POLITECNICO
MILANO 1863

School of Architecture Urban Planning Construction Engineering

Building and Architectural Engineering
(Building Engineering track)

Thesis: Green Building Project Management

How to develop a framework addressed to construction project managers to facilitate the integration of green building certifications in the project management process?

Thesis supervisor: Fulvio Re Cecconi

Alix Elisabeth Astrid Burg *913148*
Sophia Julia Feriani *917338*

A.Y. 2019/2020

Acknowledgements

We would like to thank the following people for their help in the completion of this final research project. In the light of the peculiar context of the Covid pandemic of Spring 2020, its elaboration has been challenging but the support of those people made the process more agreeable.

We would like to warmly thank our thesis supervisor, Prof. Fulvio Re Cecconi, for his support and help throughout our research process, and for being dedicated and available to answer our questions and doubts, even remotely.

We would also like to thank the LEED Accredited Professionals, Ms. Letizia Antonini and her colleague Marta, for their kindness and the time they granted us and especially for the guidance and technical expertise they provided us on the LEED certification process and LEED credits.

In addition, we wanted to express our gratitude to our master supervisor Prof. Giuliana Iannaccone, as well as all the other professors from the master programme, for helping us grow into building engineers during the last two years.

We also would like to extend our thanks to Politecnico di Milano and its staff members, for making this semester possible through distance working and for their dedication to our education.

Finally, we thank both our families and all the friends we made in Milano for their support and encouragement and hope they will stay in our lives when our Italian experience comes to an end. Special thanks to Giovanni for the Italian translation.

Table of contents

List of figures

List of tables

Abstract

In the context of ecological crisis, the construction sector being one of the most polluting in the world, construction project management needs to address sustainability in a systemic way. There exist green building certifications that award points for sustainable practices in construction, which can support this challenge. Nonetheless, the processes to get certified often reveal themselves to be complicated when implemented, as they are not properly integrated to the project. Different recommendations and tentative frameworks tackle this issue. This thesis work focuses on the development of a framework to integrate the LEED certification to the construction project management process for newly constructed buildings in Italy. The framework in question aims at identifying, through the making of a RASCI matrix, the responsibilities of the different usual project actors in completing LEED credits and prerequisites. The matrix is developed by a thorough analysis of the requirements and necessary documents of each credit/prerequisite confronted to the usual responsibilities of project actors. In addition, it is completed by a risk assessment of going overbudget for prerequisites and of not being achieved for credits, based on both LEED project experience feedback and a literature review. Eventually, the proposed framework's final results and initial assumptions are discussed.

Keywords: Green Construction, Project Management, Green Building Certification, LEED, RASCI Matrix, Responsibilities, Risk Assessment.

Italian version:

In uno scenario di crisi ecologica nel quale il settore dell'edilizia spicca in rappresentanza come uno tra i più inquinanti, diventa impellente e doveroso che la gestione dei progetti si indirizzi sistematicamente verso un approccio sostenibile. Ad oggi esistono certificazioni in materia di bioedilizia che attribuiscono punti per le pratiche virtuose e che possono sostenere la sfida, tuttavia, l'assenza di un reale sistema che le integri all'interno del progetto, le rende spesso complicate da implementarsi. Diverse le prese di coscienza e quadri sperimentali che ragionano su questo fronte. Nasce da queste problematiche il lavoro di tesi che prende in analisi lo sviluppo di un telaio di riferimento volto all'integrazione della certificazione LEED, considerando il processo di gestione dei progetti di nuova costruzione sul territorio italiano. Verrà quindi identificato attraverso lo sviluppo di una matrice RASCI, quelle che sono le responsabilità dei diversi attori coinvolti nel completamento dei crediti e prerequisiti LEED. La matrice risulta lo sviluppo postumo ad un'analisi approfondita dei suddetti requisiti, dei documenti necessari per ogni credito/prerequisito rispetto alle abituali responsabilità degli attori del progetto. Infine, è coronata da una valutazione del rischio laddove si superi il budget per i prerequisiti e del non raggiungimento dei crediti, basandosi sui feedback dell'esperienza di progetto LEED e supportati da una revisione della letteratura in materia. Infine, verranno discussi e trattati i risultati finali ottenuti così come le ipotesi inizialmente proposte per il telaio.

1 Introduction

1.1 Context of the thesis

The construction sector accounts for over a third of final energy use and approximately 30% of global carbon emissions, according to WBCSD [1]. These numbers are bound to increase if this impact is not addressed, as a rapid population growth [2] and urbanisation of the world [3] is generating a consequent increase in housing need. This need for new buildings and infrastructures implies economical, societal and environmental consequences.

In addition to this societal aspect, the ever-growing amount of proof demonstrating the construction sector's impact on climate change raises the question of what the construction industry can do to solve, or at least to mitigate, its effects. The United Nations presented the *17 Sustainable Development goals* [4] in 2016, a plan of action to achieve a better and more sustainable future for all, including the clauses 7-Affordable and Clean Energy, 12-Responsible Consumption and Production and 13-Climate Action, where the construction field can have a substantial influence.

Incorporating strategies to construct more sustainable buildings is a turning point to participate to the global effort in combatting global warming. In this context has emerged the concept of *Sustainable Construction* and *Green Buildings*, defines as "a building that, in its design, construction or operation, reduces or eliminates negative impacts, and can create positive impacts, on our climate and natural environment. Green buildings preserve precious natural resources and improve our quality of life." by World Green Building Council [5].

To help that effort, institutions have taken it upon themselves to provide builders with a way to implement green practices in the construction process and have developed Green Building Certifications aimed at guiding to mitigate the impact of buildings on the natural environment through sustainable design. There exist several ones, the main being the *Leadership in Energy and Environmental Design* (LEED) in the United States and the *Building Research Establishment Environmental Assessment Method* (BREEAM) in the United Kingdom.

Pursuing a green building certification has several benefits, not only to the environment, but also to the owner as it increases the attractivity of the building on the real estate market and can reduce its operating costs, while providing a better quality of life to the building occupants [6]. Nonetheless, it also adds conceptual and technical complexity to the construction project management process, and its implementation can be tedious and complicated.

1.2 Problem statement

The problem addressed in this thesis can be posed as the following question.

How to develop a framework addressed to construction project managers to facilitate the integration of green building certifications in the project management process?

1.3 Assumptions

In this thesis work, it will be considered that the LEED green building certification guarantees the resource and energy efficiency of the project in question as it is the most widely used. The question whether LEED certified building are indeed more efficient than non-certified building will not be addressed. The latest version to date of LEED (4.1) was considered. Consequently, the terms *Green Building* and *Sustainable Building* will be used to refer to LEED certified buildings.

Regarding the construction management process, the project life-cycle model from the *Royal British Institute of Architecture* (RIBA) [7] will be considered and used to develop the proposed framework.

2 Background

2.1 Construction Project Management

EN 16310 [8] defines *project management* as a "professional service that applies (application) methods, tools, techniques and competences to the overall planning, coordination and control of a project life cycle, from inception to completion, aimed at meeting a client's requirements in order to produce a functionally and financially viable project that will be completed on time within authorised cost and to the required quality standards". In the context of the construction sector, the focus of the project will be *buildings* which are defined in the same standard as: "construction work that has the provision of shelter for its occupants or contents as one of its main purposes; usually partially or totally enclosed and designed to stand permanently in one place."

2.1.1 Project Life Cycle

This thesis work will be based on the project lifecycle model from the RIBA [7], that offers a detailed plan of work of a construction project, with clear distinct steps throughout the lifecycle, presented in the following table.

Stage	*Step*		*Description*
Pre-design	0	Strategic Definition	Definition of the right strategic decisions to make
	1	Preparation and Brief	Briefing process where client requirements are considered more in detail
Design	2	Concept Design	Proposal of the Architectural Concept
	3	Developed Design	Testing and validation of Step 2
	4	Technical Design	Preparation of all the information required to manufacture and construct the building
Construction	5	Construction	Manufacturing and Construction of the building
Handover	6	Handover and Close out	Rectification of any defects
In use	7	In use	The building is used, operated and maintained

Table 2.1: RIBA stages and steps of the lifecycle of a project

There exist other formats from different institutes, that demonstrate some variations while keeping the same main steps and leading all the same to the completion of the project. The findings of this work can be adapted to other frameworks of project lifecycle.

2.1.2 Project Actors

A construction project involves many different actors in its process, presented in the following table, based again on the RIBA plan of work [7].

Teams	*Actors*
Client team	Client Project manager Cost consultant Health and safety advisor Commissioning authority
Design team	Lead designer Architect Interior designer Landscape designer Structural engineer Mechanical engineer Plumbing engineer Electrical engineer Façade engineer Acoustical engineer Sustainability engineer
Construction team	General contractor/Construction manager Mechanical sub-contractor Electrical sub-contractor Logistics team
Stakeholders	National/Local authorities Environmental bodies Local communities Utilities companies

Table 2.2: Actors involved in the lifecycle of a project

It is to be noted that this list is not exhaustive, and that some actors might not be present, depending on whether the project requires their expertise.

2.1.2.1 *Client team*

Client — The client is an entity, individual or organisation commissioning and funding the project, directly or indirectly. They can take many forms depending on the size and type of project.
For the sake of simplicity, 'client' will refer to the client and all of his legal and technical advisors (legal team, financial team, client representative, construction advisor, etc.).

Project manager — The project manager is appointed by the client to coordinate the engineering, procurement and construction phases of the project. Further details are provided in section §2.1.3.

Cost consultant — Cost consultant refers to a quantity surveyor, accountant or another professional that provides estimates and advises regarding the cost of construction works.

Health and safety advisor — Health and safety advisors are responsible for ensuring that risks in the worksite are controlled and that organisations are successfully meeting safety standards. They undertake risk assessments and site inspections to ensure that procedures and policies are properly implemented.

2.1.2.2 *Design team*

Lead designer	They lead the design team and are responsible for coordinating the inputs and information from each team member.
Architect	Consultant responsible for developing the overall design, from eliciting the brief to full design documentation and construction supervision.
Interior designer	Their responsibilities include visualizing and sketching design plans as per client goals, selecting products and materials, determining costs and inspecting finishing of the construction phase.
Landscape designer	They plan, design and manage open spaces and aim to provide aesthetically pleasing urban and rural environments.
Structural engineer	Consultant that designs, assesses and inspects structures to ensure they are efficient and stable. They also provide site surveys, geotechnical investigations, ground improvement studies, etc.
Mechanical engineer	The mechanical engineer is responsible for the design, assessment and inspection of the HVAC (Heating, Ventilation and Air Conditioning) systems, and piping and plumbing of the building.
Electrical engineer	The electrical engineer is responsible for the design, assessment and inspection of the electrical network of the building.
Facade engineer	Consultant designing the façades of buildings, so they are structurally and thermally sound. They are responsible for light analyses.
Acoustical engineer	An acoustical engineer helps to design, assess, manage and control sound and vibrations in the built environment.
Sustainability engineer	Sustainability engineers deliver sustainable and low-energy design projects, execute lifecycle assessments and energy modelling.

2.1.2.3 *Construction Team*

General contractor/ Construction manager	The General contractor is an organisation that carries out the construction work and is responsible for planning, managing and coordinating the project. Depending on the size of the project, a single contractor may be able to undertake and complete all the construction works themselves or not. When there is not one general contractor, a construction manager can be appointed. The construction manager also has an advisor role to the client if appointed at an early stage.

Mechanical sub-contractor	Mechanical sub-contractors are in charge of heating and cooling systems, refrigeration, piping, and plumbing, whether for production, installation, or ongoing maintenance and repair.
Electrical sub-contractor	Electrical sub-contractors are in charge of electrical systems and network installation, maintenance and repair on site.
Logistics	The logistics team does the planning, implementing and controlling of supply chain resources, from the point of origin to the point of destination. They are responsible for, amongst other things, the resource assessment, sourcing and procurement, materials handling and waste management.

2.1.2.4 *Stakeholders*

A stakeholder is any person, team or organization involved or affected by the project in question. There exist the direct and indirect stakeholders. The direct ones gather the members of the project team previously described, along with building users. Indirect stakeholders can be governmental authorities, local communities, special interest bodies, or any group that is affected by the project and can have an impact on its completion.

Both categories of stakeholders can either have a positive or negative impact on the project, and have different levels of legitimacy and acting power, whether it is financially, legally or socially. If they have concerns about the project outcome, or interests not aligned with project objectives, they can oppose and become a threat, as well as they can represent potential opportunities if they can identify their benefits from the project. Stakeholders should thus be identified, and their management and involvement need to be addressed for the success of the project.

2.1.3 Project Management

To coordinate the overall project, project managers are appointed by the owner, designer or contractor. They are responsible for carrying out the project, including coordinating the engineering, procurement and construction phases.

Most of the project manager's work consists in organizing and interacting with the other team members to identify problems that arise along the project and find solutions to those problems. They are to lead the project team to ensure a good-quality project within initial constraints (given in terms of scope, time and money). The main expected tasks can be summarized as planning, organizing, staffing, directing and controlling [9] and eventually develop a Project Management Plan, that "refines the scope, creates the Work Breakdown Structure (WBS), schedules activities, establishes budgets, defines quality requirements, develops communication plans, allocates resources, and identifies potential risks." [10]

To be able to guaranty the health and safety of the building users, several contractual approvals must be obtained to launch the construction process. The following table gathers the usual contractual documents according to the British Institution of Civil Engineering endorsed website of *Designing Buildings* [11], though more may be needed depending on the size and the context of the project:

Documents	- Application for payment - Architect's instruction / contract administrator's instruction - Bill of quantities - Building log book - Building owner's manual / operation and maintenance manual - Building users guide - Certificate of making good defects / certificate of making good - Collateral warranty - Construction phase plan - Contract sum analysis - Contractors master programme - Contractors proposals - Default payment notice - Contract drawings - Design documents - Employers requirements - Final account - Final certificate - Health and safety file - Information release schedule - Insurance - Interim certificate - Joint fire code - Method statement - Pay less notice - Payment notice - Practical completion certificate / substantial completion certificate - Preliminaries - Risk assessment - Schedule of defects - Schedule of work - Site waste management plan - Specification

Table 2.3: Contractual documents for construction projects

The RIBA framework also includes a list of documents to be produced by the end of each step of a project:

Step	*Documents*
Strategic Definition	- Client Requirements - Business Case
Preparation and Brief	- Project Brief - Feasibility Studies - Site Information - Project Budget - Project Programme - Procurement Strategy - Responsibility Matrix - Information Requirements
Concept Design	- Project Brief Derogations - Signed Off Stage report - Project Strategies - Outline Specifications - Cost Plan
Developed Design	- Signed off Stage Report - Project Strategies - Updated Outline Specification - Updated Cost Plan - Planning Application
Technical Design	- Manufacturing Information - Construction Information - Final Specifications - Residual Project Strategies - Building Regulations Application
Construction	- Building Manual including Health and Safety File and Fire Safety Information - Practical Completion certificate including Defects List - Asset Information
Handover and Close out	- Feedback on Project Performance - Final Certificate - Feedback from light touch Post Occupancy Evaluation
In use	- Feedback from Post Occupancy Evaluation - Updated Building Manual including Health and Safety File and Fire Safety Information as necessary

Table 2.4: Documents to provide at each step of the project

2.1.4 Project Delivery Systems

The main project delivery systems in construction are as follows [6]:

- Design-bid-build, or hard-bid,
- Construction management at risk, or negotiated work,
- Design-build, or design construct.

The table 2.5 on the next page provides a summary of the different systems' main characteristics, based on [6].

System	Hard-bid System	Construction Management at Risk	Design Build
Main Objective	Low-cost delivery	Efficient construction management to guaranty a maximal price	Reduce potential sources of conflict between design and construction teams
Organisation of actors	The design team is selected by the owner	Ideally, both the design and construction team are selected early on	One entity (designer-builder) forges a single contract with the owner to provide for architectural /engineering design services and construction services
		The design team is selected by the owner	
	The general contractor is selected by a bidding process where the owner hires the lowest bidder	The contractor (called construction manager) negotiates a fee for management services with the owner	
	Sub-contractors are selected by the general contractor with a similar bidding process	Sub-contractors are selected through a bidding process, based on their capability and the quality of their work	
Specificities			Single source responsibility
Documentation	The design team produces all the necessary documents to the creation of the building on behalf of the owner	Construction documents are produced by a collective effort to meet the owner's requirements, schedule and budget	The single team produces the documents

Table 2.5: Comparison of main project delivery systems

The most widely used system for classic construction projects is the hard-bid delivery system, and in the following work, traditional construction will refer to a hard-bid system.

2.2 Green Building Certification Process

2.2.1 The LEED Certification

Leadership in Energy and Environmental Design (LEED) is an American green building rating system developed by the *U.S. Green Building Council* (USBGC). It is a 3rd party certification program that relies on a system of points, awarded for green building strategies that are classified in "credits". By earning points, the project can reach different rating levels:

- 40 to 49 points to be certified,
- 50 to 59 point for a Silver rating,
- 60 to 79 points for a Gold rating,
- from 80 points, a Platinum rating.

Six rating system are available:

- Building Design + Construction (the one this thesis work will focus on),
- Interior Design + Construction,
- Operations + Maintenance,
- Residential,

- Cities and Communities,
- Recertification.

The following table shows the scoreboard of Building Design + Construction [12] giving a global overview of the most critical ones (*Energy and Atmosphere* in first place and the *Location and Transportation* and *Material and Resources* in second place in most cases):

	BD+C							
LEED Categories	*New construction*	*Core and Shell*	*Schools*	*Retail*	*Data centers*	*Warehouses & Distribution Centers*	*Hospitality*	*Healthcare*
Integrative Process	1	1	1	1	1	1	1	1
Location and Transportation	16	20	15	16	16	16	16	9
Sustainability Sites	10	11	12	10	10	10	10	9
Water Efficiency	11	11	12	12	11	11	11	11
Energy and Atmosphere	33	33	31	33	33	33	33	35
Material and Resources	13	14	13	13	13	13	13	19
Indoor Environmental Quality	16	5	16	15	16	16	16	16
Innovation	6	6	6	6	6	6	6	6
Regional Priority	4	4	4	4	4	4	4	4
Total	110	105	110	110	110	110	110	110

Table 2.6: General overview of LEED credits points depending on construction type

For some categories, there are some mandatory prerequisites to obtain before starting to gain points with credits. The process is done by point-scoring the credits that the project validated. In the LEED system, the sum of the credits is called the "LEED scorecard".

This thesis work will focus on the "New Construction" of LEED BC+D as it is the most generic sub-group in the construction sector.

2.2.2 The LEED Categories and Objectives

LEED explains the environmental impact of each of its categories, in order to instil clients to the positive impacts of sustainable choices [12].

LEED Categories	*Abbreviation*	*Intent*
Integrative Process	*IP*	To support high-performance, cost-effective project outcomes through an early analysis of the interrelationships among systems.
Location and Transportation	*LT*	To avoid development on inappropriate sites. To reduce vehicle distance travelled. To enhance liveability and improve human health by encouraging daily physical activity.
Sustainability Sites	*SS*	To reduce pollution from construction activities by controlling soil erosion, waterway sedimentation, and airborne dust.
Water Efficiency	*WE*	To reduce outdoor water consumption
Energy and Atmosphere	*EA*	To support the design, construction, and eventual operation of a project that meets the owner's project requirements for energy, water, indoor environmental quality, and durability.
Material and Resources	*MR*	To reduce the waste that is generated by building occupants and hauled to and disposed of in landfills.
Indoor Environmental Quality	*IEQ*	To contribute to the comfort and well-being of building occupants by establishing minimum standards for indoor air quality (IAQ).
Innovation	*IN*	To encourage projects to achieve exceptional or innovative performance.
Regional Priority	*RP*	To provide an incentive for the achievement of credits that address geographically specific environmental, social equity, and public health priorities.

Table 2.7: LEED categories and objectives

2.2.3 The LEED Work Plan

To obtain a LEED certification, it is recommended to follow a specific work plan (BD + C) [13]:

- **Step 1:** Initiate discovery phase,
- **Step 2:** Select a LEED rating system (among 21),
- **Step 3:** Check Minimum Program Requirements,
- **Step 4:** Establish Project Goals (by prioritizing strategies with the project context),
- **Step 5:** Define LEED Project Scope,
- **Step 6:** Develop LEED scorecard (and therefore the certification level to target: Certified, Siler Gold or Platinum),
- **Step 7:** Continue Discovery Phase (additional research),
- **Step 8:** Continue iterative process,
- **Step 9:** Assign roles and responsibilities (one primary leader and the delegation of responsibility is recommended),
- **Step 10:** Develop consistent documentation (all along the project lifecycle and by collecting data regularly),
- **Step 11:** Perform quality assurance review and submit for certification.

2.2.4 The LEED Documents

The tenth step of the recommended work plan to get certified aims at producing LEED documentation for the project. This step proves to the certifying organisation the implementation of sustainable practices in the project and therefore is of crucial importance but also the most tedious task.

Since 2010, LEED went paperless in the submission of required documents as the USGBC developed the platform "LEED Online" (*www.leedonline.com*). The LEED manager is expected to upload the corresponding documents and fill out the forms when they are required (depending

on the credit). In the annex, a list of all the documents for the credits concerning *New Construction* of *LEED Building and Construction* rating system is presented.

2.3 Integration of LEED and sustainability in project management

Integrating LEED into a construction project can add complexity at many different levels, as demonstrated by the mains steps and the number of documents needed to obtain the certification.

2.3.1 Different needs, different methods

The natural inclination would be to keep the traditional project management system and include sustainability as an extra complexity level. However, this strategy has been proven ineffective, time-consuming and costly through experience. "Green building is better regarded as a process rather than a product" [14] meaning that the whole construction process must integrate sustainable practices to be efficient.

The following table based on Charles J. Kibert [6] aims at highlighting advantages and drawbacks of the different delivery systems and rate their LEED-compatibility.

<table>
<tr><th>System</th><th>Hard-bid</th><th>Construction Management at Risk</th><th>Design Build</th></tr>
<tr><td rowspan="5">Advantages</td><td rowspan="5">Offers in theory the lowest cost</td><td>CM can provide preconstruction services to facilitate efficient and effective design process</td><td>Improves communication among project team members</td></tr>
<tr><td>Client satisfaction is a major concern of the CM, as project outcome can get him future projects</td><td>Likely to reduce typical design construction conflicts</td></tr>
<tr><td>Prevents physical conflict among systems, missing information, and other products of miscommunication</td><td>Speeds the project to completion</td></tr>
<tr><td rowspan="2">Reduces frequency and intensity of conflicts</td><td>Provides a lower price for the owner</td></tr>
<tr><td>Improves overall project quality</td></tr>
<tr><td rowspan="3">Drawbacks</td><td>Does not encourage good communication</td><td rowspan="3">Usual tension between design team and construction manager still exists</td><td rowspan="3"></td></tr>
<tr><td>Conflicts often arise between parties</td></tr>
<tr><td>Late design changes, lawsuits, etc. can result in a higher total cost</td></tr>
<tr><td>Compatibility with LEED</td><td>Low</td><td>Possible</td><td>Possible</td></tr>
</table>

Table 2.8: Project delivery systems' comparative table

Traditional construction mostly uses a hard-bid system, if not for the general contractor, for subcontractors' selection. The adversarial nature of this system makes it difficult to implement on a green project [6]. Green projects are complex and require intense initial planning and collaboration to achieve sustainability within budget and schedule, hence adjustments to the traditional project management process are needed to integrate LEED certification early in the project's life cycle. Doing so reduces the risk of reworking major aspects of the project to implement "green" considerations later, causing additional costs.

Both construction management at risk and design-build represent better options for the integration of LEED, but neither will provide 100% of integration if the definition of project team and phasing is not transformed [15].

2.3.2 *Integrated Project Delivery System*

The *American Institute of Architects* (AIA) developed the concept of *Integrated Project Delivery* (IPD), a relatively new (mid-1990s) project delivery system that relies on several other recent concepts like integrated process, lean construction, and BIM, to mention a few [6]. They provide the following definition; "an approach that integrates people, systems, business structures and practices into a process that collaboratively harnesses the talents and insights of all participants to optimize project results, increase value to the owner, reduce waste, and maximize efficiency through all phases of design, fabrication, and construction." IPD is at the source of a collaborative culture for the project, essential element of a good project, and especially for green project. Indeed, "integrated processes are being acknowledged and encouraged in sustainable ratings systems such as LEED." [16]

IPD contracts consist of at least 3 parties; the owner, architect/engineer and the contractor sign a relational contract. Subcontractors can also be included in an integrated form of agreement or triparty collaborative agreement. Relational contracts are the key document in IPD because they define the relationships among all parties to the project. They have incentive clauses such that any potential savings are shared among IPD team members and with the owner. To that end, incentive pools can be created and consolidate team cohesion [6].

The following table highlights the strong and weak points of the IPD, based on [6], [16], [17]:

Strong points	Weak points
Encourages good communication and removes 'silo' effects	Upfront investment required early in the project
Reinforces team spirit during preconstruction phase	Reduction of return on preconstruction spend if the construction phase is delayed
Financial alignment of design and construction	Without adequate time and complexity, savings might not be available to cover initial investment
The financial performance is based on overall project outcome	No firm fixed cap on cost at the start for the owner
Collaborative approach possible in new ways for complex projects	

Table 2.9: Integrated Project Delivery strong and weak points

With a high emphasis on collaboration, IPD appears as a highly compatible approach with green building delivery. Furthermore, with the development of both lean construction and BIM for green buildings, IPD has a strong advantage as it allows the implementation of new collaborative methods [16]. Using such technologies, IPD has the potential to deliver green buildings at a similar if not lower cost than the one of a conventional building [6].

2.3.3 *LEED Accredited Professional*

In practice, a way to consider the integration of LEED to the project is the appointment of LEED Accredited Professionals (LEED AP). The USGBC offers the opportunity to professionals interacting with the design, construction or operation of buildings as part of their regular job function to get accredited. The accreditation testifies of a deep knowledge in green building practices.

USGBC developed a LEED credit dedicated to the appointment of a LEED AP. This allows the project team to hire a LEED endorsed professional, that can act as a reference for the credit obtention process and guide the team towards their LEED objectives.

Usually, there are two LEED AP appointed; one part of the design team, and one part of the construction team. The client can also appoint their own LEED AP. Considering the close collaboration between the client and the design team, their LEED APs usually are one single individual.

The LEED AP of the design team is responsible for design LEED credits, and will be referred to as *LEED AP D*. The LEED AP of the general contractor, *LEED AP GC*, is in charge of construction credits.

3 State of the art

3.1 Green Project Management guidelines and advice

3.1.1 Strategic Definition

As a starting point, Kibert [6] identifies owner issues in green buildings that should be addressed and settled prior to any other preliminary analyses. Considering LEED certification as the determining green building criteria, the following table has been made to summarise those key questions.

Questions	Corresponding task
Does the owner want the building to be a certified green building?	Identification of benefits and marketability of certification
What level of certification is desired?	Setting of sustainability goals and LEED credits selection
What is the level of green building experience required for the team?	Identification of team qualifications needed to achieve the desired level of certification
What level of capital investment, beyond that required for conventional construction, will the owner provide to make the facility a high-performance green building?	Determination whether lower operational costs are worth the additional capital investment

Table 3.1: Key owner questions to be addressed at the beginning of the project (based on *[6]*)

If the project pursues a LEED certification, then defining priorities in terms of sustainability from the beginning will ensure that they are integrated to the project [18]. LEED offers a large set of credits to the owner, and the choice of target credits is crucial and has a strong influence on the lifecycle of the project and its cost. Once selected, credits must be fulfilled throughout the project to get the desired score. An inappropriate credits selection, due to lack of knowledge or experience, can lead to increased amount of time, money and labour dedicated to achieving them [19]. In the 4th part of state of the art, different methods to choose appropriate credits will be explored.

3.1.2 Team Selection and Communication

Once the level of certification and the credits have been selected, the project team shall be selected. It should include an experienced green building project manager, as well as the usual other actors [6]. Nonetheless, when sustainability aspects of a project lay on the shoulders of a single individual, productivity decreases. The accredited professional responsible for the green building certification can be perceived by the rest of the team as the person that requests documentation during the project, and thus become perceived as more of a burden than a help [20]. Team members end up feeling no ownership of the green building and misunderstandings and miscommunication issues can arise. The integration of sustainability objectives for the whole team is thus of utmost importance for the success of the project [18]. The team should be assembled as early as possible in the project's life cycle, to involve all actors and put them on an equal footing regarding sustainability.

Another threat to the project in the case of multidisciplinary teams is the so called 'Silo Effect', or lack of effective communication between different experts involved leading to teams working

separately and independently. Adding green building certification requirements to the project will further accentuate this effect if not integrated correctly [18]. Good communication and coordination from the start of the design phase is important to avoid waste of time and labour. To enable this efficient communication, the incorporation of a *charrette* is recommended. The National Charette Institute (NCI) defines a charrette as a "collaborative planning process that harnesses the talents and energies of all interested parties to create and support a buildable smart growth plan."

It consists in a multi-day workshop, where all parties brainstorm to create a joint vision for the project providing a guideline for future decision, set goals and priorities, and define a feasible plan, including the next steps to be taken. It should include all project actors and stakeholders to develop a cohesive team and real partnership [18]. If everyone feels included and listened to, the project is less likely to face opposition once the design is completed.

The project manager is responsible for initiating this process, setting a framework and rules for communication and teamwork, as well as making sure information is addressed to all, clear and frequent. The use of collaborative software and platforms is recommended, though it may require initial training. The implementation of newsletters, open website or other can also help [18], [20].

3.1.3 Project Design and Documentation

In the early design phase (*Preparation and Brief* when following the RIBA framework), the project manager must produce the initial project budget and schedule estimation. When working with a charrette, this process can be much faster than in a traditional construction, as the project manager has access to charrette documents giving guidelines and can rely on other specialized team members to improve the accuracy and fasten the delivery time of construction documents [6], [18]–[21].

The building permit obtention is also affected by the incorporation of the charrette, that speeds the process as the design is more likely to comply already with local, state and federal development regulations. The team is also more aware of possible incentives available for green buildings.

Another major problem for LEED implementation to management process is the lack of knowledge of green practices. Untrained actors unfamiliar with the required documentation find its completion burdensome [22]. The web-based platform LEED-online has been introduced by USGBC in 2010 to facilitate documents' submission and help with the overall process. However, some users describe it as difficult to work with [23]. It requires the user to input a large amount of data (see Annex XX). Proper training for LEED-online or the implementation or an efficient information management system could be of great help to facilitate the process [20].

3.1.4 Project Construction and Contracting

In the case of traditional construction, the fragmentation of accountability can cause some doubts on the use of contract savings and quality of sub-contractors as the main objective is to have the lowest cost [18]. Contractors wishing to achieve sustainability goals perceive it as adding additional costs, requirements, and risks [22]and usually add premiums to cost estimates to cover for those risks.

In the case of the integrated team for green construction, the contractor already understands the owner's vision and has been active in the construction documents' completion. Mutual trust allows the owner to resort to open book contracting for contractor and sub-contractors, that decreases the required time for the bid and negotiation phase and increases the chance of

attracting higher quality professionals. Contract negotiations will nonetheless still include an assurance to protect all parties [18].

The construction phase is long and has a strong impact on the environment. It is expected from contractor and sub-contractors to apply some green procedures, in addition to conventional ones, bearing in mind the objective to minimise disturbance to the natural environment [14]. To do so, continual communication and training is essential [18]. Workers must be aware of sustainable construction and reduce waste [14]. On-site meetings should be conducted to provide sustainable construction education and training sessions on green buildings. The organisation of conference calls and other distance training sessions can be used to supplement to on-site training [18].

Such initiatives are also useful to stimulate interest in the LEED process [20] and trigger motivation. Indeed, the level of education and the perception of green process is also crucial, as appreciation of what the certification means and what it can do for a project [20]. To maintain motivation, a system of bonuses provided for staff if the building is green mark certified [14] or rewards and recognition for work groups that complete work ahead of schedule, within cost constraints and desired level of green standards [18] can be implemented.

Innovation and use of new materials and techniques being part of sustainability objectives, contractors may end up being pressurized into the green process without being familiar with it, fearing to lose competitive advantage [22]. Considering that green technologies are usually more complex and different from conventional technologies [24], the contractor can also be more reluctant to leave his comfort zone [14]. In both cases, there is bound to be some friction within the team and incremental costs due to incompetence of non-specialized workers [20]. Again, education about why those innovative materials and techniques are introduced can help to address this problem.

Green construction is about planning and scheduling to fulfil project requirements with high efficiency and low interruption [14]. For the construction phase, this implies an attention paid to make a streamlined use of construction equipment on site.

3.1.5 Commissioning and Closing out

The commissioning in the case of a green building is more complicated than for a conventional project, and transmission of information on the operation and maintenance of the building systems is important. This can be carried out by the creation of a users' manual and/or training of the client [14].

3.2 Existing frameworks

In order to assist project managers and teams seeking to get green building certifications while avoiding the many issues detailed in the previous part, there exists some frameworks that will be presented in this section.

3.2.1 LEED Project Management Matrix

The Department of Real Estate Services of the government of the District of Columbia [25] developed the following matrix in order to guide project managers pursuing LEED. It is based on the version 2 of LEED.

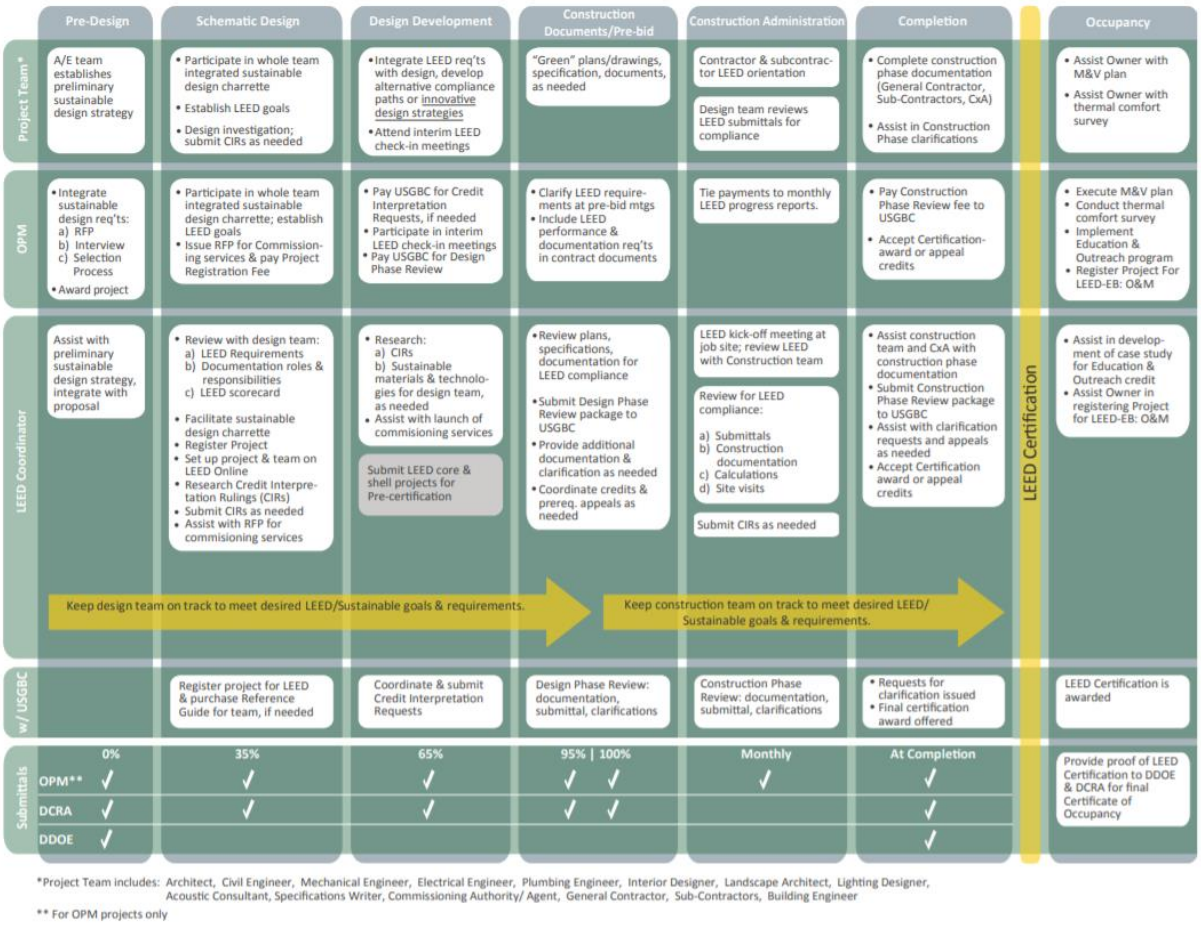

Figure 3.1: LEED Project Management matrix from Real Estate Services of the government of the District of Columbia

This table gives a general overview of the expected tasks and responsibilities of the project team, the Office Project Management (OPM) if present and the LEED Coordinator at each stage of the project's life cycle. Nonetheless, the matrix does not go into specific detail of the different credits and the corresponding work, nor in the concrete repartition of the responsibilities inside of the project team.

3.2.2 LEED-PDRI Framework for Pre-project Planning

The LEED-PDRI framework [21] is based on the fundamental role of pre-project planning in the building project management process that ensures delivery and performance of construction projects, especially in the case of green buildings. It relies on the use of LEED in pre-project planning of sustainable construction through the development of a matrix combining LEED and Project Definition Rating Index (PDRI).

The PDRI, developed by the Construction Industry Institute (CII), is a scope definition tool consisting in a weighted matrix with scope definition elements grouped into categories and further summarized into main sections. This index allows for the quantification of the completeness of the project's scope definition. At most, the PDRI reaches 1000 points, and a lower score represents a more complete scope definition.

There are two distinct steps to the framework. In a first time each LEED credit is analysed to determine the sustainable requirements and when, during pre-project planning, the appropriate decisions need to be made. These decisions are presented in a matrix to determine the relationship between LEED and PDRI-buildings decisions. In a second time, the scope definition is

explained in detail for section II: basis of design of PDRI-buildings. This section has been chosen for detailing, due to its significance in PDRI-buildings scores and green building design decisions. Section II accounts for 42.8% of the 1000 points of PDRI-buildings.

The following table illustrates the proposed framework. LEED related decisions corresponding to PDRI-buildings and pre-project planning, as well as in the execution phase are marked with an "X".

	Project Life Cycle																			
	Pre- project Planning- PDRI SECTIONS											Execution / construction								
	Basis of project decision			Basis of design				Execution approach												
	Business strategy	Owner philosophies	Project requirements	Site information	Building programming	Building / Project design parameters	Equipment	Procurement strategy	Deliverables	Project control	Project execution plan	Detail design	Bid documents & evaluation	Site clearing, site services & landscaping	Structural work	External envelope	Partitions, int.finishes	HVAC, M&E, WS&S	Common amenities	Commissioning
LEED CREDITS																				
SUSTAINABLE SITES																				
Erosion & sedimentation control				X		X						X		X						
Site selection	X											X								
Development density	X											X								
Redevelopment of contaminated sites	X			X								X		X						

	PDRI Section II - Basis of Design																															
	Site information								Building programming													Building/project design parameters								Equipment		
	D1 Site layout	D2 Site surveys	D3 Civil/Geotech. Info.	D4 Gov. regulatory req.	D5 Env. assessment	D6 Utility sources with supply conditions	D7 Site life safety considerations	D8 Special water & waste Treatment req.	E1 Program statement	E2 Building summary space list	E3 Overall Adjacency diagram	E4 stacking diagram	E5 Growth & phased development	E6 circulation & open space req.	E7 Functional relationship diagrams	E8 Loading/unloading/storage/facilities req.	E9 Transportation req.uirements	E10 Building finishes	E11 Room data sheets	E12 Fuenishings, equipment, built-ins.	E13 Window treatment	F1 Civil / site design	F2 Architectural design	F3 Structural design	F4 Mechanical dasign	F5 Electrical design	F6 Building life safety requirements	F7 Constructability analysis	F8 Technological sophistication	G1 Equipment list	G2 Equipment location drawings	G3 Equipment utility requirements
LEED CREDITS																																
SUSTAINABLE SITES																																
Erosion & sedimentation control		X		X				X														X										
Site selection																																
Development density																																
Redevelopment of contaminated sites		X			X																											

Figure 3.2: LEED-PDRI framework for pre-project planning

The tables have been shortened in this section but are presented in detail for the LEED category "Sustainable sites" in the Table 3 and Table 4 of [21].

This framework has several strong points such as increased clarity and a project scope in proper alignment with business drivers. A detailed scope definition facilitates a smooth transition from planning to design and construction and allows the project managers to set adequate cost and

schedule baselines and helps ascertain procurement requirements. However, this type of framework helps the project manager to plan but does not gives insights on ways to check practices during the construction phase. Ways to integrate LEED requirements in other stages of the building project management process need to be investigated.

3.2.3 *LEED-FOCAST Integration with Green Project Delivery*

The LEED-FOCAST integration implementation methodology [15] relies on the IPD approach. It is an iterative lean process that improves the work of the different project actors during the project's entire lifecycle. The methodology consists of:

- The creation of a FOCAST matrix by the LEED consultant in the pre-design phase where each participant expresses their inclination for each credit,
- The organisation of a design charette,
- The identification of products or services that do not add value to the building using the two previous inputs,
- A "closed-loop" process of "Plan-Do-Check-Act" is activated in order to continuously improve the output of the actors by analysing how the design, construction, maintenance and operation can be optimised.

The following figure summarises the recommended process.

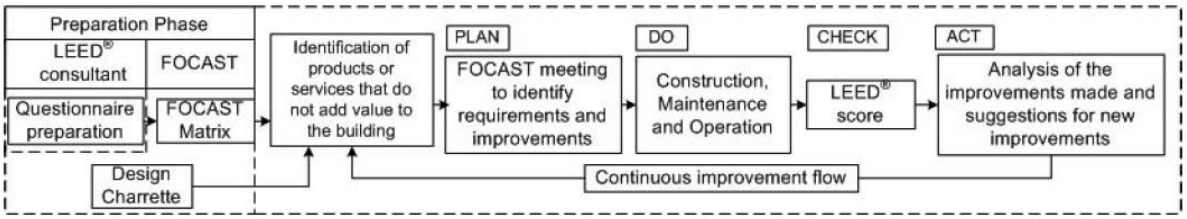

Figure 3.3: LEED-FOCAST lean methodology

The LEED-FOCAST matrix is for the use of the LEED consultant to identify responsibilities of the actors in the different project stages., by the use of the initials F-facility manager, O-owner, C-contractor, A-architect, S-speciality consultants, T-trade contractors. The following figure shows a portion of the matrix.

Owner - O, Architect- A, Contractor-C, Consultant- S, Facility Manager-F, Trade Contractors T		PLANNING & DEVELOPMENT PHASE							
FOCAST		Conceptualization							
LEED - AEC Integration		Identify Team	Determine Project Performance Goals	Determine Communication Methodologies	Development of Cost Structure and Perelimnary Schedule	Identify Potential Project Risks and Best Team Member to Handle Them	Review of Regulatory Considerations	Define Project Scope	Identify Potential Sites
	Sustainable Sites								
Prereq 1	**Construction Activity Pollution Prevention**		OSAC	FOCAS	SC	OCAS	OSC	OSAC	OSAC
Credit 1	**Site Selection**		FOCA	FOCAS	OAC	FOCA	OA		OA
Credit 2	**Development Density & Community Connectivity**		FO	FOCAS		FO	OA		OSA
Credit 3	**Brownfield Redevelopment**		FOS	FOCAS	OSAC	FOS	OS		OSA
Credit 4.1	**Alternative Transportation**, Public Transportation Access		FO	FOCAS		FO			OA
Credit 4.2	**Alternative Transportation**, Bicycle Storage & Changing Rooms		FOA	FOCAS	AC	FOA		OA	OA
Credit 4.3	**Alternative Transportation**, Low-Emitting & Fuel-Efficient Vehicles		OA	FOCAS	OAC	OA		OA	
Credit 4.4	**Alternative Transportation**, Parking Capacity & Car Pool		FOA	FOCAS		FOA		OA	
Credit 5.1	**Site Development,** Protection or Restore Habitat		OSAC	FOCAS	SC	OSAC		OSA	SAC
Credit 5.2	**Site Development,** Maximize Open Space		OSA	FOCAS	SAC	OSA	OS	OSA	SA
Credit 6.1	**Stormwater Design,** Quantity Control		FOSA	FOCAS	SC	FOSA	S	OSA	SA
Credit 6.2	**Stormwater Design,** Quality Control		OSA	FOCAS	SC	OSA	S	OS	SA
Credit 7.1	**Heat Island Effect,** Non-Roof		OSA	FOCAS	SC	OSA		OS	SA
Credit 7.2	**Heat Island Effect,** Roof		OSA	FOCAS	AC	OSA		OA	SA
Credit 8	**Light Pollution Reduction**		OSA	FOCAS	SC	OSA	S	OS	S

Figure 3.4: LEED-FOCAST matrix

The proposed framework offers a holistic view of the involvement and actors needed for the different project tasks. Its early implementation in the project fosters effective communications and interactions. Nonetheless this framework could be complemented with additional information on distribution of individual responsibilities.

3.2.4 Utilizing Project Management Processes to deliver LEED Certified Projects

The framework proposed in [10] gives recommendations on when to consider each credit in the different stages of the project and recommends project management practices. The project manager should establish a RACI Matrix, at the beginning of the project, to inform participants of the importance of their role in the obtention of each credit. This project management tool used in other engineering sectors appoints a:

- (R) Responsible: will have to complete the task, but they can be assisted,
- (A) Accountable: is the expert that will have the answer to any question related to the credit and approve the work (they can also be R),
- (C) Consult: has insight on the credits and can help if needed,
- (I) Inform: must be kept up to date with the progress of this credit (passive role).

It is important to assign a responsible actor for each credit for accountability reasons and so that it is not discarded.

The following table details the recommended order of obtention of the credits for a previous version of LEED.

Stage	Category	Credits	
Pre-design	*SS*	Credit 1	Site Selection
		Credit 2	Development Density and Community Connectivity
		Credit 3	Brownfield Redevelopment
		Credits 4.1 through 4.4	Alternative Transportation
		Credits 5.1 and 5.2	Site Development
	EA	Credit 2	Onsite Renewable Energy
	MR	Credits 1.1 and 1.2	Building Reuse
	ID	Credit 2	LEED AP
	RP	Credits 1.1 through 1.4	Regional Priorities
Design	*SS*	Prerequisite 1	Construction Pollution Prevention
		Credit 6.1	Storm Water Design
		Credit 6.2	Quality and Quantity Control
		Credit 7	Heat Island Effect – Non-Roof or Roof
		Credit 8	Light Pollution Reduction
	WE	Prerequisite 1	Water Use Reduction -20% Reduction
		Credit 1	Water Efficient Landscaping
		Credit 2	Innovative Wastewater Technologies
		Credit 3	Water Use Reduction -Above 20%
	EA	Prerequisite 1	Fundamental Commissioning
		Prerequisite 2	Minimum Energy Performance
		Prerequisite 3	Fundamental Refrigerant Management
		Credit 1	Optimize Energy Performance
		Credit 3	Enhanced Commissioning
		Credit 4	Enhanced Refrigerant Management
		Credit 5	Measurement and Verification
		Credit 6	Green Power
	MR	Prerequisite 1	Storage and Collection of Recyclables
		Credit 3	Materials Reuse
		Credit 4,	Recycled Content
		Credit 5	Regional Materials
		Credit 6	Rapidly Renewable Materials
		Credit 7	Certified Wood
	EQ	Prerequisite 1	Minimum Indoor Air Quality Performance
		Prerequisite 2	Environmental Tobacco Smoke Control
		Credit 1	Outdoor Air Delivery Monitoring
		Credit 2	Increased Ventilation
		Credits 4.1 through 4.4	Low-Emitting Materials
		Credit 5	Indoor Chemical and Pollutant Source Control
		Credits 6.1 and 6.2	Controllability of Systems
		Credits 7.1 and 7.2	Thermal Comfort
		Credits 8.1 and 8.2	Daylighting and Views
	ID	Credits 1.1 through 1.5	Innovation in Design
Construction	*MR*	Credit 1	Construction Waste Management
	EQ	Credits 3.1 and 3.2	Construction IAQ Management Plans

Table 3.2: LEED credits classified according to project stage

3.3 Frameworks to integrate LEED in BIM models

Accomplishing LEED certification is not only a matter of performance requirements but also documentation to provide at all stages of a project in order to properly review it. Building Information Modelling (BIM) technologies have been emerging in the last decades as a solution to modernize the construction sector by using intelligent tools to facilitate the extraction and sharing of all sorts of information, which fosters good communication between team members. It has been put forward to help green building certifications' assessment process.

3.3.1 BIM and Green BIM

ISO 19650-1 [26] defines BIM as: "use of a shared digital representation of a built asset to facilitate design, construction and operation processes to form a reliable basis for decisions. Built assets include, but are not limited to, buildings, bridges, roads, process plants." BIM is the computer software combination of a 3D geometry with building information, such as elevations or plans, but also spreadsheets with amount of materials needed, cost estimation, etc. The most widely used BIM software is *Revit* from Autodesk.

Green BIM is the "use of BIM tools to help achieve sustainability and/or improved building performance objectives" [27]. Its potential to help the sustainable effort is mostly untapped for now. The construction sector being slow to change, the two relatively new concepts of BIM and green construction are still in the process of being integrated into the regular practices of construction companies. Using BIM software to help the green building certification process is one of the new uses to explore.

3.3.2 Integration of BIM in LEED certification

Project initiation is the best stage for sustainability choices to be made [28] as a late integration will be more complex. BIM tools, thanks to their multi-level information management, can help the decision-making in the following domains:

- Building orientation,
- Building massing (form and envelope),
- Daylighting analysis,
- Water harvesting,
- Energy modelling including renewable energy,
- Sustainable materials,
- Site and logistics management.

BIM software (such as Revit or IES VE) can be used in order to earn LEED credits by providing quickly updated documentation for 17 LEED credits and 2 prerequisites, contributing up to a total of 38 points. Credits selection process can also be facilitated with the use of BIM.

From a more practical point of view, [23] is offering an actionable strategy to make a bridge between LEED credits and the way they are calculated, using a BIM tool like Revit. The original Revit model has a set of general parameters but does not provide all the required information for LEED assessment. Nevertheless, it allows users' add-ins to improve its offer, such as shared parameters. They can be used to respond to LEED credits requirements and facilitate data extraction; each shared parameter created inside the Revit model is then linked to a LEED criterion.

In the case of quantitative data, extraction from the model is easily automated. For instance, the vegetated area (parameter) in square meters in the site's topography (element) can be linked to

the LEED credit 5.2: Site Development – Maximize Open Space. The data already exists in the model, and just needs to be found and presented to the user in a quick and easy way.

For more qualitative data, such as the origin of the material used, or the construction of a waste management plant, there is a need of intervention from the designer during the design phase. This can be done through the manual input of the origin of the materials during material definition, placing the waste management facility on the map around the location, etc. Then, an algorithm is put in place to check whether the LEED credit can be validated, using this information. To do so, the credit is interpreted in a logic string of actions (for example, a flow chart) and created as a sequence of information towards credit validation, and eventually the algorithm is developed and implemented.

Furthermore, the algorithm will operate only if the pre-requirements are already met. If they are met, then the program will run to look for all the credits associated in that LEED category. This method assumes that the BIM model for the building is complete with all the information needed for LEED assessment (components, properties and LEED parameters and elements). The Revit Application Programme Interface (API) installed via an add-in in Revit then takes the role of collecting the right data for LEED assessment and a programme takes responsibility of showing the results in an easy way for the Revit user (report card and final score).

For instance, to get the credit 4.1: Alternative Transportation – Public Transportation Access, the building needs to have a certain number of public transportation stations of various types in a radius lesser than a given distance (to mimic the possibility of the occupants to walk comfortably to a public transportation station).

The following process is operated inside the Revit model:

- Bus stops, rail stations, bus rapid transit stations, ferry terminals (as elements in the Revit model) are searched around the building,
- If the algorithm finds one, the distance between the entrance door and the public transportation station is measured (since all objects have X, Y, Z coordinates in the 3D space). If that distance is under a threshold, the algorithm keeps track of that information,
- The algorithm continue until the credit is reached or the distance with the closest station is so big that it does not meet the requirement of the LEED criterion,
- The public transport stations that meets the distance requirements are then counted and the credit is calculated,
- Finally, the algorithm generates a report, readable for a non-programmer designer and gives the number of points the building got for that category.

As seen, a BIM software like Revit can be modified to adapt to LEED certification set of credits but more generally, to any green building certification. However, Green BIM requires an integrated design approach which can require effort to implement in a highly complex system like a construction project [27]. For now, the Green BIM approach has been technology-centric, but there remain issues in the organization and the implementation of new strategies to construct in the established sector of construction. The challenges that arise when talking about Green BIM, on top the usual ones in construction projects, are:

- Adoption and interoperability of different BIM software by the different actors (the IFC format was supposed to be a solution for the interoperability of the files but it does not hold its promises and is not reliable in practice),
- Sophistication of the model and literacy of the team members,
- Inherent fragmentation in the overall supply chain,
- Cost of certifications and of BIM software licences.

Moreover, not all tasks of LEED can be BIM compatible [27], [28] so BIM tools might not be the universal solution it claims to be.

3.4 LEED Credits Selection

The sixth step of the recommended work plan offered by LEED is the development of the LEED scorecard and as a result, the certification level to target (Certified, Siler Gold or Platinum). Three different strategies are emerging when choosing the credits to pursue in a green construction project in the context of a LEED NC (DB + C) certification:

- Based on the priorities of the project [29], [30],
- Based on the experience/knowledge of team members on green buildings [19],
- Based on previous similar projects that were "green building" certified [31], [32].

3.4.1 Based on the priorities

The first strategy [29] develops a tool to be used in the *Feasibility Studies* stage where it is possible to:

- Select the option that drives the project
- Examine the LEED credits from an owner's and Architect/Engineer perspective

The tool gathers information from most stakeholders, to have the most accurate results, in order to have as an output the optimal set of LEED credits, based on each participant's weight influence and the priorities of the project (cost, architectural aesthetics, life cycle, certifications, etc). [30] suggests a method that could be associated with this to reach the best alternative considering the criteria weights.

3.4.2 Based on the experience/knowledge of team members

Since tackling a green building project is complex, the second strategy [19] helps to choose the credits to utilize the effort of the architect, engineers and consultants in the most efficient way possible from the start of the project.

This paper identifies the following pre-requisites for a successful green building:

- Educated or experienced team members/subcontractors in green building projects,
- Early involvement of key participants in the project.

Therefore, their method considers in a quantitative way the education/experience and the perceived value weight of each team member as an input to select the right credits for a specific project. These attributes are evaluated with a questionnaire and the resulting data is processed to give a mathematical representation of the capabilities and responsibilities of all team members. The output is a checklist for each credit:

- "YES" meaning what the team is comfortable (they have the experience/knowledge and are involved at the right moment),
- "MAYBE" meaning that either the team is not that comfortable so need some extra qualifications or better involvement, or that the technology is not available in that specific context (example: material unavailable). For those credits, the project manager will need to decide whether the credit will still be included in the scorecard or it shall be let go off.
- "NO" meaning that the key team members are not at all capable to deliver the output required to get a specific credit and there is no point in putting money and time into getting that credit.

The credits are then selected accordingly. By using this questionnaire at the beginning of the project, the project manager can have a tool to help decision-making when it comes to the capabilities of its team and to not put money and time into credits that are bound to fail. For credits on the edge of not making the cut, the project manager can decide to hire an expert to consolidate that green building characteristic and not bottleneck the project delivery process. For instance, if the energy performance credit barely reaches the "YES" status, an energy modelling expert can be brought on board in the project.

This method highlights the fact that green building project is as good as the knowledge/experience and involvement of the team members. In this thesis work, it will be assumed that the team is perfectly experienced in all the credits of the LEED, and that this aspect is not a threat to the project. In effect, the team may not have all the appropriate qualifications, but this thesis will provide guidance for all the credits that are in the reach of the project.

3.4.3 Based on previous similar projects

The third strategy [32] relies on the fact that since each new project brings new challenges, a database of case studies would be helpful for a LEED manager in order to have an overview of the technologies used and the credits obtained by similar projects. The model follows four steps:

- Retrieve: Given a target problem (or a new case), retrieve from the case base to get the most relevant and similar cases. Usually, a case consists of a problem description and its solution. Reuse information from the retrieved cases to map the solution,
- Reuse: Map the solution from the retrieved cases to the target problem and provide a proposed solution. This may involve adapting the solution, as needed, to fit the new situation,
- Revise: Test the proposed solution in the real world (or in a simulation) and, if necessary, revise in order to have the confirmed solution,
- Retain: After the solution has been successfully adapted to the target problem, store the resulting outcome as a new case in the case base.

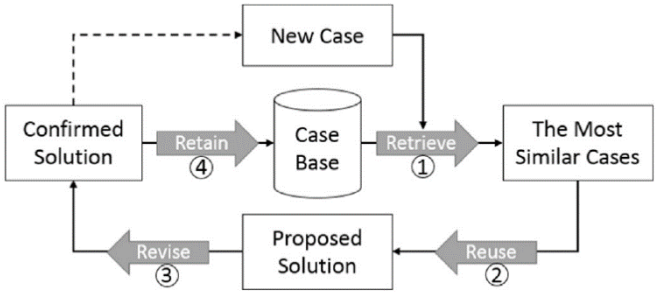

Figure 3.5: Fig 1 from [32] *to explain the process*

This model is not perfect and has around an 80% success rate for different levels of certification, but it is useful to the team to have a prediction of the points that similar projects have earned. A weakness of this method though is that the database must be very big, varied and accurate to provide usable results. New technologies and techniques might not have the time to be included in the database so the manager must have a critical eye and update the database when reviewing the output of this method.

The same authors also developed a model in another paper [31] to analyse LEED credits achievement thanks to a database so that the managers will have an understanding from the beginning on the difficulty to achieve those credits. The achievement of individual LEED credits in

previous projects gives the manager an insight into how they will proceed and the hurdles to overcome.

For each credit, the Percentage Average Score (PAS) is defined as the ratio between the average score over 1000 cases over the full score. A high PAS suggests that the credit is quite easy to get: easy validation of associated standard, documentation easy to provide, technology readily available, etc. However, this index does not inform on the cost of the credit.

The accomplishment of the credit depending on the level of certification gotten at the end can also give insight to the manager for the selection of the credits. Demanding credits in terms of costs and effort (for example: reuse of material) can appear as difficult in a lot of projects, especially if the decision to pursue these credits is taken late, so they are usually chosen for high achieving projects (Gold or Platinum) or if they are well included in the nature of the project from the beginning. That information can help the manager in the choice of the credits since other projects' experiences are more realistic than the expectations of the client and of an inexperienced design team.

Eventually, the probability that two credits are related was analysed. If the team decides to target a certain credit, it will be useful to know the effort required to gain a related credit. However, this information is mainly useful for high-achieving projects.

3.5 Conclusions

It appears that a strategic definition from the start of the project, accompanied with a charrette, and an efficient communication during the whole project are key factors to a successful green building project. Since green buildings are a novelty, a learning curve must be surmounted by all actors of the construction project with education and gaining experience. All those recommendations found in many documents will be taken into account for the development of our own framework.

Different frameworks have been analysed, and it arose that they are focusing either too much on the first stages of the project or on the credits, with little consideration of the project management aspect of carry out those credits. The proposed framework of this thesis will provide to all actors guidance on where and when their expertise is necessary and what their contribution brings to the documentation process and achievement of a specific credit.

There exists an opportunity for BIM to facilitate and automate the LEED credit assessment, that is if the BIM model is perfectly done and complete. Therefore, the modeller needs to know precisely what to model in order to get results reflecting reality. Companies see the potential of the use of BIM for green construction and seem willing to engage in adequate practices. This thesis will not address the BIM aspect of the framework.

Before starting the project management of the LEED project, choosing the appropriate credits to pursue is fundamental in order not to waste time, labour and money. Many papers explore methods to choose the credits; according to the team's skills in green buildings, similar projects, BIM or the priorities of the stakeholders. More pre-studies can be made for the selection of specific sub-categories (materials, energy, envelope, etc) to confirm the targeting of certain credits. This thesis work will cover all the LEED credits so that the team members can choose the ones they deem relevant to incorporate into the project.

4 Framework

This section aims at the implementation of a framework for project managers' use to facilitate the integration of the LEED certification process in the project management one.

4.1 RASCI matrix

To provide guidance in the process of LEED assessment a RASCI, an alternate version of a RACI matrix, is considered. This classic project management tool is a double-entry responsibility assignment matrix, that aims at defining the participation of the different actors in the completion of various tasks and documents. RASCI is an acronym and stands for:

- *Responsible*: who is realizing the task or deliverable and is responsible for getting the work done or for decision-making (R should be only one person if possible),
- *Accountable*: authoritative and answerable one, who will be questioned by higher authorities and will face direct consequences in case of failure of the tasks (only one A must be selected for each task to avoid any decisional conflicts),
- *Support:* is a resource allocated to R, and will help completing the task,
- *Consulted*: will provide information useful to completing the task or deliverable, and will be in a two-way communication with R,
- *Informed*: who need to be kept informed of progress and decisions as they are directly affected by the task, but do not need to be formally consulted, as not contributing directly to the task or decision,

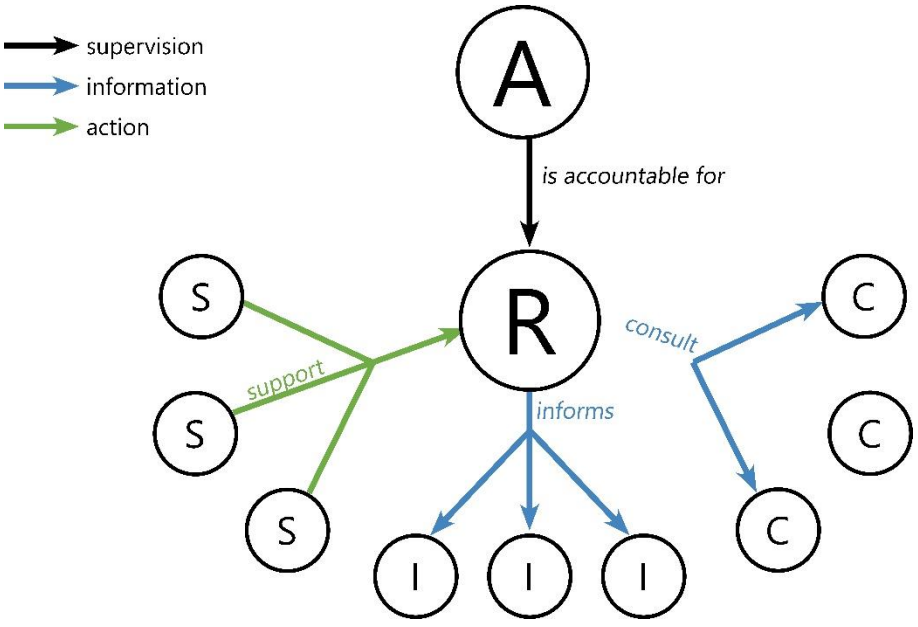

Figure 4.1: Visual representation of the RASCI interactions

The two entries that will be used as a basis for the matrix are the LEED credits horizontally and the project actors vertically. It is to be noted that in the matrix each type of actor gets one column but depending on the size of the project, one column can represent from one person up to a big team.

4.2 Assumptions for the developed framework

The actors considered are the ones detailed in the Table 2.2 of the section Background and correspond to the ones affected by the LEED certification process. As mentioned before, this list is not exhaustive and some actors may be added or left out, depending on the size and scope of the project.

A commissioning authority has been added to the client team for the sake of Energy and Atmosphere Prerequisite 1 *Fundamental Commissioning and Verification* and Credit 1 *Enhanced Commissioning*. Two LEED APs have also been considered, as Innovation Credit 2 *LEED Accredited Professional* rewards points for LEED AP appointment.

In the developed framework, when not explicitly mentioned in the RASCI matrix, the client will be marked as "in the loop" with *I*,* for they must be informed and approve the decisions of the design and construction teams.

The following chart shows the considered authority relationships between the different actors, and their organisation.

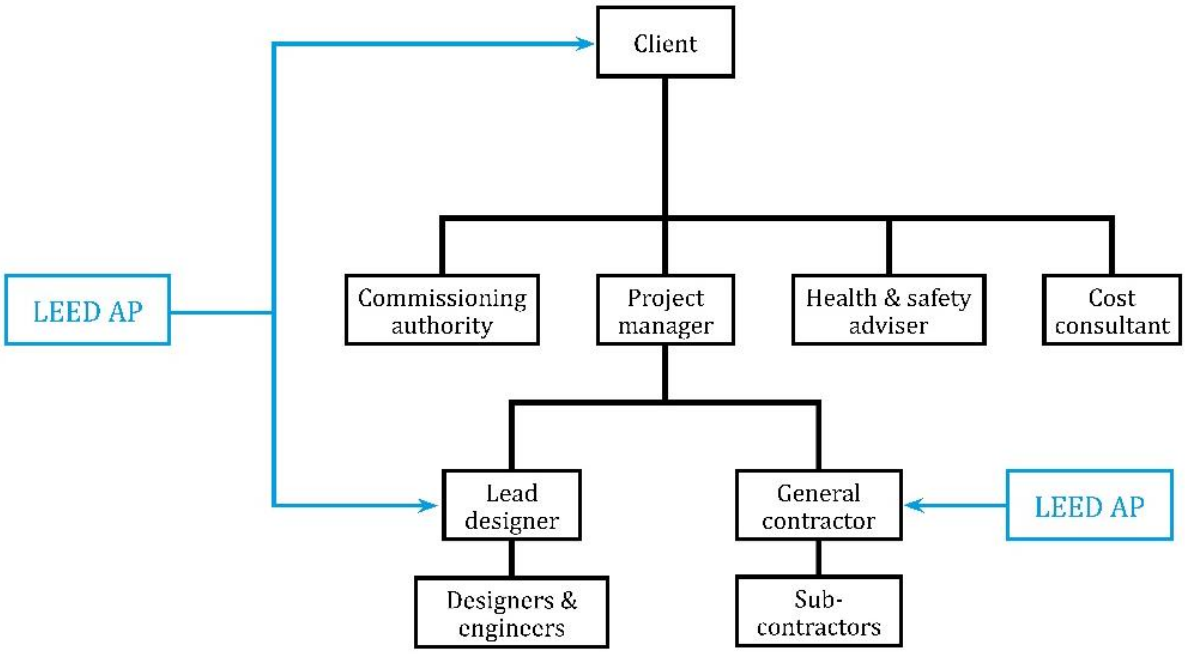

Figure 4.2: Hierarchical organigram of green project actors

This organisation relies on the appointment of a project manager, though for an optimal green project delivery, it has been seen in the State of the Art chapter that an early integration of all main actors is recommended through the implementation of a *charette* at the beginning of the project for instance.

The credits considered are the credits for LEED v4.1 BD+C *New Construction*, of which the requirements are detailed in the annex.

For the analysis, it was considered a European project, located in Italy, following European and national codes. Consequently, it is to be noted that the Energy and Atmosphere Credit 4: *Grid Harmonization* is relevant only in the United States and will thus be left out during the analysis.

4.3 Method description

The method used to develop the proposed framework is:

1. Each credit/prerequisite is considered, and its intent and requirements are analysed, along with the supporting documentation (Annex A); The expected tasks are compared to the responsibilities of the different project actors and linked to them subsequently. The letters R, A, S, C and I are accordingly assigned.
2. The risk of not reaching a credit or going overbudget for a prerequisite is assessed and impact is quantified based on information from the interview with the two LEED APs, Letizia Antonini and her colleague Marta, the Reference Guide for Building Design and Construction [13] and from a complementary literature review.

The following table shows a portion of the matrix that will be developed, and the full matrix is readable in Figure 108.

					Client Team							Design Team										Construction team					Stakeholders							
		LEED Credits	*# points*	*Risk*	Client	Project manager	Cost consultant	Health and safety advisor	Commissioning authority	LEED AP D	Lead designer	Architect	Interior designer	Landscape designer	Structural engineer	Mechanical engineer	Electrical engineer	Envelope engineer	Acoustical engineer	Sustainability engineer	General contractor	LEED AP GC	Mechanical subcontractor	Electrical subcontractor	Logistics team	National/Local authorities	Environmental Bodies	Local communities	Utilities Companies	Waste management companies	Local recycling facilities	Products manufacturers	Environmental protection agency
IP	C1	Integrative Process	1	1	A	S	S	S	S	R	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S					
LT	C1	LEED for Neighborhood Development Location	16	5	C	I				R	A	S								I												
	C2	Sensitive Land Protection	1	3	I*	I				R	A	S		I						I					C	C						
	C3	High-Priority Site	2	3	C	I	C			R	A	S								I					C	C	C					S
	C4	Surrounding Density and Diverse Users	5	3	I*	I				R	A	S								I					C							
	C5	Access to Quality Transit	5	3	I*	I				R	A	S													C							
	C6	Bicycle Facilities	1	3	I*	I				R	A	S				I				I					C							
	C7	Reduced Parking Footprint	1	1	I*	I				R	A	S								I					C		I					
	C8	Electric Vehicles	1	4	I*	I				R	A	S					C			I				C				I					

Figure 4.3: Portion of the RASCI matrix

4.3.1 First step: Requirements and Documents

In the first step of the method, the intent, requirements and needed documentation of the analysed credit is presented in the form of a table. A colour code is used for the documentation:

To upload as file in LEED Online

To input directly on LEED Online

Figure 4.4: Colour legend for LEED documentation

Then, comparing actors' responsibilities and the LEED credit table of annex A, a responsibility summary table is made. Eventually, the results from each credit analysis are gathered in the final RASCI matrix.

For example, let's explain the Materials and Resources Prerequisite 2 - *Construction and Demolition Waste Management Planning*. Here is the table explaining the requirements and the documents to provide in order to achieve the prerequisite:

Materials and Resources	Prerequisite 2	Construction and Demolition Waste Management Planning
	Intent	To reduce construction and demolition waste disposed of in landfills and incineration facilities by recovering, reusing, and recycling materials.
	Requirements	Develop and implement a construction and demolition waste management plan: Establish waste diversion goals for the project by identifying at least five materials (both structural and non-structural) targeted for diversion. Specify whether materials will be separated or comingled and describe the diversion strategies planned for the project. Describe where the material will be taken and how the recycling facility will process the material including expected diversion rates for each material stream. Provide a final report detailing all major waste streams generated, including disposal and diversion rates. Alternative daily cover (ADC) does not qualify as material diverted from disposal. Include materials destined for ADC in the calculations as waste. Land-clearing debris is not considered construction, demolition, or renovation waste that can contribute to waste diversion.
	Documents	General information about construction waste Construction and demolition waste management plan. The plan must outline at least 5 materials targeted for diversion. Specify whether materials will be separated or commingled and describe the diversion strategies planned for the project. Describe where the material will be taken and, for those materials sent for recycling, how the recycling facility will process the material including expected diversion rates. Indicate any commingled recycling facilities used that have third party verification of recycling rates.

Table 4.1: LEED Documents and Requirements MR P2

Using those requirements and documents, the following table explaining the involvement of all the actors in the completion of this specific credit was created and the letters R, A, S, C and I assigned.

	Actor	Involvement
R	LEED AP GC	is responsible for the completion of LEED construction prerequisites
A	General contractor	is the construction team leader that approves all aspects of the construction phase
S	Logistics team	is responsible for the making of construction and demolition waste management plan
C	Waste management companies	are consulted for disposal and diversion rates, and for the waste-to-energy
	Local recycling facilities	are consulted for the recycling of materials
I	Project Manager	needs to be informed to oversee the project

Table 4.2: RASCI - method example MR P2

Once it is done, the results are input in the general RACSI matrix that summarises the responsibilities.

	Client Team						Design Team										Construction team					Stakeholders							
	Client	Project manager	Cost Consultant	Health and safety advisor	Commissioning authority	LEED AP of the Client/Design team	Lead designer	Architect	Interior designer	Landscape designer	Structural engineer	Mechanical engineer	Electrical engineer	Envelope engineer	Acoustical engineer	Sustainability engineer	General contractor/Construction manager	LEED AP of General contractor	Mechanical subcontractor	Electrical subcontractor	Logistics team	National/Local authorities	Environmental Bodies	Local communities	Utilities Companies	Waste management companies	Local recycling facilities	Products manufacturers	Environmental protection agency
P2	I*	I															A	R			S					C	C		

Table 4.3: Total RASCI matrix extract for MR P2

4.3.2 *Second step: Risk assessment*

The risk assessment has two distinct steps. First, an interview of the two LEED APs, Letizia Antonini and her colleague Marta, was conducted; each credit was discussed and potential threats to its completion were analysed. In this report, information coming from this interview will be followed by [AP]. In a second time, a complementary literature review was conducted.

The risk analysed is different based on whether a prerequisite or a credit is analysed;

- For a prerequisite, the risk of going overbudget to fulfil it is considered,
- For a credit, the risk of not achieving it is considered.

Five grades of risk are considered from 1 to 5 (5 being a high risk). The following table shows the colour code adopted to represent the level of risk. These grades have been translated into probability ranges considering a linear increase for the grades.

	Grades of risk	Probability range
1	Low risk	[0;20%[
2	Relatively low risk	[20%;40%[
3	Medium risk	[40%;60%[
4	Relatively high risk	[60%;80%[
5	High risk	[80%;100%]

Table 4.4: Grades of risk considered

As some credits have multiple points to be awarded, that can depend on paths and options considered for their obtention, grades of risk were assigned in detail for the different ways to achieve the credit in question. In the end, the global risk of the credit is calculated considering the individual grades and number of points represented by the different paths.

This is incorporated in the global level of risk through a weighted average:

$$p(X) = \frac{\sum_i p(x_i) \cdot n_i}{\sum_i n_i}$$

Where:

X is the event "the credit is not achieved",
$p(X)$ is the probability of the event X,
x_i is the event "the option or path i is not achieved",
$p(x_i)$ is the probability of the event x_i,
n_i is the number of points that can be awarded to the option or path i.

For a prerequisite, considering that the risk regards the possible event of "going overbudget" and that the different options to fulfil are not awarded points, a simple average is considered.

$$p(Y) = \frac{\sum_{i=1}^{N} p(y_i)}{N}$$

Where:

Y is the event "the prerequisite goes overbudget",
$p(Y)$ is the probability of the event Y,
y_i is the event "the option or path i creates extra unaccounted costs",
$p(y_i)$ is the probability of the event x_i,
N is the total number of paths and options.

In practice, the weighted average and simple average are applied to the boundaries of the interval for each risk grade, to calculate an interval of risk for the credit or prerequisite considered. Then, the average of the calculated interval is placed as on the following figure and the risk grade is attributed accordingly.

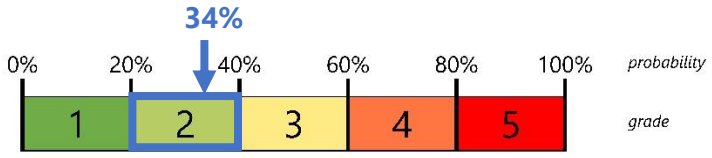

Figure 4.5: Probability intervals and risk grades – 34% risk 2

The risk grades are attributed using, as mentioned before, the information from the [AP] interview and complementary documentation, and correspond to:

- The $p(x_i)/p(y_i)$ if the credit/prerequisite has different options and/or paths,
- The $p(X)/p(Y)$ if the credit/prerequisite has a unique path.

The risks considered mainly concern [33]:

- Energy saving uncertainty,
- Complex procedures to obtain approvals,
- Shortage of funds,
- Unclear requirements of owners,
- Poor communication among project's actors,
- Technical issues,
- Lack of availability of green material and equipment,
- Lack of experience,
- Poor design.

For example, for the credit LT C3 – *High Priority Site*, the risk is assessed as follows:

LT	C3	**High Priority Site**			**2**	**3.00**
		AND/OR	Option 1. High Priority Site		1	3.00
			OR	*Path 1. Economically Disadvantaged Community Location*	*1*	*3.00*
				Path 2. Brownfield Remediation	*1*	*3.00*
			Option 2. Equitable Development		1	3.00
			OR	*Path 1. Equity & Community Benefits*	*1*	*2.00*
				Path 2. Affordable Housing in Residential or Mixed-Use Projects	*1*	*3.00*

Table 4.5: Risk table example LT C3

In a first time, considering the risk level attributed to each path of option 1, the lower and upper interval boundaries of option 1 are calculated with a weighted average:

$$p(option1_{lower}) = \frac{p(path1_{lower})\cdot n_{path1} + p(path2_{lower})\cdot n_{path2}}{n_{path1} + n_{path2}} \text{ and } p(option1_{upper}) = \frac{p(path1_{upper})\cdot n_{path1} + p(path2_{upper})\cdot n_{path2}}{n_{path1} + n_{path2}}$$

$$p(option1_{lower}) = \frac{0.4 \cdot 1 + 0.4 \cdot 1}{1 + 1} = 40\% \text{ and } p(option1_{upper}) = \frac{0.6 \cdot 1 + 0.6 \cdot 1}{1 + 1} = 60\%$$

$$\frac{p(option1_{lower}) + p(option1_{upper})}{2} = \frac{40\% + 60\%}{2} = 50\%$$

Considering the average of 50% and the following graph, the risk assessed is medium.

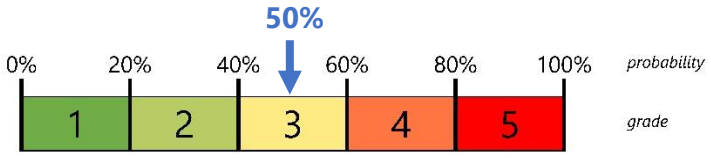

Figure 4.6: Risk assessment example LT C3 option 1

Similarly, option 2 is assessed a medium grade of risk.

$$p(option2_{lower}) = \frac{0.2 \cdot 1 + 0.4 \cdot 1}{1 + 1} = 30\% \text{ and } p(option1_{upper}) = \frac{0.4 \cdot 1 + 0.6 \cdot 1}{1 + 1} = 50\%$$

$$\frac{p(option1_{lower}) + p(option1_{upper})}{2} = \frac{30\% + 50\%}{2} = 40\%$$

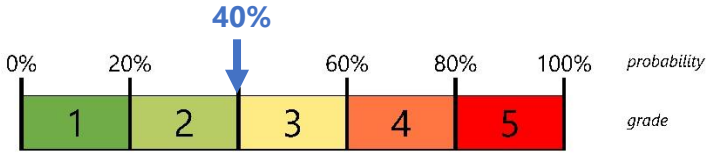

Figure 4.7: Risk assessment example LT C3 option 2

Ultimately, the risk grade of the whole credit is assessed following the same procedure.

$$p(LT\ C3) = \frac{p(option1_{low/up}) \cdot n_{option1} + p(option2_{low/up}) \cdot n_{option2}}{n_{option1} + n_{option2}} \in [35\%; 45\%[$$

The average being of 40%, the final grade of risk is medium for the credit.

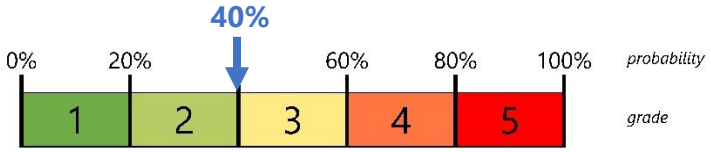

Figure 4.8: Risk assessment example LT C3 final

It is to be noted that due to its specificity of being achieved only if specific credits are achieved, the risk grade of RP C1 - *Regional Priority* is taken equal to the highest of the grades of the credits in the list as it will be the limiting credit.

4.4 Framework development

4.4.1 Integrative process

4.4.1.1 *Credit 1 - Integrative Process*

	Actor	Involvement
R	LEED AP D	is responsible for LEED design credits completion
A	Client	sets the LEED level objective and approves the letter
S	Project manager	writes the letter and works on supporting documentation for the Exemplary Performance option if pursued
	All the other team members and key stakeholders	must agree and sign the letter and the ambitions mentioned

Table 4.6: RASCI IP C1 – Integrative Process

This credit consists in the implementation of a *charrette* and usually does not represent a challenge [AP]. The credit has been assigned a **low** risk of not being achieved.

		LEED Credits	*pts*	Risk
IP	C1	Integrative Process	**1**	1

Table 4.7: Risk IP C1 – Integrative Process

4.4.2 Location and transportation

4.4.2.1 *Credit 1 - LEED for Neighbourhood Development Location*

	Actor	Involvement
R	LEED AP D	is responsible for LEED design credits completion
A	Lead designer	is the design team leader that approves all aspects of the design
S	Architect	helps to the production of a vicinity plan containing the boundaries of the current project as well as the project boundaries of the qualifying LEED for Neighbourhood Development certified plan
C	Client	is consulted for project information
I	Project Manager	needs to be informed to oversee the project
	General contractor	needs to be informed to anticipate the construction phase

Table 4.8: RASCI LT C1 - LEED for Neighbourhood Development Location

This credit is described as a "rigorous and complex" process in [34], a guide for LEED for Neighbourhood Development Location from the Natural Resources Defence Council. It is thus often not pursued [AP]. The credit has been assigned a **high** risk of not being achieved.

		LEED Credits	*pts*	Risk
LT	C1	**LEED for Neighborhood Development Location**	**16**	**5**

Table 4.9: Risk LT C1 - LEED for Neighbourhood Development Location

.

4.4.2.2 *Credit 2 - Sensitive Land Protection*

	Actor	Involvement
R	LEED AP D	is responsible for LEED design credits completion
A	Lead designer	is the design team leader that approves all aspects of the design
S	Architect	helps to the production of a site map showing project boundaries, development footprint, sensitive areas, etc. (in the case of option 1)
C	National/Local authorities	grant access to the necessary documents and archives on previous development of the site (in the case of option 1) and flood hazard maps, water bodies and wetlands maps and prime farmland maps (in the case of option 2)
	Environmental bodies	provide information on species or ecological communities listed as threatened, possibly extinct, imperilled, or endangered that might be present in the site area considered (in the case of option 2)
I	Project Manager	needs to be informed to oversee the project
	Landscape designer	needs to be informed of potential sensitive areas on the site (in the case of option 1)
	General contractor	needs to be informed to anticipate the construction phase

Table 4.10: RASCI LT C2 – Sensitive Land Protection

The completion of this credit is strongly affected by and dependent of site features [AP]. There are two distinct options through which the credit can be achieved.

Option 1. Previously Developed Land: this option requires that the site is located on previously developed land and the supporting documentation. The credit completion is not complicated, but relies on the sharing of information with stakeholders, hence it has been assigned a **medium** level of risk of not being achieved.

Option 2. Avoidance of Sensitive Land: this option requires that the site is located avoiding sensitive lands and a description of how this was verified. It also relies on the sharing of information between actors and stakeholders, but the process is not complicated. To account for the uncertainty on site features, the credit has been assigned a **medium** level of risk of not being achieved.

Overall, the risk of the credit not being achieved is **medium**.

		LEED Credits		*pts*	Risk
LT	C2	**Sensitive Land Protection**		**1**	**3**
		OR	*Option 1. Previously Developed Land*	*1*	3
			Option 2. Avoidance of Sensitive Land	*1*	3

Table 4.11: Risk LT C2 – Sensitive Land Protection

4.4.2.3 *Credit 3 - High-Priority Site*

	Actor	Involvement
R	LEED AP D	is responsible for LEED design credits completion
A	Lead designer	is the design team leader that approves all aspects of the design
S	Architect	produces the vicinity map (option 1 path 1)
	Environmental protection agency	performs site tests and remediation of brownfield (option 1 path 2)
C	National/Local authorities	grant access to the necessary documents and information on economic status in the area around the site (in the case of option 1 path 1) and on soil/groundwater contaminants existing on project site and remediations (in the case of option 1 path 2)
	Local communities and major stakeholders	develop and implement an equity plan and help in the description of the demonstrated community benefits (in the case of option 2 path 1)
	Client	agrees on affordable rental rates for dwelling units to be maintained for at least 15 years (in the case of option 2 path 2)
	Cost consultant	consulted to agree on a viable strategy
I	Project manager	needs to be informed to oversee the project
	General contractor	needs to be informed to anticipate the construction phase

Table 4.12: RASCI LT C3 – High-Priority Site

As for LT C2, the completion of this credit is highly site location and site features dependant [AP]. There are two distinct options through which the credit can be achieved, each option having two paths.

Option 1. High Priority Site:

- Path 1. Economically Disadvantaged Community Location: the collection of the census tract that are public and a study of the surrounding of the site are easily available, so the procedure is not complicated.
- Path 2. Brownfield Remediation: since brownfield remediation is mandatory in Italy (N. 582—18/11/1996) by law, if the site is considered as a brownfield, there is no risk of not reaching the requirements of this path.

For the two paths and to account for the uncertainty on site features, the credit has been assigned a **medium** level of risk of not being achieved.

Option 2. Equitable Development:

- Path 1. Equity and Community Benefits: a summary of community engagement activities and benefits need to be written but require good coordination and communication. A **relatively low** risk of not being achieved is assigned to the path.
- Path 2. Affordable Housing in Residential or Mixed-Use Projects: a binding agreement from the responsible developer that the affordable rental rates for the required number of units will be maintained for at least 15 years, starting from the date of unit occupancy. This path highly depends on the type of project built, the intentions of the client and the city's authorities. To account for the uncertainty on the client and the city, the credit has been assigned a **medium** level of risk of not being achieved.

Overall, the risk of the credit not being achieved is **medium**.

		LEED Credits			*pts*	Risk
LT	C3	**High-Priority Site**			**2**	**3**
		AND/OR	Option 1. High Priority Site		1	3
			OR	*Path 1. Economically Disadvantaged Community Location*	*1*	*3*
				Path 2. Brownfield Remediation	*1*	*3*
			Option 2. Equitable Development		1	3
			OR	*Path 1. Equity & Community Benefits*	*1*	*2*
				Path 2. Affordable Housing in Residential or Mixed-Use Projects	*1*	*3*

Table 4.13: Risk LT C3 – High-Priority Site

4.4.2.4 *Credit 4 - Surrounding Density and Diverse Users*

	Actor	Involvement
R	LEED AP D	is responsible for LEED design credits completion
A	Lead designer	is the design team leader that approves all aspects of the design
S	Architect	helps to the production of an area map showing the project site, the surrounding area and a 400m offset from the project boundary highlighting buildings used for density calculations (in the case of option 1) and an area map showing the project site, use locations and walking routes to each use (in the case of option 2)
C	National/Local authorities	grant access to the necessary information and documents on density of the surrounding area (in the case of option 1) and on use locations (in the case of option 2)
I	Project manager	needs to be informed to oversee the project
	General contractor	needs to be informed to anticipate the construction phase

Table 4.14: RASCI LT C4 – Surrounding Density and Diverse Uses

As the previous credit, this one depends a lot on site location. There are two cumulative options for the credit completion, both having two distinct paths.

Option 1. Surrounding Density: depending on the density of the surrounding area, the option is easily achieved in urban areas but difficult in less dense areas. As a result, a **medium** risk of not achieving the credit is assigned for the more restrictive option (3 points) and a **relatively low** for the less restrictive option (2 points).

Option 2. Diverse Uses: similarly to option 1, the completion of this option is dependent on the density of the surrounding areas and more specifically of the proximity of stores, restaurants, etc. As a result, a **medium** risk of not achieving the credit is assigned for the more restrictive option (2 points) and a **relatively low** risk for the less restrictive option (1 point).

Overall, the risk of the credit not being achieved is **medium**.

		LEED Credits		*pts*	Risk
LT	C4	**Surrounding Density and Diverse Users**		**5**	**3**
		AND/OR	Option 1. Surrounding density	*2*	*2*
				3	*3*
			Option 2. Diverse uses	*1*	*2*
				2	*3*

Table 4.15: Risk LT C4 – Surrounding Density and Diverse Uses

4.4.2.5 *Credit 5 - Access to Quality Transit*

	Actor	Involvement
R	LEED AP D	is responsible for LEED design credits completion
A	Lead designer	is the design team leader that approves all aspects of the design
S	Architect	helps to the production of a map indicating project location, and transit stops, routes serving them and walking routes between the stops and the location
C	National/Local authorities	grant access to information on planned stops and stations and their progress status
I	Project manager	needs to be informed to oversee the project

Table 4.16: RASCI LT C5 – Access to Quality Transit

In Italy, the two only cities able to reach points in this credit are Milan and Rome [AP]. The requirements and documentation to provide are not inherently complex but since the credit is very dependent of the transit offer around the site, it has been assigned a **medium** level of risk of not being achieved.

		LEED Credits	*pts*	Risk
LT	C5	**Access to Quality Transit**	**5**	**3**

Table 4.17: Risk LT C5 – Access to Quality Transit

4.4.2.6 *Credit 6 - Bicycle Facilities*

	Actor	Involvement
R	LEED AP D	is responsible for LEED design credits completion
A	Lead designer	is the design team leader that approves all aspects of the design
S	Architect	designs the project to have a functional entry within the appropriate walking distance from a bicycling network and bicycle storage
		integrates the necessary infrastructures (showers, changing rooms) to the project
C	National/Local authorities	grant access to information on planned bicycle networks and their progress status
I	Project manager	needs to be informed to oversee the project
	Mechanical engineer	needs to be informed of the need of additional showers
	General contractor	needs to be informed to anticipate the construction phase

Table 4.18: RASCI LT C6 – Bicycle Facilities

This credit depends a lot on the site and the client strategy [AP]. Its completion is not inherently complicated (vicinity maps production, adapting of entry placement, addition of showers and bike storage, etc.), but can be limited by space available for bike storage in the case of high occupancy/frequentation projects. Considering the site-dependent nature of this credit, it has been assigned a **medium** risk of not being achieved.

		LEED Credits	*pts*	Risk
LT	C6	**Bicycle Facilities**	**1**	**3**

Table 4.19: Risk LT C6 – Bicycle Facilities

4.4.2.7 *Credit 7 - Reduced Parking Footprint*

	Actor	Involvement
R	LEED AP D	is responsible for LEED design credits completion
A	Lead designer	is the design team leader that approves all aspects of the design
S	Architect	makes the site or vicinity map including project boundaries, and parking used by building occupants (in the case of options 1 and 2), and in addition, parking dedicated to carshare vehicles and distance from project boundary (in the case of option 3)
C	National/Local authorities	is consulted for parking fees and daily cost of municipal public transit (in the case of option 4)
I	Project manager	needs to be informed to oversee the project
	General contractor	needs to be informed to anticipate the construction phase
	Local communities	can be informed of opportunities of car sharing (in the case of option 3)

Table 4.20: RASCI LT C7 – Reduced Parking Footprint

This credit can depend on the client strategy [AP]. There are four distinct options through which the credit can be achieved.

Option 1. No Off-Street Parking: this option requires not to design any off-street parking, to identify parking used by building occupants and provide the total parking capacity and project boundary. None of those tasks represent a challenge to credit completion. This option has been assigned a **low** risk of not achieving.

Option 2. Reduce Parking: this option requires to design a parking with reduced capacity and the same documents as option 1. This option is not inherently difficult because the designer simply needs to reduce of 30% below the base ratio recommended by the Parking Consultant Council. This option has been assigned a **low** risk of not achieving.

Option 3. Carshare: this option requires the dedication of a certain number of parking spots for care sharing vehicles and supporting documentation. If this option is pursued, a certain percentage of already designed parking spots should be for carshare and their implementation compared to a classic parking spot is a bit more demanding. Therefore, this option has been assigned a **relatively low** risk of not being achieved.

Option 4. Unbundling Parking: this option requires the setting of parking fees and its comparison with the cost of municipal public transit. This option has been assigned a **low** risk of not being achieved.

Overall, the risk of the credit not being achieved is **low**.

		LEED Credits		*pts*	Risk
LT	C7	**Reduced Parking Footprint**		**1**	**1**
		OR	Option 1. No Off-Street Parking	1	1
			Option 2. Reduce Parking	1	1
			Option 3. Carshare	1	2
			Option 4. Unbundling Parking	1	1

Table 4.21: Risk LT C7 – Reduced Parking Footprint

4.4.2.8 *Credit 8 - Electric Vehicles*

	Actor	Involvement
R	LEED AP D	is responsible for LEED design credits completion
A	Lead designer	is the design team leader that approves all aspects of the design
S	Architect	designs the installations for electrical vehicles on site
C	Electrical engineer	helps in the design of the charging infrastructures and ensures access to electricity
	Electrical sub-contractor	provides manufacturer information, construction documents, specifications, etc.
I	Project manager	needs to be informed to oversee the project
	General contractor	needs to be informed to anticipate the construction phase
	Local communities	can be informed of the presence of electric vehicles charging stations if parking access is granted to local communities

Table 4.22: RASCI LT C8 – Electric Vehicles

This credit depends on the number of parking spots in the project [AP]. There are two distinct options through which the credit can be achieved.

Option 1. Electric Vehicle Charging: the percentage of electric vehicles needed for the credit depends on the parking size. If the parking space is small, the option is easily reached, otherwise, the completion of this option is difficult. Considering the site-dependent nature of this credit, it has been assigned a **medium** risk of not being achieved.

Option 2. Electric Vehicle Charging Infrastructure: the same comments as option 1 can be written for option 2. However, the installation of the infrastructure is more difficult and less common, so it has been assigned a **relatively high** risk of not being achieved.

Overall, the risk of the credit not being achieved is **relatively high**.

		LEED Credits		*pts*	Risk
LT	C8	**Electric Vehicles**		**1**	**4**
		OR	Option 1. Electric Vehicle Charging	1	3
			Option 2. Electric Vehicle Charging Infrastructure	1	4

Table 4.23: Risk LT C8 – Electric Vehicles

4.4.3 Sustainable sites

4.4.3.1 *Prerequisite 1 – Construction Activity Pollution Prevention*

	Actor	Involvement
R	LEED AP GC	is responsible for LEED construction credits completion
A	General contractor	is the construction team leader that approves all aspects of the construction phase
S		organises the construction site to comply with regulations
C	Structural engineer	surveys the site for erosion and sedimentation control
I	Project manager	needs to be informed to oversee the project

Table 4.24: RASCI SS P1 – Construction Activity Pollution Prevention

Two options are available for this prerequisite following either American or equivalent local standards and codes, so the options were analysed together.

The requirements of this prerequisite are already mandatory in Italy so there is no difficulty to achieve it [AP]. Moreover, implementing it is low cost. The prerequisite is assigned a **low** risk of going overbudget.

		LEED Credits	*pts*	Risk
SS	P1	**Construction Activity Pollution Prevention**	**-**	**1**

Table 4.25: Risk SS P1 – Construction Activity Pollution Prevention

4.4.3.2 *Credit 1 – Site Assessment*

	Actor	Involvement
R	LEED AP D	is responsible for the LEED design credits completion
A	Lead designer	is the design team leader that approves all aspects of the design
S	Structural engineer	performs the site survey of the site (topology, hydrology, climate and soils)
	Landscape designer	performs the site survey of the site (vegetation and species)
C	National/local authorities	provide information on transportation around the site, human health effects and urban characteristics of the site
	Local communities	
I	Project manager	needs to be informed to oversee the project
	Architect	needs to be informed to complement the building design
	General contractor	needs to be informed to anticipate the construction phase

Table 4.26: RACI SS C1 – Site Assessment

This credit is easy to achieve but requires a lot of information and site surveys as well as good communication between the actors is needed to achieve it [AP]. The credit is assigned a **relatively low** risk of not being achieved.

		LEED Credits	*pts*	Risk
SS	C1	**Site Assessment**	**1**	**2**

Table 4.27: Risk SS C1 – Site Assessment

4.4.3.3 *Credit 2 – Protect or Restore Habitat*

	Actor	Involvement
R	LEED AP D	is responsible for LEED design credits completion
A	Lead designer	is the design team leader that approves all aspects of the design
S	Landscape designer	elaborates a protection/restoring plan (option 1)
	Cost consultant	develops a financial support plan (option 2)
C	Structural engineer	provides information on topology, hydrology, climate and soils thanks to a site assessment (option 1)
	Environmental bodies	provide information on projects they support
	Client	chooses the organisations to support
I	Project manager	needs to be informed to oversee the project
	General contractor	anticipates the potential restauration (option 1)

Table 4.28: RASCI SS C2 – Protect or Restore Habitat

For this credit, the project needs to preserve and protect from all development and construction activity 40% of the greenfield area on the site. In addition, two distinct options are possible:

Option 1. On-site restoration: depending on the initial state and size of the site, its completion can be expensive since at least 25% of the site must be restored. To translate the uncertainty linked to the site, a **medium** risk of not being achieved was assigned.

Option 2. Financial support: for this option, the client needs to give financial support to conservation organisations of a minimum amount depending on the size of the site in addition to the initial requirement. For small sites, the client can anticipate this in the project budget but for larger sites, the amount of money to forward can be viewed as deterrent. hence this option has been assigned a **medium** risk of not being achieved.

Overall, the risk of the credit not being achieved is **medium**.

		LEED Credits		*pts*	Risk
SS	C2	**Protect or Restore Habitat**		**2**	**3**
		OR	Option 1. On-site restoration	2	3
			Option 2. Financial support	1	3

Table 4.29: Risk SS C2 – Protect or Restore Habitat

4.4.3.4 *Credit 3 – Open Spaces*

	Actor	Involvement
R	LEED AP D	is responsible for LEED design credits completion
A	Lead designer	is the design team leader that approves all aspects of the design
S	Landscape designer	elaborates an open space plan
C	Architect	is consulted for building integration in the open space
	National/local authorities	provide information on the urban makeup of the site
I	Project manager	needs to be informed to oversee the project
	General contractor	needs to be informed to anticipate the construction phase
	Local communities	needs to be informed of the new spaces that will be created

Table 4.30: RASCI SS C3 – Open Spaces

This credit strongly depends on the surrounding area and requires at least 30% total site area of open space. In urban areas, such as Milan, this credit is very hard to achieve and unlikely to be pursued [AP]. For sites in less dense areas, the creation of an open space meeting the credit requirement is less challenging. Nonetheless, the completion of *SS Credit 2 – Protect or Restore Habitat* is needed to achieve the credit, hence a **medium** risk of not being achieved is assigned.

		LEED Credits	*pts*	Risk
SS	C3	**Open Space**	**1**	**3**

Table 4.31: Risk SS C3 – Open Spaces

4.4.3.5 *Credit 4 – Rainwater Management*

	Actor	Involvement
R	LEED AP D	is responsible for LEED design credits completion
A	Lead designer	is the design team leader that approves all aspects of the design
S	Mechanical engineer	designs permanent infiltration and collection features and assists to vegetated roof design
	Mechanical sub-contractor	installs of the rainwater management system
	Landscape designer	designs passive solutions using native or adapted plants
	Architect	optimises building design for the chosen strategy
C	Logistics team	is in charge of rainwater management equipment procurement
	Structural engineer	is consulted to make the rainwater management systems structurally sound and consider them in the structural analysis
I	Project manager	needs to be informed to oversee the project
	General contractor	needs to be informed to anticipate the construction phase

Table 4.32: RASCI SS C4 – Rainwater Management

The *Invarianza idraulica e idrologica* of the Lombardy region (*regolamento regionale n. 7 del 2017*) requires cities in the region to limit the quantity of rainwater flowing into their sewage system. The requirements of this credit are therefore already integrated in the design of new Italian buildings.

Two options are available for this credit: zero and non-zero lot line projects. A zero-lot-line property is a building that comes to the very edge of the property line on at least one side. In each option, points are awarded when certain percentiles of rainfall retained are reached. As those thresholds have been adapted for zero and non-zero lot line to be of equivalent effect on the rainwater management, the risk of those two options can be assessed together.

Since rainwater management is already a requirement in the region and the difficulty lays in the amount of surface to cover [AP], a **relatively low** risk of not achieving this credit is assigned.

		LEED Credits	*pts*	Risk
SS	C4	**Rainwater Management**	**3**	**2**

Table 4.33: Risk SS C4 – Rainwater Management

4.4.3.6 *Credit 5 – Heat Island Reduction*

	Actor	Involvement
R	LEED AP D	is responsible for LEED design credits completion
A	Lead designer	is the design team leader that approves all aspects of the design
S	Architect	chooses the heat island reduction strategy to adopt and integrates it in the design of the building
	LEED AP GC	makes sure the credit is achieved at the construction phase
C	Products manufacturers	provide documentation or realise lab tests in case of absence of documents
	Landscape designer	is consulted in the case of vegetated areas (option 1)
	Structural engineer	is consulted to make the rainwater management systems structurally sound and consider them in the structure analysis
	Logistics team	is in charge of the heat island reduction materials procurement
I	Project manager	needs to be informed to oversee the project
	General contractor	needs to be informed to anticipate the construction phase
	Sustainability engineer	needs to be informed in order to have an up-to-date energy model at all times

Table 4.34: RASCI SS C5 – Heat Island Reduction

There are two options that can be cumulated to achieve this credit, and both depend on the site.

Option 1. Nonroof and Roof: in Italy, the decree of 26/06/2015 (in the *allegato* 1 part 2.3 paragraph 3) makes it mandatory to use high solar reflectance (SR) materials for roofs, with solar reflectance of at least 0.65 for flat roofs and 0.30 for pitched roofs. LEED does not use SR but SRI (solar reflectance index), the initial SRI thresholds are 82 for low-sloped roofs and 39 for steep-sloped roofs. As indicated in [35], most common materials for roofs satisfying the Italian decree also satisfy the LEED requirements, so the high-reflectance roof solution is often the solution chosen to get this credit [AP].

Moreover, the cost of the strategy followed depends on the chosen materials [AP]. For example, light-coloured TPO membranes are cheap and widely available. For some other materials, regulations compliant testing can be needed and result in extra costs. The following testing standards should be considered:

- For Solar Reflectance: ASTM C1549 – Standard Test Method for Determination of Solar Reflectance
- For Thermal Emittance: ASTM E408 – Standard Test Method for Total Normal Emittance of Surfaces Using Inspection-Meter Techniques
- For Solar Reflectance Index: ASTM E 1980 – Standard Practice for Calculating Solar Reflectance Index of Horizontal and Low-Sloped Opaque Surfaces

A **relatively low** risk is therefore assigned to this option of the credit.

Option 2. Parking under Cover: similarly to option 1, the lack of proper documentation can make the completion of the option difficult. However, as not all projects include parking spaces, a **medium** risk of not being achieved is assigned to the option.

Overall, the risk of the credit not being achieved is **relatively low**.

		LEED Credits		pts	Risk
SS	C5	**Heat Island Reduction**		**2**	**2**
		AND/OR	Option 1. Nonroof and Roof	2	2
			Option 2. Parking Under Cover	1	3

Table 4.35: Risk SS C5 – Heat Island Reduction

4.4.3.7 *Credit 6 – Light Pollution Reduction*

	Actor	Involvement
R	LEED AP D	is responsible for LEED design credits completion
A	Lead designer	is the design team leader that approves all aspects of the design
S	Architect	realises site plans
	Interior designer	chooses the luminaires
C	Landscape designer	consulted so that the luminaires are optimised for the landscape design
	Logistics team	is in charge of luminaires procurement
I	Project manager	needs to be informed to oversee the project
	General contractor	needs to be informed to anticipate the construction phase
	Electrical sub-contractor	is informed of the luminaire schedule

Table 4.36: RASCI SS C6 – Light Pollution Reduction

This credit method depends on the type of luminaires used (uplight and light trespass), and for each, two distinct options can be chosen to assess light pollution reduction:

- Option 1. BUG rating method
- Option 2. Calculation method

Both methods are of equivalent difficulty and guaranty the same number of points, hence the risk is assessed as a global risk.

In Italy, there are regional laws against light pollution (L.R. *5 ottobre 2015,* N.31 for Lombardy), so designers are conscious of this aspect of the project when designing the building. Moreover, the only obstacle can be the cost of the luminaires for both options.

This credit is therefore easily achieved and a **low** risk of not being achieved is assigned.

		LEED Credits	pts	Risk
SS	C6	**Light Pollution Reduction**	**1**	1

Table 4.37: Risk SS C6 – Light Pollution Reduction

4.4.4 Water efficiency

4.4.4.1 *Prerequisite 1 - Outdoor Water Use Reduction*

	Actor	Involvement
R	LEED AP D	is responsible for the LEED design credits completion
A	Lead designer	is the design team leader that approves all aspects of the design
S	LEED AP GC	makes sure the credit is achieved at the construction phase
	Landscape designer	performs the plant/water survey (option 1) or draws the site plans that shows the landscape zones (option 2)
I	Mechanical sub-contractor	needs to be informed to anticipate the irrigation implementation (option 2)
	Project manager	needs to be informed to oversee the project
	General contractor	needs to be informed to anticipate the construction phase

Table 4.38: RASCI WE P1 – Outdoor Water Use Reduction

Two distinct options exist for this prerequisite:

Option 1. No irrigation required: providing native plants is enough to get the option [AP] so it was assigned a **low** risk of going overbudget.

Option 2. Reduced irrigation: the project must reduce by at least 30% the landscape water needs, compared to a calculated baseline. It can be achieved through good plant species selection and an efficient irrigation system. Reaching that goal is easily: "careful plant selection and design can reduced the water from 20 to 50%" [36] so a **low** risk of going overbudget was assigned to this option.

Overall, the risk of the prerequisite not going overbudget is **low**.

		LEED Credits		*pts*	Risk
WE	P1	**Outdoor Water Use Reduction**		**-**	**1**
		OR	Option 1. No irrigation required	**-**	1
			Option 2. Reduced irrigation	**-**	1

Table 4.39: Risk WE P1 – Outdoor Water Use Reduction

4.4.4.2 *Prerequisite 2 - Indoor Water Use Reduction*

	Actor	Involvement
R	LEED AP D	is responsible for the LEED design credits completion
A	Lead designer	is the design team leader that approves all aspects of the design
S	LEED AP GC	makes sure the credit is achieved at the construction phase
	Mechanical engineer	supports with the indoor water needs calculations
	Interior designer	chooses of the appliances
C	Architect	optimises the building for reduction of indoor water consumption
	Logistics team	is in charge of the equipment procurement
I	Project manager	needs to be informed to oversee the project
	General contractor	needs to be informed to anticipate the construction phase

Table 4.40: RASCI WE P2 – Indoor Water Use Reduction

To reach this prerequisite, at least a 20% reduction of cumulated water consumption from the calculated baseline must be achieved. This reduction can be obtained through flow fixtures and fittings installation, as well as appliances and equipment compliant with water efficiency European Union *A+++* label. The fixtures are readily available and cheap, and equipment has a price range a bit higher than usual equipment, so a **relatively low** risk of going overbudget was assigned to this prerequisite.

		LEED Credits	*pts*	Risk
WE	P2	**Indoor Water Use Reduction**	**-**	**2**

Table 4.41: Risk WE P2 – Indoor Water Use Reduction

4.4.4.3 *Prerequisite 3 - Building-Level Water Metering*

	Actor	Involvement
R	LEED AP D	is responsible for the LEED design credits completion
A	Lead designer	is the design team leader that approves all aspects of the design
S	LEED AP GC	makes sure the credit is achieved at the construction phase
	Mechanical sub-contractor	installs the water metering systems
	Logistics team	is in charge of water meters procurement
	Client	commits to monitor and share water usage data during a period of 5-years
C	Mechanical engineer	is consulted to include the water metering system in the plumbing network
I	Project manager	needs to be informed to oversee the project
	General contractor	needs to be informed to anticipate the construction phase

Table 4.42: RASCI WE P3 – Building-Level Water Metering

Installing a water meter is very easy and cheap [AP], so the risk of not reaching the prerequisite is associated with the fact that the client will not share the data in the next 5 years. This has no effect on the cost of this prerequisite which was thus assigned a **low** risk of going overbudget.

		LEED Credits	*pts*	Risk
WE	P3	**Building-Level Water Metering**	**-**	**1**

Table 4.43: Risk WE P3 – Building-Level Water Metering

4.4.4.4 *Credit 1 - Outdoor Water Use Reduction*

	Actor	Involvement
R	LEED AP D	is responsible for the LEED design credits completion
A	Lead designer	is the design team leader that approves all aspects of the design
S	LEED AP GC	makes sure the credit is achieved at the construction phase
	Landscape designer	performs the plant/water survey (option 1) or draws the site plans that shows the landscape zones (option 2)
I	Mechanical sub-contractor	needs to be informed to anticipate the irrigation implementation (option 2)
	Project manager	needs to be informed to oversee the project
	General contractor	needs to be informed to anticipate the construction phase

Table 4.44: RASCI WE C1 – Outdoor Water Use Reduction

The options for this credit are the same as the ones from the *WE Prerequisite 1 – Outdoor Water Use Reduction.*

Option 1. No irrigation required: as for the prerequisite, this option is assigned a **low** risk of not reaching.

Option 2. Reduced Irrigation: this option rewards 1 point for a 50% reduction of irrigation compared to the calculated baseline, and 2 for a 100% reduction. As seen in the corresponding prerequisite, up to 50% of water reduction can be reached through smart plant selection. Further reduction may be achieved using combination of efficient systems, alternative water sources, and smart scheduling technologies. Such solutions can get expensive to implement [AP]. The following risk grades are therefore assigned:

- 50% reduction: **low** risk,
- 100% reduction: **relatively low** risk.

Overall, the risk of the credit not being achieved is **low**.

		LEED Credits			*pts*	Risk
WE	C1	**Outdoor Water Use Reduction**			**2**	**1**
		OR	Option 1. No irrigation required		2	1
			Option 2. Reduced irrigation		2	2
			OR	*50% reduction*	*1*	*1*
				100% reduction	*2*	*2*

Table 4.45: Risk WE C1 – Outdoor Water Use Reduction

4.4.4.5 *Credit 2 - Indoor Water Use Reduction*

	Actor	Involvement
R	LEED AP D	is responsible for the LEED design credits completion
A	Lead designer	is the design team leader that approves all aspects of the design
S	LEED AP GC	makes sure the credit is achieved at the construction phase
	Mechanical engineer	supports with the indoor water needs calculations
	Interior designer	chooses of the appliances
C	Architect	optimises the building for reduction of indoor water consumption
	Logistics team	is in charge of the equipment procurement
I	Project manager	needs to be informed to oversee the project
	General contractor	needs to be informed to anticipate the construction phase

Table 4.46: RASCI WE C2 - Indoor Water Use Reduction

This credit uses the corresponding prerequisite as a baseline (20% reduction of the cumulated water consumption). The higher the reduction, the more points are obtained. To translate the increasing difficulty of getting points, the following risks have been assigned, still considering that the fixtures and fittings are cheap:

- 1-2 points (up to 30% reduction): **low** risk. [37] shows that even in the previous version of LEED with the highest threshold being 30% reduction, almost all projects managed to reach this goal,
- 3-4 points (up to 40% reduction): **relatively low** risk,
- 5-6 point (up to 50% reduction): **medium** risk.

Overall, the risk of the credit not being achieved is **relatively low**.

			LEED Credits	*pts*	Risk
WE	C2		**Indoor Water Use Reduction**	**6**	**2**
		OR	Up to 30% reduction	1-2	1
			Up to 40% reduction	3-4	2
			Up to 50% reduction	5-6	3

Table 4.47: Risk WE C2 - Indoor Water Use Reduction

4.4.4.6 *Credit 3 - Cooling Tower and Process Water Use*

	Actor	Involvement
R	LEED AP D	is responsible for the LEED design credits completion
A	Lead designer	is the design team leader that approves all aspects of the design
S	LEED AP GC	makes sure the credit is achieved at the construction phase
	Mechanical engineer	performs the measurements of the maximum concentrations for parameters in condenser water, the relevant calculations (option 1 and 3) and the plan drawing (option 2 and 3)
	Mechanical sub-contractor	maintains and does the water treatment of the cooling tower (option 1)
	Logistics team	is in charge of the water subsystem procurement (option 3)
	National/local authorities	provide information and documentation on recycled alternative water percentage used in the district cooling systems (option 3)
I	Project manager	needs to be informed to oversee the project
	General contractor	needs to be informed to anticipate the construction phase

Table 4.48: RASCI WE C3 – Cooling Tower and Process Water Use

Three distinct options are possible for this credit. However, this credit is rarely pursued in Italy as it is very complex and often not worth it [AP]. The site either has a cooling tower system and the requirements are too stringent, or it does not have a cooling tower, but does not satisfy the criteria set to get the points. Therefore, the credit is assigned a **high** risk of not being achieved.

Overall, the risk of the credit not being achieved is **high**.

			LEED Credits	*pts*	Risk
WE	C3		**Cooling Tower and Process Water Use**	**2**	**5**
		OR	Option 1. Cooling Tower Water Use	1-2	5
			Option 2. No Cooling Tower	2	5
			Option 3. Process Water Use	1-2	5

Table 4.49: Risk WE C3 – Cooling Tower and Process Water Use

4.4.4.7 *Credit 4 - Water Metering*

	Actor	Involvement
R	LEED AP D	is responsible for the LEED design credits completion
A	Lead designer	is the design team leader that approves all aspects of the design
S	LEED AP GC	makes sure the credit is achieved at the construction phase
	Mechanical engineer	analyses the results and identifies opportunities for additional water savings
	Mechanical sub-contractor	installs the submeters
	Logistics team	is in charge of water submeter procurement
C	Landscape designer	is consulted to know if an irrigation system is needed
	Interior designer	is consulted to know the day-to-day equipment connected to the water network (dishwasher, clothes washer, pools, etc)
	Architect	sets the building layout and can adapt his design for metering
I	Project manager	needs to be informed to oversee the metering
	General contractor	needs to be informed to anticipate the construction phase

Table 4.50: RASCI WE C4 – Water Metering

For the completion of this credit, installation of permanent meters for two or more water subsystems from a list is needed. Submeters are cheap and easy to implement [AP], though problems can arise and make their installation difficult if the size of the building is significant and/or if the building layout does not consider their implementation. The credit is assigned a **medium** risk of not being achieved.

		LEED Credits	*pts*	Risk
WE	C4	**Water Metering**	**1**	**3**

Table 4.51: Risk WE C4 – Water Metering

4.4.5 *Energy and atmosphere*

4.4.5.1 *Prerequisite 1 - Fundamental Commissioning and Verification*

	Actor	Involvement
R	LEED AP GC	is responsible for LEED construction credits completion
A	General contractor	is the construction team leader that approves all aspects of the construction phase
S	Commissioning authority	does the commissioning process and produces the required documents
	Client	is responsible for the appointment of a commissioning authority, that can be a qualified employee of the client if the project is small, or an independent consultant, and the completion of the commissioning process scope
C	Project manager	are consulted for the development of the owner project's requirements
	Cost consultant	
	Lead designer	are consulted for the development of the basis of design and provide information on their respective expertise
	Architect	
	Sustainability engineer	
	Mechanical engineer	
	Electrical engineer	
	Envelope engineer	

Table 4.52: RASCI EA P1 – Fundamental Commissioning and Verification

This prerequisite represents a major cost of the LEED certification process [AP]. The commissioning authority has lots of tasks and must visit the site every month. As there is no unified method for the commissioning, there can be a lot of checks and tests carried out, that can result in extra costs. This prerequisite has thus been assigned a **high** risk of going overbudget.

		LEED Credits	*pts*	Risk
EA	P1	**Fundamental Commissioning and Verification**	**-**	**5**

Table 4.53: Risk EA P1 – Fundamental Commissioning and Verification

4.4.5.2 *Prerequisite 2 -Minimum Energy Performance*

	Actor	Involvement
R	LEED AP D	is responsible for the LEED design credits completion
A	Lead designer	is the design team leader that approves all aspects of the design
S	LEED AP GC	makes sure the credit is achieved at the construction phase
	Sustainability engineer	analyses the energy efficiency of the building and its systems through energy modelling
C	Architect	provide inputs for the energy simulation
	Interior designer	
	Envelope engineer	
	Electrical engineer	
	Mechanical engineer	
	Utilities companies	provide utility tariffs for the energy simulation
	Electrical sub-contractor	is consulted for the implementation of renewable energies on-site (PV-panels, etc)
I	Project manager	needs to be informed to oversee the project
	General contractor	needs to be informed to anticipate the construction phase

Table 4.54: RASCI EA P2 – Minimum Energy Performance

This prerequisite represents also a major cost of the LEED certification process [AP]. The energy modelling performed must be compliant with ASHRAE and requires specific software with such features. The licences are expensive and robust software experience is essential for the prerequisite's completion, and these costs must be addressed for they can be significant. It is possible to anticipate them and consider them in the initial budget, hence this prerequisite has been assigned a **medium** risk of going overbudget.

		LEED Credits	*pts*	Risk
EA	P2	**Minimum Energy Performance**	**-**	**3**

Table 4.55: Risk EA P2 – Minimum Energy Performance

4.4.5.3 *Prerequisite 3 - Building-Level Energy Metering*

	Actor	Involvement
R	LEED AP D	is responsible for LEED design credits completion
A	Lead designer	is the design team leader that approves all aspects of the design
S	Mechanical sub-contractor	installs energy metering systems for the mechanical systems
	Electrical sub-contractor	installs energy metering systems for the electrical systems
	Logistics team	is in charge of energy meters procurement
	Client	commits to monitor and share energy usage data during a period of 5 years
C	Mechanical engineer	are consulted to include the metering system in their designs
	Electrical engineer	
I	Project manager	needs to be informed to oversee the metering
	General contractor	needs to be informed to anticipate the metering implementation in the construction phase

Table 4.56: RASCI EA P3 – Building-Level Energy Metering

This prerequisite requires the implementation of total building energy metering. The meters installation is not complicated and cheap [AP], so the risk of not reaching the prerequisite is associated with the fact that the client will not share the data in the next 5 years. This has no effect on the cost of this prerequisite which was thus assigned a **low** risk of going overbudget.

		LEED Credits	*pts*	Risk
EA	P3	**Building-Level Energy Metering**	**-**	**1**

Table 4.57: Risk EA P3 – Building-Level Energy Metering

4.4.5.4 *Prerequisite 4 - Fundamental Refrigerant Management*

	Actor	Involvement
R	LEED AP D	is responsible for the LEED design credits completion
A	Lead designer	is the design team leader that approves all aspects of the design
S	LEED AP GC	makes sure the credit is achieved at the construction phase
	Client	commits to the sharing of energy use data with USGBC for a certain period
	Mechanical engineer	choose the HVAC&R equipment
	Mechanical sub-contractor	
I	Project manager	needs to be informed to oversee the project
	General contractor	needs to be informed to anticipate the construction phase

Table 4.58: RASCI EA P4 – Fundamental Refrigerant Management

This prerequisite requires not to use CFC based refrigerants in HVAC&R systems, which is mandatory in Italy since 1994 with the *Montreal Protocol*. This prerequisite has thus been assigned a **low** risk of going overbudget.

		LEED Credits	*pts*	Risk
EA	P4	**Fundamental Refrigerant Management**	**-**	**1**

Table 4.59: Risk EA P4 – Fundamental Refrigerant Management

4.4.5.5 *Credit 1 - Enhanced Commissioning*

	Actor	Involvement
R	LEED AP GC	is responsible for the LEED construction credits completion
A	General contractor	is the construction team leader that approves all aspects of the construction phase
S	Commissioning authority	carries out the commissioning plan
C	Project manager	provide the relevant information to the commissioning authority
	Mechanical engineer	
	Electrical engineer	
	Envelope engineer	
	Mechanical sub-contractor	
	Electrical sub-contractor	
I	Client	is responsible for the appointment of a commissioning authority and should be kept up to date for the systems manual and occupants training plan

Table 4.60: RASCI EA C1 – Enhanced commissioning

There are two cumulative options through which the credit can be achieved, of which the first one has two distinct paths.

Option 1. Enhanced Systems Commissioning:

- Path 1: Enhanced Commissioning: this path requires a complete commissioning with reviewed contractor submittals and verification of inclusion of systems manual and occupant training in construction documents, of systems manual updates and delivery, of training of occupants and operators, of seasonal testing results, development of schedule for revision of building operations before the arrival of tenants and commissioning plan. The listed tasks are numerous, time consuming, require diligence and involvement from the Commissioning Authority and can result in a high cost but the tasks are not inherently complicated. This path has been assigned a **relatively low** risk of not being achieved.
- Path 2: Enhanced and Monitoring-Based Commissioning: this path requires achieving path 1 and developing monitoring-based procedures to assess performance of energy and water consuming systems, to be included in the commissioning plan. This path has been assigned a **medium** risk of not being achieved.

Option 2. Building Enclosure Commissioning: this option requires the commissioning of the building envelope, for which expensive testing procedures, such as blower door test or thermographic test, must be conducted, in addition to demanding commissioning documentation. For small buildings, it is easier to have control over the envelope commissioning process, but for bigger ones, it can become quite complex [AP]. This option thus has been assigned a **medium** risk of not being achieved.

Overall, the risk of the credit not being achieved is **medium**.

		LEED Credits			*pts*	Risk
EA	C1	**Enhanced Commissioning**			**6**	**3**
		AND/OR	Option 1. Enhanced Systems Commissioning		4	3
			OR	*Path 1: Enhanced Commissioning*	*3*	*2*
				Path 2: Enhanced and Monitoring-Based Commissioning	*4*	*3*
			Option 2. Building Enclosure Commissioning		2	3

Table 4.61: Risk EA C1 – Enhanced commissioning

4.4.5.6 *Credit 2 - Optimize Energy Performance*

	Actor	Involvement
R	LEED AP D	is responsible for the LEED design credits completion
A	Lead designer	is the design team leader that approves all aspects of the design
S	LEED AP GC	makes sure the credit is achieved at the construction phase
	Sustainability engineer	analyses the energy efficiency of the building and its systems through energy modelling
C	Architect	provide inputs for the energy simulation
	Interior designer	
	Envelope engineer	
	Electrical engineer	
	Mechanical engineer	
	Utilities companies	provide utility tariffs for the energy simulation
	Electrical sub-contractor	is consulted for the implementation of renewable energies on-site (PV-panels, etc)
I	Project manager	needs to be informed to oversee the project
	General contractor	needs to be informed to anticipate the construction phase

Table 4.62: RASCI EA C2 – Optimize Energy Performance

This credit has the highest number of points reachable (18 points) and is one of the most complete credit, as it is the principal intent of the LEED certification to reduce building energy consumption. The credit requires the analysis of efficiency measures during the design process and the use of the results for design decision making, through an energy simulation of efficiency opportunities, past energy simulation analyses for similar buildings, or published data from analyses for similar buildings. There are 3 options through which points can be earned in this credit.

Option 1. Energy Performance Compliance (1-18 points): in this option, a Performance Cost Index (PCI) below the PCItarget is needed. The calculation of the PCI depends on the building use, and a percentage improvement using metrics of cost and greenhouse gas (GHG) emissions. For each energy source serving the building, the GHG emission factors must be identical for the Baseline and Proposed building models. LEED points are calculated based on the project percent improvement PCI below the PCItarget using metrics of cost and GHG emissions.

Option 2. Prescriptive Compliance: ASHRAE Advanced Energy Design Guide (1-6 points): for this option, the project must meet the Scope requirements of the applicable AEDGs and implement and document compliance with the applicable recommendations and standards in Chapter 4, Design Strategies and Recommendations by Climate Zone, for the appropriate ASHRAE 50% Advanced Energy Design Guide and climate zone (building envelope, interior and exterior lighting, plug loads, HVAC efficiency and control requirements).

Option 3. Systems Optimization (1-4 points): for this option, projects must use the ASHRAE 90.1-2016 Prescriptive compliance path in EA Prerequisite 1 - *Minimum Energy Performance* and must not have more than 2,000 square feet of data centre space, laboratory space, or manufacturing space and should demonstrate an improvement beyond ASHRAE standards for daylight controls, building envelope, interior and exterior lighting, equipment and appliances, HVAC and service water heating equipment efficiency.

The success of this credit depends a lot on the type of envelope considered and the person performing the simulation [AP]. Nonetheless, regarding energy performance and energy optimisation, European standards are more demanding than ASHRAE standards requirements.

Usually in Italy, at least 8 points are obtained in this credit [AP]. For this reason, the risk has been assessed considering 8 points as having a low risk of not being reached. Then it is used as a reference point and risk grades have been equally distributed as follows:

- 9-10 points: **low** risk
- 11-12 points: **relatively low** risk
- 13-14: **medium** risk
- 15-16: **relatively high** risk
- 17-18: **high** risk

Overall, the risk of the credit not being achieved is **medium**.

		LEED Credits		*pts*	Risk
EA	C2	**Optimize Energy Performance**		**18**	**3**
		OR	Up to 10 points	1-10	1
			Up to 12 points	11-12	2
			Up to 14 points	13-14	3
			Up to 16 points	15-16	4
			Up to 18 points	17-18	5

Table 4.63: Risk EA C2 – Optimize Energy Performance

4.4.5.7 *Credit 3 - Advanced Energy Metering*

	Actor	Involvement
R	LEED AP D	is responsible for the LEED design credits completion
A	Lead designer	is the design team leader that approves all aspects of the design
S	LEED AP GC	makes sure the credit is achieved at the construction phase
	Mechanical sub-contractor	installs energy metering systems for the mechanical systems
	Electrical sub-contractor	installs energy metering systems for the electrical systems
	Logistic teams	is in charge of energy meters procurement
C	Architect	consulted to adapt building layout to make meters accessible
I	Project manager	needs to be informed to oversee the metering
	Mechanical engineer	needs to be informed of energy metering results
	Electrical engineer	
	Client	needs to be informed to share metering data for 5 years with USGBC
	General contractor	needs to be informed to anticipate the construction phase

Table 4.64: RASCI EA C3 – Advanced Energy Metering

This credit requires the implementation of energy metering for all energy sources in the building, for each output. Depending on the building layout/function and organisation of the building systems, the metering can become expensive. For instance, in the case of office buildings, this credit usually is quite easy because outputs are limited. Considering these uncertainties, the credit has been assigned a **medium** risk of not being reached.

		LEED Credits	*pts*	Risk
EA	C3	**Advanced Energy Metering**	**1**	**3**

Table 4.65: Risk EA C3 – Advanced Energy Metering

4.4.5.8 *Credit 5 - Renewable Energy*

	Actor	Involvement
R	LEED AP D	is responsible for the LEED design credits completion
A	Lead designer	is the design team leader that approves all aspects of the design
S	LEED AP GC	makes sure the credit is achieved at the construction phase
	Mechanical sub-contractor	support the implementation of on-site renewable energies (tier 1)
	Electrical sub-contractor	
	Utilities companies	support for the use of off-site renewable energies (tier 2 to 5)
C	Cost consultant	consulted to choose the different tiers pursued
I	Mechanical engineer	informed on energy source to be used for mechanical systems
	Electrical engineer	informed on energy source to be used for electrical network
	Project manager	needs to be informed to oversee the project
	General contractor	needs to be informed to anticipate the construction phase

Table 4.66: RASCI EA C5 – Renewable Energy

This credit requires the use of on-site energy systems, procurement of renewable energy from off-site sources and/or the offset of the greenhouse gas emissions from all or a portion of the building's annual energy use.
Renewable energy procurement can be done through the following tiers:

- Tier 1. On-site renewable energy generation
- Tiers 2 and 3. Off-site renewable energy generation produced by a generation asset built within the last 5 years or contracted to be operational within one year of building occupancy
- Tiers 4 and 5. Off-site renewable energy that is Green-e certified or equivalent or produced by a generation asset meeting Green-e's certification or equivalent criteria for eligible renewable.

For all tiers, renewable energy must be contracted, owned or leased for a period of time between 1 and 15 years. Carbon offsets must be contracted for at least 15 years. The following tables provide the possible points that can be obtained for this credit.

Points	Tier 1	Tier 2		Tier 3		Tier 4		Tier 5	
		15-Year	1-Year	15-Year	1-Year	15-Year	1-Year	15-Year	1-Year
1	2%	20%	150%	30%	225%	40%	300%	50%	375%
2	5%	30%	225%	40%	300%	60%	450%	75%	562.5%
3	10%	40%	300%	50%	375%	80%	600%		
4	20%	50%	375%	60%	450%				
5	40%	60%	450%	70%	525%				
EP	60%	70%	525%	80%	600%	100%	750%	100%	750%

Figure 4.9: EA C5 table from USGBC for points for renewable energy procurement

Points	Green-e Climate certified or equivalent Carbon Offsets
1	100%
2	200%

Figure 4.10: EA C5 table from USGBC for points for carbon offsets procurement

In Italy, electricity generated from renewable energy sources is promoted through VAT and real estate tax deductions. All new or refurbished buildings must integrate renewable energy sources, with an additional 10% to the obligation level for public buildings. Grid operators are obliged to give priority dispatch to electricity from renewable sources (in Italy called the *Renewable Energy Ministerial Decree*). There exists an "ecobonus" for the installation of photovoltaic panels for the use of water heater *(2019 Budget Law, Article 1, Paragraph 67(a)*).

The credit is thus not an intrinsically complicated one, and as points increase with the percentages reached in renewable energy sources, the level of risk was attributed depending on the points as follows:

- 1-2 points: **low** risk,
- 3-4 points: **relatively low** risk,
- 5-EP points: **medium** risk.

Overall, the risk of the credit not being achieved is **relatively low**.

		LEED Credits		*pts*	Risk
EA	C5	**Renewable Energy**		**5**	**2**
		AND/OR	1 to 2 points	1-2	1
			3 to 4 points	3-4	2
			5 points or Exemplary Performance	5-EP	3

Table 4.67: Risk EA C5 – Renewable Energy

4.4.5.9 Credit 6 - Enhanced Refrigerant Management

	Actor	Involvement
R	LEED AP D	is responsible for the LEED design credits completion
A	Lead designer	is the design team leader that approves all aspects of the design
S	LEED AP GC	makes sure the credit is achieved at the construction phase
	Mechanical engineer	designs the mechanical systems, which impact refrigerant choice, and supports the documentation process
	Mechanical sub-contractor	installs the mechanical systems, and performs leak testing of commercial refrigeration systems
C	Logistics team	consulted for refrigerant procurement
I	Cost consultant	needs to be informed to check if the strategy adopted is within budget
	Project manager	needs to be informed to oversee refrigerant management
	General contractor	needs to be informed to anticipate the construction phase

Table 4.68: RASCI EA C6 – Enhanced Refrigerant Management

There are two distinct options to achieve this credit.

Option 1. No refrigerants or low-impact refrigerants: this option requires the use of no or low-impact refrigerant, which is mandatory in Italy since 1994 with the *Montreal Protocol*, hence this option has a low risk of not being reached.

Option 2. Calculation of refrigerant impact: the complexity of this option depends on the type of mechanical systems and building size (quantity of refrigerant), hence a **medium** risk of not being achieved has been assigned.

Overall, the risk of the credit not being achieved is **relatively low**.

		LEED Credits		*pts*	Risk
EA	C6	**Enhanced Refrigerant Management**		**1**	**2**
		OR	Option 1. No refrigerants or low-impact refrigerants	1	1
			Option 2. Calculation of refrigerant impact	1	3

Table 4.69: Risk EA C6 – Enhanced Refrigerant Management

4.4.6 Materials and resources

4.4.6.1 Prerequisite 1 - Storage and Collection of Recyclables

	Actor	Involvement
R	LEED AP D	is responsible for the LEED design credits completion
A	Lead designer	is the design team leader that approves all aspects of the design
S	LEED AP GC	makes sure the credit is achieved at the construction phase
	Architect	supports for the design and sizing of the recycling storage areas of the project and provides the corresponding floor plans
C	Interior designer	collaborate so that the storage area does not clash with the rest of the design
	Landscape designer	
I	Waste management companies	need to be informed to prepare the safe disposal of the recycled materials
	Project Manager	needs to be informed to oversee the project
	Client	needs to be informed of the storage and collection of recyclables
	General contractor	needs to be informed to anticipate the construction phase

Table 4.70: RASCI MR P1 – Storage and Collection of Recyclables

This prerequisite does not have any cost [AP] hence it has been assigned a **low** risk of going overbudget.

		LEED Credits	*pts*	Risk
MR	P1	**Storage and collection of Recyclables**	**-**	**1**

Table 4.71: Risk MR P1 – Storage and Collection of Recyclables

4.4.6.2 Prerequisite 2 - Construction and Demolition Waste Management Planning

	Actor	Involvement
R	LEED AP GC	is responsible for the completion of LEED construction prerequisites
A	General contractor	is the construction team leader that approves all aspects of the construction phase
S	Logistics team	is responsible for the making of construction and demolition waste management plan
C	Waste management companies	are consulted for disposal and diversion rates, and for the waste-to-energy
	Local recycling facilities	are consulted for the recycling of materials
I	Project Manager	needs to be informed to oversee the project

Table 4.72: RASCI MR P2 – Construction and Demolition Waste Management Planning

The general contractor saves money when achieving this prerequisite, hence it has been assigned a **low** risk of going overbudget.

		LEED Credits	*pts*	Risk
MR	P2	**Construction and Demolition Waste Management Planning**	**-**	**1**

Table 4.73: Risk MR P2 – Construction and Demolition Waste Management Planning

4.4.6.3 *Credit 1 - Building Life-Cycle Impact Reduction*

	Actor	Involvement
R	LEED AP GC	responsible for the completion of LEED construction credits
A	General contractor	is the construction team leader that approves all aspects of the construction phase
S	Sustainability engineer	provides a whole building life cycle assessment (in the case of option 4)
C	Logistics team	is consulted for the sourcing and procurement of re-used or salvaged materials from off site or on site (in the case of option 3)
	Structural engineer	consulted for the estimation of structurally hazardous portions of historic buildings and development of strategies to mitigate negative effects on the rest of the building (in the case of option 1)
I	National/Local authorities	needs to be informed of historic building demolition (in the case of option 1) and control criteria for abandoned/blighted buildings (in the case of option 2)
	Project manager	needs to be informed to oversee the project

Table 4.74: RASCI MR C1 – Building Life-Cycle Impact Reduction

There are four distinct options that can be considered for this credit's obtention.

The options 1. Historic Building Reuse and 2. Renovation of Abandoned or Blighted only require maintaining a certain percentage of the existing building and the corresponding documentation which is an easy process. Nonetheless, the completion of these options depends on the initial state of the building, and whether the parts that are considered to be kept are structurally sound. These options have thus been assigned a **medium** risk of not being achieved, to represent this uncertainty.

Option 3. Building and Material Reuse: this option provides 3 paths:

- Path 1: Maintain A Combination of Structural and Non-Structural Elements,
- Path 2: Maintain Existing Walls, Floors and Roofs,
- Path 3: Maintain Interior Non-structural Elements (that can be combined with path 2).

It has been considered a medium risk for reuse of 50% for all paths as it is strongly dependent on initial building and building components state. This was translated to:

- Path 1: 2 points - **relatively low** risk, 3 points - **medium** risk, 4 points - **relatively high** risk,
- Path 2: 1 point - **relatively low** risk, 2 points - **medium** risk, 3 points - **relatively high** risk,
- Path 3: 1 point - **relatively low** risk.

Option 4. Whole-Building Life-Cycle Assessment: this option has 4 paths with increasing number of points and increasing reduction percentage compared with a baseline building in at least 3 out of 6 impact categories:

- Path 1: Conduct a life cycle assessment of the project's structure and enclosure
- Path 2: path 1 + at least 5% reduction
- Path 3: path 1 + at least 10% reduction
- Path 4: path 3 + incorporate building reuse and/or salvage materials into the project's structure and enclosure for the proposed design + at least 20% reduction for global warming potential + at least 10% reduction in 2 additional impact categories

Based on the path chosen, this credit can end up costing a lot [AP]. The risk has been assessed based on the risk of the path 1, assessed as low risk of not being achieved as it consists in a life

cycle assessment, which is costly but not inherently risky. Each extra requirement adds one more level of risk to the path. Consequently:

- Path 1: **low** risk,
- Path 2: **relatively low** risk,
- Path 3: **medium** risk,
- Path 4: **relatively high** risk.

Overall, the risk of the credit not being achieved is **medium**.

		LEED Credits		*pts*	Risk
MR	C1	**Building Life-Cycle Impact Reduction**		**5**	**3**
		OR	Option 1. Historic building reuse	5	3
			Option 2. Renovation of abandoned or blighted building	5	3
			Option 3. Building and material reuse	1-4	3
			OR *Path 1: Maintain A Combination Of Structural And Non-Structural Elements*	*2*	*2*
				3	*3*
				4	*4*
			OR *Path 2: Maintain Existing Walls, Floors and Roofs*	*1*	*2*
				2	*3*
				3	*4*
			AND/OR *Path 3: Maintain Interior Non-structural Elements*	*1*	*1*
			Option 4. Whole building life-cycle assessment	1-4	3
			AND/OR *Path 1*	*1*	*1*
			Path 2	*1*	*2*
			Path 3	*1*	*3*
			Path 4	*1*	*4*

Table 4.75: Risk MR C1 – Building Life-Cycle Impact Reduction

4.4.6.4 *Credit 2/3/4 - Building Product Disclosure and Optimization - Environmental Product Declarations / Sourcing Raw Materials / Material Ingredients*

	Actor	Involvement
R	LEED AP GC	is responsible for the completion of LEED construction credits
A	General contractor	is the construction team leader that approves all aspects of the construction phase
S	Logistics team	supports for the sourcing and procurement of the specific products for credit compliance
C	Products manufacturers	are consulted to check availability and feasibility of product obtention
	Cost consultant	is consulted to check if the strategy adopted is within budget
I	Project manager	needs to be informed to oversee the construction phase

Table 4.76: RASCI MR C2/C3/C4 – Building Product Disclosure and Optimization

The credits 2, 3 and 4 of Materials and Resources tackle the disclosure and optimisation of building products and require the use of materials of which the environmental impact has been demonstrated by the manufacturer. These products are often expensive and can sometimes be challenging to find in Italy therefore LEED AP can have to resort to delivery from other countries to pursue these credits [AP]. In the case of Environmental Product Declarations, it is a bit easier, but it remains complicated.

The level of risk has been assessed considering that the main difficulty is finding the corresponding products as follows:

- Credit 2: **relatively high** risk for both 1 and 2 points,
- Credits 3 and 4: **high** risk for both 1 and 2 points.

Overall, the risk of the credits not being achieved is **relatively high** for C2 and **high** for C3 and C4.

		LEED Credits		*pts*	Risk
MR	C2	**Building Product Disclosure and Optimization - Environmental Product Declarations**		**2**	**4**
		AND/OR	Option 1. Environmental product declaration (EPD)	1	4
			Option 2. Multi-attribute optimization	1	4
	C3	**Building Product Disclosure and Optimization - Sourcing Raw Materials**		**2**	**5**
	C4	**Building Product Disclosure and Optimization - Material Ingredients**		**2**	**5**
		AND/OR	Option 1. Material Ingredient Reporting	1	5
			Option 2: Material Ingredient Optimization	1	5

Table 4.77: Risk MR C2/C3/C4 – Building Product Disclosure and Optimization

4.4.6.5 *Credit 5 - Construction and Demolition Waste Management*

	Actor	Involvement
R	LEED AP GC	is responsible for the completion of LEED construction prerequisites
A	General contractor	is the construction team leader that approves all aspects of the construction phase
S	Logistics team	is responsible for the making of construction and demolition waste management plan
C	Waste management companies	are consulted for disposal and diversion rates, and for the waste-to-energy
	Local recycling facilities	are consulted for the recycling of materials
I	Project Manager	needs to be informed to oversee the project

Table 4.78: RASCI MR C5 – Construction and Demolition Waste Management

This credit is the extension of MR *Prerequisite 2 - Construction and Demolition Waste Management Planning*, and can be achieved through two distinct options, the first having 4 distinct paths.

Option 1. Diversion: it requires the diversion of certain percentages of construction and demolition materials.

- The first two paths demand a 50% reduction that can be performed either diverting through at least 2 materials streams or through an offsite certified sorting facility and are awarded 1 point when completed.
- The remaining paths require a 75% reduction through either 3 materials streams or through an offsite certified sorting facility and one more materials stream and are awarded 2 points when completed.

Usually in Italy, about 90% of diversion is reached [AP], hence option 1 has been assessed an overall **low** risk of not being reached.

Option 2. Reduction of Total Waste Material: it also requires the salvage or recycling of at least 75% in addition to the reduction of waste generation from new construction activities to be less than 36kg/m^2. Considering that the average composition of waste generated on site is mostly concrete and ceramic materials [38], which represent for new residential and new non-residential construction between 17.8 and 32.9 kg/m^2 and between 18.3 and 40.1 kg/m^2, respectively for a

reinforced concrete structure. Considering this, that additional requirement adds a little more complexity and this option has been assigned a **relatively low** level of risk.

Overall, the risk of the credit not being achieved is **relatively low**.

		LEED Credits			*pts*	Risk
MR	C5	**Construction and Demolition Waste Management**			**2**	**2**
		AND/OR	Option 1. Diversion		2	1
			OR	*Path 1. Divert 50% and Two Material Streams*	*1*	*1*
				Path 2. Divert 50% using Certified Commingled Recycling Facility	*1*	*1*
				Path 3. Divert 75% and Three Material Streams	*2*	*1*
				Path 4. Divert 75% using Certified Commingled Recycling Facility and One More Material Stream	*2*	*1*
			Option 2. Reduction of total waste material		2	2

Table 4.79: Risk MR C5 – Construction and Demolition Waste Management

4.4.7 Indoor environmental quality

4.4.7.1 *Prerequisite 1 – Minimum indoor air quality performance*

	Actor	Involvement
R	LEED AP D	is responsible for the LEED design credits completion
A	Lead designer	is the design team leader that approves all aspects of the design
S	LEED AP GC	makes sure the credit is achieved at the construction phase
	Mechanical engineer	supports with the IAQ calculations and the monitoring
	Mechanical sub-contractor	assists the mechanical engineer
	Sustainability engineer	realises the ventilation modelling
	Logistics team	is in charge of the monitoring devices procurement
C	Acoustical engineer	is consulted to reduce the HVAC system's impact on acoustic comfort of the occupants (related to the credit 9 of Indoor Environmental Quality)
I	Project manager	needs to be informed to oversee the project
	General contractor	needs to be informed to anticipate the construction phase

Table 4.80: RASCI IEQ P1 – Minimum Indoor Air Quality Performance

Since the ASHRAE requirements and their ISO equivalent are quite stringent [AP], this prerequisite is already quite demanding in terms of Indoor Air Quality performance. Two complementary paths exist for this prerequisite:

- Path 1. Mechanically ventilated spaces: the criteria to meet this path are difficult and, in addition, a monitoring of the mechanical ventilation system is mandatory so a **relatively high** risk of going overbudget is given to this path
- Path 2. Naturally ventilated spaces: similarly to path 1, criteria to meet path 2 are difficult and a monitoring is required (additional requirements exist for historical buildings) so a **relatively high** risk of going overbudget is also given to this path.

Overall, the prerequisite has a **relatively high** risk of going overbudget.

		LEED Credits		*pts*	Risk
IEQ	P1	**Minimum Indoor Air Quality Performance**		**-**	**4**
		AND/OR	Path 1. Mechanically Ventilated Spaces	-	4
			Path 2. Naturally Ventilated Spaces	-	4

Table 4.81: Risk IEQ P1 – Minimum Indoor Air Quality Performance

4.4.7.2 *Prerequisite 2 - Environmental Tobacco Smoke Control*

	Actor	Involvement
R	LEED AP D	is responsible for the LEED design credits completion
A	Lead designer	is the design team leader that approves all aspects of the design
S	LEED AP GC	makes sure the credit is achieved at the construction phase
	Client	defines the smoking policy
	Architect	maps the designated smoking and non-smoking areas
C	Project manager	helps the client develop an initial strategic brief
	Mechanical engineer	is qualified to execute the differential air pressure test reports (for residential units)
	Mechanical sub-contractor	assist the mechanical engineer in the differential air pressure test (for residential units)
	Interior designer	chooses the door schedule (for residential units)
I	Local communities	are informed of the smoking policy
	General contractor	needs to be informed to anticipate the construction phase

Table 4.82: RASCI IEQ P1 – Environmental Tobacco Smoke Control

The requirements of the prerequisite are already mandatory in Italy (*Legge 16 gennaio 2003, n.3*) therefore a **low** risk of going overbudget is assigned to the prerequisite.

		LEED Credits	*pts*	Risk
IEQ	P2	**Environmental Tobacco Smoke Control**	**-**	**1**

Table 4.83: Risk IEQ P1 – Environmental Tobacco Smoke Control

4.4.7.3 *Credit 1 - Enhanced Indoor Air Quality Strategies*

	Actor	Involvement
R	LEED AP D	is responsible for the LEED design credits completion
A	Lead designer	is the design team leader that approves all aspects of the design
S	LEED AP GC	makes sure the credit is achieved at the construction phase
	Mechanical engineer	supports with the IAQ calculations and the monitoring
	Mechanical sub-contractor	assists the mechanical engineer
	Sustainability engineer	realises the ventilation modelling
	Logistics team	is in charge of the monitoring devices procurement
C	Acoustical engineer	is consulted to reduce the HVAC system's impact on acoustic comfort of the occupants (related to the credit 9 of Indoor Environmental Quality)
I	Project manager	needs to be informed to oversee the project
	General contractor	needs to be informed to anticipate the construction phase

Table 4.84: RASCI IEQ C1 – Enhanced Indoor Air Quality Strategies

Additional requirements are demanded for the obtention of this credit compared to the corresponding prerequisite (IEQ P1 - *Minimum Indoor Air Quality Performance*) depending on the strategy pursued (mechanical, natural or mixed ventilation). The complexity of the process is therefore similar, if not superior, to the prerequisite. Two cumulative options are available to get the 2 points:

- Option 1. Enhanced IAQ Strategies: floor plans, documentation and schedules are required. A **relatively high** risk of not being achieved is assigned to this option.
- Option 2. Additional Enhanced IAQ Strategies: more requirements are necessary and require modelling of the IAQ output. A **high** risk of not being achieved is assigned to this option.

Overall, the risk of the credit not being achieved is **high**.

		LEED Credits		*pts*	Risk
IEQ	C1	**Enhanced Indoor Air Quality Strategies**		**2**	**5**
		AND/OR	Option 1. Enhanced IAQ Strategies	1	4
			Option 2. Additional Enhanced IAQ Strategies	1	5

Table 4.85: Risk IEQ C1 – Enhanced Indoor Air Quality Strategies

4.4.7.4 *Credit 2 - Low-Emitting Materials*

	Actor	Involvement
R	LEED AP GC	is responsible for LEED construction credits completion
A	General contractor	is the construction team leader that approves all aspects of the construction
S	Logistics team	makes sure that the chosen materials are available, respect the requirements and the corresponding documentation
C	Products manufacturers	provide documentation or realise lab tests in case of absence of documents
	Interior designer	is consulted for architectural finishes and furniture low-emitting materials
	Acoustical engineer	is consulted for acoustic board low-emitting materials
	Envelope engineer	is consulted for thermal board low-emitting materials
	Architect	is consulted for the rest of the low-emitting materials
I	Project manager	needs to be informed to oversee the project

Table 4.86: RASCI IEQ C2 – Low-Emitting Materials

At least 2 type of low-emitting materials must be included in the building to have 1 point and by adding more types of low-emitting materials, the number of point increases (up to a maximum of 3 points).

Each material of the building interior is monitored by the general contractor, but some materials are more easily checked than others [AP]. For example, even common construction materials (such as sealant, wood products, fire protection, etc.) do not have the information required to validate the credit. Laboratory tests are therefore necessary to prove the low-emitting nature of the material selected and can be expensive.

A **relatively low** risk of not being achieved is assigned to this credit

		LEED Credits	*pts*	Risk
IEQ	C2	**Low-Emitting Materials**	**3**	**2**

Table 4.87: Risk IEQ C2 – Low-Emitting Materials

4.4.7.5 *Credit 3 - Construction Indoor Air Quality Management Plan*

	Actor	Involvement
R	LEED AP GC	is responsible for LEED construction credits completion
A	General contractor	needs to approve the strategy and plan the construction accordingly
S	Health and Safety adviser	comes up with a strategy to minimize the IAQ problems associated with the construction and is responsible for the well-being of the construction workers
	Logistics team	provides the equipment to guarantee the IAQ
C	Mechanical engineer	helps to put in place the IAQ plan during construction
I	Project manager	needs to be informed to oversee the project
	Sub-contractors	are informed of the IAQ measures to protect them and their workers
	Lead designer	needs to be informed and to inform the design team of the IAQ measures when the go on site

Table 4.88: RASCI IEQ C3 – Construction Indoor Air Quality Management Plan

To fulfil this credit, all ducts must be sealed and monitored weekly [AP]. This credit creates extra costs for the general contractor but is not inherently difficult to realise so a **relatively low** risk of not being achieved is assigned to this credit.

		LEED Credits	*pts*	Risk
IEQ	C3	**Construction Indoor Air Quality Management Plan**	**1**	**2**

Table 4.89: Risk IEQ C3 – Construction Indoor Air Quality Management Plan

4.4.7.6 *Credit 4 - Indoor Air Quality Assessment*

	Actor	Involvement
R	LEED AP GC	is responsible for LEED construction credits completion
A	General contractor	oversees the post-construction quality assessments
S	Mechanical engineer	is responsible for monitoring the IAQ after construction ends
	Mechanical sub-contractor	assists the mechanical engineer in the IAQ assessment
I	Project manager	needs to be informed to oversee the post-construction phase

Table 4.90: RASCI IEQ C4 – Indoor Air Quality Assessment

After construction, 2 options exist to assess the indoor air quality:

- Option 1. Flush-out: it depends on the amount of air volume the system can provide, and it is the option usually done, a **medium** risk is assigned.
- Option 2. Air testing: IAQ testing can be performed but in Italy, those tests are very expensive [AP] so a relatively high risk of not being achieved is assigned to this option.

Overall, the risk of the credit not being achieved is **relatively high**.

		LEED Credits		*pts*	Risk
IEQ	C4	**Indoor Air Quality Assessment**		**2**	**4**
		OR	Option 1. Flush-out	1	3
			Option 2. Air testing	1-2	4

Table 4.91: Risk IEQ C4 – Indoor Air Quality Assessment

4.4.7.7 *Credit 5 - Thermal Comfort*

	Actor	Involvement
R	LEED AP D	is responsible for LEED design credits completion
A	Lead designer	is the design team leader that approves all aspects of the design
S	Mechanical engineer	performs the thermal calculations and supporting documentation
C	Architect	optimises the building layout for thermal comfort
	Envelope engineer	optimises the envelope to the thermal requirements
I	Project manager	needs to be informed to oversee the project

Table 4.92: RASCI IEQ C5 – Thermal comfort

To complete this credit, thermal comfort needs to be modelled using UNI EN ISO 7730:2006 (*Ergonomia degli ambienti termici - Determinazione analitica e interpretazione del benessere termico mediante il calcolo degli indici PMV e PPD e dei criteri di benessere termico locale*) when the building is in Italy. The licences are expensive and robust software experience is essential for the credit's completion, and these costs must be addressed for they can be significant. It is possible to anticipate them and consider them in the initial budget, hence this credit has been assigned a **relatively low** risk of being achieved.

		LEED Credits	*pts*	Risk
IEQ	C5	**Thermal Comfort**	**1**	**2**

Table 4.93: Risk IEQ C5 – Thermal comfort

4.4.7.8 *Credit 6 - Interior Lighting*

	Actor	Involvement
R	LEED AP D	is responsible for LEED design credits completion
A	Lead designer	is the design team leader that approves all aspects of the design
S	Interior designer	chooses the appropriate lighting control and quality while keeping in mind the occupants' comfort
	Logistics team	makes sure that the chosen equipments are available and respect the requirements
	Products manufacturers	provide the documentation
I	Electrical engineer	is informed for the design the electrical lighting network and control units
	Electrical sub-contractor	is informed to anticipate the lighting installation
	Project manager	needs to be informed to oversee the project

Table 4.94: RASCI IEQ C6 – Interior Lighting

To complete this credit, the lighting must be chosen in a strategic way for option 1. (Lighting control) and for option 2. (Lighting quality) but since lightings are low cost and readily available, a **low** risk of not being achieved is assigned.

		LEED Credits	*pts*	Risk
IEQ	C6	**Interior Lighting**	**2**	**1**

Table 4.95: Risk IEQ C6 – Interior Lighting

4.4.7.9 *Credit 7 – Daylight*

	Actor	Involvement
R	LEED AP D	is responsible for LEED design credits completion
A	Lead designer	is the design team leader that approves all aspects of the design
S	Envelope engineer	performs the daylight calculations, simulations and measurements
C	Architect	optimises the building layout for daylight comfort
	Interior designer	optimises the interior design for daylight comfort
I	Project manager	needs to be informed to oversee the project

Table 4.96: RASCI IEQ C7 – Daylight

To complete this credit, a glare control strategy resorting to shading systems must be put in place and in addition, three distinct options are possible:

Option 1. Simulation - Spatial Daylight Autonomy and Annual Sunlight Exposure: annual computer simulations for $sDA_{300/50\%}$ and $ASE_{1000,250}$ (as defined in IES LM-83-12) are performed for each regularly occupied space. $ASE_{1000,250}$ must be higher than 10%. The higher is the minimum average $sDA_{300/50\%}$ for the regularly occupied floor area, the more points are awarded (1 point for 40%, 2 points for 55% and 3 points for 75%).

Option 2. Simulation - Illuminance Calculations: computer simulations are performed for illuminance at 9 a.m. and 3 p.m. on a clear-sky day at the equinox for each regularly occupied space. Illuminance must be between 300 lux and 3000 lux at both 9 a.m. and 3 p.m. Points are awarded according to the percentage of regularly occupied floor area reaching this goal (1 point for 55%, 2 points for 75% and 3 points for 90%).

For the two first options, Italy having a high solar exposure, the building is most likely to meet those criteria easily, but the daylight analysis results will mostly depend on the architectural building layout. For both options, a low risk is assigned to the 1-point threshold, **relatively low** risk for the 2 points threshold and a **medium** risk for the 3 points threshold.

Option 3. Measurement: unlike option 2, illuminance is measured in the real building instead of performing a daylight simulation. The same thresholds as option 2 are considered. As a result, the same distribution of risks as the previous option is given to option 3.

Overall, the risk of the credit not being achieved is **relatively low**.

		LEED Credits		*pts*	Risk
IEQ	C7	**Daylight**		**3**	**2**
		OR	Option 1. Simulation: Spatial Daylight Autonomy and Annual Sunlight Exposure	1	1
				2	2
				3	3
			Option 2. Simulation: Illuminance Calculations	1	1
				2	2
				3	3
			Option 3. Measurement	1	1
				2	2
				3	3

Table 4.97: Risk IEQ C7 – Daylight

4.4.7.10 *Credit 8 - Quality Views*

	Actor	Involvement
R	LEED AP D	is responsible for LEED design credits completion
A	Lead designer	is the construction team leader that approves all aspects of the construction
S	Envelope engineer	performs the quality views calculations
	Architect	optimises the building for quality views and draws the plans, sections and elevations
	Interior designer	optimises the interior design for quality views
	Landscape designer	adapts their design to provide a quality view to the occupants
I	Project manager	needs to be informed to oversee the project

Table 4.98: RASCI IEQ C8 – Quality Views

The quality of the view depends on the site and has no cost associated to it. Because of the impossibility to predict the exact location and field of view of the site, a **medium** risk of not being achieved is assigned.

		LEED Credits	*pts*	Risk
IEQ	C8	**Quality Views**	**1**	**3**

Table 4.99: Risk IEQ C8 – Quality Views

4.4.7.11 *Credit 9 - Acoustic Performance*

	Actor	Involvement
R	LEED AP D	is responsible for LEED design credits completion
A	Lead designer	is the design team leader that approves all aspects of the design
S	Acoustical engineer	performs the acoustical calculations, measurement and documentation
C	Architect	is consulted for information on the building layout
	Interior designer	is consulted for information on interior design materials
	Envelope engineer	is consulted for information on the envelope
	Mechanical engineer	is consulted for information on the HVAC systems (option 1)
I	Project manager	needs to be informed to oversee the project

Table 4.100: RASCI IEQ C9 – Acoustic Performance

To complete this credit, the acoustic performances need to be modelled, calculated and measured for the three following options:

- For option 1. HVAC background noise,
- For option 2. Sound transmission,
- For option 3. Reverberation time requirements.

The risk of not being achieved resides in the price of the licence of the software to model the acoustic performance, the competence of the modeller/acoustical engineer and if the actual measurements on-site meet the requirements set. A **medium** risk is assigned.

		LEED Credits	*pts*	Risk
IEQ	C9	**Acoustic Performance**	**1**	**3**

Table 4.101: Risk IEQ C9 – Acoustic Performance

4.4.8 Innovation

4.4.8.1 Credit 1 – Innovation

	Actor	Involvement
R	LEED AP D	is responsible for LEED design credits completion
A	Lead designer	is the design team leader that approves all aspects of the design
S	Sustainability engineer	offers possible strategies at the beginning of the project to the design team and then analyses their feasibility
C	Rest of the design team	are consulted to come up with ideas and feasibility expertise that are not covered by the LEED certification
	Project manager	
	General contractor	
	Cost consultant	needs to be consulted to check if the strategies adopted are within budget
I	Client	needs to be informed to check if the strategies adopted are within budget

Table 4.102: RASCI IN C1 – Innovation

To achieve all five innovation points, a project team must achieve at least one pilot credit, at least one innovation credit and no more than two exemplary performance credits.

Option 1. Innovation: an innovative strategy not already present in LEED green building rating system must be implemented. The accomplishment of this option depends on the project and the creativity of the project team so a **medium** risk of not being achieved is assigned to the credit.

Option 2. Pilot: green education is usually chosen [AP] because it requires only to put information on the green aspects of the building design and give tenants guidelines to reduce their consumption of water and/or energy. The option was assigned a **low** risk of not being achieved.

Option 3. Additional strategies: in addition to meeting the requirements of the 2 options above, exemplary performances must be achieved by the project. This option depends on the selection and achievement of exemplary performances of other credits so a **medium** risk of not being achieved is assigned to the credit.

Overall, the risk of the credit not being achieved is **relatively low**

		LEED Credits		*pts*	Risk
IN	C1	**Innovation**		**5**	**2**
		AND/OR	Option 1. Innovation	4	3
			Option 2. Pilot	4	1
			Option 3. Additional Strategies	2	3

Table 4.103: Risk IN C1 – Innovation

4.4.8.2 Credit 2 – LEED Accredited Professional

	Actor	Involvement
R	Client and general contractor	appoint their respective LEED AP
A		
I	Project manager	needs to be informed of the new team members

Table 4.104: RASCI IN C2 – LEED Accredited Professional

Hiring a LEED AP does not represent a risk to the project, so a **low** risk of not being achieved is assigned to this credit

		LEED Credits	*pts*	Risk
IN	C2	**LEED Accredited Professional**	**1**	**1**

Table 4.105: Risk IN C2 – LEED Accredited Professional

4.4.9 Regional Priority

4.4.9.1 *Credit 1 – Regional Priority*

The credit *Regional priority* is unique, in the sense that it is earned by the completion of a list of other LEED credits. Depending on the region of the world where the project is located, there is a list of credits that are considered a priority, and the *Regional priority* credit encourages their pursuit.

Considering Italy, the following list for Milan is considered:

- *Location and Transportation, Credit 2: Sensitive Land Protection*, 1 point
- *Location and Transportation, Credit 7: Reduced Parking Footprint*, 1 point
- *Location and Transportation, Credit 8: Electric Vehicles*, 1 point
- *Sustainable Sites, Credit 6: Light Pollution Reduction*, 1 point
- *Water Efficiency, Credit 1: Outdoor Water Use Reduction*, at least 1 point
- *Indoor Environmental Quality, Credit 7: Daylight*, at least 1 point

Whereas in Rome, the following credits must be earned to get the *Regional Priority* credit:

- *Location and Transportation, Credit 2: Sensitive land protection*, 1point
- *Location and Transportation, Credit 7:* Reduced parking footprint, 1 point
- *Location and Transportation, Credit 8: Electric vehicles*, 1 point
- *Sustainable Sites, Credit 2: Protect or restore habitat*, 2 points
- *Sustainable Sites, Credit 4: Rainwater management*, at least 2 points
- *Indoor Environmental Quality, Credit 9:* Acoustic performance, 1 point

Considering this specificity of the credit, the following table was obtained:

	Actor	**Involvement**
R	LEED AP D/GC	are responsible for LEED credit completion
A	Client	chooses the credits to be pursued
I	Project manager	is informed of the credit selection

Table 4.106: RASCI RP C1 – Regional Priority

For the risk a weighted average of the 6 credits of the regional priorities of Milano is calculated. Overall, the risk of the credit not being achieved is **relatively high**.

		LEED Credits		*pts*	Risk
RP	C1	**Regional priority**		**4**	**4**
		AND	LT C2 - Sensitive Land Protection	-	3
			LT C7 - Reduced Parking Footprint	-	1
			LT C8 - Electric Vehicles	-	4
			SS C6 - Light Pollution Reduction	-	1
			WE C1 - Outdoor Water Use Reduction	-	1
			IEQ C7 - Daylight	-	2

Table 4.107: Risk RP C1 – Regional Priority

4.4.10 Summary matrix

The following table summarises the attribution of the letters explained the previous sub-chapters.

					Client Team						Design Team										Construction team					Stakeholders								
		LEED Credits	*# points*	*Risk*	Client	Project manager	Cost consultant	Health and safety advisor	Commissioning authority	LEED AP D	Lead designer	Architect	Interior designer	Landscape designer	Structural engineer	Mechanical engineer	Electrical engineer	Envelope engineer	Acoustical engineer	Sustainability engineer	General contractor	LEED AP GC	Mechanical subcontractor	Electrical subcontractor	Logistics team	National/Local authorities	Environmental Bodies	Local communities	Utilities Companies	Waste management companies	Local recycling facilities	Products manufacturers	Environmental protection agency
IP	C1	Integrative Process	1	1	A	S	S	S	S	R	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S						
LT	C1	LEED for Neighborhood Development Location	16	5	C	I				R	A	S									I												
	C2	Sensitive Land Protection	1	3	I*	I				R	A	S		I							I					C	C						
	C3	High-Priority Site	2	3	C	I	C			R	A	S									I					C	C	C					S
	C4	Surrounding Density and Diverse Users	5	3	I*	I				R	A	S									I					C							
	C5	Access to Quality Transit	5	3	I*	I				R	A	S														C							
	C6	Bicycle Facilities	1	3	I*	I				R	A	S				I					I					C							
	C7	Reduced Parking Footprint	1	1	I*	I				R	A	S									I					C		I					
	C8	Electric Vehicles	1	4	I*	I				R	A	S					C				I			C				I					
SS	P1	Construction Activity Pollution Prevention	-	1	I*	I									C						A/S	R											
	C1	Site Assessment	1	2	I*	I				R	A	I		S	S						I					C	C						
	C2	Protect or Restore Habitat	2	3	C	I	S			R	A			S	C						I						C						
	C3	Open Space	1	3	I*	I				R	A	C		S							I					C		I					
	C4	Rainwater Management	3	2	I*	I				R	A	S		S	C	S					I		S		C								
	C5	Heat Island Reduction	2	2	I*	I				R	A	S		C	C						I	S			C							C	
	C6	Light Pollution Reduction	1	1	I*	I				R	A	S	S	C							I			I	C								
WE	P1	Outdoor Water Use Reduction	-	1	I*	I				R	A			S							I	S	I										
	P2	Indoor Water Use Reduction	-	2	I*	I				R	A	C	S			S					I	S			C								
	P3	Building-Level Water Metering	-	1	S	I				R	A					C					I	S	S		S								
	C1	Outdoor Water Use Reduction	2	1	I*	I				R	A			S							I	S	I										
	C2	Indoor Water Use Reduction	6	2	I*	I				R	A	C	S			S					I	S			C								
	C3	Cooling Tower and Process Water Use	2	5	I*	I				R	A	C	C	C		S					I	S	S		S								
	C4	Water Metering	1	3	I*	I				R	A	C	C	C		S					I	S	S		S								
EA	P1	Fundamental Commissioning and Verification	-	5	S	C	C		S		C	C				C	C	C		C	A	R											
	P2	Minimum Energy Performance	-	3	I*	I				R	A	C	C			C	C	C		S	I	S		C					C				
	P3	Building-Level Energy Metering	-	1	S	I				R	A					C	C				I		S	S	S								
	P4	Fundamental Refrigerant Management	-	1	S	I				R	A					S					I	S	S										
	C1	Enhanced Commissioning	18	3	I	C			S							C	C	C			A	R	C	C									
	C2	Optimize Energy Performance	6	3	I*	I				R	A	C	C			C	C	C		S	I	S		C					C				
	C3	Advanced Energy Metering	1	3	I	I				R	A	C				I	I				I	S	S	S	S								
	C4	Grid Harmonization	2	-	*Not applicable in Europe*																												
	C5	Renewable Energy	5	2	I*	I				R	A					I	I				I	S	S	S					S				
	C6	Enhanced Refrigerant Management	1	2	I*	I				R	A					S					I	S	S		C								
MR	P1	Storage and collection of Recyclables	-	1	I	I				R	A	S	C	C							I	S								I			
	P2	Construction and Demolition Waste Management Planning	-	1	I*	I															A	R			S					C	C		
	C1	Building Life-Cycle Impact Reduction	5	3	I*	I									C					S	A	R			C	I							
	C2	Building Product Disclosure and Optimization - Environmen	2	4	I*	I	C														A	R			S							C	
	C3	Building Product Disclosure and Optimization - Sourcing Rav	2	5	I*	I	C														A	R			S							C	
	C4	Building Product Disclosure and Optimization - Material Ingr	2	5	I*	I	C														A	R			S							C	
	C5	Construction and Demolition Waste Management	2	2	I*	I															A	R			S					C	C		
IEQ	P1	Minimum Indoor Air Quality Performance	-	4	I*	I				R	A					S			C	S	I	S	S		S								
	P2	Environmental Tobacco Smoke Control	-	1	S	C				R	A	S	C			C					I	S	C					I					
	C1	Enhanced Indoor Air Quality Strategies	2	5	I*	I				R	A					S			C	S	I	S	S		S								
	C2	Low-Emitting Materials	3	2	I*	I	C					C	C					C	C		A	R			S							C	
	C3	Construction Indoor Air Quality Management Plan	1	2	I*	I		S			I					C					A	R	I	I	S								
	C4	Indoor Air Quality Assessment	2	4	I*	I										S					A	R	S										
	C5	Thermal Comfort	1	2	I*	I				R	A	C				S		C															
	C6	Interior Lighting	2	1	I*	I				R	A		S				I							I	S							S	
	C7	Daylight	3	2	I*	I				R	A	C	C					S															
	C8	Quality Views	1	3	I*	I				R	A	S	S	S				S															
	C9	Acoustic Performance	1	3	I*	I				R	A	C	C			C		C	S														
IN	C1	Innovation	5	2	I	C	C			R	A	C	C	C	C	C	C	C	C	S	C												
	C2	LEED Accredited Professional	1	1	R/A	I															R/A												
RP	C1	Regional priority	4	4	A	I				R												R											

Table 4.108: Total RASCI matrix

5 Discussion

5.1 Distribution of responsibilities

Statistical analyses on the distribution of responsibilities in the RASCI matrix have been performed, and the results are presented in the following.

First, the number of times each actor is involved in a credit or prerequisite obtention, regardless of the weight of their implication (R, A S, C or I), has been plotted as a bar chart.

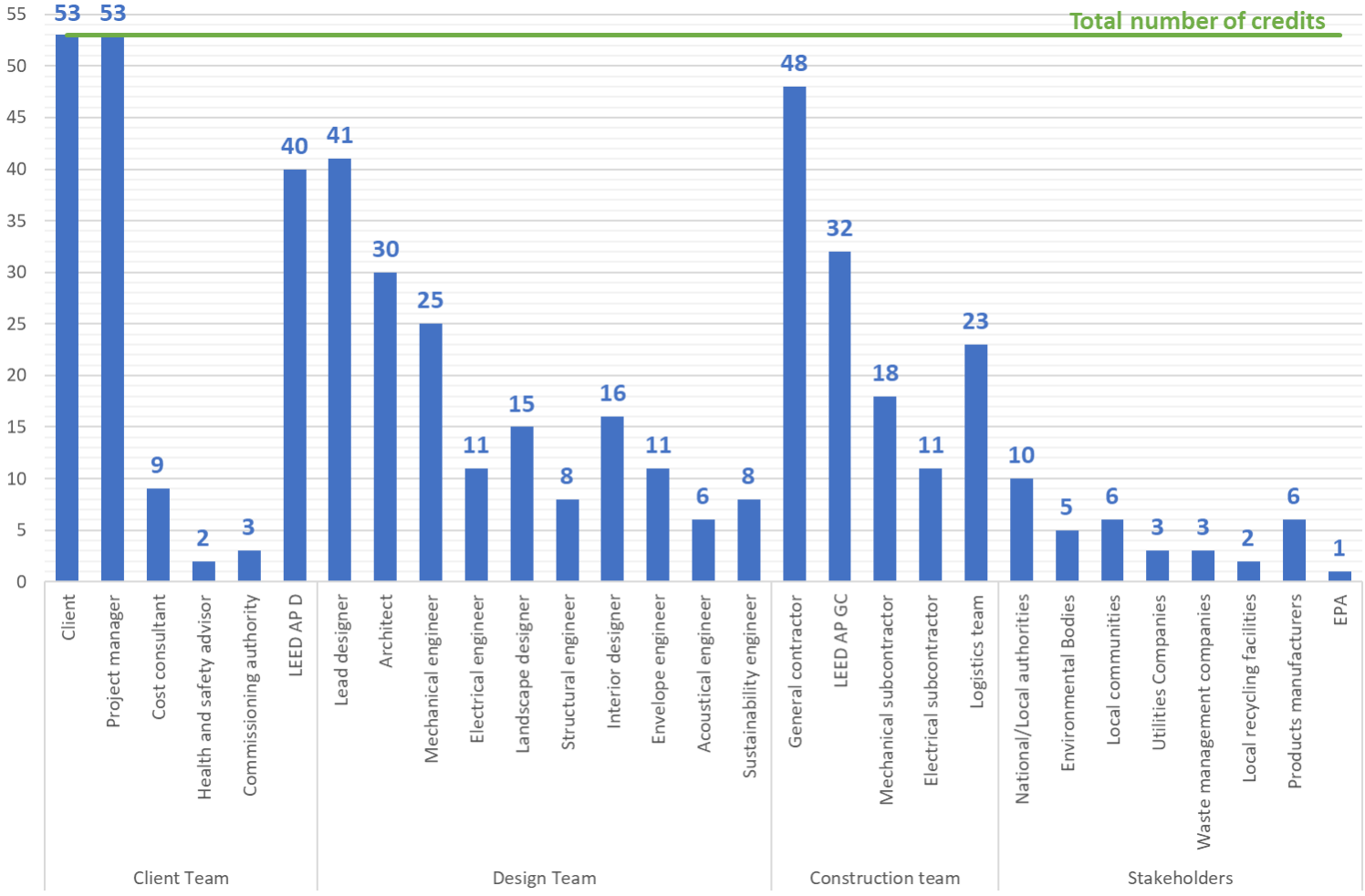

Figure 5.1: Involvement of project actors in credits and prerequisites obtention - bar chart

It is to be noted that the credit EA C4 – *Grid Harmonization* was not considered in the analysis.

Several statements can be made regarding the obtained results. First, the client is present for all the credits, as it has been considered that they need to approve all the choices made, for they pay for the deployed strategies. The project manager is also involved in all credits as it was considered that they need to oversee the project as a whole. Those two actors are hence very present in the developed framework, even if not actively participating to all the credits and prerequisites' completion. It can also be seen that the general contractor is involved in a lot of credits, and the lead designer too in a lesser amount.

In order to further understand the results obtained, pie charts for responsible and accountable actors were made and are presented in the following.

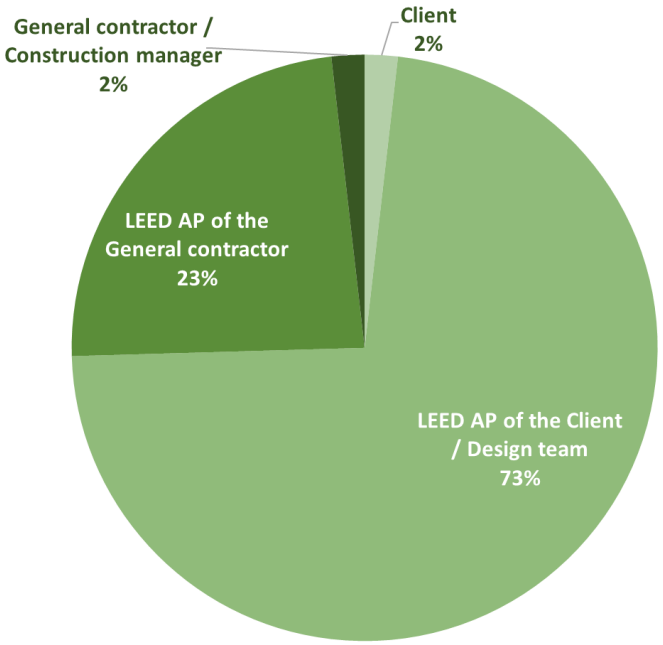

Figure 5.2: Repartition of actors responsible for LEED credits and prerequisites obtention – pie chart

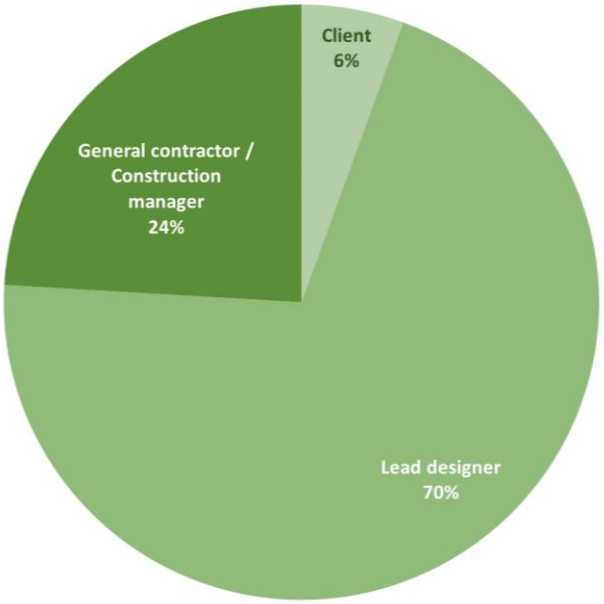

Figure 5.3: Repartition of actors accountable for LEED credits and prerequisites obtention – pie chart

It can be observed that the distributions of R and A responsibilities are uneven.

In terms of R actors, the LEED AP of the client and design team and the LEED AP of the general contractor are the two main ones, as they are responsible for the completion of the LEED credits. The client and general contractor appear in the graph because they are only responsible for the appointment of the two LEED APs in the IN C2 – *LEED Accredited Professional*.

When comparing figure 5.2 and figure 5.3, similarities in percentages of responsibility of construction team professionals and design team professionals in A and R actors can be pointed out.

Indeed, the client, lead designer and general contractor are always the A actors for the credits, as accountability was hierarchically attributed to the leader of the team where the R actor belongs. The only credits where the client is accountable are for three special credits: IP C1 - *Integrative process*, IN C2 - *LEED Accredited Professional* and RP C1 - *Regional priority credits*.

The design credits represent the majority of the credits, as testifies the high percentages reached by the design team members as R and A actors. Nonetheless, looking back at figure 5.1, the general contractor appears more involved than the lead designer. This reflects the fact that design related credits can require the practical knowledge from the construction team, in addition to the design team's participation. There is also the effect of keeping the general contractor informed, for credits of Sustainable Sites for instance, so that he can anticipate construction in accordance with site specificities.

As for the other types of responsibilities (Supports, Consulted and Informed), the following spider chart shows their distribution among the design team members (excluding the lead designer).

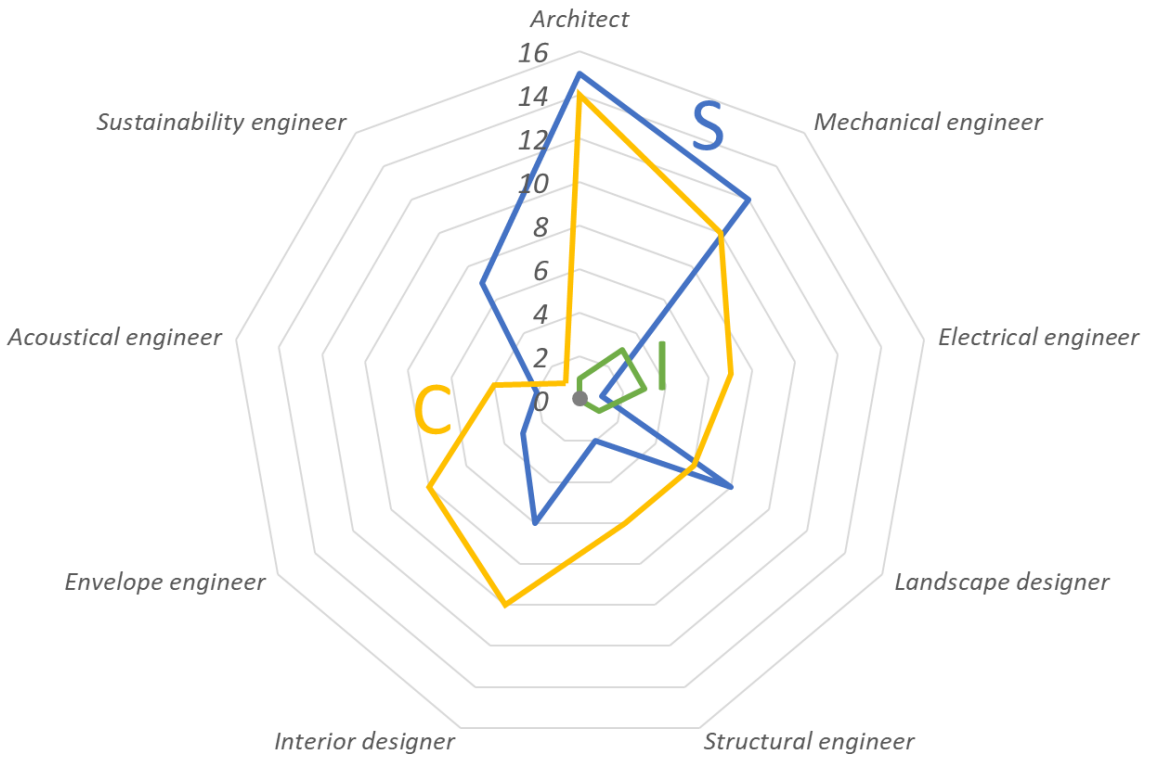

Figure 5.4: Repartition of S, C, I roles in the design team - spider chart

The designers and engineers are the actors that support the completion of design LEED credits and prerequisites. They can also monitor the completion of the construction LEED credits and prerequisites, so they are quite involved in the LEED certification process.

The most involved actor of the design team appears to be the architect, almost as much as a support to the LEED AP D than as a consultant for design decisions. As they set the building design, it is representative of their impact on sustainable aspects project. It is to be noted from figure 5.1 that they are also more involved in the LEED certification process than constructions team members that are not the general contractor and their LEED AP. Indeed, the focus of LEED being energy performance optimization, as highlighted by the 18 points that can be awarded to EA C2 – *Optimize Energy Performance*, smart and sensible project design is of utmost importance.

Mechanical and electrical engineers are also quite sought for their respective expertise. The mechanical engineer supports the LEED AP D in a consequent number of credits and prerequisite and is also quite often consulted. This again expresses the cornerstone aspect of energy performance, that is very much linked to the performance of building systems. Their expertise is crucial to limit the building's carbon footprint.

The landscape designer mostly supports the LEED AP D regarding the optimisation of water usage through smart landscape design. They are also essential to offer a better quality of life to the occupants in the surrounding environment of the building.

The structural engineer mainly intervenes in site surveys conducted for some credits and is informed when a credit can affect the structure's permanent and non-permanent loads. The structural stability guaranteeing the safety of building occupant, and thus being non-negotiable, this aspect of the building has little to no room for improvement from a sustainability point of view.

Both the interior designer and envelope engineer actively contribute to the energy performance of the building, through their design choices. The design of the envelope engineer has a strong

impact on heating, cooling and lighting needs of the tenants, hence is this actor is often consulted for the LEED credits completion to account for and analyse through energy modelling their design. The interior designer chooses materials and day-to-day life equipment of the tenants, that will impact overall energy consumption of the building, hence is often consulted for LEED.

The acoustical engineer is strongly involved for the dedicated credit IEQ C9 – *Acoustic Performance.* They are also consulted when the HVAC system must be chosen since the background noise of the machinery can be detrimental to the acoustical comfort of the occupants. They intervene also in the IEQ C2 - *Low Emitting Materials* for the choice of the acoustic panels.

The sustainability is in charge of the energy modelling, of which the results are very important to identify non-sustainable or inefficient sustainability design choices. They also perform life cycle analyses to assess global building impact on its environment, a core concern of LEED.

An equivalent chart was plotted for the actors of the construction team.

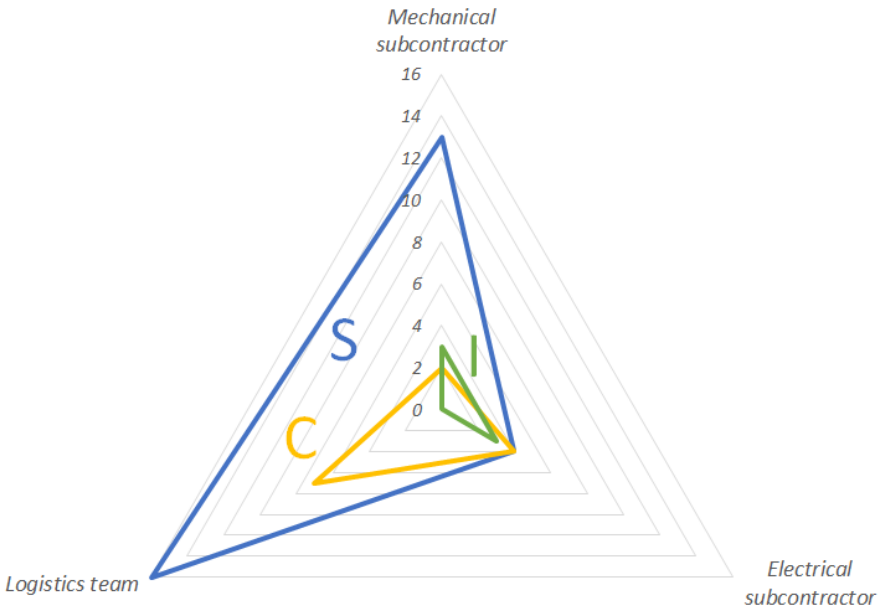

Figure 5.5: Repartition of S, C, I roles in the construction team - spider chart

The logistics team appears to be the most involved actor of the construction team, when A and R actors are not considered, as shown in figure 5.1. The figure 5.5 highlights the team's important involvement in support to the LEED AP. Indeed, another main focus of LEED is the reduction of the global environmental impact of the building, hence the sustainable sourcing and procurement of materials as well as sensible construction and demolition waste management. These sustainable practices are carried out by the logistic teams.

The mechanical and electrical sub-contractors observe similar trends in their distribution of S responsibility as the mechanical and electrical engineers but are much less consulted. This reflects the stronger influence of design in the LEED certification process.

5.2 Risk assessment

Depending on the LEED certification level pursued by the project team, risk is more or less tolerated. As a reminder, a project reaches:

- A Certified level from 40 to 49 points,
- A Silver level from 50 to 59 points,
- A Gold level from 60 to 79 points,
- A Platinum level over 80 points.

To analyse the effect of risk on the developed framework, risk assessment matrices are created.

A risk assessment matrix reflects the level of acceptability of credit risk depending on the credit impact on the certification's score. *In other words, they are visual tools indicating which credits are recommended to be pursued or not from a return on investment point of view.* The prerequisites are not considered in this analysis since they do not earn any points.

A colour code is used to convey different levels of risk acceptability:

- Green: represents an acceptable level of risk, to which the client is willing to commit,
- Orange: represents a tolerable level of risk, that will require mitigation effort or external support,
- Red: represents a dissuasive level of risk, that places the credit's completion on hold.

The following shows the obtained results, based on the obtention of a Platinum level. The colours have been assigned considering the amount of points to be reached for the desired level of certification.

		Ranges of points					
Total		1-3	4-6	7-9	10-12	13-15	16-18
Risk	Low	6	0	0	0	0	0
	Relatively low	9	3	0	0	0	0
	Medium	9	4	0	0	0	1
	Relatively high	3	1	0	0	0	0
	High	4	0	0	0	0	1

Table 5.1: Risk assessment matrix – risk likelihood vs possible points

The cells of the table are filled with the cumulated number of LEED credits with a certain risk grade that can earn a specific number of points. For example, there are 9 medium risk credits that can earn 1 to 3 points.

For the different levels of certification, the colours of the cells were attributed so that the sum of the green cells weighted by their corresponding number of points meet the lower threshold of the level certification. The orange cells were coloured so that the cumulated weighted sum reaches the upper threshold of the certification level. The rest was coloured red.

The table 5.1 can also been shown as follows in a more detailed way, in terms of points.

Platinium		Number of points possible							
Total		1	2	3	4	5	6	16	18
Risk	Low	4	2	0	0	0	0	0	0
	Relatively low	4	2	3	0	2	1	0	0
	Medium	7	2	0	0	3	1	0	1
	Relatively high	1	2	0	1	0	0	0	0
	High	0	4	0	0	0	0	1	0

Table 5.2: Risk assessment matrix for a platinum level

The green cells correspond to credits for which the risk is accounted for and considered acceptable in the certification strategy. They should be completed to reach the desired level. It is to be noted that this matrix represents an option considering that the maximum number of points in each pursued credit is aimed for.

The next tables show examples of risk assessment matrices for the other certification levels, made using the same assumptions:

Gold		Number of points possible							
Total		1	2	3	4	5	6	16	18
Risk	Low	4	2	0	0	0	0	0	0
	Relatively low	4	2	3	0	2	1	0	0
	Medium	7	2	0	0	3	1	0	1
	Relatively high	1	2	0	1	0	0	0	0
	High	0	4	0	0	0	0	1	0

Table 5.3: Risk assessment matrix for a gold level

Silver		Number of points possible							
Total		1	2	3	4	5	6	16	18
Risk	Low	4	2	0	0	0	0	0	0
	Relatively low	4	2	3	0	2	1	0	0
	Medium	7	2	0	0	3	1	0	1
	Relatively high	1	2	0	1	0	0	0	0
	High	0	4	0	0	0	0	1	0

Table 5.4: Risk assessment matrix for a silver level

Certified		Number of points possible							
Total		1	2	3	4	5	6	16	18
Risk	Low	4	2	0	0	0	0	0	0
	Relatively low	4	2	3	0	2	1	0	0
	Medium	7	2	0	0	3	1	0	1
	Relatively high	1	2	0	1	0	0	0	0
	High	0	4	0	0	0	0	1	0

Table 5.5: Risk assessment matrix for a certified level

The higher the targeted certification level, the higher levels of risk are accepted by the project team. This can be seen in a more visual way by the translation of the orange line towards the bottom right corner when increasing the number of points aimed.

6 Conclusion

In a complicated ecological context of the construction industry, sustainable buildings and green construction are evermore important issues. As they are quite recent and still not mastered by many construction professionals, this thesis work was aimed to develop a framework integrating green considerations to the project management process.

In order to design this framework, several assumptions were made, the most significant one being considering green buildings and LEED certified buildings equivalent. This equivalence is a much-discussed issue. Indeed, the requirements described in the credits can end up not being aligned with the sustainability objectives in practice. Furthermore, in order to set a frame, an Italian context was chosen for the project, both in terms of location and legislations. European and Italian norms differ from American ones and, as it has been seen in the chapter 4 of this thesis, some credits or prerequisites' requirements do not make as much sense in Europe as they might in America.

The framework developed in this thesis is a RASCI matrix aimed at highlighting the roles of usual project actors in the process of LEED certification and is completed by a risk assessment of not being reached for credits and of going overbudget for prerequisites. The overall distribution of responsibilities appears in accordance with the relative importance of actors in the certification process. Though, it is to be noted that a non-exhaustive list of project actors was considered, and that the framework shall be adapted to fit the expected roles to the actual actors present in the actual project. Another point that needs to be paid attention to is that the proposed risk assessment reflects the uncertainty that exists on the site location and features and does not take into account the client's strategy. For a real project, credits are often pursued when they make sense, for instance the credit LT C5 – *Access to Quality Transit* will be pursued in a city where there indeed is access to quality transit. The work presented should therefore be considered in its academic and theoretical context.

A possible way to enlarge the scope and the validity of the framework, is to adapt it to different Europeans certifications for comparison. As mentioned in the State of the Art, the integration of BIM represents a real opportunity that is not reflected in the proposed framework and further investigations on this dimension could be carried out.

7 Annex

Integrative Process	
Credit 1	Integrative Process
Intent	To support high-performance, cost-effective project outcomes through an early analysis of the interrelationships among systems.
# points	1 point
Requirements	Beginning in pre-design and continuing throughout the design phases, identify and use opportunities to achieve synergies across disciplines and building systems. Use the analyses described below to inform the owner's project requirements (OPR), basis of design (BOD), design documents, and construction documents.
	Energy-Related Systems: Establish an energy performance target no later than the schematic design phase. The target must be established using one of the following metrics:
	- kWh/m^2.year of site energy use
	- kWh/m^2.year of source energy use
	- kg/m^2.year of greenhouse gas emissions
	- energy cost/m^2.year
	Perform a preliminary "simple box" energy modeling analysis before the completion of schematic design that explores how to reduce energy loads in the building and accomplish related sustainability goals by questioning default assumptions. Assess strategies associated with each of the following, as applicable:
	- Site conditions. Assess shading, exterior lighting, hardscape, landscaping, and adjacent site conditions.
	- Massing and orientation. Assess how massing and orientation affect HVAC sizing, energy consumption, lighting, and renewable energy opportunities.
	- Basic envelope attributes. Assess insulation values, window-to-wall ratios, glazing characteristics, shading, and window operability.
	- Lighting levels. Assess interior surface reflectance values and lighting levels in occupied spaces.
	- Thermal comfort ranges. Assess thermal comfort range options.
	- Plug and process load needs. Assess reducing plug and process loads through programmatic solutions (e.g., equipment and purchasing policies, layout options).
	- Programmatic and operational parameters. Assess multifunctioning spaces, operating schedules, space allotment per person, teleworking, reduction of building area, and anticipated operations and maintenance.
	Water-Related Systems: Perform a preliminary water budget analysis before the completion of schematic design that explores how to reduce potable water loads in the building, reduce the burden on municipal supply or wastewater treatment systems, and accomplish related sustainability goals. Assess and estimate the project's potential nonpotable water supply sources and water demand volumes, including the following, as applicable:
	- Indoor water demand. Assess flow and flush fixture design case demand volumes, calculated in accordance with WE Prerequisite Indoor Water Use Reduction.
	- Outdoor water demand. Assess landscape irrigation design case demand volume calculated in accordance with WE Credit Outdoor Water-Use Reduction.
	- Process water demand. Assess kitchen, laundry, cooling tower, and other equipment demand volumes, as applicable.
	- Supply sources. Assess all potential nonpotable water supply source volumes, such as on-site rainwater and graywater, municipally supplied nonpotable water, and HVAC equipment condensate. Analyze how nonpotable water supply sources can contribute to the water demand components listed above.
	Implementation: Develop a Project Team Letter. Provide a dated letter on the letterhead of the Integrative Process Facilitator that summarizes the team's integrative process approach and describes the difference that this integrative approach made in terms of improving project team interaction and project performance.
	- Describe the approach developed by the project team for engaging a clearly defined and manageable integrative design process beginning in pre-design and continuing throughout the design phases.
	- The letter must include a separate summary for each issue area analyzed by the project team, describing how the analysis informed the design and building form decisions in the project's OPR and BOD and the eventual design of the project. Describe the most important goals for each issue area and provide clear guidance on how to evaluate the project's impact on the selected goals.
	The creation of this letter should be a team effort facilitated by the Integrative Process Facilitator. The letter must be signed by all principal project team members and made available to key stakeholders including, but not limited to the owner(s), facility manager(s), tenant(s), and community members. Describe how the letter was distributed to these stakeholders and/or made publicly available
Documents	Signed project team letter
	Energy performance target
	Indicate the exemplary performance option pursued
	Supporting documentation for the Exemplary Performance option not addressed in the Project Team Letter. (Optional)

Location and Transportation

Credit 1	LEED for Neighborhood Development Location
Intent	To avoid development on inappropriate sites. To reduce vehicle distance traveled. To enhance livability and improve human health by encouraging daily physical activity.
# points	Up to 16 points
Requirements	Locate the project within the boundary of a development certified under LEED for Neighborhood Development (Stage 2 or Stage 3 under the Pilot or v2009 rating systems, Certified Plan or Certified Built Project under the LEED v4 rating system). Projects attempting this credit are not eligible to earn points under other Location and Transportation credits.
Documents	General information about the name, ID, Rating system verision, certification level and certification date of the project
	Vicinity plan that contains the project boundary of the current project as well as the project boundary of the qualifying LEED for Neighborhood Development certified plan or project.

Credit 2	Sensitive Land Protection	
Intent	To avoid the development of environmentally sensitive lands and reduce the environmental impact from the location of a building on a site.	
# points	1 point	
Option 1. Previously Developed Land (1 point)		
Requirements	Locate the development footprint on land that has been previously developed.	
Documents	Site map(s) showing project boundaries, development footprint, any previous development, any sensitive areas, and any minor improvements in required buffers.	
	Description of the previous development on the site, immediately prior to this project (e.g., type of use, extent, etc.)	
Option 2. Avoidance of Sensitive Land (1 point)		
Requirements	Locate the development footprint on land that does not meet the following criteria for sensitive land:	
	Prime farmland. Prime farmland, unique farmland, or farmland of statewide or local importance and identified in a state Natural Resources Conservation Service soil survey (or local equivalent for projects outside the U.S.).	
	Floodplains. A flood hazard area shown on a legally adopted flood hazard map or otherwise legally designated by the local jurisdiction or the state. For projects in places without legally adopted flood hazard maps or legal designations, locate on a site that is entirely outside any floodplain subject to a 1% or greater chance of flooding in any given year.	
	Habitat. Land identified as habitat for the following:	
		species listed as threatened or endangered under the U.S. Endangered Species Act or the state's endangered species act.
		species or ecological communities classified by NatureServe as GH (possibly extinct), G1 (critically imperiled), or G2 (imperiled).
		species listed as threatened or endangered specifies under local equivalent standards (for projects outside the U.S.) that are not covered by NatureServe data.
	Water bodies. Areas on or within 30m of a water body, except for minor improvements.	
	Wetlands. Areas on or within 15m of a wetland, except for minor improvements.	
Document	Description of how the project team verified that this criterion was met	

Credit 3	High Priority Site and Equitable Development		
Intent	To build the economic and social vitality of communities, encourage project location in areas with development constraints, and promote the ecological and community health of the surrounding area.		
# points	Up to 2 points		
Option 1. High Priority Site (1 point)			
Path 1	Path 1. Economically Disadvantaged Community Location (1 point)		
	Locate within one of the following areas:		
		Census tract* in which average household income is at or below 80% area median income (AMI)	
		Census tract in which at least 20% of population is at or below poverty rate of state, provincial, or other regional jurisdiction	
		Census tract in which unemployment is at least 150% of the state, provincial, or other regional jurisdiction.	
	*or local equivalent government-defined municipal tract for projects outside the U.S.		
Documents	Census tracts		
	Vicinity map with the project boundary or other documentation demonstrating that the project is located within the priority area(s) identified.		
Path 2	Path 2. Brownfield Remediation (1 point)		
	Locate on a brownfield where soil or groundwater contamination has been identified, and where the local, state, or national authority (whichever has jurisdiction) requires its remediation. In cases of voluntary remediation by the project team, provide confirmation by the local, state, or national authority (whichever has jurisdiction) to verify that the site is a brownfield. Perform remediation to the satisfaction of the relevant authority.		
Documents	Provide documentation from the local, state, or national government authority that includes the following elements:		
		Declaration that soil and/or groundwater contaminants exist on project site	
		Date of remediation and responsible parties	
		Confirmation that the project team remediated all contaminants on-site to the satisfaction of the authority with jurisdiction	
Option 2. Equitable Development (1 point)			
Path 1	Path 1. Equity & Community Benefits (1 point)		
	Develop and implement an equity plan.		
Documents	Summary of community engagement activities and benefits Upload should include descriptions of the following:		
		Stakeholder Coordination	
		Community Assessment and Equity Prioritization	
		Community Partnership	
		Community Engagement Process	
		Demonstrated Community Benefits	
Path 2	Path 2. Affordable Housing in Residential or Mixed-Use Projects (1 point)		
	Include a proportion of new rental and/or for-sale dwelling units priced for households earning less than the AMI. Rental units must be maintained at affordable levels for a minimum of 15 years. Existing dwelling units are exempt from requirement calculations. Meet or exceed the minimum thresholds in Table 1. Projects must meet or exceed the minimum percentage of units mandated through inclusionary zoning by their local jurisdictions.		
	Table 1. Minimum affordable units		
	a	Rental Dwelling Units : 10% of total rental units (or at least 1 unit) priced up to 60% AMI	
	b	For-Sale Dwelling Units : 5% of total for-sale units (or at least 1 unit) priced up to 80% AMI	
Documents	Finding agreement from the responsible developer that the affordable rental rates for the required number of units will be maintained for at least 15 years, starting from the date of unit occupancy. The agreement may be in the form of a deed restriction, operating agreement, or other recorded document.		

Credit 4	Surrounding Density and Diverse Uses
Intent	To conserve land and protect farmland and wildlife habitat by encouraging development in areas with existing infrastructure. To promote walkability, and transportation efficiency and reduce vehicle distance traveled. To improve public health by encouraging daily physical activity.
# points	U to 5 pionts
Option 1. Surrounding Density (2–3 points)	
Requirements	Locate on a site whose surrounding existing density within a 400m offset of the project boundary meets the values in Table 1. Use either the "separate residential and nonresidential densities" or the "combined density" values.
Documents	Scaled area plan or map showing the project site, the surrounding area, and a 400m offset from the project boundary. Label the buildings that are included in the density calculations.
Path 1	Path 1. Document surrounding density with separate residential and nonresidential densities.
	Table 1a. Points for average density within 400m of project site
Documents	Table: Mixed-use density
	Residential Density
	Nonresidential Density
	Summary
Path 2	Path 2. Document surrounding density with combined residential and nonresidential densities.
	Table 1b. Points for average density within 400m of project site
Documents	Table: Average density within 400 m
Option 2. Diverse Uses (1–2 points)	
Requirements	Construct or renovate a building or a space within a building such that the building's main entrance is within a 800m walking distance from the following number of uses (see Appendix 1), as listed below.
	Table 1. Points for proximity to uses
	The following restrictions apply.
	A use counts as only one type (e.g., a retail store may be counted only once even if it sells products in several categories).
	No more than two uses in each use type may be counted (e.g. if five restaurants are within walking distance, only two may be counted).
	The counted uses must represent at least three of the five categories, exclusive of the building's primary use.
Documents	Table: Diverse uses
	Area plan or map showing the project site, use locations, and walking route to each use. Label each use.

Credit 5	Access to Quality Transit
Intent	To encourage development in locations shown to have multimodal transportation choices or otherwise reduced motor vehicle use, thereby reducing greenhouse gas emissions, air pollution, and other environmental and public health harms associated with motor vehicle use.
# points	Up to 5 points
Requirements	Locate any functional entry of the project within a 400m walking distance of existing or planned bus, streetcar, or informal transit stops, or within a 800m walking distance of existing or planned bus rapid transit stops, passenger rail stations (i.e. light, heavy, or commuter rail) or commuter ferry terminals. The transit service at those stops and stations in aggregate must meet the minimums listed in Table 1. Planned stops and stations may count if they are sited, funded, and under construction by the date of the certificate of occupancy and are complete within 24 months of that date. Both weekday and weekend trip minimums must be met.
	For each qualifying transit route, only trips in one direction are counted towards the threshold.
	For weekend trips, only trips on the day with the higher number of trips are counted towards the threshold.
	If a qualifying transit route has multiple stops within the required walking distance, only trips from one stop are counted towards the threshold.
	Privately-run shuttles are only acceptable if the service is also made available to the public.
	Table 1. Minimum daily transit service
	If existing transit service is temporarily rerouted outside the required distances for less than two years, the project may meet the requirements, provided the local transit agency has committed to restoring the routes with service at or above the prior level.
Documents	Table: Transit service
	Map indicating the project location, location of the transit stop(s), routes serving each stop, and the walking routes (with walking distance noted) between the location of the project functional entry and the stop(s).
	All the transit types, provide weekday and weekend route schedules showing the frequency of trips and service.
	For projects counting planned stops or stations
	Verification that planned stops or stations will be sited, funded, and under construction by the date of the certificate of occupancy and will be complete within two years of that date.

Credit 6	Bicycle Facilities
Intent	To promote bicycling and transportation efficiency and reduce vehicle distance traveled. To improve public health by encouraging utilitarian and recreational physical activity.
# points	1 point
Bicycle Network	
Requirements	Design or locate the project such that a functional entry or bicycle storage is within a 180m walking distance or bicycling distance from a bicycle network that connects to at least one of the following:
	at least 10 diverse uses (see Appendix 1)
	a school or employment center, if the project total floor area is 50% or more residential
	a bus rapid transit stop, passenger rail station, or ferry terminal
	All destinations must be within a 4800m bicycling distance of the project boundary. Planned bicycle trails or lanes may be counted if they are fully funded by the date of the certificate of occupancy and are scheduled for completion within one year of that date.
Documents	Vicinity map that shows routes along a bicycle network to the destination(s) selected. The map must identify use type, bicycling distance to the destination(s) from the project boundary (must be within 4,800m), and each segment of the bicycling network identified by type according to the bicycle network definition.
	For projects located in historic urban locations
	Description of the project area's historicity and/or legal protection and affected bicycle routes. Routes that meet the alternative minimum requirements for historic urban locations must be clearly identified by type within the vicinity map above.
	For projects with planned bicycle networks
	Capital improvement plan or equivalent document signed on developer letter head that confirms that the bicycle network will be fully funded by the date of the certificate of occupancy and is scheduled for completion within one year of that date.

Bicycle Storage and Shower Rooms	
	Case 1. Commercial or Institutional Projects
Requirements	Provide short-term bicycle storage for at least 2.5% of all peak visitors, but no fewer than four storage spaces per building. Provide long-term bicycle storage for at least 5% of all regular building occupants, but no fewer than four storage spaces per building in addition to the short-term bicycle storage spaces. Provide at least one on-site shower with changing facility for the first 100 regular building occupants and one additional shower for every 150 regular building occupants thereafter.
Documents	Site map that includes main and functional building entrances, short-term bicycle storage and long-term bicycle storage, walking distance from short-term storage to the main entrance and from long-term storage to a functional entrance. Label bicycle storage according to type and capacity.
	Table: Commercial/institutional short-term bicycle storage
	Table: Commercial/institutional long-term bicycle storage
	Table: Showers
	Case 2. Residential Projects
Requirements	Provide short-term bicycle storage for at least 2.5% of all peak visitors but no fewer than four storage spaces per building. Provide long-term bicycle storage for at least 15% of all regular building occupants, but no less than one storage space per three residential units.
Documents	Site map that includes main and functional building entrances, short-term bicycle storage and long-term bicycle storage, walking distance from short-term storage to the main entrance and from long-term storage to a functional entrance. Label bicycle storage according to type and capacity.
	Table: Residential short-term bicycle storage
	Table: Residential long-term bicycle storage
	Case 3. Mixed-Use Projects
Requirements	Meet the Case 1 and Case 2 storage requirements for the nonresidential and residential portions of the project, respectively.
Documents	Site map that includes main and functional building entrances, short-term bicycle storage and long-term bicycle storage, walking distance from short-term storage to the main entrance and from long-term storage to a functional entrance. Label bicycle storage according to type and capacity.
	All 5 tables of case 1 and 2
Large-Occupancy Projects Only	
Requirements	The following guidance should be applied when determining the number of showers needed for projects with a large number of occupants: Provide at least one on-site shower with changing facility for the first 100 regular building occupants and one additional shower for every 150 regular building occupants thereafter, up to 999 regular building occupants.
	one additional shower for every 500 regular building occupants, for the additional 1,000 – 4,999 regular building occupants
	one additional shower for every 1,000 regular building occupants, for the additional 5,000 + regular building occupants
All Projects	
Requirements	Short-term bicycle storage must be within 60m walking distance of any main entrance. Long-term bicycle storage must be within 90m walking distance of any functional entry. Vertical distances travelled by elevator are exempt from counting towards the walking distance requirements. Bicycle storage capacity may not be double-counted: storage that is fully allocated to the occupants of non-project facilities cannot also serve project occupants. Indoor storage is acceptable as long as it meets the walking distance requirements. On-site bicycle sharing stations within the project boundary may count for 50% of the long-term and short-term bicycle storage space. Zero lot line projects may count publicly available bicycle parking towards their short-term storage requirements if it meets the maximum allowable walking distance. Provide at least one on-site shower with changing facility for the first 100 regular building occupants and one additional shower for every 150 regular building occupants thereafter. Exclude patients and K-12 students from the regular building occupant count.

Credit 7	Reduced Parking Footprint
Intent	To minimize the environmental harms associated with parking facilities, including automobile dependence, land consumption, and rainwater runoff.
# points	1 point
Requirements	The credit calculations must include all existing and new off-street parking spaces that are leased or owned by the project, including parking that is outside the project boundary but is used by the project. On-street parking in public rights-of-way is excluded from these calculations.
Option 1. No Off-Street Parking (1 point)	
Requirement	Do not provide off-street parking.
Documents	Total Parking Capacity
	Parking plan: site or vicinity map that includes the following elements:
	Project boundary
	Parking used by building occupants
Option 2. Reduce Parking (1 point)	
Requirements	Do not exceed the minimum local code requirements for parking capacity.
	Provide parking capacity that is a 30% reduction below the base ratios recommended by the Parking Consultants Council, as shown in the Institute of Transportation Engineers' Transportation Planning Handbook, 4th edition, Table 11-12.
Documents	Total Parking Capacity
	Parking plan: site or vicinity map that includes the following elements:
	Project boundary
	Parking used by building occupants
Option 3. Carshare (1 point)	
Requirements	Provide dedicated parking for carshare vehicles. Provide at least one vehicle parking space for every 100 occupants, rounded up. If the project has fewer than 100 occupants, provide one carshare vehicle parking space.
	Existing carshare vehicles located in nearby on- or off-street parking areas do not contribute to credit achievement.
Documents	Total Parking Capacity
	Parking plan: site or vicinity map that includes the following elements:
	Project boundary
	Parking used by building occupants
	Parking dedicated for carshare vehicles
	Walking distance measurements between carshare space(s) and project boundary
	Carshare Agreement: legal agreement between the carshare company and the project, demonstrating a minimum 2-year agreement to dedicate carshare parking space.
Option 4. Unbundling Parking (1 point)	
Requirements	Sell parking separately from all property sales or leases.
	Implement a daily parking fee at a cost equal to or greater than the daily cost of municipal public transit.
Document	Brief narrative describing parking fees and the daily (i.e., roundtrip) cost of municipal public transit.

Credit 8	Electric Vehicles
Intent	To reduce pollution by promoting alternatives to conventionally fueled automobiles
# points	1 point
Requirements	Provide charging infrastructure for electric vehicles for on-site parking.
Option 1. Electric Vehicle Charging (1 point)	
Requirements	Install electrical vehicle supply equipment (EVSE) in 2% of all parking spaces used by the project or at least two spaces, whichever is greater. Clearly identify and reserve these spaces for the sole use by plug-in electric vehicles. The EVSE must:
	Provide a Level 2 charging capacity (208 – 240 volts) or greater.
	Comply with the relevant regional or local standard for electrical connectors, such as SAE Surface Vehicle Recommended Practice J1772, SAE Electric Vehicle Conductive Charge Coupler or IEC 62196 of the International Electrotechnical Commission for projects outside the U.S.
	Be capable of responding to time-of-use market signals (e.g. price). Projects pursuing EA credit Grid Harmonization should incorporate EVSE into any demand response program or load flexibility and management strategies.
Documents	Information about parking capacity
	Photographs or diagrams of the signage and/or pavement markings used to indicate reserved parking for plug-in electric vehicles.
	Manufacturer information highlighting charging capacity, compliance with relevant standard for electrical connectors, and vehicle-to-grid (V2G) capability.
Option 2. Electric Vehicle Charging Infrastructure (1 point)	
Requirements	Make 6% of all parking spaces or at least 6 spaces EV Ready, whichever is greater. To be EV Ready, meet all of the following:
	Install listed raceway capable of accommodating a 208/240-volt dedicated branch circuit.
	The raceway shall not be less than trade size 1 (nominal 1-inch inside diameter).
	The raceway shall originate at the main service or subpanel and shall terminate into a listed cabinet, box or enclosure in close proximity to the proposed location of the EV space.
	The service panel and/or subpanel shall provide capacity to install a 40-ampere minimum dedicated branch circuit and space(s) reserved to permit installation of a branch circuit overcurrent protective device.
	When multiple charging spaces are required, raceway(s) is/are required to be installed at the time of construction.
	The raceway(s) shall originate at a service panel or subpanel(s) serving the area, and shall terminate in close proximity to the proposed location of the charging equipment into listed cabinet(s), box(es), enclosure(s) or equivalent.
	Construction documents shall indicate raceway termination point and proposed location of future EV spaces and EV chargers. Construction documents shall also provide information on amperage of future EVSE, raceway method(s), wiring schematics and electrical load calculations to verify electrical panel service capacity and electrical system, including any on-
	Plan design shall be based upon a 40-ampere minimum branch circuit.
	Electrical calculations shall substantiate the design of the electrical system, to include the rating of equipment and any on-site distribution transformers and have sufficient capacity to simultaneously charge all required EVs at its full rated amperage.
	The service panel or subpanel(s) shall have sufficient capacity to accommodate the required number of dedicated branch circuit(s) for the future installation of the EVSE.
Documents	Information about parking capacity
	Site plan or drawing that shows the location of the installed raceways, including termination points, and the location of proposed EV spaces.
	Construction documents, specifications, and electrical calculations that highlight compliance with credit requirements for the electrical system, installed equipment, and proposed charging stations.

Sustainable Sites

Prerequisite 1	Construction Activity Pollution Prevention
Intent	To reduce pollution from construction activities by controlling soil erosion, waterway sedimentation, and airborne dust.
Pre-Requirements	Create and implement an erosion and sedimentation control plan for all construction activities associated with the project. The plan must conform to the erosion and sedimentation requirements of the 2017 U.S.EPA Construction General Permit (CGP) or local equivalent, whichever is more stringent. Projects must apply the CGP regardless of size. The plan must describe the measures implemented.
Option 1. EPA Construction General Permit	
Pre-Requirements	The project team created and implemented an erosion and sedimentation control (ESC) plan that conforms to the requirements of the 2017 EPA Construction General Permit (CGP). The requirements of the CGP are more stringent than local standards and codes.
Documents	Description of how the project complies with the requirements of the 2017 EPA CGP.
	For zero lot line projects and projects with minimal or no exterior work
	Description of the special conditions of the project and how the project complies with the prerequisite requirements.
Option 2. Local standards and codes	
Pre-Requirements	The project team created and implemented an erosion and sedimentation control (ESC) plan that conforms to local standards and codes, which are as or more stringent than the 2017 EPA Construction General Permit (CGP).
Documents	Description of how the local erosion and sedimentation control standards and codes are equal to or more stringent than the requirements of the 2017 EPA CGP.
	Description of how the project complies with the requirements of local erosion and sedimentation control standards and codes.
	ESC plan or construction drawings describing the erosion and sedimentation control measures implemented on the site.
	Select one of the following:
	Written declaration from the general contractor or builder who implemented the plan, confirming that the ESC plan was carried out appropriately.
	Date-stamped photos showing the measures taken, including any corrective action, to effectively implement the ESC plan. Photos should be taken at regular intervals and show all areas of the site covered in the plan.
	Description of how the ESC plan was implemented, including the timing of the implementation of the plan, specific control measures applied on site, and the maintenance protocol used to ensure the proper function of control measures.
	For zero lot line projects and projects with minimal or no exterior work
	Description of the special conditions of the project and how the project complies with the prerequisite requirements.

Credit 1	Site Assessment
Intent	To assess site conditions before design to evaluate sustainable options and inform related decisions about site design.
# points	1 point
Requirements	Complete and document a site survey or assessment (it should demonstrate the relationships between the site features and topics listed above and how these features influenced the project design; give the reasons for not addressing any of those topics.) that includes the following information:
	Topology:
	Contour mapping
	Unique topographic features
	Slope stability risks
	Hydrology:
	Special Flood Hazard Areas (SPFHA) as determined by FEMA's Flood Insurance Rate Map (FIRM) (or local equivalent for projects outside the U.S.)
	Delineated natural water bodies wetlands, lakes, streams, and shorelines (refer to U.S. EPA's Clean Water Act or local equivalent for projects outside the U.S.)
	Rainwater collection and reuse opportunities
	Impervious and pervious surfaces within the site boundary
	Climate:
	Solar exposure and shading opportunities
	Heat island effect potential
	Seasonal sun angles
	Prevailing winds
	Average monthly precipitation and temperature ranges
	Vegetation:
	Primary vegetation types
	Greenfield area
	Significant tree mapping
	Federal or state threatened or endangered species lists; for projects outside the U.S., International Union for Conservation of Nature (IUCN) Red List of Threatened
	Species:
	Invasive plant species listed by regional, state, or federal entities
	EPA Level III ecoregion description (or local equivalent)
	Soils:
	Natural Resources Conservation Service soils delineation (or local equivalent for projects outside the U.S.)
	U.S. Natural Resources Conservation Service (or local equivalent for projects outside the United States) prime farmland, unique farmland, farmland of statewide importance, or farmland of local importance
	Healthy soils
	Previous development
	Disturbed soils
	Human use:
	Views
	Adjacent transportation infrastructure, bicycle network, and bicycle storage
	Adjacent diverse uses
	Construction materials with existing recycle or reuse potential
	Human health effects:
	Proximity of vulnerable populations
	Adjacent physical activity opportunities
	Proximity to major sources of air and water pollution
Documents	Site survey or assessment detailing of the site's topograhy, climate, soils, human health effects, hydrology, vegatation, human use
	Site Assessment Worksheet or an equivalent narrative description
	Map illustrating the topography of the site
	Map illustrating the site's Special Flood Hazard Areas (SPFHA) as determined by FEMA's Flood Insurance Rate Map (FIRM) (or local equivalent showing the 100-year floodplain for projects outside the U.S.)
	Description of the site's EPA Level III ecoregion

Credit 2	Protect or Restore Habitat
Intent	To conserve existing natural areas and restore damaged areas to provide habitat and promote biodiversity.
# points	Up to 2 points
Requirement	Preserve and protect from all development and construction activity 40% of the greenfield area on the site (if such areas exist) AND select option 1 OR 2
For projects with greenfield area	
Documents	Information about greenfields area on the site
	Description of the strategies undertaken to preserve and protect greenfield area from all development and construction activity by:
Option 1. On-site restoration (2 points)	
Requirements	Using native or adapted vegetation, restore 25% (including the building footprint) of all portions of the site identified as previously disturbed. Vegetated roof surfaces may be included if the plants are native or adapted and provide habitat. Soils Restore all soils on site that have been disturbed or replace all soils removed by current construction activities that will later serve as the final vegetated area.
	Restore or replace soils to a minimum depth of 30.48 cm or depth of root ball for larger plant materials.
	Provide a soils test of imported soils that includes recommended amendments. Incorporate test recommended amendments prior to planting.
	Imported soils must be reused for functions comparable to their original function
	Imported soils may not include the following:
	soils defined regionally by the Natural Resources Conservation Service web soil survey (or local equivalent for projects outside the U.S.) as prime farmland, unique farmland, or farmland of statewide or local importance; or
	soils from other greenfield sites
	sphagnum peat moss
	Vegetation: Use only plant species that are appropriate for the project's EPA Level III ecoregion and that are suitable for site conditions, climate, and design intent. Both native and adapted vegetation may qualify
	Use only plant species not currently listed as invasive on any federal or qualifying regional lists
	Protect the root zone of trees found on site. Planting within the 0.30 m radius per inch (2.54 cm) Diameter Breast Height (DBH) should be avoided
	Conserve endangered species
Documents	Infomation about Native or Adapted Vegetation areas
	For projects including vegetated roof surfaces: indicate if the plants used for the vegetated roof surfaces are native or adapted, provide habitat, and promote biodiversity.
	Soil restoration
	Imported soil test analysis results with recommended amendments
	For all disturbed or compacted soils that have been revegetated within the project's development footprint, description of:
	how they have been reused for functions comparable to their original function
	the source of any imported topsoils or topsoil blends
	the process and strategies used to revegetate disturbed or compacted soils
	Site plan that depicts the project boundary, building footprint(s), preserved greenfield area (if applicable), previously disturbed area, restored area, native/adapted vegetation, and plant list.
	Information on the existing soil characteristics, as well as the results of the soils test with recommended amendments to demonstrate the qualities of the restored soils.
	Documentation showing that test recommended amendments have been incorporated.
	Description of the project's EPA Level III ecoregion.
Option 2. Financial support (1 point)	
Requirements	Provide financial support equivalent to at least $0.20 per square foot (US2 per square meter) for the total site area (including the building footprint). Financial support must be provided to a conservation land trust or accredited conservation organization within the same EPA Level III ecoregion or the project's state (or within 160km of the project for projects outside the U.S.). For U.S. projects, the land trust must be accredited by the Land Trust Alliance. For projects outside of the U.S., the conservation land trust must either be a project supported by The Nature Conservancy or World Land Trust.
Documents	Information about financial support
	For projects outside the U.S.
	Description of the qualifications and mission of the conservation organization
	Verification that the land trust or conservation project is supported by The Nature Conservancy or World Land Trust
	For projects within the U.S.
	Document from the Land Trust Alliance confirming that the land trust or conservation organization is accredited
	Contract or agreement with the land trust or conservation organization describing the use of the funds. Include information on the location of the organization (EPA Level III ecoregion, state, or distance within 160 km of the project, for projects outside the U.S.), amount of financial support, and activities that the funds will support.

Credit 3	Open Space
Intent	To create exterior open space that encourages interaction with the environment, social interaction, passive recreation, and physical activities.
# points	1 point
Requirements	Provide outdoor space greater than or equal to 30% of the total site area (including building footprint). 25% of the minimum 30% total outdoor space requirement must be planted with a diversity of vegetation or have overhead vegetated canopy. The outdoor space must be physically accessible and be one or more of the following:
	a pedestrian-oriented paving or landscape area that accommodate outdoor social activities
	a recreation-oriented paving or landscape area that encourage physical activity;
	a landscape area with a diversity of vegetation types and species that provide opportunities for year-round visual interest;
	a garden space dedicated to community gardens or urban food production;
	preserved or created habitat that meets the criteria of SS Credit Protect or Restore Habitat and also includes elements of human interaction.
	Extensive or intensive vegetated roofs that are physically accessible can be used toward the minimum 25% vegetation requirement, and qualifying roof-based physically accessible paving areas can be used toward credit compliance. Wetlands or naturally designed ponds may count as open space if the side slope gradients average 1:4 (vertical:horizontal) or less and are vegetated.
Documents	Information about open space
	Description of how the open space is physically accessible and meets the criteria of one or more of the following types of areas:
	a pedestrian-oriented paving or landscape area that accommodate outdoor social activities
	a recreation-oriented paving or landscape area that encourage physical activity;
	a landscape area with a diversity of vegetation types and species that provide opportunities for year-round visual interest;
	a garden space dedicated to community gardens or urban food production;
	preserved or created habitat that meets the criteria of SS Credit Protect or Restore Habitat and also includes elements of human interaction.

Credit 4	Rainwater Management
Intent	To reduce runoff volume and improve water quality by replicating the natural hydrology and water balance of the site, based on historical conditions and undeveloped ecosystems in the region.
# points	Up to 3 points
Resources	LEED v4.1 Rainfall Events Calculator
Requirements	Treat run-off from pollutant-generating impervious surfaces (i.e. vehicle pavement, service courts, trash enclosures) using low-impact development (LID) practice.
	In a manner best replicating natural site hydrology processes, retain (i.e. infiltrate, evapotranspirate, or collect and reuse) on site the runoff from the developed site for, at minimum, the 80th percentile of regional or local rainfall events using low-impact development (LID) /green infrastructure (GI) practices. GI and LID strategies can be either structural or non-structural. Points are awarded according to Table 1. For all projects, the use of coal tar sealants shall be prohibited in any application exposed to stormwater, wash waters, condensates, irrigation water, snowmelt, or icemelt. Examples of acceptable techniques include the following:
	- planting rain gardens with native or adapted plant material (e.g. trees shrubs);
	- installing a vegetated roof;
	- using permeable paving, consisting of porous above-ground materials (e.g., open pavers, engineered products), a base layer designed to drain water away from the building, and (often) a 6-inch-deep (150 millimeters) subbase; and
	- installing permanent infiltration or collection features (e.g., vegetated swale, rain garden, rainwater cistern) that can retain 100% of the runoff from at minimum, the 80th percentile of regional or local rainfall events.
	A combination of LID approaches are recommended (but not required) as they are holistic measures which maximize benefits. In contrast to LID, conventional stormwater techniques include grey infrastructure, such as detention or retention ponds, pipes, and vaults. Conventional grey infrastructure devices may be accepted only if integrated within a holistic LID system (ie. a combination of LID techniques). Use daily rainfall data and the methodology in the U.S. Environmental Protection Agency (EPA) Technical Guidance on Implementing the Stormwater Runoff Requirements for Federal Projects under Section 438 of the Energy Independence and Security Act to determine the percentile amount to be retained.
	Table 1. Points for percentile of rainfall retained
	Zero Lot Line projects only : The following requirement applies to zero lot line projects in urban areas with a minimum density of 1.5 FAR. Treat run-off from pollutant-generating impervious surfaces (i.e. vehicle pavement, service courts, trash enclosures) using low-impact development (LID) practice/green infrastructure (GI) (or a traditional stormwater treatment device if LID/GI is not feasible for lack of space). Any above-ground setback area must be designed and used as a pedestrian-oriented space (e.g. restaurant seating, outdoor displays, private vendors, or related public purpose). In a manner best replicating natural site hydrology processes, retain on site the runoff from the developed site for, at minimum, the 70th percentile of regional or local rainfall events, using LID/GI. Points are awarded according to Table 2. If the Zero Lot Line project meets the credit requirements and achieves at least the minimum percentile threshold of rainfall retained, additional volume can be retained offsite so long as the LID/GI system is designed to accommodate use by the project.
	Table 2. Points for percentile of rainfall retained on Zero Lot Line projects
Option 1. Non- zero lot line project	
Documents	Indicate the threshold to attempt
Option 2. Zero lot line project	
Documents	Indicate the threshold to attempt
	Description of the conditions that make this a zero lot line project.
For all projects	
Documents	Rainfall Events Calculator (at least in the last 10 years otherwise summarize why those data are not avalable)
	Runoff Calculations
	LIC Documentation
	Description of the proposed practices to be implemented on the project site and what qualifies these strategies as LID or green infrastructure techniques that best replicate natural site hydrology processes
	For projects unable to provide at least 10 years of historic rainfall data:
	- Summary why additional historic data are not available for the project location.
	For projects that are part of a multitenant complex:
	- Description of the centralized approach affecting the defined project site that is within the master plan boundary. Also include a description of the distributed techniques based on a watershed approach

Credit 5	Heat Island Reduction
Intent	To minimize effects on microclimates and human and wildlife habitats by reducing heat islands.
# points	Up to 2 points
Requirements	Choose one of the following options:
Option 1. Nonroof and Roof	
Requirements	Meet the following criterion: $\frac{Area\ of\ nonroof\ measures}{0.5} + \frac{Area\ of\ High-Reflectance\ Roof}{0.75} + \frac{Area\ of\ Vegetated\ Roof}{0.75} \geq Total\ Site\ Paving\ Area + Total\ Roof\ Area$
	Alternatively, an SRI and SR weighted average approach may be used to calculate compliance. Use any combination of the following strategies.
	Nonroof measures:
	- Use the existing plant material or install plants that provide shade over paving areas (including playgrounds) on the site within 10 years of planting. Install vegetated planters. Plants must be in place at the time of occupancy permit and cannot include artificial turf.
	- Provide shade with structures covered by energy generation systems, such as solar thermal collectors, photovoltaics, and wind turbines.
	- Provide shade with architectural devices or structures. If the device or structure is a roof, it shall have an aged solar reflectance (SR) value of at least 0.28 as measured in accordance with ANSI/CRRC S100. If the device or structure is not a roof, or if aged solar reflectance information is not available, it shall have at installation an initial SR of at least 0.33 as measured in accordance with ANSI/CRRC S100.
	- Provide shade with vegetated structures.
	- Use paving materials with an initial solar reflectance (SR) value of at least 0.33.
	- Use an open-grid pavement system (at least 50% unbound).
	High-reflectance roof:
	- Use roofing materials that have an aged SRI equal to or greater than the values in Table 1. If aged SRI is not available, the roofing material shall have an initial SRI equal to or greater than the values in Table 1.
	- Table 1. Minimum solar reflectance index value, by roof slope
	- Roof area that consists of functional, usable spaces (such as helipads, recreation courts, and similar amenity areas) may meet the requirements of nonroof measures. Applicable roof area excludes roof area covered by mechanical equipment, solar energy panels, skylights, and any other appurtenances
	Vegetated Roof
	- Install a vegetated roof using native or adapted plant species
Documents	Table: contributing nonroof measures
	Table: Contributing high-reflectance roof
	Table: Summary of nonroof and roof
	Site plan, other drawings, or photos that show the materials used on the site
	Manufacturer documentation of SRI, SR, and paving permeability, as applicable to the project.

Option 2. Parking under Cover	
Requirements	Place a minimum of 75% of parking spaces under cover. Any roof used to shade or cover parking must either:
	have a three-year aged SRI of at least 32 (if three-year aged value information is not available, use materials with an initial SRI of at least 39 at installation),
	be a vegetated roof,
	be covered by energy generation systems, such as solar thermal collectors, photovoltaics, and wind turbines.
	The credit calculations must include all existing and new off-street parking spaces that are leased or owned by the project, including parking that is outside the project boundary but is used by the project. On-street parking in public rights-of-way is excluded from these calculations.
Documents	Tabe: Parking
	Manufacturer documentation of SRI, SR, and paving permeability, as applicable to the project. (Optional)

Credit 6	Light Pollution Reduction
Intent	To increase night sky access, improve nighttime visibility, and reduce the consequences of development for wildlife and people.
# points	1 point
Requirements	Meet uplight and light trespass requirements, using either Option 1 (BUG rating method) OR 2 (Calculation method).
	Projects may use different options for uplight and light trespass. Meet these requirements for all exterior luminaires located inside the project boundary (except those listed under "Exemptions"), based on the following:
	the photometric characteristics of each luminaire when mounted in the same orientation and tilt as specified in the project design; and
	the lighting zone of the project property (at the time construction begins). Classify the project under one lighting zone using the lighting zones definitions provided in the Illuminating Engineering Society and International Dark Sky Association (IES/IDA) Model Lighting Ordinance (MLO) User Guide.
	Additionally, meet the internally illuminated signage requirement: Do not exceed a luminance of 200 cd/m2 (nits) during nighttime hours and 2000 cd/m2 (nits) during daytime hours.
Documents	Indicate the classification of the project under one of the following lighting zones:
	LZ0: No ambient lighting
	LZ1: Low ambient lightings
	LZ2: Moderate ambient lighting
	LZ3: Moderately high ambient lighting
	LZ4: High ambient lighting
	Site lighting plan depicting the project boundary, the property line (if different from the project boundary), the lighting boundary, any additional properties included in the lighting boundary (if applicable), the location and label of all exterior luminaires within the project boundary (both exempt and nonexempt), and any relevant project site conditions.
Uplight	
Requirements	Option 1. BUG rating method
	Do not exceed the following luminaire uplight ratings, based on the specific light source installed in the luminaire, as defined in IES TM-15-11, Addendum A.
	Table 1. maximum uplight ratings for luminaires
Documents	Luminaire schedule showing the uplight rating of each unique luminaire (lamp/ballast combination) in the orientation and tilt specified in the project design. If there are multiple orientations/tilts, show the uplight rating for each orientation/tilt.
Requirements	Option 2. calculation method
	Do not exceed the following luminaire uplight ratings, based on the specific light source installed in the luminaire, as defined in IES TM-15-11, Addendum A.
	Table 2. maximum percentage of total lumens emitted above horizontal, by lighting zone
Documents	Table: Lumens emitted above horizontal
Light Trespass	
Requirements	Option 1. BUG rating method
	Do not exceed the following luminaire backlight and glare ratings (based on the specific light source installed in the luminaire), as defined in IES TM-15-11, Addendum A, based on the mounting location and distance from the lighting boundary.
	Table 3. maximum backlight and glare ratings
	The lighting boundary is located at the property lines of the property, or properties, that the LEED project occupies. The lighting boundary can be modified under the following conditions:
	When the property line abuts a public area that includes, but is not limited to, a walkway, bikeway, plaza, or parking lot, the lighting boundary may be moved to 1.5 m beyond the property line.
	When the property line abuts a public street, alley, or transit corridor, the lighting boundary may be moved to the center line of that street, alley, or corridor.
	When there are additional properties owned by the same entity that are contiguous to the property, or properties, that the LEED project is within and have the same or higher MLO lighting zone designation as the LEED project, the lighting boundary may be expanded to include those properties.
	Orient all luminaires less than two mounting heights from the lighting boundary such that the backlight points toward the nearest lighting boundary line. Building-mounted luminaires with the backlight oriented toward the building are exempt from the backlight rating requirement.
Documents	Luminaire schedule showing the backlight and glare ratings of each unique luminaire (lamp/ballast combination) in the orientation and tilt specified in the project design. If there are multiple orientations/tilts, show the backlight and glare ratings for each orientation/tilt. Also include the mounting height for each unique luminaire (photometric center of the luminaire above grade).
Requirements	Option 2. calculation method
	Do not exceed the following vertical illuminances at the lighting boundary (use the definition of lighting boundary in Option 1). Calculation points may be no more than 1.5 m apart. Vertical illuminances must be calculated on vertical planes running parallel to the lighting boundary, with the normal to each plane oriented toward the property and perpendicular to the lighting boundary, extending from grade level to 10 meters above the height of the highest luminaire.
	Table 4. maximum vertical illuminance at lighting boundary, by lighting zone
Documents	Vertical illuminance calculations: greatest vertical illuminance value for each of the vertical calculation planes at the lighting boundary. Also provide the calculation grid for the one vertical plane that has the greatest vertical illuminance (worst case scenario) with the point of the greatest illuminance highlighted.

Water Efficiency

Prerequisite 1 /Credit 1	Outdoor Water Use Reduction
Intent	To reduce outdoor water consumption.
# points	up to 2 points (for the credit)
Pre-Requirements	Reduce outdoor water use through one of the following options. Nonvegetated surfaces, such as permeable or impermeable pavement, should be excluded from landscape area calculations. Athletic fields and playgrounds (if vegetated) and food gardens may be included or excluded at the project team's discretion.
Option 1. No irrigation required (0-2 points)	
(Pre)-Requirements	Show that the landscape does not require a permanent irrigation system beyond a maximum two-year establishment period
Documents	List of the plant species and water needs for the landscape area. If applicable, include irrigation establishment plan information.
Option 2. Reduced irrigation (0-2 points)	
Pre-Requirements	Reduce the project's landscape water requirement by at least **30%** from the calculated baseline for the site's peak watering month. Reductions must be achieved through plant species selection and irrigation system efficiency, as calculated by the EPA WaterSense Water Budget Tool.
Requirements	Reduce the project's landscape water requirement by at least **50%** from the calculated baseline for the site's peak watering month. Reductions must first be achieved through plant species selection and irrigation system efficiency as calculated in the EPA WaterSense Water Budget Tool. Additional reductions beyond 30% may be achieved using any combination of efficiency, alternative water sources, and smart scheduling technologies.
Documents	Completed EPA WaterSense Water Budget Tool OR Outdoor Water Use Reduction Calculator
	Landscape or site drawings/plans showing the location and size of landscape zones described in the EPA WaterSense Water Budget Tool or Outdoor Water Use Reduction Calculator.
	For projects attempting WE Credit Outdoor Water Use Reduction with additional reductions:
	Values from the EPA WaterSense Water Budget Tool or Outdoor Water Use Reduction Calculator
	Additional reduction calculations or other supporting documentation showing projected alternative water supply for the year or smart scheduling technology savings over the year.

Prerequisite 2 /Credit 2	Indoor Water Use Reduction
Intent	To reduce indoor water consumption.
# points	Up to 6 points (for the credit)
Resources	LEED v4 Indoor Water Use Reduction
Requirements	Further reduce fixture and fitting water use from the calculated baseline in WE Prerequisite Indoor Water Use Reduction. Additional potable water savings can be earned above the prerequisite level using alternative water sources. Include fixtures and fittings necessary to meet the needs of the occupants. Some of these fittings and fixtures may be outside the tenant space (for Commercial Interiors) or project boundary (for New Construction). Points are awarded according to Table 1.
	Table 1. Points for reducing water use
	Projects located where standard supply pressure is different than the LEED baseline supply pressure may calculate the water consumption of flow fixtures and fittings at the local standard supply pressure; the supply pressure must be consistent in the baseline and proposed case.
Building Water Use	
Pre-Requirements	For the fixtures and fittings listed in Table 1, as applicable to the project scope, reduce aggregate water consumption by 20% from the baseline. Base calculations on the volumes and flow rates shown in Table 1. All newly installed toilets, urinals, private lavatory faucets, and showerheads that are eligible for labeling must be WaterSense labeled (or a local equivalent for projects outside the U.S.).
	Table 1. Baseline water consumption of fixtures and fittings
	Projects located where standard supply pressure is different than the LEED baseline supply pressure may calculate the water consumption of flow fixtures and fittings at the local standard supply pressure; the supply pressure must be consistent in the baseline and proposed case.
Requirements	Table 1 (Points for reducing water use) show the number of points awarded per percentage reduction reached
Documents	Cutsheets for all fixtures and fittings installed in the project
	Option 1. Prescriptive achievement
	Table: Prescriptive
	Option 2. Usage-Based Calculation
	Completed Indoor Water Use Calculator
	Alternative water system design drawings, a narrative describing the alternative source, and calculations confirming the alternative water quantity. Include climate data and storage size/use calculations. Note alternative water use for irrigation or other purposes and the corresponding prerequisite/credit submittal(s) (i.e. WE Prerequisite/Credit Outdoor Water Use). The sum total of all alternative water use across all water-consuming systems must not exceed system production.
Appliance and Process Water Use	
Pre-Requirements	Install appliances, equipment, and processes within the project scope that meet the requirements listed in the tables below. Existing appliances intended for reuse in the project are not required to meet the requirements in Table 2.
	Table 2. Standards for appliances
	Table 3. Standards for processes
Requirements	Install equipment within the project scope that meets the minimum requirements in Table 2, 3, 4, or 5 . One point is awarded for meeting all applicable requirements in any one table. All applicable equipment listed in each table must meet the standard. Schools, Retail, and Healthcare projects can earn a second point for meeting the requirements of two tables.
	Table 2. Compliant commercial washing machines
	Table 3. Standards for commercial kitchen equipment
	Table 4. Compliant laboratory and medical equipment
	Table 5. Compliant municipal steam systems
Documents	Table: Appliances
	Table: Process water
	Cutsheets documenting compliance with the appliance and process water requirements

Prerequisite 3	Building-Level Water Metering
Intent	To support water management and identify opportunities for additional water savings by tracking water consumption.
Requirements	Install permanent water meters that measure the total potable water use for the building and associated grounds. Meter data must be compiled into monthly and annual summaries; meter readings can be manual or automated. Commit to sharing with USGBC the resulting whole-project water usage data for a 5-year period beginning on the date the project accepts LEED certification or typical occupancy, whichever comes first. This commitment must carry forward for 5 years or until the building changes ownership or lessee.
Documents	Letter from the project owner committing to share water usage data, compiled into monthly and annual summaries, with USGBC for a five-year period beginning on the date of LEED certification or when the project reaches typical occupancy, whichever comes first.
	Select the data source used:
	USGBC-approved data template. The project owner commits to providing water consumption data to USGBC and acknowledges that USGBC will only accept the data using ENERGY STAR's Portfolio Manager import facility data templates.
	Third-party data source. The project owner commits to providing water consumption data to USGBC and acknowledges that USGBC will only accept the data in an approved third-party source or format.

Credit 3	Cooling Tower and Process Water Use
Intent	To conserve water used for mechanical processes and cooling tower makeup while controlling microbes, corrosion, and scale in the condenser water system
# points	Up to 2 points
Requirements	Reduce outdoor water use through one of the following options. Nonvegetated surfaces, such as permeable or impermeable pavement, should be excluded from landscape area calculations. Athletic fields and playgrounds (if vegetated) and food gardens may be included or excluded at the project team's discretion.
Option 1. Cooling Tower Water Use (1-2 points)	
Requirements	For cooling towers and evaporative condensers, conduct a one-time potable water analysis, measuring at least the five control parameters listed in Table 1.
	Table 1. Maximum concentrations for parameters in condenser water
	Calculate the maximum number of cooling tower cycles by dividing the maximum allowed concentration level of each parameter by the actual concentration level of each parameter found in the potable makeup water analysis. Limit cooling tower cycles to avoid exceeding maximum values for any of these parameters.
	Table 2. Points for cooling tower cycles
	Minimum percentage recycled nonpotable water used in cooling tower makeup should be based on water use during the month with the highest demand for make-up water. Projects whose cooling is provided by district cooling systems are eligible to achieve Option 1 if the district cooling system complies with the above requirements
Documents	Table: Potable water analysis
	Number of cycles designed for project cooling tower(s) and if the number of cycles designed for the project cooling tower(s) exceeds the level calculated in Table: Potable water analysis, description of the treatment strategy used to maintain the appropriate levels of concentration and the method for removing or preventing deposit build-up. (Optional)
	For projects pursuing 1 additional point: Indicate which strategy was pursued
	Narrative describing the methodology that was used to conduct the potable water analysis and the location where the potable water was measured. OR, upload the results of the analysis done by the project team or municipality. Highlight the parameters identified in Table: Potable water analysis. If using at least 20% nonpotable water, upload the nonpotable water calculations and a description of the nonpotable source and the water analysis conducted and/or treatment strategy used to maintain the appropriate levels of concentration.
Option 2. No Cooling Tower (2 points)	
Requirements	For projects without cooling towers or evaporative condensers, projects may earn full credit if all conditions are met: the baseline system designated for the building using ASHRAE 90.1-2016 Appendix G Table G3.1.1 includes a cooling tower (systems 7 & 8)
	- the project design case does not include a cooling tower
	- the design case mechanical system does not use the latent heat of the evaporative cooling of water.
	- the project does not receive any cooling from a District cooling system
	All other system types are ineligible for credit.
Documents	Documentation showing that project is designated as systems 7 or 8 under ASHRAE 90.1-2016 Table G3.1.1
	Site or mechanical systems plan, energy model or other showing project design
Option 3. Process Water Use (1-2 points)	
Requirements	Demonstrate that the project is using minimum 20% recycled alternative water to meet process water demand for 1 point, or using minimum 30% recycled alternative water to meet process water demand for 2 points. Ensure that recycled alternative water is of sufficient quality for its intended end use. Minimum percentage of recycled alternative water used should be based on water use during the month with the highest water demand. Process water uses eligible for achievement of Option 3 must represent at least 10% of total building water use. Eligible subsystems may include:
	- Boilers
	- Humidification systems
	- Other subsystems using process water
	Projects whose cooling is provided by district cooling systems are eligible to achieve Option 3 if the district cooling system complies with minimum thresholds for recycled alternative water use.
Documents	Description of the process water subsystem and the recycled alternative water source being used to meet process water demand
	Site or mechanical systems plan, energy model or other showing project design
	Water subsystem monthly demand calculations
	Recycled alternative water source quantity calculations and plumbing drawings/schematics of the alternative water system
	Documentation that the municipality has agreed to supply the volume of recycled alternative water claimed by the project (for municipally supplied alternative water only)
	Manufacturer information for water subsystem

Credit 4	Water Metering
Intent	To support water management and identify opportunities for additional water savings by tracking water consumption.
# points	1 point
Requirements	Install permanent water meters for two or more of the following water subsystems, as applicable to the project:
	- Irrigation. Meter water systems serving at least 80% of the irrigated landscaped area. Calculate the percentage of irrigated landscape area served as the total metered irrigated landscape area divided by the total irrigated landscape area. Landscape areas fully covered with xeriscaping or native vegetation that requires no routine irrigation may be excluded from the calculation.
	- Indoor plumbing fixtures and fittings. Meter water systems serving at least 80% of the indoor fixtures and fitting described in WE Prerequisite Indoor Water Use Reduction, either directly or by deducting all other measured water use from the measured total water consumption of the building and grounds.
	- Domestic hot water. Meter water use of at least 80% of the installed domestic hot water heating capacity (including both tanks and on-demand heaters).
	- Boiler with aggregate projected annual water use of 378 500 L or more, or boiler of more than 150 kW. A single makeup meter may record flows for multiple boilers.
	- Reclaimed water. Meter reclaimed water, regardless of rate. A reclaimed water system with a makeup water connection must also be metered so that the true reclaimed water component can be determined.
	- Other process water. Meter at least 80% of expected daily water consumption for process end uses, such as humidification systems, dishwashers, clothes washers, pools, and other subsystems using process water.
Documents	Description of the submeters. Include a list of submeters, their locations, and the percentage of each subsystem metered (as applicable).

Energy and Atmosphere

Prerequisite 1	Fundamental Commissioning and Verification
Intent	To support the design, construction, and eventual operation of a project that meets the owner's project requirements for energy, water, indoor environmental quality, and durability.
Commissioning Process Scope	
Requirements	Complete the following commissioning (Cx) process activities for mechanical, electrical, plumbing, and renewable energy systems and assemblies, in accordance with ASHRAE Guideline 0-2013 and ASHRAE Guideline 1.1–2007 for HVAC&R Systems, as they relate to energy, water, indoor environmental quality, and durability.
	Develop the OPR
	Develop a BOD.
	The commissioning authority (CxA) must do the following:
	Review the OPR, BOD, and project design.
	Develop and implement a Cx plan.
	Confirm incorporation of Cx requirements into the construction documents.
	Develop construction checklists.
	Develop a system test procedure.
	Verify system test execution
	Maintain an issues and benefits log throughout the Cx process.
	Prepare a final Cx process report.
	Document all findings and recommendations and report directly to the owner throughout the process.
	Requirements for exterior enclosures are limited to inclusion in the owner's project requirements (OPR) and basis of design (BOD), as well as the review of the OPR, BOD and project design. ASTM E2947-16: Standard Guide for Building Enclosure Commissioning provides additional guidance. The review of the exterior enclosure design may be performed by a qualified independent member of the design or construction team (or an employee of that firm) who is not directly responsible for design of the building enclosure for the project.
Documents	Commissioning Scope
	Table: Commissioning systems scope
	If N/A was selected for any of the subsystems in the table above, explain why the subsystem is not applicable to the commissioning scope. If all subsystems are included, enter "N/A" below.
	Table of contents for the commissioning plan. The plan should include a commissioning program overview and information on the commissioning team and process activities
	At least one complete functional performance test for each of the applicable systems indicated in Table: Commissioning systems scope (mechanical, electrical, plumbing, and renewable energy).
	Tables of contents for the current facilities requirements and operations and maintenance (O&M) plan. Confirm that all sections listed in the credit requirements have been included.
	Executive summary of the commissioning report that includes a list of systems commissioned (and by whom), a summary of issues corrected, and a list of major outstanding/unresolved issues.
Commissioning Authority Qualifications	
Requirements	By the end of the design development phase, engage a commissioning authority with the following qualifications.
	The CxA must have documented commissioning process experience on at least two building projects with a similar scope of work. The experience must extend from early design phase through at least 10 months of occupancy;
	The CxA may be a qualified employee of the owner, an independent consultant, or an employee of the design or construction firm who is not part of the project's design or construction team, or a disinterested subcontractor of the design or construction team.
	For projects smaller than 20,000 square feet (1 860 square meters), the CxA may be a qualified member of the design or construction team. In all cases, the CxA must report his or her findings directly to the owner.
	Project teams that intend to pursue EA Credit Enhanced Commissioning should note a difference in the CxA qualifications: for the credit, the CxA may not be an employee of the design or construction firm nor a subcontractor to the construction firm.
Documents	Commissioning Authority: documentation demonstrating the commissioning authority's appropriate project experience for at least two similar projects of comparable size. Include the individual's name, certifications, company, and any other relevant information.
	Owner's Project Requirements: Indicate if the owner's project requirements (OPR) include the following elements, at a minimum:
	Owner and user requirements
	Environmental and sustainability goals
	Energy efficiency goals
	Indoor environmental quality requirements
	Equipment and system expectations
	Building occupant operations and maintenance personnel requirements
	Building envelope requirements
	Owner's Project Requirements: Indicate if the owner's project requirements (OPR) include the following elements, at a minimum:
	Specific codes, standards, and guidelines considered during design
	Information regarding ambient conditions
	Usage assumptions
	Operations and maintenance assumptions
	Performance criteria from OPR
	Design and operations narratives
	Equipment make and model used as basis of drawings and specifications
	Envelope design criteria
	Commissioning Activities: Indicate if the commissioning authority (CxA) has completed the following tasks for all mechanical, electrical, plumbing, and renewable energy systems:
	Developed and implemented a commissioning plan
	Confirmed incorporation of commissioning requirements into the construction documents
	Developed construction checklists
	Developed a system test procedure
	Verified system test execution
	Maintained an issues and benefits log throughout the commissioning process
	Prepared a final commissioning process report
	Documented all findings and recommendations and reported directly to the project owner throughout the process
	CxA Review: Information

Prerequisite 2	Minimum Energy Performance
Intent	To reduce the environmental and economic harms of excessive energy use by achieving a minimum level of energy efficiency for the building and its systems.
Requirements	Comply with ANSI/ASHRAE/IESNA Standard 90.1–2016, with errata or a USGBC-approved equivalent standard. ASHRAE 90.1-2016 Compliance pathways in Section 4.2.1.1 include compliance with all mandatory provisions, and compliance with one of the following:
	Prescriptive provisions of Sections 5 through 10
	Section 11 Energy Cost Budget Method
	Normative Appendix G Performance Rating Method. When using Appendix G, the Performance Cost Index (PCI) shall be less than or equal to the Performance Cost Index Target (PCIt) in accordance with the methodology provided in Section 4.2.1.1. Document the PCI, PCIt, and percentage improvement using metrics of cost or greenhouse gas (GHG) emissions.
For projects using Normative Appendix G Performance Rating Method:	
Requirements	Greenhouse gas emissions: The total greenhouse gas emissions, in terms of carbon dioxide equivalents, shall be calculated for the baseline building performance rating and for the proposed building performance rating, and the percentage improvement shall be determined using carbon dioxide equivalent emissions.
	International:
	use national grid mix coefficients from the International Energy Agency CO2 Emissions from Fuel Combustion 2017 report to calculate GHG emissions by energy source
	ISO 52000-1:2017: Greenhouse gas emission factors for each building energy source shall be determined consistently with ISO Standard 52000-1:2017 and published for the country or region where the project is located
	Exception to Mandatory Measures requirements: For ASHRAE 90.1-2016 mandatory controls provisions that are quantified in the Appendix G Performance Rating Method, (e.g. lighting occupancy sensor controls, lighting daylighting controls, automated receptacle controls, etc.), projects may model the Proposed Building Performance control parameters identically to the Baseline Building Performance control parameters in lieu of compliance with the mandatory provisions.
	Exceptional Calculations modeled in accordance with Section G2.5 may be modeled to document minimum prerequisite compliance
	Only on-site or on-campus renewable energy that meets ASHRAE Standard 90.1-2016 Section G 2.4.1 requirements for on-site renewable energy may be used to meet minimum ASHRAE Standard 90.1-2016 performance requirements
Documents	Option 1. Energy Performance Compliance (ASHRAE 90.1-2016 Appendix G Performance Rating Method)
	On-site renewable energy plans indicating location of renewable energy system, and relevant design details (e.g. PV module capacity, quantity, inverter capacity, tilt, orientation, etc. for a photovoltaic array), and confirming that the renewable energy is part of the project scope of work (or campus scope of work for a campus development).
	Energy modeling reports and provide the following reports for both the proposed and the 0 degree buildings.
	Simulation input summary reports:
	A sample of the wall, roof, floor, and window assembly inputs showing U-values and window SHGC, as well as the infiltration for a few representative spaces
	Sample lighting and plug load inputs for a few representative spaces
	Sample inputs at the thermal zone, system, and plant level (as applicable) for each system type, including the cooling, heating, fans, controls, outside air, and service water heating system
	Inputs for the utility tariffs, if there is a variance of at least 10% between the baseline and proposed virtual rates
	Inputs for the greenhouse gas emissions calculations, including emissions factors used
	Simulation output summary reports:
	Energy consumption by end use and fuel source
	Total energy consumption and cost by fuel source
	Total energy consumption and greenhouse gas emissions by fuel source
	Completed Minimum Energy Performance Calculation
	For projects pursuing EA Credit Grid Harmonization: On-peak electrical demand documentation: Provide the energy modeling output report that shows the on-peak electrical demand.
	Option 2. Prescriptive Compliance
	Documentation demonstrating compliance with ASHRAE 90.1-2016 mandatory measures and prescriptive measures.
	Option 3. Section 11 Energy Cost Budget Method Compliance
	Energy modeling reports and provide the following reports for both the proposed and the 0 degree buildings.
	Simulation input summary reports:
	A sample of the wall, roof, floor, and window assembly inputs showing U-values and window SHGC, as well as the infiltration for a few representative spaces
	Sample lighting and plug load inputs for a few representative spaces
	Sample inputs at the thermal zone, system, and plant level (as applicable) for each system type, including the cooling, heating, fans, controls, outside air, and service water heating system
	Inputs for the utility tariffs, if there is a variance of at least 10% between the baseline and proposed virtual rates
	Simulation output summary reports:
	Energy consumption by end use and fuel source
	Total energy consumption and cost by fuel source
	Documentation demonstrating compliance with ASHRAE 90.1-2016 Mandatory Measures and the ASHRAE 90.1-2016 Energy Cost Budget Method.

Prerequisite 3	Building-Level Energy Metering
Intent	To support energy management and identify opportunities for additional energy savings by tracking building-level energy use.
Requirements	Install new or use existing building-level energy meters, or submeters that can be aggregated to provide building-level data representing total building energy consumption (electricity, natural gas, chilled water, steam, fuel oil, propane, biomass, etc). Utility-owned meters capable of aggregating building-level resource use are acceptable. Commit to sharing with USGBC the resulting energy consumption data and electrical demand data (if metered) for a five-year period beginning on the date the project accepts LEED certification. At a minimum, energy consumption must be tracked at one-month intervals. This commitment must carry forward for five years or until the building changes ownership or lessee.
Documents	Letter from the project owner committing to share energy usage data, compiled into monthly and annual summaries, with USGBC for a five-year period beginning on the date of LEED certification or when the project reaches typical occupancy, whichever comes first.
	Select the data source used:
	USGBC-approved data template. The project owner commits to providing energy consumption data to USGBC and acknowledges that USGBC will only accept the data using ENERGY STAR's Portfolio Manager import facility data templates.
	Third-party data source. The project owner commits to providing energy consumption data to USGBC and acknowledges that USGBC will only accept the data in an approved third-party source or format.

Prerequisite 4	Fundamental Refrigerant Management
Intent	To reduce stratospheric ozone depletion.
Requirements	Do not use chlorofluorocarbon (CFC)-based refrigerants in new heating, ventilating, air-conditioning, and refrigeration (HVAC&R) systems. When reusing existing HVAC&R equipment, complete a comprehensive CFC phase-out conversion before project completion. Phase-out plans extending beyond the project completion date will be considered on their merits. Existing small HVAC&R units (defined as containing less than 225g of refrigerant) and other equipment, such as standard refrigerators, small water coolers, and any other equipment that contains less than 225g of refrigerant, are exempt.
Documents	Letter from the project owner committing to share energy usage data, compiled into monthly and annual summaries, with USGBC for a five-year period beginning on the date of LEED certification or when the project reaches typical occupancy, whichever comes first.
	Indicate if USGBC-aproved data template or Third party data source

Credit 1	Enhanced Commissioning	
Intent	To further support the design, construction, and eventual operation of a project that meets the owner's project requirements for energy, water, indoor environmental quality, and durability.	
# points	Up to 6 pionts	
Requirements	Implement, or have in place a contract to implement, the following commissioning process activities in addition to those required under EA Prerequisite Fundamental Commissioning and Verification. Commissioning Authority Qualifications:	
	The CxA must have documented commissioning process experience on at least two building projects with a similar scope of work. The experience must extend from early design phase through at least 10 months of occupancy;	
	The CxA may be a qualified employee of the owner, an independent consultant, or a disinterested subcontractor of the design team.	
Option 1. Enhanced Systems Commissioning (3-4 points)		
Requirements	Path 1. Enhanced Commissioning (3 points)	
	Complete the following commissioning process (CxP) activities for mechanical, electrical, plumbing, and renewable energy systems and assemblies in accordance with ASHRAE Guideline 0–2013 and ASHRAE Guideline 1.1–2007 for HVAC&R systems, as they relate to energy, water, indoor environmental quality, and durability. The commissioning authority must do the following:	
		Review contractor submittals.
		Verify inclusion of systems manual requirements in construction documents.
		Verify inclusion of operator and occupant training requirements in construction documents.
		Verify systems manual updates and delivery.
		Verify operator and occupant training delivery and effectiveness.
		Verify seasonal testing.
		Review building operations 10 months after substantial completion.
		Develop an on-going commissioning plan.
	Include all enhanced commissioning tasks in the OPR and BOD	
Documents	Documentation demonstrating the commissioning authority's appropriate project experience for at least two similar projects of comparable size. Include the individual's name, certifications, company, and any other relevant information.	
	Indicate that the commissioning authority has completed the following tasks for all mechanical, electrical, plumbing, and renewable energy systems:	
		Reviewed contractor submittals
		Verified inclusion of systems manual and operator and occupant training requirements in the construction documents
		Verified systems manual updates and delivery
		Verified operator and occupant training and delivery
		Verified seasonal testing
		Reviewed or is scheduled to review building operations 10 months after substantial completion
		Developed an ongoing commissioning plan
	Training plan and/or schedule for operator and occupant training, including planned participants and training scope, OR provide a narrative describing the operator and occupant training plan.	
	Table of contents for the ongoing commissioning plan	
Requirements	Path 2. Enhanced and Monitoring-Based Commissioning (4 points)	
	Achieve Path 1. AND Develop monitoring-based procedures and identify points to be measured and evaluated to assess performance of energy- and water-consuming systems. Include the procedures and measurement points in the commissioning plan. Address the following:	
		roles and responsibilities;
		measurement requirements (meters, points, metering systems, data access);
		the points to be tracked, with frequency and duration for trend monitoring;
		the limits of acceptable values for tracked points and metered values (where appropriate, predictive algorithms may be used to compare ideal values with actual values);
		the elements used to evaluate performance, including conflict between systems, out-of-sequence operation of systems components, and energy and water usage profiles;
		an action plan for identifying and correcting operational errors and deficiencies;
		training to prevent errors;
		planning for repairs needed to maintain performance; and
		the frequency of analyses in the first year of occupancy (at least quarterly).
	Update the systems manual with any modifications or new settings, and give the reason for any modifications from the original design	
Documents	Documentation demonstrating the commissioning authority's appropriate project experience for at least two similar projects of comparable size. Include the individual's name, certifications, company, and any other relevant information.	
	Indicate that the commissioning authority has completed the following tasks for all mechanical, electrical, plumbing, and renewable energy systems:	
		Reviewed contractor submittals
		Verified inclusion of systems manual and operator and occupant training requirements in the construction documents
		Verified systems manual updates and delivery
		Verified operator and occupant training and delivery
		Verified seasonal testing
		Reviewed or is scheduled to review building operations 10 months after substantial completion
		Developed an ongoing commissioning plan
	Training plan and/or schedule for operator and occupant training, including planned participants and training scope, OR provide a narrative describing the operator and occupant training plan.	
	Table of contents for the ongoing commissioning plan	
	Indicate that the commissioning plan addresses the following as they relate to monitoring-based procedures:	
		Roles and responsibilities
		Measurement requirements (meters, points, metering systems, data access)
		Points to be tracked, with frequency and duration for trend monitoring
		Limits of acceptable values for tracked points and metered values
		Elements used to evaluate performance
		Action plan for identifying and correcting operational errors and deficiencies
		Training to prevent errors
		Planning for repairs needed to maintain performance
		Frequency of analyses in the first year of occupancy (at least quarterly)
	List of measurement points to be tracked, including frequency and duration for trend monitoring	

Option 2. Building Enclosure Commissioning (2 points)	
Requirements	Fulfill the requirements in EA Prerequisite Fundamental Commissioning and Verification as they apply to the building's enclosure in addition to mechanical and electrical systems and assemblies. Complete the following commissioning process (CxP) activities for the building's thermal envelope in accordance with ASHRAE Guideline 0–2013 and ASTM E2947-16: Standard Guide for Building Enclosure Commissioning, as they relate to energy, air and water tightness, indoor environmental quality, and durability. The qualified independent member of the design or construction team responsible for building enclosure commissioning must complete the following:
	Review contractor submittals.
	Verify inclusion of systems manual requirements in construction documents for enclosure systems.
	For specialty enclosure systems with controls and automation
	Verify inclusion of operator and occupant training requirements in construction documents.
	Verify systems manual updates and delivery.
	Verify operator and occupant training delivery and effectiveness.
	Verify seasonal testing.
	Review building operations 10 months after substantial completion
	Develop an on-going enclosure commissioning plan for maintenance, renewal and revitalization cycles
Documents	Documentation demonstrating the commissioning authority's appropriate project experience for at least two similar projects of comparable size. Include the individual's name, certifications, company, and any other relevant information.
	Indicate if EA Prerequisite Fundamental Commissioning and Verification was completed for the building(s)'s enclosure in addition to all mechanical, electrical, plumbing, and renewable energy systems
	Indicate if the commissioning authority has completed the following tasks for the building(s)'s enclosure
	Reviewed contractor submittals
	Verified inclusion of systems manual and operator and occupant training requirements in the construction documents for enclosure systems
	Verified systems manual updates and delivery
	Verified operator and occupant training and delivery
	Verified seasonal testing
	Reviewed or is scheduled to review building operations 10 months after substantial completion
	Developed an ongoing enclosure commissioning plan for maintenance, renewal and revitalization cycles

Credit 2	Optimize Energy Performance
Intent	To achieve increasing levels of energy performance beyond the prerequisite standard to reduce environmental and economic harms associated with excessive energy use.
# points	Up to 18 points
Requirements	Analyze efficiency measures during the design process and account for the results in design decision making. Use energy simulation of efficiency opportunities, past energy simulation analyses for similar buildings, or published data (e.g., Advanced Energy Design Guides) from analyses for similar buildings. Analyze efficiency measures, focusing on load reduction and HVAC-related strategies (passive measures are acceptable) appropriate for the facility. Project potential energy savings and holistic project cost implications related to all affected systems. Choose one of the options below.
Option 1. Energy Performance Compliance (1-18 points)	
Requirements	Demonstrate a Performance Cost Index (PCI)1 below the Performance Cost Index Target (PCIt) calculated in accordance with Section 4.2.1.1 of ANSI/ASHRAE/IESNA Standard 90.1-2016, Appendix G, Table 4.2.1.1. For mixed use buildings, the required PCI shall be calculated by using an area weighted average of the building types. Calculate the PCI, PCIt, and percentage improvement using metrics of cost and greenhouse gas (GHG) emissions. For each energy source serving the building, the GHG emission factors must be identical for the Baseline and Proposed building models. LEED points are calculated based on the project percent improvement PCI below the PCIt using metrics of cost and GHG emissions. Total points have been divided equally between the metrics of energy cost and greenhouse gas emissions. Points are awarded according to Table 1 and Table 2. For project percent improvement for the cost metric, on-site renewable energy may be subtracted from proposed energy cost prior to calculating proposed building performance per ASHRAE Standard 90.1-2016 Section G 2.4.1.
	Table 1. Points for percentage improvement in energy performance – % Cost PCI below PCIt
	Table 2. Points for percentage improvement in energy performance – % Greenhouse Gas Emissions PCI below PCIt
Documents	On-site renewable energy plans indicating location of renewable energy system, and relevant design details (e.g. PV module capacity, quantity, inverter capacity, tilt, orientation, etc. for a photovoltaic array), and confirming that the renewable energy is part of the project scope of work (or campus scope of work for a campus development).
	Energy modeling reports and provide the following reports for both the proposed and the 0 degree buildings.
	Simulation input summary reports:
	A sample of the wall, roof, floor, and window assembly inputs showing U-values and window SHGC, as well as the infiltration for a few representative spaces
	Sample lighting and plug load inputs for a few representative spaces
	Sample inputs at the thermal zone, system, and plant level (as applicable) for each system type, including the cooling, heating, fans, controls, outside air, and service water heating system
	Inputs for the utility tariffs, if there is a variance of at least 10% between the baseline and proposed virtual rates
	Inputs for the greenhouse gas emissions calculations, including emissions factors used
	Simulation output summary reports:
	Energy consumption by end use and fuel source
	Total energy consumption and cost by fuel source
	Total energy consumption and greenhouse gas emissions by fuel source
	Completed Minimum Energy Performance Calculator

Option 2. Prescriptive Compliance: ASHRAE Advanced Energy Design Guide (1-6 points)	
Requirements	Projects must meet the Scope requirements of the applicable AEDGs and must use the ASHRAE 90.1-2016. Implement and document compliance with the applicable recommendations and standards in Chapter 4, Design Strategies and Recommendations by Climate Zone, for the appropriate ASHRAE 50% Advanced Energy Design Guide and climate zone.
	ASHRAE 50% Advanced Energy Design Guide for Small to Medium Office Buildings
	Building envelope: roofs, walls, floors, slabs, doors, continuous air barriers, and vertical fenestration
	Interior and exterior lighting, including daylighting and interior finishes
	Plug loads, including equipment and controls
	HVAC Systems and Controls
	ASHRAE 50% Advanced Energy Design Guide for Medium to Large Box Retail Buildings
	Building envelope: roofs, walls, floors, slabs, doors, vestibules and fenestration – all orientations (1 point)
	Interior and exterior lighting, excluding lighting power density for sales floor (1 point).
	Additional interior lighting for sales floor (1 point)
	Plug loads, including equipment choices and controls (1 point)
	HVAC efficiency and control requirements (2 points)
	ASHRAE 50% Advanced Energy Design Guide for K–12 School Buildings
	Building envelope: roofs, walls, floors, slabs, doors and vertical fenestration (1 point)
	Interior and exterior lighting, including daylighting and interior finishes (1 point)
	Plug loads, including equipment choices, controls, and kitchen equipment (2 points)
	HVAC efficiency and control requirements (2 points)
	ASHRAE 50% Advanced Energy Design Guide for Large Hospitals
	Building envelope: roofs, walls, floors, slabs, doors, vestibules, continuous air barriers, and vertical fenestration (1 point)
	Interior and exterior lighting, including daylighting (form or nonform driven) and interior finishes (1 point).
	Plug loads, including equipment choices, controls, and kitchen equipment (1 point)
	HVAC and Service Water Heating Systems and Equipment (2 points)
	ASHRAE 50% Advanced Energy Design Guide for Grocery Stores
	Building envelope: roofs, walls, floors, slabs, doors, vestibules, continuous air barriers, and vertical fenestration (1 point)
	Interior and exterior lighting, including sales floor (1 points)
	Refrigeration, Plug, and Process loads, including equipment choices and controls (2 points)
	HVAC efficiency and control requirements (1 point)
Documents	Documentation demonstrating compliance with ASHRAE 90.1-2016 mandatory measures and prescriptive measures.
Option 3. Systems Optimization (1-4 points)	
Requirements	Projects must use the ASHRAE 90.1-2016 and must not have more than 2,000feet^2 of data center space, laboratory space, or manufacturing space. Demonstrate an improvement beyond ASHRAE/ASHRAE/IESNA Standard 90.1–2016, with errata, for the following systems:
	Interior and Exterior Lighting (see values)
	Daylight controls: Install daylight-responsive controls for a given percentage of connected lighting load (see values)
	Building envelope: (see values depending on climate zone)
	HVAC and Service Water Heating Equipment Efficiency (see values for different systems)
	Electric resistance heating except heat pump auxiliary heat must be included in total capacity.
	Equipment and Appliances: Install a percentage (by rated power) of eligible equipment and appliances meeting the following requirements
	ENERGY STAR equipment including appliances, office equipment, electronics, and commercial food service equipment (lighting and building envelope products are excluded from this credit). (Electronic Product Environmental Assessment Tool (EPEAT) equipment may be used in lieu of Energy Star equipment where applicable).
	Prescriptive commercial kitchen and refrigeration equipment requirements listed in Appendix 3, Table 1.
	The project scope of work must include at least 0.25 Watts per square foot of eligible equipment to apply this strategy.
	Percent of Eligible Equipment Installed by Rated Power (see percentage)
Documents	Energy modeling reports and provide the following reports for both the proposed and the 0 degree buildings.
	Simulation input summary reports:
	A sample of the wall, roof, floor, and window assembly inputs showing U-values and window SHGC, as well as the infiltration for a few representative spaces
	Sample lighting and plug load inputs for a few representative spaces
	Sample inputs at the thermal zone, system, and plant level (as applicable) for each system type, including the cooling, heating, fans, controls, outside air, and service water heating system
	Inputs for the utility tariffs, if there is a variance of at least 10% between the baseline and proposed virtual rates
	Simulation output summary reports:
	Energy consumption by end use and fuel source
	Total energy consumption and cost by fuel source
	Documentation demonstrating compliance with ASHRAE 90.1-2016 Mandatory Measures and the ASHRAE 90.1-2016 Energy Cost Budget Method.

Credit 3	Advanced Energy Metering
Intent	To support energy management and identify opportunities for additional energy savings by tracking building-level and system-level energy use.
# points	1 point
Requirements	Install advanced energy metering for the following:
	all whole-building energy sources used by the building;
	any individual energy end uses that represent 10% or more of the total annual consumption of the building
	The advanced energy metering must have the following characteristics.
	Meters must be permanently installed, record at intervals of one hour or less, and transmit data to a remote location.
	Electricity meters must record both consumption and demand. Whole-building electricity meters should record the power factor, if appropriate.
	The data collection system must use a local area network, building automation system, wireless network, or comparable communication infrastructure.
	The system must be capable of storing all meter data for at least 36 months.
	The data must be remotely accessible.
	All meters in the system must be capable of reporting hourly, daily, monthly, and annual energy use.
Documents	Table: Advanced meters
	Cutsheets for meters that clearly indicate the following information:
	Recording interval
	Ability to record both consumption and demand (for electrical meters)
	Data transmission capability
	Data collections system description and storage capability
	Remote data retrieval capability

Credit 4	Grid Harmonization
Intent	To increase participation in demand response technologies and programs that make energy generation and distribution systems more efficient, increase grid reliability, and reduce greenhouse gas emissions.
# points	Up to 2 points
Requirement	Design building and equipment for participation in demand response programs through load shedding or shifting. On-site electricity generation does not meet the intent of this credit.
Case 1. Demand Response Program Available and Participation (2 points)	
Requirements	Participate in an existing demand response (DR) program and complete the following activities. Design a system with the capability for real-time, fully-automated DR based on external initiation by a DR Program Provider. Semi-automated DR may be utilized in practice.
	Enroll in a minimum one-year DR participation amount contractual commitment with a qualified DR program provider, with the intention of multiyear renewal, for at least 10% of the annual on-peak electricity demand. On-peak demand is determined under EA Prerequisite Minimum Energy Performance. The on-peak demand may vary based on the utility climate and pricing structures.
	Develop a comprehensive plan for meeting the contractual commitment during a Demand Response event.
	Include the DR processes in the scope of work for the commissioning authority, including participation in at least one full test of the DR plan.
	Include the DR program and any installed technologies in the building systems manual or include in the current facilities requirements and operations and maintenance plan if the project is not pursuing EA credit Enhanced Commissioning.
	Initiate at least one full test of the DR plan.
Documents	Comprehensive action plan for meeting a demand response event. Ensure that the plan includes roles, responsibilities, expectations, and descriptions of end-use systems impacted
	At least one full test of the demand response plan, demonstrating that the full contractual amount can be met
	Proof of enrollment in a demand response participation amount contractual commitment. Highlight the notification process, monitoring requirements, enrollment period, contract amount, and renewal options.
	Evidence of the project's ability to shed at least 10% of peak electricity demand, or indicate in the Special Circumstances narrative the relevant upload where this information has been reported. For projects not pursuing the EA Prerequisite Minimum Energy Performance, Option 1, Energy Performance path, include a description of how the peak electric demand and peak electric demand reduction during an event were calculated.
Case 2. Demand Response Capable Building (1 point)	
Requirements	Have infrastructure in place to take advantage of future demand response programs or dynamic, real-time pricing programs and complete the following activities:
	Install interval recording meters with communications and ability for the building automation system to accept an external price or control signal.
	Develop a comprehensive plan for shedding at least 10% of the annual on-peak electricity demand. On-peak demand is determined under EA Prerequisite Minimum Energy Performance.
	Include the DR processes in the scope of work for the commissioning authority, including participation in at least one full test of the DR plan.
	Include the DR program and any installed technologies in the building systems manual or include in the current facilities requirements and operations and maintenance plan if the project is not pursuing EA credit Enhanced Commissioning.
	Contact local utility representatives to discuss participation in future DR programs.
Documents	Comprehensive action plan for meeting a demand response event. Ensure that the plan includes roles, responsibilities, expectations, and descriptions of end-use systems impacted.
	At least one full test of the demand response plan as part of the building commissioning program
	Evidence of the project's ability to shed at least 10% of peak electricity demand, or indicate in the Special Circumstances narrative the relevant upload where this information has been reported. For projects not pursuing the EA Prerequisite Minimum Energy Performance, Option 1, Energy Performance path, include a description of how the peak electric demand and peak electric demand reduction during an event were calculated.
Case 3. Load Flexibility and Management Strategies (1-2 points)	
Requirements	Analyze the building's annual load shape and peak load based as calculated for EA prerequisite Minimum Energy Performance. Review the regional grid load profile using the metric of peak load or peak carbon emissions. The U.S. Environmental Protection Agency's (EPA) AVoided Emissions and geneRation Tool (AVERT) provides regional grid emissions data; local utilities may also provide this data. Coordinate review of building load shape and peak load with review of the regional grid profile to identify the best value load management strategies that the building can provide. Implement one or more of the load flexibility and management strategies described below for a maximum of up to two points. All projects must install interval recording meters with communications and the ability for the building automation system to accept an external price signal. Load Flexibility and Management Strategies:
	Peak Load Optimization: demonstrate that strategy reduces on-peak load by at least 10% as compared to peak electrical demand (1 point)
	Flexible Operating Scenarios: demonstrate that strategy moves at least 10% of peak load by a time period of 2 hours (1 point)
	On-site thermal and/or electricity storage: demonstrate that strategy reduces on-peak load by at least 10% as compared to peak electrical demand (1 point)
	Grid resilience technologies: project served by utilities with resilience programs in place, which leverage strategies such as islanding and part-load operation, automatically achieve this credit (1 point)
	Include installed technology in the scope of work for the commissioning authority. Include load flexibility and management strategies and installed technologies in the building systems manual or include in the current facilities requirements and operations and maintenance plan if the project is not pursuing EA credit Enhanced Commissioning. Contact local utility representatives to discuss participation in future DR programs and to inform utility of building load flexibility and management strategies.
Documents	For all strategies except Grid Resilience Technologies, narrative or report and energy simulation summary that includes a summary of building annual load shape and regional grid profile analysis, and a description of the building load flexibility and/or management strategies implemented. Include sufficient detail to confirm the peak electric demand prior to applying the strategies for an ASHRAE 90.1-2016 Appendix G compliant design, and to confirm at least 10% of on-peak electric demand reduced or shifted as a result of the strategy.
	Documentation of grid resilience program or technologies serving the project.

Credit 5	Renewable Energy
Intent	To reduce the environmental and economic harms associated with fossil fuel energy and reduce greenhouse gas emissions by increasing the supply of renewable energy and carbon mitigation projects.
# points	Up to 5 points
Requirements	Use on-site renewable energy systems, procure renewable energy from offsite sources, or offset the greenhouse gas emissions from all or a portion of the building's annual building energy use. Renewable Energy Choose one or more strategies for renewable energy procurement from the categories below. Points achieved in each category may be added for a total of 5 points.
	Tier 1: On-site renewable energy generation
	Tier 2: Off-site renewable energy produced by a generation asset(s) built within the last 5 years, or contracted to be operational within one year of building occupancy, and generated by either:
	an asset(s) in the project's grid subregion
	an asset(s) in a grid subregion with higher greenhouse gas emissions rates
	Tier 3: Off-site renewable energy that is produced by a generation asset(s) built within the last 5 years or contracted to be operational within one year of building occupancy
	Tier 4: Off-site renewable energy that is Green-e Energy certified or equivalent
	Tier 5: Off-site renewable energy that is produced by a generation asset(s) that meet Green-e's certification criteria (or equivalent) for eligible renewables, has a mechanism to prevent double counting in place, and is third-party certified to an ecolabel standard.

Documents	LEED Renewable Energy Calculator summarizing the renewable energy procurement for the project.
	Tier 1 to 5 systems, as applicable (not required for Tier 4 and 5 unbundled EAcs): Narrative that describes each on-site renewable system and off-site renewable system, and explanation the calculation method used to estimate the annual energy generated for each system. Indicate any factors influencing performance (e.g., DC-to-AC derate factor, tilt, orientation, and adjacent shading structures for photovoltaic arrays). Include screen shots or printouts of the calculation summary results (e.g. PV Watts Calculator results).
	On-site Renewable Energy Systems and Off-site Renewable Energy Systems - Contract and evidence of renewable attribute ownership:
	For each on-site renewable system, confirmation of renewable attribute ownership if the on-site renewable energy system is owned by the building owner; or executed contract indicating duration and renewable attribute ownership if the on-site system is owned by a third party.
	For Tier 2 through 5 off-site renewable procurement (with the exception of Tier 4 and 5 unbundled EAcs), executed contract indicating the annual energy generation allocated to the project or building owner, contract duration consistent with the information provided in the LEED Renewable Energy Calculator, and evidence of renewable attribute ownership for the duration of the contract. For Tier 2 and Tier 3 renewable procurement, the contract must indicate the specific location of the new off-site system(s). The contract must show that the system was built within the last 5 years, or has been contracted specifically for the building project (or portfolio of building projects or tenant improvement spaces) to be operational within one year of building occupancy. The contract must confirm Green-e certification as applicable, or a supporting narrative must describe the methodology for tracking and retiring EACs.
	Tier 4 and 5 unbundled Energy Attribute Certificates and Carbon Offsets:
	Provide a purchase letter or executed contract of commitment showing renewable electricity, EACs, or carbon offsets for targeted point thresholds.
	If procuring unbundled EACs that are certified by an eco-label that is not Green-e, upload documentation that demonstrates the renewable energy meets Green-e certification criteria for eligible renewables, and that the eco-label has a mechanism to prevent double counting in place.
	Table 1. Renewable Energy Procurement
	Table 2. Carbon Offset Procurement

Credit 6	Enhanced Refrigerant Management
Intent	To reduce ozone depletion and support early compliance with the Montreal Protocol while minimizing direct contributions to climate change.
# points	1 point
Option 1. No refrigerants or low-impact refrigerants (1 point)	
Requirements	Do not use refrigerants, or use only refrigerants (naturally occurring or synthetic) that have an ozone depletion potential (ODP) of zero and a global warming potential (GWP) of less than 50.
Documents	If low-impact refrigerants are used, provide the names of these refrigerants. If no refrigerants are used, description of why no refrigerants are needed
Option 2. Calculation of refrigerant impact (1 point)	
Requirements	Select refrigerants that are used in heating, ventilating, air-conditioning, and refrigeration (HVAC&R) equipment to minimize or eliminate the emission of compounds that contribute to ozone depletion and climate change. The combination of all new and existing base building and tenant HVAC&R equipment that serve the project must comply with a formula detailed in the book
Documents	Table: Mechanical Cooling and Refrigeration Equipment
	For projects with variable refrigerant flow (VRF) systems: Supporting documentation for how the refrigerant charge value for the VRF system(s) was calculated.
	For projects with commercial refrigeration systems:
	Indicate if the project has attained GreenChill's silver-level certification for newly constructed stores OR meets the following requirements:
	Average HFC refrigerant charge is no more than 1.75 lb of refrigerant per 1,000 BTU/h (2.72 g of refrigerant per kW) total evaporator cooling load.
	Predicted project-wide annual refrigerant emissions rate is no more than 15%.
	Leak testing has been conducted using the procedures in GreenChill's best practices guideline for leak tightness at installation.
	Refrigerant equipment schedule and leak test results OR proof of attainment of GreenChill's silver-level store certification for newly constructed stores

Materials and Resources

Prerequisite 1	Storage and Collection of Recyclables
Intent	To reduce the waste that is generated by building occupants and hauled to and disposed of in landfills.
Requirements	Provide dedicated areas accessible to waste haulers and building occupants for the collection and storage of recyclable materials for the entire building. Collection and storage areas may be separate locations. Recyclable materials must include mixed paper, corrugated cardboard, glass, plastics, and metals. Take appropriate measures for the safe collection, storage, and disposal of two of the following: batteries, mercury-containing lamps, and electronic waste.
Documents	Description of the dedicated recycling storage areas for the project. Include the size of the areas, accessibility, and expected volume for the project. Demonstrate that the recycling storage areas are appropriately sized and located. Demonstrate that safe storage and collection has been provided for batteries, mercury-containing lamps, and/or e-waste
	Floor plan(s) highlighting the recycling storage areas in the project and select online the recycling storage areas

Prerequisite 2	Construction and Demolition Waste Management Planning
Intent	To reduce construction and demolition waste disposed of in landfills and incineration facilities by recovering, reusing, and recycling materials.
Requirements	Develop and implement a construction and demolition waste management plan:
	Establish waste diversion goals for the project by identifying at least five materials (both structural and nonstructural) targeted for diversion.
	Specify whether materials will be separated or comingled and describe the diversion strategies planned for the project. Describe where the material will be taken and how the recycling facility will process the material including expected diversion rates for each material stream.
	Provide a final report detailing all major waste streams generated, including disposal and diversion rates. Alternative daily cover (ADC) does not qualify as material diverted from disposal. Include materials destined for ADC in the calculations as waste. Land-clearing debris is not considered construction, demolition, or renovation waste that can contribute to waste diversion.
Documents	General information about construction waste
	Construction and demolition waste management plan. The plan must outline at least 5 materials targeted for diversion, Specify whether materials will be separated or commingled and describe the diversion strategies planned for the project. Describe where the material will be taken and, for those materials sent for recycling, how the recycling facility will process the material including expected diversion rates. Indicate any commingled recycling facilities used that have third party verification of recycling rates.

Credit 1	Building Life-Cycle Impact Reduction
Intent	To encourage adaptive reuse and optimize the environmental performance of products and materials.
# points	Up to 5 points
Requirement	Demonstrate reduced environmental effects during initial project decision-making by reusing existing building resources or demonstrating a reduction in materials use through life-cycle assessment. Achieve one of the following options.
Option 1. Historic Building Reuse (5 points)	
Requirements	Maintain the existing building structure, envelope, and interior nonstructural elements of a historic building or contributing building in a historic district. To qualify, the building or historic district must be listed or eligible for listing in the local, state, or national register of historic places. Do not demolish any part of a historic building or contributing building in a historic district unless it is deemed structurally unsound or hazardous. For buildings listed locally, approval of any demolition must be granted by the local historic preservation review board. For buildings listed in a state register or the U.S. National Register of Historic Places (or local equivalent for projects outside the U.S.), approval must appear in a programmatic agreement with the state historic preservation office or National Park Service (or local equivalent for projects outside the U.S.).
	Any alteration (preservation, restoration, or rehabilitation) of a historic building or a contributing building in a historic district on the project site must be done in accordance with local or national standards for rehabilitation, whichever are applicable. If building is not subject to historic review, include on the project team a preservation professional who meets U.S. federal qualifications for historic architects (or local equivalent for projects outside the U.S.); the preservation professional must confirm conformance to the Secretary of Interior's Standards for the Treatment of Historic Properties (or local equivalent for projects outside the U.S.).
Documents	If any portion of the historic building will be demolished because of hazardous or unsound structure, provide the following information:
	The portion(s) of the building to be demolished
	How the portions are designated hazardous or structurally unsound
	What strategies are being implemented to mitigate negative effects on the rest of the building
Option 2. Renovation of Abandoned or Blighted Building (5 points)	
Requirements	Maintain at least 50%, by surface area, of the existing building structure, enclosure, and interior structural elements for buildings that meet local criteria of abandoned or are considered blight. The building must be renovated to a state of productive occupancy. Up to 25% of the building surface area may be excluded from credit calculation because of deterioration or damage.
Documents	Description of how the project building meets local municipal or government criteria of an abandoned building or a building considered blight.
	Table: Reused blighted building surface area
Option 3. Building and Material Reuse (1–4 points)	
Path 1	Materials contributing toward this credit may not contribute toward MR Credit Material Disclosure and Optimization – Sourcing of Raw Materials. Path 1 or Path 2 and/or Path 3 may be attempted but combining Path 1 and Path 2 or Path 1 and Path 3 to achieve points is not allowed.
	Path 1: Maintain A Combination Of Structural And Non-Structural Elements (2-4 points)
	Reuse or salvage building materials from off site or on site as a percentage of the surface area, as listed in Table 1. Include structural elements (e.g., floors, roof decking), enclosure materials (e.g., skin, framing), and permanently installed interior elements (e.g., walls, doors, floor coverings, ceiling systems). Exclude from the calculation window assemblies and any hazardous materials that are remediated as a part of the project.
	Table 1. Points for reuse of building materials
Document	Table: Reused building surface area
Path 2	Path 2: Maintain Existing Walls, Floors and Roofs (1-3 points):
	Maintain the existing building structure (including floor and roof decking) and envelope (the exterior skin and framing, excluding window assemblies and nonstructural roofing materials).
Documents	Description of the building reuse elements included in the project. Include a description of the systems or materials reused in-place, materials reused from other parts of the building, or materials from offsite (salvaged materials) incorporated into the project. Include structure, enclosure, and/or interior nonstructural elements as applicable.
	Table: Reused building surface area
Path 3	Path 3: Maintain Interior Nonstructural Elements (1 point)
	Use existing interior nonstructural elements (e.g. interior walls, doors, floor coverings and ceiling systems) in at least 33% (by area) of the completed building, including additions.
Documents	Description of the building reuse elements included in the project. Include a description of the systems or materials reused in-place, materials reused from other parts of the building, or materials from offsite (salvaged materials) incorporated into the project. Include structure, enclosure, and/or interior nonstructural elements as applicable.
	Table: Reused building surface area

Option 4. Whole-Building Life-Cycle Assessment (1-4 points)	
Requirements	For new construction (buildings or portions of buildings), conduct a life-cycle assessment of the project's structure and enclosure and select one or more of the following paths below to earn up to 4 points:
	Path 1: Conduct a life cycle assessment of the project's structure and enclosure (1 point).
	Path 2: Conduct a life cycle assessment of the project's structure and enclosure that demonstrates a minimum of 5% reduction, compared with a baseline building in at least three of the six impact categories listed below, one of which must be global warming potential (2 points).
	Path 3: Conduct a life cycle assessment of the project's structure and enclosure that demonstrates a minimum of 10% reduction, compared with a baseline building, in at least three of the six impact categories listed below, one of which must be global warming potential (3 points).
	Path 4: Meet requirements of Path 3 and incorporate building reuse and/or salvage materials into the project's structure and enclosure for the proposed design. Demonstrate reductions compared with a baseline building of at least 20% reduction for global warming potential and demonstrate at least 10% reduction in two additional impact categories listed below (4 points).
	For Paths 2, 3 and 4 listed above, no impact category assessed as part of the life-cycle assessment may increase by more than 5% compared with the baseline building. Include a narrative of how the life cycle assessment was conducted and if applicable for paths 2, 3 and 4 what changes were made to proposed buildings in order to achieve the related impact reductions.
	The baseline and proposed buildings must be of comparable size, function, orientation, and operating energy performance as defined in EA Prerequisite Minimum Energy Performance. The service life of the baseline and proposed buildings must be the same and at least 60 years to fully account for maintenance and replacement. Use the same life-cycle assessment software tools and data sets to evaluate both the baseline building and the proposed building, and report all listed impact categories. Data sets must be compliant with ISO 14044.
	Select at least three of the following impact categories for reduction:
	global warming potential (greenhouse gases), in kg CO2e;
	depletion of the stratospheric ozone layer, in kg CFC-11e;
	acidification of land and water sources, in moles H+ or kg SO2e;
	eutrophication, in kg nitrogen eq or kg phosphate eq;
	formation of tropospheric ozone, in kg NOx, kg O3 eq, or kg ethene; and
	depletion of nonrenewable energy resources, in MJ using CML / depletion of fossil fuels in TRACI.
	Europe ACP: Option 4 Whole Building Life-Cycle Assessment
	For European projects, EN standard 15978 may be used as framework for the Life-Cycle-Assessment instead of ISO 14044 for this credit. Where implementation of EN 15978 conflicts with any of requirements of this credit, the credit requirements prevail, including the life-cycle stages required and treatment of EPD data (See Further Explanation - Incorporation of EPD data in WBLCA Tools). Note that the CML indicators are acceptable per the Further Explanation section of the Reference Guide language of this credit. Projects will still need to meet the individual requirements of the pathway chosen for this credit option.
Documents	Indicate what life-cycle assessment the project has
	Table: Life-cycle assessment impact measures
	Various description depending on the path chosen

Credit 2	Building Product Disclosure and Optimization - Environmental Product Declarations
Intent	To encourage the use of products and materials for which life-cycle information is available and that have environmentally, economically, and socially preferable life-cycle impacts. To reward project teams for selecting products from manufacturers who have verified improved environmental life-cycle impacts.
# points	Up to 2 points
Option 1. Environmental Product Declaration (EPD) (1 point)	
Requirements	Use at least 20 different permanently installed products sourced from at least five different manufacturers that meet one of the disclosure criteria below.
	Life-cycle assessment and environmental product declarations
	Products with a publicly available, critically reviewed life-cycle assessment conforming to ISO 14044 that have at least a cradle to gate scope are valued as one whole product for the purposes of credit achievement calculation.
	Product-specific Type III EPD -- Internally Reviewed. Products with an internally critically reviewed LCA in accordance with ISO 14071. Products with product-specific internal EPDs which conform to ISO 14025, and EN 15804 or ISO 21930 and have at least a cradle to gate scope are valued as one whole product for the purposes of credit achievement calculation.
	Industry-wide Type III EPD -- Products with third-party certification (Type III), including external verification, in which the manufacturer is explicitly recognized as a participant by the program operator. Products with industry-wide EPDs, which conform to ISO 14025, and EN 15804 or ISO 21930 and have at least a cradle to gate scope are valued as one whole product for the purposes of credit achievement calculation.
	Environmental Product Declarations which conform to ISO 14025 and EN 15804 or ISO 21930 and have at least a cradle to gate scope.
	Product-specific Type III EPD -- Products with third-party certification (Type III), including external verification and external critical review in which the manufacturer is explicitly recognized as the participant by the program operator are valued as 1.5 products for the purposes of credit achievement calculation.
	USGBC approved program – Products that comply with other USGBC approved environmental product declaration frameworks.
Documents	Completed BPDO Calculator or equivalent documentation. Include all of the products contributing toward credit compliance.
	Summary of the BPDO Calculator
	For each product, provide link to LCA report or EPD or provide a PDF of EPD or LCA report. Reports must fulfill the criteria in the reference guide.

Option 2. Multi-Attribute Optimization (1 point)	
Requirements	Use products that comply with one of the criteria below for 10%, by cost, of the total value of permanently installed products in the project, or use at least 10 permanently installed products sourced from at least three different manufacturers. Products will be valued as below. Life Cycle Impact Reduction Action Plan (value at 50% by cost or ½ product) The manufacturer has produced a product specific LCA using EN 15804 or ISO 21930 for the product and has provided a publicly available action plan to mitigate or reduce life cycle impacts. The action plan must be product-specific using the specified PCR functional unit, be critically reviewed, and must include the following information:
	Description of the LCA conducted including the dataset, software or platform used by manufacturer to complete the analysis.
	Identification of the largest life cycle impact areas identified in the analysis and a narrative description of the impact areas targeted for reduction in the action plan.
	Description of specific steps anticipated in implementation of the action plan. Include proposed changes in formulation or manufacturing processes that are planned as part of impact reduction strategy.
	Specific dates and a full timeline for completion of all the steps described in the action plan.
	Life Cycle Impact Reductions in Embodied Carbon. Products that have demonstrated environmental impact reductions for the specified functional unit based on a current third-party EPD or verified LCA that conforms to the comparability requirements of ISO 14025 and ISO 21930.
	The comparative analysis must show impact reduction in the global warming potential (GWP) impact category and must include a narrative describing how reductions in impacts were achieved. The published comparisons must be third-party verified (value at 100% by cost or 1 product).
	The comparative analysis must show impact reduction(s) of at least 10% in the global warming potential (GWP) impact category and must include a narrative describing how the impact reductions were achieved. The published comparisons must be third-party verified (value at 150% by cost or 1.5 products).
	The comparative analysis must show impact reduction(s) of at least 20% in the global warming potential (GWP) impact category, and demonstrate at least 5% reduction in two additional impact categories. A narrative describing how the impact reductions were achieved is required. The published comparisons must be third-party verified (value at 200% by cost or 2 products).
	Impact categories:
	global warming potential (greenhouse gases), in CO2e;
	depletion of the stratospheric ozone layer, in kg CFC-11e;
	acidification of land and water sources, in moles H+ or kg SO2e;
	eutrophication, in kg nitrogen equivalent or kg phosphate equivalent;
	formation of tropospheric ozone, in kg NOx, kg O3 eq, or kg ethene; and
	depletion of nonrenewable energy resources, in MJ using CML / depletion of fossil fuels in TRACI.
Documents	Completed BPDO Calculator or equivalent documentation. Include all of the products contributing toward credit compliance.
	Summary of the BPDO Calculator
	Documentation demonstrating compliance including all Action Plans and/or comparative analysis reports showing life cycle impact reductions in embodied carbon with supporting reports as described in the Reference Guide. If pursuing the regional multiplier criteria for some products, provide documentation that the product source location (extraction, manufacture, and purchase) is within 160 km of the project site.

Credit 3	Building Product Disclosure and Optimization - Sourcing of Raw Materials
Intent	To encourage the use of products and materials for which life cycle information is available and that have environmentally, economically, and socially preferable life cycle impacts. To reward project teams for selecting products verified to have been extracted or sourced in a responsible manner.
# points	Up to 2 points
Responsible Sourcing of Raw Materials	
Requirements	Use products sourced from at least three different manufacturers that meet at least one of the responsible sourcing and extraction criteria below for at least 20%, by cost, of the total value of permanently installed building products in the project (1 point). Use products sourced from at least five different manufacturers that meet at least one of the responsible sourcing and extraction criteria below for at least 40%, by cost, of the total value of permanently installed building products in the project (2 points).
	Extended producer responsibility. Products purchased from a manufacturer (producer) that participates in an extended producer responsibility program or is directly responsible for extended producer responsibility. Products meeting extended producer responsibility criteria are valued at 50% of their cost for the purposes of credit achievement calculation.
	Bio-based materials. Bio-based raw materials other than wood must be tested using ASTM Test Method D6866 and be legally harvested, as defined by the exporting and receiving country. Exclude hide products, such as leather and other animal skin material.
	Bio-based products that meet the criteria above: value at 50% of cost multiplied by the biobased content of the product for the purposes of credit achievement calculation.
	Bio-based products that meet the Sustainable Agriculture Network's Sustainable Agriculture Standard: value at 100% of cost multiplied by the biobased content of the product for the purposes of credit achievement calculation.
	Wood products. Wood products must be certified by the Forest Stewardship Council or USGBC-approved equivalent. Products meeting wood products criteria are valued at 100% of their cost for the purposes of credit achievement calculation.
	Materials reuse. Reuse includes salvaged, refurbished, or reused products. Products meeting materials reuse criteria are valued at 200% of their cost for the purposes of credit achievement calculation.
	Recycled content. Products meeting recycled content criteria are valued at 100% of their cost for the purposes of credit achievement calculation.
	Recycled content is the sum of postconsumer recycled content plus one-half the preconsumer recycled content, based on weight.
	The recycled fraction of the assembly is then multiplied by the cost of assembly to determine the recycled content value.
	USGBC approved program. Other USGBC approved programs meeting responsible sourcing and extraction criteria.
	For credit achievement calculation, products sourced (extracted, manufactured, purchased) within 100 miles (160 km) of the project site are valued at twice their base contributing cost (or number of products), up to a maximum of 200% of cost, or 2 products.
Documents	Completed BPDO Calculator or equivalent documentation. Include all of the products contributing toward credit compliance
	Summary of the BPDO Calculator
	Compliant manufacturer documentation or third party claim documentation demonstrating that products meet at least one of the sustainable extraction criteria listed in the credit requirements. If pursuing the regional multiplier criteria for some products, provide documentation that the product source location (extraction, manufacture, and purchase) is within 160 km of the project site.
	For projects that include re-use: Descrition of the re-use strategies (include salvaged, refurbished, etc.)
	For projects that include products from a USGBC-approved program: Indicate if documentation has been provided for all products complying under a USGBC-approved program.

Credit 4	Building Product Disclosure and Optimization - Material Ingredients
Intent	To encourage the use of products and materials for which life-cycle information is available and that have environmentally, economically, and socially preferable life-cycle impacts. To reward project teams for selecting products for which the chemical ingredients in the product are inventoried using an accepted methodology and for selecting products verified to minimize the use and generation of harmful substances. To reward raw material manufacturers who produce products verified to have improved life-cycle impacts.
# points	Up to 2 points
Option 1. Material Ingredient Reporting (1 point)	
Requirements	Use at least 20 different permanently installed products from at least five different manufacturers that use any of the following programs to demonstrate the chemical inventory of the product to at least 0.1% (1000 ppm).
	Manufacturer Inventory. The manufacturer has published complete content inventory for the product following these guidelines:
	A publicly available inventory of all ingredients identified by name and Chemical Abstract Service Registration Number (CASRN) and/or European Community Number (EC Number).
	Materials defined as trade secret or intellectual property may withhold the name and/or CASRN/EC Number but must disclose ingredient/chemical role, amount and hazard score/class using either:
	Greenscreen List Translator (LT) score and/or Full GreenScreen Benchmark (BM)
	The Globally Harmonized System of Classification and Labeling of Chemicals rev.6 (2015) (GHS)
	The hazard screen must be applied to each trade secret ingredient and the inventory lists the hazard category for each of the health hazards included in Part 3 of GHS (e.g. "GHS Category 2 Carcinogen").
	Health Product Declaration. The end use product has a published and complete Health Product Declaration with full disclosure of known hazards in compliance with the Health Product Declaration open Standard.
	Cradle to Cradle. Product has Material Health Certificate or is Cradle to Cradle Certified™ under standard version 3 or later with a Material Health achievement level at the Bronze level or higher.
	Declare. The Declare product label must meet the following requirements
	Declare labels designated as Red List Free or Declared.
	Declare labels designated as LBC Compliant that demonstrate content inventory to 0.1% (1000 ppm).
	Living Product Challenge. The included Declare product label must demonstrate content inventory to 0.1% (1000 ppm).
	ANSI/BIFMA e3 Furniture Sustainability Standard. The documentation from the assessor or scorecard from BIFMA must demonstrate the product earned at least 3 points under 7.5.1.3 Advanced Level in e3-2014 or 3 points under 7.4.1.3 Advanced Level in e3-2012.
	Product Lens Certification
	Facts – NSF/ANSI 336: Sustainability Assessment for Commercial Furnishings Fabric at any certification level.
	USGBC approved program. Other USGBC approved programs meeting the material ingredient reporting criteria.
	Any compliant reports above with third-party verification that includes the verification of content inventory are worth 1.5 products for credit achievement calculations.
Documents	Completed BPDO Calculator or equivalent documentation. Include all of the products contributing toward credit compliance.
	Summary of the BPDO Calculator
	Documentation of chemical inventory for all products contributing toward credit compliance. The inventory can be provided by the manufacturer, Health Product Declaration, Cradle to Cradle certification, or a USGBC-approved program.
Option 2: Material Ingredient Optimization (1 point)	
Requirements	Use permanently installed products from at least three different manufacturers that document their material ingredient optimization using the paths below. Choose either 10 compliant products, or select products that constitute at least 10%, by cost, of the total value of permanently installed products in the project. Material Ingredient Screening and Optimization Action Plan (value at 50% by cost or ½ product)
	The manufacturer has screened the product to at least 1,000 ppm and has provided a publicly available inventory meeting the requirements of Option 1 and completed a detailed action plan to mitigate or reduce known hazards using the principles of green chemistry. The action plan must be product-specific (not company, manufacturer or brand), and must include the following information:
	Description of the screening or assessment platform used by manufacturer to complete the material ingredient screening and analysis.
	Identification of the specific green chemistry principles targeted for implementation in the action plan.
	Description of specific steps anticipated in implementation of the action plan. Include proposed changes in formulation or manufacturing processes that are planned as part of green chemistry optimization strategy.
	Specific dates and a full timeline for completion of all the steps described in the action plan
	Advanced Inventory & Assessment (value at 100% by cost or 1 product):
	The end use product meets the requirements of any of the following
	Manufacturer Inventory or Health Product Declaration: The product has demonstrated a chemical inventory to at least 0.01% by weight (100 ppm) with no GreenScreen LT-1 hazards or GHS Category 1 hazards. The HPD or Manufacturer Inventory must be third party verified.
	Manufacturer Inventory or HPD: The product has demonstrated a chemical inventory to at least 0.01% by weight (100ppm) and at least 75% by weight of product is assessed using GreenScreen Benchmark assessment. The remaining 25% by weight of product has been inventoried. The GreenScreen assessment must be publicly available. The HPD or Manufacturer Inventory must be third-party verified.
	Declare labels designated as Red List Free that are third-party verified, or Living Product Challenge certified products that include a Red List Free Declare label.
	Cradle to Cradle. Product has Material Health Certificate or is Cradle to Cradle Certified™ under standard version 3 or later with a Material Health achievement level at the Bronze level or higher.
	Material Ingredient Optimization (value at 150% by cost or 1.5 products)
	The end use product has demonstrated a product inventory and assessment of ingredients using any of the following programs:
	Manufacturer Inventory or HPD: The product has demonstrated a chemical inventory to at least 0.01% by weight (100ppm) and at least 95% by weight of product is assessed using GreenScreen Benchmark assessment. No Benchmark 1 hazards (BM-1) are present in the end use product. The remaining 5% by weight of product not assessed has been inventoried and screened using GreenScreen List Translator and no GreenScreen LT-1 hazards are present in the end use product. The documents must be third party verified.
	Cradle to Cradle. Product has Material Health Certificate or is Cradle to Cradle Certified™ under standard version 3 or later with a Material Health achievement level at the Silver level or higher.
	Living Product Challenge. Products certified to the Living Product Challenge which includes achievement of Imperative 09: Transparent Material Health.
	International Alternative Compliance Path – REACH Optimization (value at 100% of cost or 1 product)
	End use products and materials have fully inventoried chemical ingredients to 100 ppm and assess each substance against the Authorization List – Annex XIV, the Restriction list – Annex XVII and the SVHC candidate list, (the version in effect June 2013,) proving that no such substance is included in the product. If the product contains no ingredients listed on the REACH Authorization, Restriction, and Candidate list.
	Global Green Tag International: product has a certified Product Health Declaration (PhD) report. Value at 100% or 1 product.
	USGBC approved program.
	Products that comply with USGBC approved building product optimization criteria for material ingredient optimization and/or advanced inventory & assessment pathways.
	For credit achievement calculation, products sourced (extracted, manufactured, purchased) within 100 miles (160 km) of the project site are valued at twice their base contributing cost (or number of products), up to a maximum of 200% of cost, or 2 products.

Documents	Completed BPDO Calculator or equivalent documentation. Include all of the products contributing toward credit compliance.
	Summary of the BPDO Calculator
	For international projects that include products with no ingredients on REACH list: Indicate if verification of criteria compliance from manufacturer or third party has been provided for all products meeting REACH criteria.
	For projects that include products from a USGBC-approved program: Indicate if documentation has been provided for all products complying under a USGBC-approved program.
	Documentation demonstrating that products have optimized material ingredients through action plans, advanced inventory & assessment, or material ingredient optimization reports. If pursuing the regional multiplier criteria for some products, provide documentation that the product source location (extraction, manufacture, and purchase) is within 160 km of the project site.

Credit 5	Construction and Demolition Waste Management
Intent	To reduce construction and demolition waste disposed of in landfills and incineration facilities by recovering, reusing, and recycling materials.
# points	Up to 2 points
Requirements	Recycle and/or salvage nonhazardous construction and demolition materials. Calculations can be by weight or volume but must be consistent throughout. Exclude excavated soil, land-clearing debris from calculations. Include materials destined for alternative daily cover (ADC) in the calculations as waste (not diversion). Include wood waste converted to fuel (biofuel) in the calculations; other types of waste-to-energy are not considered diversion for this credit. However, for international projects that cannot meet credit requirements using reuse and recycling methods, waste-to-energy systems may be considered waste diversion if the European Commission Waste Framework Directive 2008/98/EC and Waste Incineration Directive 2000/76/EC are followed and Waste to Energy facilities meet applicable European Committee for Standardization (CEN) EN 303 standards.
Option 1. Diversion (1–2 points)	
Path 1	Path 1. Divert 50% and Two Material Streams (1 point)
	Divert at least 50% of the total construction and demolition material; diverted materials must include at least two material streams.
Path 2	Path 2. Divert 50% using Certified Commingled Recycling Facility (1 Point)
	Divert at least 50% of the total construction and demolition material. All commingled recycling must be sent to offsite sorting facility(ies) certified by the Recycling Certification Institute or approved equivalent.
Path 3	Path 3. Divert 75% and Three Material Streams (2 points)
	Divert at least 75% of the total construction and demolition material; diverted materials must include at least three material streams.
Path 4	Path 4. Divert 75% using Certified Commingled Recycling Facility and One More Material Stream (2 points)
	Divert at least 75% of the total construction and demolition material; diverted materials must include at least two material streams. All commingled recycling is required to be one of the streams and must be sent to offsite sorting facility(ies) certified by the Recycling Certification Institute or approved equivalent
Documents	Completed Construction and Demolition Waste Calculator or equivalent documentation.
	Summary of the Construction and Demolition Waste Calculator
	For projects diverting commingled waste: Documentation verifying the diversion rate of commingled waste. Include proof that the facility is regulated by a local or state governing authority. Include an accurate recycling rate for the facility during the time period that waste was sent to the facility for processing. If attempting Path 2 or 4, include proof of third-party recycling rate and facility certification through an approved program, such as Recycling Certification Institute
	For international projects using waste-to-energy systems: Brief description how recycling and reuse were used as diversion strategies prior to using waste-to-energy
	Waste diverted to a waste-to-energy facility, provide documentation that the facility follows the European Commission Waste Framework Directive 2008/98/EC and Waste Incineration Directive 2000/76/EC and meets the applicable European Committee for Standardization (CEN) EN 303 standards
Option 2. Reduction of Total (Construction and Demolition) Waste Material (2 points)	
Requirements	Salvage or recycle renovation and demolition debris and utilize onsite waste minimizing design strategies for new construction activities. Achieve the waste generation thresholds in Table 1 and create a narrative describing how a project is addressing waste prevention and/or achieving waste generation thresholds via design strategies and onsite waste minimization practices. Do not generate more than 7.5 pounds of construction waste per square foot (36.6 kilograms of waste per square meter) of the building's floor area for all BD+C projects except Warehouses and Distribution Centers.
	Table 1: Thresholds of compliance for reduction of total waste material to reflect the attached resource
Documents	General information about waste material
	Reduction of Total Waste Material Narrative: Descripton on how the project is addressing waste prevention and/or achieving the waste generation thresholds via design strategies. Examples include panelized building components, ordering pre-cut sizes to eliminate on-site waste, prefabrication prior to jobsite delivery, or reducing finishes of the final building.
	Documentation of 75% diversion from landfill, ADC and incineration for all renovation, demolition, or other waste other than new construction waste

Indoor Environmental Quality

Prerequisite 1	Minimum Indoor Air Quality Performance
Intent	To contribute to the comfort and well-being of building occupants by establishing minimum standards for indoor air quality (IAQ).
Resources	Minimum Indoor Air Quality Performance Calculator (excel)
Requirement	Select one or two type of ventilation
Path 1. Mechanically ventilated spaces	
Requirements	For mechanically ventilated spaces (and for mixed-mode systems when the mechanical ventilation is activated), meet the requirements for both ventilation (option 1 OR 2) AND monitoring.
Option 1.	Option 1. ASHRAE Standard 62.1–2016
	Meet the requirements of ASHRAE Standard 62.1–2016, Sections 4, 5, 6.2, 6.5, and 7, or a local equivalent, whichever is more stringent
Documents	Description of the outdoor air quality investigation performed for the project, per ASHRAE Standard 62.1-2016 Section 4. Include the conclusions regarding the acceptability of outdoor air quality and specify if the project is located in a non-attainment area for PM2.5 and/or ozone.
	If applicable, documentation for the particle filters or air-cleaning devices included in the design to comply with ASHRAE 62.1-2016 Section 6.2.1. (Optional)
	Documentation to support the ventilation systems comply with ASHRAE 62.1-2016, Section 6.2. The documentation should account for the worst case ventilation conditions (generally, heating mode) and should list all relevant variables used in the calculations (e.g., Ez, Ds, Ev, etc.). It is acceptable to provide values only for the critical zones.
Option 2.	Option 2. ISO 17772-1:2017 and EN 16798-3: 2017
	Projects outside the U.S. may instead meet the requirements of ISO Standard 17772-1:2017, Section 6.3, using Method 1—Perceived air quality with Category I or II and local standard for ventilation system design such as EN Standard 16798-3: 2017, Sections 7-10.
Documents	Documentation to support the ventilation systems comply with ISO 17772-1:2017, Section 6.3, using Method 1- Perceived air quality with category I or II . The documentation should list all relevant variables used in the calculations (e.g., n, qP, AR, qB, etc.), the IEQ category and low pollutant building category used for design, the applied occupancy schedules, and design flow rates and control range of ventilation in l/s per m2 and l/s per occupant.
All	Monitoring for mechanical ventilation systems
	Provide outdoor air monitors for all mechanical ventilation systems with outdoor air intake flow greater than 1000 cfm (472 L/s). The monitoring device must be capable of measuring the minimum outdoor air intake flow and be capable of measuring the design minimum outdoor air intake flow with an accuracy of +/–10%. An alarm must indicate when the outdoor airflow value varies by 15% or more from the setpoint. Alternatively, for constant-volume systems that do not employ demand control ventilation, provide an indicator capable of confirming the intake damper is open to the position needed to maintain the design minimum outdoor airflow as determined during the system startup and balancing.
Documents	Controls drawing or similar documentation showing the monitoring devices for all ventilation systems with outdoor air intake flow greater than 1000 cfm (472 L/s) (outdoor airflow monitoring devices, indicator for intake damper, or similar monitors).
Path 2. Naturally ventilated spaces	
Requirements	For naturally ventilated spaces (and for mixed-mode systems when the mechanical ventilation is inactivated), confirm that natural ventilation is an effective strategy for the project by following the flow diagram in the CIBSE Applications Manual AM10, March 2005, Natural Ventilation in Nondomestic Buildings, Figure 2.8 and meet the requirements for both ventilation (option 1, option 2, or option 3) and monitoring.
Option 1.	Option 1. ASHRAE Standard 62.1–2016
	Meet the requirements of ASHRAE 62.1-2016, Sections 4, 6.4, and 6.5.
Documents	Documentation demonstrating that the outdoor air opening and space configurations meet or exceed the minimum values from the natural ventilation procedure outlined in ASHRAE 62.1-2016, Section 6.4.1 and 6.4.2.
	Confirmation and explanation of at least one of the following:
	The spaces include mechanical ventilation systems designed in accordance with ASHRAE 62.1-2016 section 6.2.
	The natural ventilation openings are permanently open or have controls that prevent the openings from being closed during periods of expected occupancy.
	The spaces are not served by heating or cooling equipment
Option 2.	Option 2. Engineered natural ventilation system
	Projects outside the U.S. may instead meet the requirements of ISO Standard 17772-1:2017, Section 6.3, using Method 1—Perceived air quality with Category I or II and local standard for ventilation system design such as EN Standard 16798-3: 2017, Sections 7-10.
Documents	Design documentation and a narrative describing the engineered ventilation modeling or calculation approach
	If applicable, evidence documenting that plans have been approved by the authority having jurisdiction (Optional)
Option 3.	Option 3. Historic building
	Available to projects located in a building registered as a local or national historic building. Meet the requirements of ASHRAE 62.1-2016, Sections 4, 6.4.1, 6.4.2, 6.4.3, and 6.5.
Documents	Documentation demonstrating that the outdoor air opening and space configurations meet or exceed the minimum values from the natural ventilation procedure outlined in ASHRAE 62.1-2016, Section 6.4.1 and 6.4.2.
All	Monitoring for mechanical ventilation systems
	Comply with at least one of the following strategies.
	Provide a direct exhaust airflow measurement device capable of measuring the exhaust airflow. This device must measure the exhaust airflow with an accuracy of +/–10% of the design minimum exhaust airflow rate. An alarm must indicate when airflow values vary by 15% or more from the exhaust airflow setpoint. This strategy is not allowed for projects using Natural Ventilation Option 3. Historic building.
	Provide automatic indication devices on all natural ventilation openings intended to meet the minimum opening requirements. An alarm must indicate when any one of the openings is closed during occupied hours.
	Monitor carbon dioxide (CO2) concentrations within each thermal zone. CO2 monitors must be between 3 and 6 feet (900 and 1 800 millimeters) above the floor and within the thermal zone. CO2 monitors must have an audible or visual indicator or alert the building automation system if the sensed CO2 concentration exceeds the setpoint by more than 10%. Calculate appropriate CO2 setpoints using the methods in ASHRAE 62.1–2016, Appendix D.
Documents	Indicate the applicable monitoring strategy for the project:
	Direct exhaust airflow measurement
	Automatic indication devices on natural ventilation openings
	Carbon dioxide monitoring
	Controls drawing sample showing the exhaust airflow measurement devices, automatic indication devices, or carbon dioxide monitors, as applicable. The monitoring devices must meet the credit requirements.
For residential projects	
Requirements	In addition to the requirements above, if the project building contains residential units, each dwelling unit must meet the requirements of the following documents
Documents	Completed forms from LEED v4.1 Multifamily EQ Prerequisite Minimum indoor air quality performance, EQ Prerequisite Combustion venting and EQ Prerequisite Radon-resistant construction.

Prerequisite 2	Environmental Tobacco Smoke Control
Intent	To prevent or minimize exposure of building occupants, indoor surfaces, and ventilation air distribution systems to environmental tobacco smoke.
All	
Requirements	For this prerequisite smoking includes tobacco smoke, as well as smoke produced from the combustion of cannabis and controlled substances and the emissions produced by electronic smoking devices.
	Prohibit smoking inside the building.
	Prohibit smoking outside the building except in designated smoking areas located at least 7.5 m (or the maximum extent allowable by local codes) from all entries, outdoor air intakes, and operable windows. This smoking requirement also applies to any spaces outside the property line that are used for business purposes.
Documents	One of the following documents to explain the no smoking policy:
	A copy of the no-smoking policy
	A letter signed by the project owner describing the project's no-smoking policy
	A copy of legally binding covenants/restrictions to verify the status of the residential units as no-smoking, if applicable
	Description of how the no-smoking policy is communicated to the project occupants. Include details of enforcement provisions or no-smoking signage.
	Scaled site plan or map showing the location of designated outdoor smoking and non-smoking areas, the property line, and the site boundary. Label the distance to any designated smoking areas to show that they are at least 7.5 m from building openings.
For projects with residential units	
Requirements	Option 1. No Smoking
	Meet the requirements above.
	Option 2. Compartmentalization of Smoking Areas
	Meet the requirements above for all areas inside and outside the building except dwelling units and private balconies. Each dwelling unit where smoking is permitted must be compartmentalized to prevent excessive leakage between units:
	Weather-strip all exterior doors and operable windows in the residential units to minimize leakage from outdoors.
	Weather-strip all doors leading from residential units into common hallways.
	Minimize uncontrolled pathways for the transfer of smoke and other indoor air pollutants between residential units by sealing penetrations in the walls, ceilings, and floors and by sealing vertical chases (including utility chases, garbage chutes, mail drops, and elevator shafts) adjacent to the units
	Demonstrate a maximum leakage of 1.53 L/s.m^2 at 50 Pa of enclosure (i.e., all surfaces enclosing the apartment, including exterior and party walls, floors, and ceilings). Renovation projects that retain their existing envelope must meet an allowable maximum leakage of 2.54 L/s.m^2 of enclosure area
Documents	Door schedule showing weather-stripping at exterior unit doors and doors leading from units to common hallways
	Differential air pressure test report for units in the project

Credit 1	Enhanced Indoor Air Quality Strategies
Intent	To promote occupants' comfort, well-being, and productivity by improving indoor air quality.
# points	Up to 2 points
Requirement	Each option gives 1 point
Option 1. Enhanced IAQ Strategies (1 point)	
Requirements	Comply with all of the following requirements, as applicable. Mechanically ventilated spaces: A, B and C. Naturally ventilated spaces: A and D. Mixed-mode systems: A, B, C, D and E
List of requirements and documents	A. Entryway Systems
	Install permanent entryway systems at least 3m long in the primary direction of travel to capture dirt and particulates entering the building at regularly used exterior entrances. Acceptable entryway systems include permanently installed grates, grilles, slotted systems that allow for cleaning underneath, rollout mats, and any other materials manufactured as entryway systems with equivalent or better performance. Maintain all on a weekly basis.
	Floor plan(s) (with scale) highlighting the permanent entryway systems locations and measurements. The systems must meet the credit requirements.
	For mechanically ventilated spaces (and mixed-mode spaces when mechanical ventilation is activated)
	B. Interior Cross-Contamination Prevention
	Sufficiently exhaust each space where hazardous gases or chemicals may be present or used (e.g., garages, housekeeping and laundry areas, copying and printing rooms), using the exhaust rates determined in EQ Prerequisite Minimum Indoor Air Quality Performance or a minimum of 0.50 cfm per square foot (2.54 l/s per square meter), to create negative pressure with respect to adjacent spaces when the doors to the room are closed. For each of these spaces, provide self-closing doors and deck-to-deck partitions or a hard-lid ceiling.
	Documentation demonstrating how these spaces have been designed for sufficient exhaust and separation. The documentation must include a list of spaces, exhaust rates, and separation strategy.
	C. Filtration
	Each ventilation system that supplies outdoor air to occupied spaces must have particle filters or air-cleaning devices that meet one of the following filtration media requirements: 1. minimum efficiency reporting value (MERV) of 13 or higher, in accordance with ASHRAE Standard 52.2–2017; or 2. Equivalent filtration media class of ePM1 50% or higher, as defined by ISO 16890-2016, Particulate Air Filters for General Ventilation, Determination of the Filtration Performance. Replace all air filtration media after completion of construction and before occupancy.
	Mechanical schedule(s) (or similar documentation) for each ventilation system in the project scope of work that supplies outdoor air to occupied spaces. The documentation must highlight the MERV or ISO 16890-2016 filter performance for the filtration media that will be installed after construction and prior to occupancy.
	For naturally ventilated spaces (and mixed-mode spaces when mechanical ventilation is inactivated)
	D .Natural Ventilation Design Calculations
	Demonstrate that the system design for occupied spaces employs the appropriate strategies in CIBSE. Applications Manual AM10, March 2005, Natural Ventilation in Non-Domestic Buildings, Section 2.4.
	Description of the basic forms of ventilation strategy from CIBSE AM10-2005, Section 2.4 that apply to the project. Include a narrative or diagrams to explain how the applicable rules of thumb and guidance from the manual were considered.
	For mixed-mode spaces
	E. Mixed-Mode Design Calculations
	Demonstrate that the system design for occupied spaces complies with CIBSE Applications Manual 13–2000, Mixed Mode Ventilation.
	Description of the basic forms of ventilation strategy from CIBSE AM13-2000 Section 2.1, the operation strategy from CIBSE AM13-2000 Section 2.2, and the optimization strategy from Figure 2.2 that apply to the project. Include a narrative or diagrams to explain how the guidance from these sections in the manual was considered.
Option 2. Additional Enhanced IAQ Strategies (1 point)	
Requirements	Comply with one of the following requirements: Mechanically ventilated spaces (select one): A, B, C or D. Naturally ventilated spaces (select one): A, D or E. Mixed-mode systems (select one): A, B, C, D or E

Documents	A. Exterior Contamination Prevention
	Design the project to minimize and control the entry of pollutants into the building. Ensure through the results of computational fluid dynamics modeling, Gaussian dispersion analyses, wind tunnel modeling, or tracer gas modeling that outdoor air contaminant concentrations at outdoor air intakes are below the thresholds listed in Table 1 (or local equivalent for projects outside the U.S., whichever is more stringent).
	Table 1. Maximum concentrations of pollutants at outdoor air intakes
	Description of the modeling that was performed to ensure that outdoor air contaminant concentrations at outdoor air intakes are less than the required thresholds
	Modeling outputs. Highlight the modeled contaminant levels and how they compare to the required thresholds.
	B. Increased ventilation (for mechanically ventilated and mixed-mode spaces only)
	Increase breathing zone outdoor air ventilation rates to all occupied spaces by at least 30% above the minimum rates as determined in EQ Prerequisite Minimum Indoor Air Quality Performance.
	Indicate of the project team has increased breathing zone outdoor air ventilation rates to all occupied spaces by at least 30% above the minimum rates, as determined in EQ Prerequisite Indoor Air Quality Performance. Compliance with this requirement is shown within EQ Prerequisite Indoor Air Quality Performance.
	C. Carbon Dioxide Monitoring
	Monitor CO2 concentrations within all densely occupied spaces. CO2 monitors must be between 3 and 6 feet (900 and 1 800 millimeters) above the floor. CO2 monitors must have an audible or visual indicator or alert the building automation system if the sensed CO2 concentration exceeds the setpoint by more than 10%. Calculate appropriate CO2 setpoints using methods in ASHRAE 62.1–2016, Appendix D.
	Controls drawing sample showing the carbon dioxide monitors and a list of densely occupied spaces. The monitoring devices must meet the credit requirements.
	D. Additional Source Control and Monitoring
	For spaces where air contaminants are likely, evaluate potential sources of additional air contaminants besides CO2. Develop and implement a materials-handling plan to reduce the likelihood of contaminant release. Install monitoring systems with sensors designed to detect the specific contaminants. An alarm must indicate any unusual or unsafe conditions.
	Description of the likely air contaminants and how these air contaminants were evaluated.
	Description of the materials handling plan.
	Construction drawing(s) (or similar documentation) highlighting the installed monitoring system.
	E. Natural Ventilation Room-by-Room Calculations
	Follow CIBSE AM10, Section 4, Design Calculations, to predict that room-by-room airflows will provide effective natural ventilation.
	Calculations or summary results for the design calculations performed in accordance with the CIBSE AM10-2005, Section 4, Design Calculations. The documentation should confirm that natural ventilation openings meet or exceed the sizes calculated for all spaces.

Credit 2	Low-Emitting Materials
Intent	To reduce concentrations of chemical contaminants that can damage air quality, human health, productivity, and the environment.
# points	Up to 3 points
Resources	LEED v4.1 Low-Emitting Materials Calculator
Requirements	Use materials on the building interior (everything within the waterproofing membrane) that meet the low-emitting criteria below. Points are awarded according to Table 1
	Table 1. Points for low-emitting materials
Documents	Completed Low-Emitting Materials Calculator or equivalent documentation. Include all of the products contributing toward credit compliance
List of requirements and documents	Paints and coating
	At least 75% of all paints and coatings, by volume or surface area, meet the VOC emissions evaluation AND 100% meet the VOC content evaluation. The paints and coatings product category includes all interior paints and coatings applied on site.
	Percentage of paints and coatings meeting VOC emissions and content evaluation (%)
	Adhesives and sealants
	At least 75% of all adhesives and sealants, by volume or surface area, meet the VOC emissions evaluation AND 100% meet the VOC content evaluation. The adhesives and sealants product category includes all interior adhesives and sealants applied on site.
	Percentage of adhesives and sealants meeting VOC emissions and content evaluation (%)
	Flooring
	At least 90% of all flooring, by cost or surface area, meets the VOC emissions evaluation OR inherently nonemitting sources criteria, OR salvaged and reused materials criteria. The flooring product category includes all types of hard and soft surface flooring (carpet, ceramic, vinyl, rubber, engineered, solid wood, laminates), wall base, underlayments, and other floor coverings. Subflooring is excluded.
	Percentage of flooring meeting VOC emissions evaluation OR inherently nonemitting sources criteria OR salvaged and reused materials criteria.
	Wall panels
	At least 75% of all wall panels, by cost or surface area, meet the VOC emissions evaluation, OR inherently nonemitting sources criteria, OR salvaged and reused materials criteria. The wall panels product category includes all finish wall treatments (wall coverings, wall paneling, wall tile), surface wall structures such as gypsum or plaster, cubicle/curtain/partition walls, trim, doors, frames, windows, and window treatments. Removable/interchangeable fabric panels, built-in cabinetry, and vertical structural elements are excluded.
	Percentage of wall panels meeting VOC emissions evaluation OR inherently nonemitting sources criteria OR salvaged and reused materials criteria.
	Ceilings
	At least 90% of all ceilings, by cost or surface area, meet the VOC emissions evaluation, OR inherently nonemitting sources criteria, OR salvaged and reused materials criteria. The ceilings product category includes all ceiling panels, ceiling tile, surface ceiling structures such as gypsum or plaster, suspended systems (including canopies and clouds), and glazed skylights. Overhead structural elements (exposed, finished, and unfinished) are excluded.
	Percentage of ceilings meeting VOC emissions evaluation OR inherently nonemitting sources criteria OR salvaged and reused materials criteria.
	Insulation
	At least 75% of all insulation, by cost or surface area, meets the VOC emissions evaluation. The insulation material category includes all thermal and acoustic boards, batts, rolls, blankets, sound attention fire blankets, foamed-in place, loose-fill, blown, and sprayed insulation. Insulation for HVAC ducts and plumbing piping are excluded.
	Percentage of insulation meeting VOC emissions evaluation.
	Furniture
	At least 75% of all furniture in the project scope of work, by cost, meets the furniture emissions evaluation, OR inherently nonemitting sources criteria, OR salvaged and reused materials criteria. The furniture product category includes all stand-alone furniture items purchased for the project.
	Percentage of furniture meeting furniture emissions evaluation OR inherently nonemitting sources criteria OR salvaged and reused materials criteria.
	Composite Wood
	At least 75% of all composite wood, by cost or surface area, meets the Formaldehyde emissions evaluation OR salvaged and reused materials criteria. The composite wood product category includes all particleboard, medium density fiberboard, hardwood veneer plywood, and structural composite wood not included in the flooring, ceiling, wall panels, or furniture material categories.
	Percentage of composite wood products meeting formaldehyde emissions evaluation OR salvaged and reused materials criteria.
Documents	Low-emitting product documentation
	Documentation for each compliant product, demonstrating the product meets the low-emitting criteria. Documentation may include product information, product certificates, indoor air testing reports, cutsheets, etc.
	For products demonstrating compliance with the VOC emissions evaluation, include the exposure scenario(s) used, the amount of wet-applied product applied in mass per surface area (if applicable), and the range of total VOCs.
	For products demonstrating compliance with the furniture emissions evaluation, include the exposure scenario(s) used.

Credit 3	Construction Indoor Air Quality Management Plan
Intent	To promote the well-being of construction workers and building occupants by minimizing indoor air quality problems associated with construction and renovation.
# points	1 points
Requirements	Develop and implement an IAQ management plan for the construction and preoccupancy phases of the building. The plan must address all of the following. During construction, meet or exceed all applicable recommended control measures of the Sheet Metal and Air Conditioning National Contractors Association (SMACNA) IAQ Guidelines for Occupied Buildings under Construction, 2nd edition, 2007, ANSI/SMACNA 008–2008, Chapter 3. Protect absorptive materials stored on-site and installed from moisture damage. Do not operate permanently installed air-handling equipment during construction unless filtration media with a minimum efficiency reporting value (MERV) of 8, as determined by ASHRAE 52.2–2017, with errata (or media with ISOcoarse 90% or higher, as defined by ISO 16890-2016, Particulate Air Filters for General Ventilation, Determination of the Filtration Performance), are installed at each return air grille and return or transfer duct inlet opening such that there is no bypass around the filtration media. Immediately before occupancy, replace all filtration media with the final design filtration media, installed in accordance with the manufacturer's recommendations. Prohibit the use of smoking inside the building and within 7.5 m of the building openings during construction. Smoking includes tobacco smoke, as well as smoke produced from the combustion of cannabis and controlled substances and the emissions produced by electronic smoking devices.
Documents	Description of the methods by which absorptive materials (installed or stored on-site) were protected from moisture damage during the construction and preoccupancy phases
	For projects that operated permanently installed air handling units during construction
	Description of the filtration used on air handling units. Include the rating (MERV or ISOcoarse 90% or higher) and dates filters were replaced.
	IAQ management plan for the project. Highlight IAQ management practices implemented during construction and preoccupancy phases.
	Photographs or a narrative documenting each of the IAQ measures implemented. Photographs should be annotated to indicate the IAQ measure depicted and the general location of the photograph. Additionally, provide photographs or a narrative documenting the methods employed to protect absorptive materials from moisture damage during construction and pre-occupancy. Highlight materials stored or installed on-site.

Credit 4	Indoor Air Quality Assessment
Intent	To establish better quality indoor air in the building after construction and during occupancy.
# points	Up to 2 points
Requirements	Select one of the following two options, to be implemented after construction ends and the building has been completely cleaned. All interior finishes, such as millwork, doors, paint, carpet, acoustic tiles, and movable furnishings (e.g., workstations, partitions), must be installed, and major VOC punch list items must be finished. The options cannot be combined.
Option 1. Flush-out (1 point)	
Requirements	Chose one of the two paths
	Path 1. Before occupancy (1 point)
	Install new filtration media and perform a building flush-out by supplying a total air volume of 14 267 140 L of outdoor air per m^2 of gross floor area while maintaining an internal temperature of at least 15°C and no higher than 27°C and relative humidity no higher than 60%.
Documents	Description of the flush-out procedure. Include flush-out date(s), outdoor air delivery rates, internal temperature, and relative humidity
Requirements	Path 2. During Occupancy (1 point)
	If occupancy is desired before the flush-out is completed, the space may be occupied only after delivery of a minimum of 1 066 260 liters of outdoor air per m^2 of gross floor area while maintaining an internal temperature of at least 15°C and no higher than 27°C and relative humidity no higher than 60%. Once the space is occupied, it must be ventilated at a minimum rate of 1.5 L/s.m^2 of outside air or the design minimum outdoor air rate determined in EQ Prerequisite Minimum IAQ Performance, whichever is greater. During each day of the flush-out period, ventilation must begin at least three hours before occupancy and continue during occupancy. These conditions must be maintained until a total of 4 270 L of outdoor air per m^2 has been delivered to the space.
Documents	Describe the flush-out procedure. Include flush-out date(s), outdoor air delivery rates, internal temperature, and relative humidity
Option 2. Air testing (1-2 points)	
Requirements	After construction ends and before occupancy, but under ventilation conditions typical for occupancy, conduct baseline IAQ testing in occupied spaces for the contaminants listed in Path 1. AND/OR Path 2. Retail projects may conduct the testing within 14 days of occupancy.
	Path 1. Particulate Matter and Inorganic Gases (1 point)
	Test for the particulate matter (PM) and inorganic gases listed in Table 1, using an allowed test method, and demonstrate the contaminants do not exceed the concentration limits listed in the table.
	Table 1. Particulate Matter and inorganic gases
	Path 2. Volatile Organic Compounds (1 point)
	Perform a screening test for Total Volatile Organic Compounds (TVOC). Use ISO 16000-6, EPA TO-17, or EPA TO-15 to collect and analyze the air sample. Calculate the TVOC value per EN 16516:2017, CDPH Standard Method v1.2 2017 section 3.9.4, or alternative calculation method as long as full method description is included in test report. If the TVOC levels exceed 500 µg/m3, investigate for potential issues by comparing the individual VOC levels from the GC/MS results to associated cognizant authority health-based limits. Correct any identified issues and re-test if necessary. Additionally, test for the individual volatile organic compounds listed in Table 2 using an allowed test method and demonstrate the contaminants do not exceed the concentration limits listed in the table. Laboratories that conduct the tests must be accredited under ISO/IEC 17025 for the test methods they use. Exemplary performance is available for projects that test for the additional target volatile organic compounds specified in CDPH Standard Method v1.2-2017, Table 4-1 and do not exceed the full CREL levels for these compounds adopted by Cal/EPA OEHHA in effect on June 2016.
	Table 2. Volatile organic compounds
Documents	Description of the locations selected for testing (sampling locations) and how they were selected.
	Test report highlighting the following:
	Test dates and individuals involved in the testing
	Measured concentrations for the particulate matter and inorganic gases listed in Table 1 of the credit requirements (if pursuing path 1)
	Results of TVOC screening test including analysis if TVOC levels exceeded 500 µg/m3 (if pursuing path 2)
	Measured concentrations for the VOCs listed in Table 2 of the credit requirements (if pursuing path 2)
	Measured concentrations of additional VOCs (if pursuing exemplary performance)
	Test and analysis method for each contaminant included in the testing and information on ISO/IEC 17025 accreditation for the laboratory if applicable.

Credit 5	Thermal Comfort
Intent	To promote occupants' productivity, comfort, and well-being by providing quality thermal comfort.
# points	1 point
Requirement	Meet the requirements for both thermal comfort design and thermal comfort control
Thermal comfort design	
Requirements	Chose one of the two options
	Option 1. ASHRAE Standard 55-2017
	Design HVAC systems and the building envelope to meet the requirements of ASHRAE Standard 55–2017, Thermal Comfort Conditions for Human Occupancy with errata or a local equivalent. For natatoriums, demonstrate compliance with ASHRAE HVAC Applications Handbook, 2015 edition, Chapter 5, Places of Assembly, Typical Natatorium Design Conditions, with errata
Documents	Supporting documentation verifying that the thermally conditioned spaces meet ASHRAE Standard 55-2017 for 80% acceptability. Documentation may include a psychometric chart, PMV/PPD calculations, ASHRAE Thermal Comfort Tool results, a copy of ASHRAE Standard 55-2017 Figure I2, Figure I4, and/or Figure I5, or predicted worst case (both heating and cooling) indoor conditions for each month on a copy of ASHRAE Standard 55-2017 Figure 5.4.2.

Requirements	Option 2. ISO Standards 7730:2005 and 17772-1:2017	
		Design HVAC systems and the building envelope to meet the requirements of the applicable standard: - ISO 7730:2005, Ergonomics of the Thermal Environment, analytical determination and interpretation of thermal comfort, using calculation of the PMV and PPD indices and local thermal comfort criteria; and - ISO 17772-1:2017, Energy Performance of Buildings- Indoor environmental quality- Part 1. Indoor environmental input parameters for the design and assessment of energy performance of buildings Section A2.
Documents		Supporting documentation verifying that the thermally conditioned spaces meet ISO Standard 7730:2005 and/or ISO Standard 17772-1:2017, as applicable. For ISO Standard 7730:2005, documentation may include calculations based on Section 4.1 and Section 6 or Annex H, computer program results based on Annex D, tables based on Annex E, and/or a copy of Figures 2, 3, 4, A.1, A.2 of the standard. For ISO Standard 17772-1:2017, documentation may include worst case indoor conditions for each month on Figure A1 of the standard.
Thermal comfort control		
Requirements	Provide individual thermal comfort controls for at least 50% of individual occupant spaces. Provide group thermal comfort controls for all shared multioccupant spaces. Thermal comfort controls allow occupants, whether in individual spaces OR shared multioccupant spaces, to adjust at least one of the following in their local environment: air temperature, radiant temperature, air speed, and humidity.	
Documents	Table: Individual occupant OR shared multioccupant spaces	

Credit 6	Interior Lighting	
Intent	To promote occupants' productivity, comfort, and well-being by providing high-quality lighting.	
# points	Up to 2 points	
Resources	Interior Lighting Calculator	
Requirement	Select one or both of the following two options.	
Option 1. Lighting Control (1 point)		
Requirements	For at least 90% of individual occupant spaces, provide individual lighting controls that enable occupants to adjust the lighting to suit their individual tasks and preferences, with at least three lighting levels or scenes (on, off, midlevel). Midlevel is 30% to 70% of the maximum illumination level (not including daylight contributions). For all shared multioccupant spaces, meet all of the following requirements.	
		Have in place multizone control systems that enable occupants to adjust the lighting to meet group needs and preferences, with at least three lighting levels or scenes (on, off, midlevel).
		Lighting for any presentation or projection wall must be separately controlled.
		Switches or manual controls must be located in the same space as the controlled luminaires. A person operating the controls must have a direct line of sight to the controlled luminaires.
Documents	For projects with individual occupant spaces	
		Table: Individual occupant lighting controls
	For projects with shared multioccupant spaces	
		Table: Shared multioccupant lighting controls
	For projects with presentation and/or project walls	
		Table: Individual occupant lighting controls
Option 2. Lighting Quality (1 point)		
Requirements	Choose four of the following strategies.	
		A. For all regularly occupied spaces, use light fixtures with a luminance of less than 2,500 cd/m2 between 45 and 90 degrees from nadir. Exceptions include wallwash fixtures properly aimed at walls, as specified by manufacturer's data, indirect uplighting fixtures, provided there is no view down into these uplights from a regularly occupied space above, and any other specific applications (i.e. adjustable fixtures).
		B. For the entire project, use light sources with a CRI of 80 or higher. Exceptions include lamps or fixtures specifically designed to provide colored lighting for effect, site lighting, or other special use.
		C. For at least 75% of the total connected lighting load, use light sources that have a rated life (or L70 for LED sources) of at least 24,000 hours (at 3-hour per start, if applicable)
		D. Use direct-only overhead lighting for 25% or less of the total connected lighting load for all regularly occupied spaces.
		E. For at least 90% of the regularly occupied floor area, meet or exceed the following thresholds for area-weighted average surface reflectance: 85% for ceilings, 60% for walls, and 25% for floors.
		F. If furniture is included in the scope of work, select furniture finishes to meet or exceed the following thresholds for area-weighted average surface reflectance: 45% for work surfaces, and 50% for movable partitions.
		G. For at least 75% of the regularly occupied floor area, meet a ratio of average wall surface illuminance (excluding fenestration) to average work plane (or surface, if defined) illuminance that does not exceed 1:10. Must also meet strategy E, strategy F, or demonstrate area-weighted surface reflectance of at least 60% for walls.
		H. For at least 75% of the regularly occupied floor area, meet a ratio of average ceiling illuminance (excluding fenestration) to work surface illuminance that does not exceed 1:10. Must also meet strategy E, strategy F, or demonstrate area-weighted surface reflectance of at least 85% for ceilings.
Documents	Completed Interior Lighting Calculator or equivalent documentation	
	Indicate if the requirement are respected for: A. Light fixture luminance B. Color rendering index (CRI) C. Lamp life D. Direct-only overhead lighting E. Surface reflectance: ceilings, walls, floors F. Surface reflectance: furnishings G. Surface illuminance ratio: wall to work surface H. Surface illuminance ratio: ceiling to work surface	
	For A, B, E, G and H: Description of the light fixtures, light sources, and/or regularly occupied spaces (if any) that have been excluded from the light source illuminance calculations and the reason for exclusion.	
	For F: Descrition of the method for determining reflectance values	
	For G and H: Descrition of the method for determining illuminance values	

Credit 7	Daylight
Intent	To connect building occupants with the outdoors, reinforce circadian rhythms, and reduce the use of electrical lighting by introducing daylight into the space.
# points	Up to 3 points
Resources	LEED v4.1 Daylight and Quality Views Calculator
Requirements	Provide manual or automatic (with manual override) glare-control devices for all regularly occupied spaces. AND Select one of the following three options.
Documents	Completed Daylight and Quality Views Calculator
	Description of the glare control devices provided for all regularly occupied spaces. Specify whether the devices are manually controlled or automatic with manual override. Explain the sequence of operation for automatic shading devices.
Option 1. Simulation: Spatial Daylight Autonomy and Annual Sunlight Exposure (1-3 point)	
Requirements	Perform annual computer simulations for spatial daylight autonomy300/50% (sDA300/50%), and annual sunlight exposure1000,250 (ASE1000,250) as defined in IES LM-83-12 for each regularly occupied space. Additionally, calculate the average sDA300/50% value for the total regularly occupied floor area. For any regularly occupied spaces with ASE1000,250 greater than 10%, identify how the space is designed to address glare. Points are awarded according to Table 1.
	Table 1. Points for Option 1
	The sDA and ASE calculation grids should be no more than 600 mm square and laid out across the regularly occupied area at a work plane height of 76 mm above finished floor (unless otherwise defined). Use an hourly time-step analysis based on typical meteorological year data, or an equivalent, for the nearest available weather station. Include any permanent interior obstructions. Moveable furniture and partitions may be excluded.
Documents	Output summary from the daylight computer simulations for spatial daylight autonomy (sDA) and annual sunlight exposure (ASE)
	Daylight Summary
	Description of how the space(s) with ASE1000,250 greater than 10% are designed to address glare.
Option 2. Simulation: Illuminance Calculations (1-3 point)	
Requirements	Perform computer simulations for illuminance at 9 a.m. and 3 p.m. on a clear-sky day at the equinox for each regularly occupied space. Demonstrate illuminance levels are between 300 lux and 3,000 lux at both 9 a.m. and 3 p.m. Spaces with view-preserving automatic (with manual override) glare-control devices may demonstrate compliance for only the minimum 300 lux illuminance level. Points are awarded according to Table 2.
	Table 2. Points for Option 2
	Calculate illuminance intensity for sun (direct component) and sky (diffuse component) for clear-sky conditions as follows: Use typical meteorological year data, or an equivalent, for the nearest available weather station. Select one day within 15 days of September 21 and one day within 15 days of March 21 that represent the clearest sky condition. Use the average of the hourly value for the two selected days. Exclude blinds or shades from the model. Include any permanent interior obstructions. Moveable furniture and partitions may be excluded.
Documents	Output summary from the daylight computer simulations
	Daylight Summary
Option 3. Measurement (1-3 point)	
Requirements	Measure illuminance in each regularly occupied space. Healthcare projects should use the regularly occupied spaces located in the perimeter area determined under EQ Credit Quality Views. Achieve illuminance levels between 300 lux and 3,000 lux. Spaces with view-preserving automatic (with manual override) glare-control devices may demonstrate compliance for only the minimum 300 lux illuminance level. Points are awarded according to Table 3.
	Table 3. Points for Option 3
	With furniture, fixtures, and equipment in place, measure illuminance levels as follows: Measure at appropriate work plane height during any hour between 9 a.m. and 3 p.m. If pursuing one point, take one measurement in any regularly occupied month. If pursuing two points, take two measurements: one measurement in any regularly occupied month, and take a second as indicated in Table 4. For spaces larger than 14 m^2, take measurements on a maximum 3 m square grid. For spaces 14 m^2 or smaller, take measurements on a maximum 900 mm square grid.
	Table 4. Timing of measurements for illuminance
Documents	Project drawing(s) with the recorded daylight measurements and time that measurements were taken.
	Daylight Summary

Credit 8	Quality Views
Intent	To give building occupants a connection to the natural outdoor environment by providing quality views.
# points	1
Resources	LEED v4.1 Daylight and Quality Views Calculator
Requirements	Achieve a direct line of sight to the outdoors via vision glazing for 75% of all regularly occupied floor area. View glazing in the contributing area must provide a clear image of the exterior, not obstructed by frits, fibers, patterned glazing, or added tints that distort color balance. Additionally, 75% of all regularly occupied floor area must have at least two of the following four kinds of views:
	multiple lines of sight to vision glazing in different directions at least 90 degrees apart;
	views that include at least two of the following: (1) flora, fauna, or sky; (2) movement; and (3) objects at least 7.5 m from the exterior of the glazing;
	unobstructed views located within the distance of three times the head height of the vision glazing; and
	views with a view factor of 3 or greater, as defined in "Windows and Offices; A Study of Office Worker Performance and the Indoor Environment."
	Include in the calculations any permanent interior obstructions. Movable furniture and partitions may be excluded. Views into interior atria may be used to meet up to 30% of the required area.
Documents	Completed Daylight and Quality Views Calculator
	For projects with multiple lines of sight to vision glazing
	Plan view drawings, photographs, or other documentation showing the line of sight from interior spaces through exterior windows. Demonstrate that sight lines are at least 90 degrees apart.
	Sections or interior elevations with glazing elements and sight lines demonstrating that sight lines do not encounter permanent interior obstructions.
	For projects with views that include at least two features
	Plan view drawings, photographs, or other documentation showing the line of sight from interior spaces through exterior windows. Highlight at least two features for each view.
	Sections or interior elevations with glazing elements and sight lines. Documentation must demonstrate that sight lines do not encounter permanent interior obstructions and must address view feature differences with elevation.
	For projects with unobstructed views
	Plan view drawings, photographs, or other documentation showing the regularly occupied floor area within three times the head height
	Sections or interior elevations with glazing elements and sight lines demonstrating that sight lines do not encounter permanent interior obstructions.
	For projects with views with a view factor of three or greater
	Plan view drawings, photographs, or other documentation showing the regularly occupied floor area with a view factor of three or greater
	Sections or interior elevations with glazing elements, sight lines, and view factor (primary view or break view) or similar documentation for the regularly occupied area with a view factor of three or greater.

Credit 9	Acoustic Performance
Intent	To provide workspaces and classrooms that promote occupants' well-being, productivity, and communications through effective acoustic design.
# points	1 points
Resources	LEED v4.1 Acoustic Performance Calculator (excel)
Requirement	For all occupied spaces, meet at least two options (examplary performance if all three)
Option 1. HVAC background noise	
Requirements	Achieve maximum background noise levels from HVAC systems per 2015 ASHRAE Handbook-- HVAC Applications, Chapter 48, Table 1 ; AHRI Standard 885-2008, Table 15; or a local equivalent. If confirming compliance via measurements, use a sound level meter that conforms to ANSI S1.4 for type 1 (precision) or type 2 (general purpose) sound measurement instrumentation, the International Electrotechnical Commission IEC 61672-1:2013. Comply with design criteria for HVAC noise levels resulting from the sound transmission paths listed in 2015 ASHRAE Handbook—HVAC Applications, Chapter 48, Table 6; or a local equivalent.
Documents	Select the method used to demonstrate maximum noise level among:
	Measured per 2015 ASHRAE Handbook --HVAC Applications, Chapter 48, Noise and Vibration Control
	Calculated per 2015 ASHRAE Handbook --HVAC Applications, Chapter 48, Noise and Vibration Control
	Calculated per AHRI Standard 885-2008, Procedure for Estimating Occupied Space Sound Levels in the Application of Air Terminals and Air Outlets
	Determined through a local standard, procedure, or handbook
	Measurement results, calculations, design documentation from person(s) experienced in the field of acoustics, or the Acoustic Performance Calculator to demonstrate the maximum background noise levels. Documentation may be from representative rooms in the building
	For all sound transmission paths from sound sources included in the project, provide a narrative explaining how the noise reduction methods from 2015 ASHRAE Handbook --HVAC Applications, Chapter 48, Table 6 were implemented for the occupied spaces impacted by the sound source.
Option 2. Sound transmission	
Requirements	Categorize all occupied spaces by use and desired level of acoustic privacy. Meet the composite sound transmission class (STCC) ratings or noise isolation class (NIC) listed in Table 1. For NIC measurements, use ASTM E336-17a or Annex A.3 of ANSI S12.60-2010.
	Table 1. Minimum composite sound transmission class ratings or noise isolation class for adjacent spaces
	The overall level for sound masking must be set by an acoustical professional and must not exceed 48 dBA in open offices, libraries, cafeterias, corridors/hallways, 45 dBA in enclosed offices, and 42 dBA in conference rooms, and wellness rooms. The combined level of masking and HVAC background noise must not exceed these limits.
	The system design and commissioning must provide overall level uniformity of +/-1 dBA and one-third octave band uniformity of +/-2 dB from at least 100 to 5,000 Hz when tested according to ASTM E1573-18
	The sound masking spectrum must conform to the National Research Council of Canada COPE Optimum Masking Spectrum or an alternate spectrum if specified by an acoustical engineer.
Documents	Explanation of how the occupied spaces have been categorized in terms of use and acoustic privacy and provide documentation demonstrating the STCc or NIC criteria have been met for each space. Upload NIC measurement results, STCc calculations, design documentation from person(s) experienced in the field of acoustics, the Acoustic Performance Calculator or other documents as needed
	If sound masking systems are used, explanation of how they have been designed and commissioned to meet the credit requirements for overall sound level, sound uniformity, and sound masking spectrum
Option 3. Reverberation time	
Requirements	Meet the reverberation time requirements in Table 2 (adapted from Table 9.1 in the Performance Measurement Protocols for Commercial Buildings).
	Table 2. Reverberation time requirements
Documents	Measurement results, calculations, design documentation from person(s) experienced in the field of acoustics, or the Acoustic Performance Calculator to demonstrate the reverberation time values. Documentation may be from representative rooms in the building.

Innovation

Credit 1	Innovation
Intent	To encourage projects to achieve exceptional or innovative performance.
# points	Up to 5 points
Requirements	To achieve all five innovation points, a project team must achieve at least one pilot credit, at least one innovation credit and no more than two exemplary performance credits.
	Option 1. Innovation
	Achieve significant, measurable environmental performance using a strategy not addressed in the LEED green building rating system. Identify the following:
	the intent of the proposed innovation credit;
	proposed requirements for compliance;
	proposed submittals to demonstrate compliance; and
	the design approach or strategies used to meet the requirements.
	Option 2. Pilot
	Achieve one pilot credit from USGBC's LEED Pilot Credit Library
	Option 3. Additional Strategies
	In addition of meeting the requirement of the 2 options above, acheive exemplary performance in an existing LEED v4 prerequisite or credit that allows exemplary performance, as specified in the LEED Reference Guide, v4 edition. An exemplary performance point is typically earned for achieving double the credit requirements or the next incremental percentage threshold.
Documents	Indicate the number of points pursued for each approach the project team is attempting

Credit 2	LEED Accredited Professional
Intent	To encourage the team integration required by a LEED project and to streamline the application and certification process.
# points	1 point
Requirements	At least one principal participant of the project team must be a LEED Accredited Professional (AP) with a specialty appropriate for the project.
Documents	Name and credential of the LEED Accredited Professional with specialty who is a principal participant on the project team
	Description of the extent and depth of participation of the LEED Accredited Professional on the project.

8 References

[1] WBCSD, 'Energy Efficiency in Buildings: An insight from companies', Washington DC, US, 2014.

[2] United Nations - Department of Economic and Social Affairs - Population Division, 'World Population Prospects 2019: Highlights', 2019.

[3] United Nations - Department of Economic and Social Affairs - Population Division, 'World Urbanization Prospects: The 2018 Revision', New York: United Nations, 2019.

[4] United Nations, 'Transforming our World: The 2030 Agenda for sustainable development', 2016.

[5] World Green Building Council, 'Home | World Green Building Council', 2017. http://www.worldgbc.org/.

[6] C. J. Kibert, *Sustainable construction, Green Building Design and Delivery*, 4th editio. Hoboken, New Jersey: Wiley, 2016.

[7] RIBA, 'Plan of Work 2020 Overview', 2020.

[8] 'EN 16310: Engineering services — Terminology to describe engineering services for buildings , infrastructure and industrial facilities', 2013.

[9] G. D. Oberlender, *Project Management for Engineering and Construction*, 2nd editio. Thomas Casson, 2000.

[10] L. A. Blomfield, 'Utilizing Project Management Processes to Deliver LEED Certified Project', 2011.

[11] Designing Buildings, 'Contractual Documents', 2020. https://www.designingbuildings.co.uk/wiki/Contractual_documents.

[12] U.S. Green Building Council, 'LEED v4.1 Building Design and Construction', 2020.

[13] U.S. Green Building Council, *Reference Guide for Building Design and Construction*, 4th ed. 2019.

[14] P. Wu and S. P. Low, 'Project Management and Green Buildings: Lessons from the Rating Systems', *J. Prof. Issues Eng. Educ. Pract.*, vol. 136, no. 2, pp. 64–70, Apr. 2010, doi: 10.1061/(ASCE)EI.1943-5541.0000006.

[15] D. Castro-Lacouture, A. M. Ospina-Alvarado, and K. O. Roper, 'AEC+P+F integration with green project delivery and lean focus', *J. Green Build.*, vol. 3, no. 4, pp. 154–169, Nov. 2008, doi: 10.3992/jgb.3.4.154.

[16] The American Insitute of Architects, 'Integrated Project Delivery: A Guide', 2007.

[17] Lean IPD, 'What is Integrated Project Delivery?', 2020. https://leanipd.com/integrated-project-delivery/.

[18] L. B. Robichaud and V. S. Anantatmula, 'Greening Project Management Practices for Sustainable Construction', *J. Manag. Eng.*, vol. 27, no. 1, pp. 48–57, 2011, doi:

10.1061/(ASCE)ME.1943-5479.0000030.

[19] S. Seyis and E. Ergen, 'A decision making support tool for selecting green building certification credits based on project delivery attributes', *Build. Environ.*, vol. 126, pp. 107–118, 2017, doi: 10.1016/j.buildenv.2017.09.028.

[20] Å. I. Nesteby, M. E. Aarrestad, J. Lohne, and R. A. Bohne, 'Integration of BREEAM-NOR in Construction Projects: Utilizing the Last Planner System', *Energy Procedia*, vol. 96, no. 1876, pp. 100–111, Sep. 2016, doi: 10.1016/j.egypro.2016.09.110.

[21] G. Weerasinghe, K. Soundararajan, and J. Ruwanpura, 'LEED–PDRI Framework for Pre-project Planning of Sustainable Building Projects', *J. Green Build.*, vol. 2, no. 3, pp. 123–143, Aug. 2007, doi: 10.3992/jgb.2.3.123.

[22] A. Ofori-Boadu, D. Owusu-Manu, D. Edwards, and G. Holt, 'Exploration of management practices for LEED projects', *Struct. Surv.*, vol. 30, no. 2, pp. 145–162, 2012, doi: 10.1108/02630801211228743.

[23] T. H. Nguyen, S. H. Toroghi, and F. Jacobs, 'Automated Green Building Rating System for Building Designs', *J. Archit. Eng.*, vol. 22, no. 4, pp. 1–10, Dec. 2016, doi: 10.1061/(ASCE)AE.1943-5568.0000168.

[24] B.-G. Hwang and J. S. Tan, 'Sustainable Project Management for Green Construction', *Challenges, Impact Solut.*, no. June, p. 9, 2012.

[25] Government of the Disctrict of Columbia - Department of Real Estate Services, 'LEED Certification Guidebook', 2008.

[26] 'ISO 19650-1:2018: Organization and digitization of information about buildings and civil engineering works , including building information modelling (BIM) - Information management using building information - Part 1: Concepts and principles modelling', pp. 1–46, 2018.

[27] W. Wu and R. R. A. Issa, 'BIM Execution Planning in Green Building Projects: LEED as a Use Case', *J. Manag. Eng.*, vol. 31, no. 1, pp. 1–18, Jan. 2015, doi: 10.1061/(ASCE)ME.1943-5479.0000314.

[28] S. Azhar, W. A. Carlton, D. Olsen, and I. Ahmad, 'Building information modeling for sustainable design and LEED ® rating analysis', *Autom. Constr.*, vol. 20, no. 2, pp. 217–224, 2011, doi: 10.1016/j.autcon.2010.09.019.

[29] J. Choi, A. Bhatla, C. Stoppel, and J. Shane, 'LEED Credit Review System and Optimization Model for Pursuing LEED Certification', *Sustainability*, vol. 7, no. 10, pp. 13351–13377, Sep. 2015, doi: 10.3390/su71013351.

[30] M. Medineckiene, E. K. Zavadskas, F. Björk, and Z. Turskis, 'Multi-criteria decision-making system for sustainable building assessment/certification', *Arch. Civ. Mech. Eng.*, vol. 15, no. 1, pp. 11–18, Jan. 2015, doi: 10.1016/j.acme.2014.09.001.

[31] J. Ma and J. C. P. Cheng, 'Data-driven study on the achievement of LEED credits using percentage of average score and association rule analysis', *Build. Environ.*, vol. 98, pp. 121–132, 2016, doi: 10.1016/j.buildenv.2016.01.005.

[32] J. C. P. Cheng and L. J. Ma, 'A non-linear case-based reasoning approach for retrieval of similar cases and selection of target credits in LEED projects', *Build. Environ.*, vol. 93, no.

P2, pp. 349–361, 2015, doi: 10.1016/j.buildenv.2015.07.019.

[33] B.-G. Hwang, M. Shan, H. Phua, and S. Chi, 'An Exploratory Analysis of Risks in Green Residential Building Construction Projects: The Case of Singapore', *Sustainability*, vol. 9, no. 7, p. 1116, Jun. 2017, doi: 10.3390/su9071116.

[34] A. Welch, K. Benfield, and M. Raimi, 'A Citizen ' s Guide to LEED for Neighborhood Development : How to Tell if Development is Smart and Green', pp. 2–44, 2011.

[35] A. L. Pisello, 'High-albedo roof coatings for reducing building cooling needs', in *Eco-Efficient Materials for Mitigating Building Cooling Needs*, Elsevier, 2015, pp. 243–268.

[36] U. Environmental Protection Agency and W. Program, 'Water Efficiency Management Guide Landscaping and Irrigation Landscaping and Irrigation', no. November, 2017.

[37] L. Da Silva and J. Y. Ruwanpura, 'Review of the LEED Points Obtained by Canadian Building Projects', *J. Archit. Eng.*, vol. 15, no. 2, pp. 38–54, Jun. 2009, doi: 10.1061/(ASCE)1076-0431(2009)15:2(38).

[38] M. Mália, J. de Brito, M. D. Pinheiro, and M. Bravo, 'Construction and demolition waste indicators', *Waste Manag. Res.*, vol. 31, no. 3, pp. 241–255, Mar. 2013, doi: 10.1177/0734242X12471707.