HEAT ISLAND REDUCTION CREDIT**

PROTOCOL'S EQUATION TO SATISFY AND CALCULATIONS SUMMARY

$$\frac{\text{Area of Nonroof Measures}}{0.5} + \frac{\text{Area of High-Reflectance Roof}}{0.75} + \frac{\text{Area of Vegetated Roof}}{0.75} \geq \text{Total Site Paving Area} + \text{Total Roof Area}$$

→ **2** **POSITIVE RESULT FROM CALCULATION: TWO POINTS GAINED**

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Industrial Warehouse: WE category, Outdoor Water Use Reduction Credit

Sheet n°
05.L

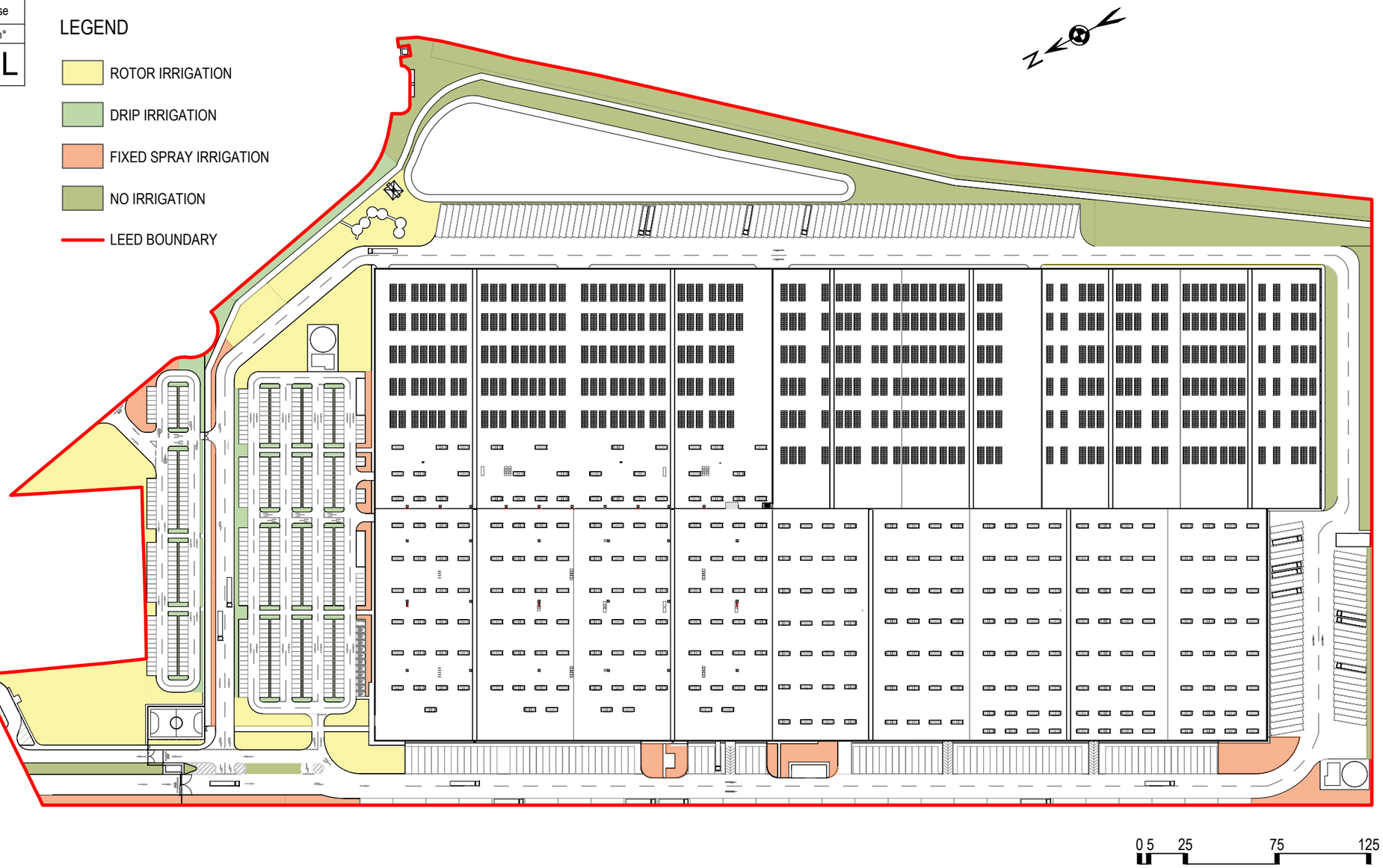
DISPOSITION OF DIFFERENT IRRIGATION PLANT ON OUTDOOR GREEN AREAS

REPRESENTATION OF THE TYPE OF IRRIGATION SYSTEM USED

Rotor irrigation system

Drip irrigation system

Fixed spray irrigation system



WATER EFFICIENCY CATEGORY → **DIFFERENT TYPES OF IRRIGATION SYSTEM** →

Landscape water baseline (l/month)	5.762.460
Landscape water requirement (LWR) (l/month)	2.496.909
Percentage reduction from baseline (%)	57%

SUMMARY TABLE OF CREDIT CALCULATION

→ 1 **REDUCTION HIGHER THAN 50% SO ONE POINT IS GAINED**

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