

Building Our Future:

A Guide to Sustainable
Practices for the Built
Environment

Building Our Future: A Guide to Sustainable Practices for the Built Environment.
© 2024, COHERENTIA ZERO CARBON
Edited by Gallo E., Daniela; Baeza Z., Alejandro; Olvera A., Rafael
Published by COHERENTIA ZERO CARBON, S.A.P.I. de C.V.
First edition
ISBN No: 978-607-69787-0-2

This publication may be reproduced in whole or in part, in any format, for educational or non-profit purposes without prior permission, provided the source is cited. COHERENTIA ZERO CARBON appreciates receiving a copy of any publication referencing this guide.

No reproduction of this publication is allowed for resale or any other commercial purpose without prior written consent from COHERENTIA ZERO CARBON. Requests for such permissions, including a statement detailing the purpose and extent of reproduction, can be directed to info@coherentia.com.mx.

Disclaimers:

This document may mention commercial companies or products, but such mentions do not constitute endorsement by COHERENTIA ZERO CARBON or the authors. Information from this document may not be used for publicity or advertising. Trademark names and symbols are used editorially with no intention of infringing trademark or copyright laws.

The views expressed in this publication belong to the authors and do not necessarily reflect the opinions of COHERENTIA ZERO CARBON. While every effort has been made to check the accuracy and quality of the information given in this publication, neither the authors nor COHERENTIA ZERO CARBON accept any responsibility for the subsequent use of this information, for any errors or omissions that it may contain, or for any misunderstanding arising from it. We apologize for any unintentional errors or omissions.

Image inside the cover: The Kendeda Building for Innovative Sustainable Design photographed by Jonathan Hillyer. The image was adapted chromatically from the original for the cover of this ebook. You may find the original picture in: <https://www.hillyerphoto.com/PROJECTS/KENDEDA-LIVING-BUILDING/7>

The rest of the images inside the e-book are by Freepik (www.freepik.com) unless otherwise is specified.

Suggested Citation:

COHERENTIA ZERO CARBON. (2024). Building Our Future: A Guide to Sustainable Practices for the Built Environment (D. M. Gallo, A. Baeza, & R. Olvera, Eds.; 1st ed.). Mexico City

This ebook is available for download at www.coherentia.com.mx.

Content

Acknowledgments	5
About COHERENTIA ZERO CARBON	6
Preface - The Challenge: Construction's Crucial Role in Climate Change.	8
The Urgency: Witnessing the Devastating Consequences	8
The Opportunity: Transforming the Built Environment	9
Beyond "Green" Buildings: A Systemic Shift	10
Part 1: Fundamentals of Green Building	11
• Understanding Sustainability	11
1. Triple Bottom Line (TBL):	11
2. Life Cycle Assessment (LCA):	12
3. Embodied Carbon	12
4. Interconnectedness of systems	12
• Benefits of Green Buildings	13
Green Buildings: A Triple Win for Environment, Economy, and Society	13
• Challenges and Opportunities	14
Challenges:	14
1. Technical:	14
2. Financial:	15
3. Market:	15
Opportunities:	15
1. Innovative solutions:	15
2. Financial solutions:	16
3. Market development:	16
Part 2: Design and Construction Strategies	17
• Site Planning and Development:	17
• Energy Efficiency	18
Passive design principles	18
» Proper orientation	18
» Daylighting and Passive Solar Design (Window placement and shading)	18
» Ventilation	18
Energy Efficient Systems	18
» High-performance building envelope	18
» Ventilation, Heating and Air Conditioning	19
» Energy-efficient lighting	19
» Energy Conservation Codes	20
Climate zones	21
Building envelope	21
Building mechanical systems	21
Specialized Equipment	22
Service water heating	23

Electrical power and lighting systems	23
Additional efficiency requirements	23
Total building performance	23
» Renewable Energy Generation	23
» Energy storage	23
» Energy associated with mobility	24
• Water Conservation	24
• Material Selection and Management	24
• Indoor Environmental Quality	25
Part 3: Construction Practices and Technologies	26
• Green Building Materials and Products:	26
• Prefabrication and Modular Construction:	26
• Building Information Modeling (BIM):	26
• Construction Waste Management:	27
Part 4: Green Building Certifications and Standards	28
• Overview of Popular Certifications	28
LEED	28
EDGE	29
Passive House	30
BREEAM	31
Living Building Challenge	31
WELL	32
• Certification Selection and Application	32
• Benefits of Certification	33
Part 5: Operation and Maintenance	35
• Green Building Operations Best Practices:	35
Energy management	35
Energy Audits	35
Retrocommissioning	36
• Maintenance for Sustainability	36
Building System Maintenance	36
Equipment Optimization	37
Proactive Approaches	37
• Continuous Improvement and Performance Tracking	37
Monitoring	37
Data Analysis	38
Improvement Strategies	38
Measurement and Verification	38
Part 6: Emerging Trends and Innovation	39
• Advances in Building Technologies:	39
• Future of Green Construction	41
Additional Resources	42
Bibliography	43

Acknowledgments

We extend our sincere gratitude to Juan Carlos Olvera Sanmiguel and Rafael Olvera Arévalo for their generous sponsorship during the COHERENTIA crowdfunding campaign from February to April 2023. Special thanks are also due to Natalia Vanesa Gallo Enamorado for her unwavering and generous support, particularly in sponsoring the logo design, graphic identity of COHERENTIA, and the graphic edition of this guide. Their invaluable contributions not only made the creation of this e-book possible, but also ensured its accessibility to the public. We deeply appreciate their commitment and collaborative efforts in bringing this initiative to fruition. Thank you for making it happen together!

About COHERENTIA ZERO CARBON

At COHERENTIA ZERO CARBON, S.A.P.I. de C.V.,(COHERENTIA), we are a passionate startup committed to facilitating the transition towards sustainable construction practices. Founded with the purpose of decarbonizing the construction sector, we connect green and non-toxic solutions to building projects, ultimately aiming to improve public health and streamline the procurement process for sustainable building materials that meet international standards.

Team

Our team boasts over 10 years of experience in the fields of sustainable construction, technology development, and related sectors. We leverage our expertise in sales, business development, project management, and technical consultancy to drive positive change within the industry. Meet the co-founders and leaders shaping our mission:



Daniela Gallo, CEO - Business & Sales

Ph.D City, Territory and Sustainability, MPM, BArch., LEED AP BD+C

Background: Roles as a Manager in Commercial Development and Green Building Technical Consultant.



Rafael Olvera, Advisor Board Member for Energy Modelling

MEng. Thermic Eng., ASHRAE - BEMP, LEED AP BD+C

Background: Roles as Manager in Building Energy Modelling, and Green Building Technical Consultant and Energy Efficiency.



Alejandro Baeza, Advisor Board Member for Commissioning

MEng. Sustainable Energy, ASHRAE - CPMP, LEED AP O+M

Background: Roles as Manager in Commissioning and Energy Efficiency Technical Consultant.



Víctor Morales, CTO - Programmer and Developer

Master in Cognitive Science and Computational Logic, Bach. Graphic Design

Background: Roles as CTO of a hardware & software developer company



Natalia Gallo, COO - Digital Marketing

Master in Project Management, Bach. in Marketing and International Businesses with a specialization in SMB Management.

Background: Roles as IT Project Manager +20 IT projects, Customer Experience, Brand and Operational Manager.

Join us on our mission to build a greener future!

Preface – The Challenge: Construction’s Crucial Role in Climate Change.

The stark reality is that the construction sector plays a disproportionate role in the climate crisis. Uncontrolled climate change could cost the global economy \$178 trillion over the next 50 years. Reducing the environmental impact of construction projects is crucial, as they are responsible for 39% of global carbon emissions: 28% from operational emissions and 11% from materials and construction, due to the use of carbon-intensive materials and high levels of pollutants. In addition, cities will grow globally by 230 billion square metres by 2060, equivalent to building a New York City every month until 2060, and generating a total of 100 to 200 gigatons of embedded carbon in the materials used to build them.

This means the built environment is both a significant contributor to anthropogenic climate change and holds immense potential as a powerful solution. We cannot ignore the complex yet undeniable relationship between our buildings and infrastructure, and the escalating threats they face from extreme weather events.

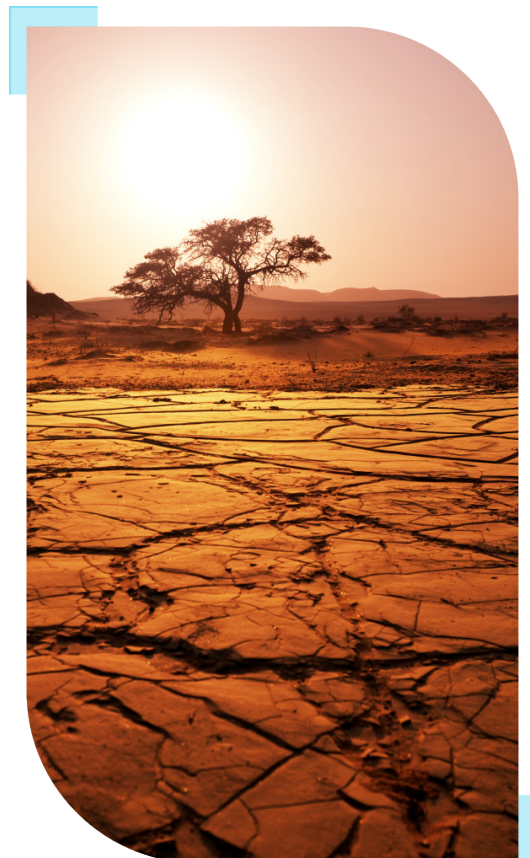
Building Our Future: A Guide to Sustainable Practices for the Built Environment brings you over ten years of our experience, distilled into actionable strategies. This comprehensive guide leverages established frameworks like LEED, EDGE, Passive House, BREEAM, Living Building Challenge, and WELL, along with international energy efficiency standards, to empower you to confidently navigate the path towards a sustainable built environment, in every single phase of the cycle of your building project.

The Urgency: Witnessing the Devastating Consequences

We are all painfully aware of the dire consequences of human-made emissions across the globe. Heatwaves, floods, droughts, storms, and wildfires are becoming more frequent and intense, impacting families, communities, and economies worldwide. These events pose a dire threat to biodiversity and lead to significant social and economic losses.

The economic ripple effects are widespread, encompassing:

- Loss of property and infrastructure damage
- Disruption of essential services and long-term recovery costs
- Reduced worker productivity and potential job losses
- Disruption of livelihoods and businesses
- Reduced agricultural productivity and water scarcity



- Business closures and supply chain disruptions
- Strain on healthcare systems, leading to increased costs
- Higher insurance costs burdening individuals and businesses

Industries like agriculture and tourism are particularly vulnerable, leading to job losses and economic hardship for entire regions. Furthermore, the social consequences are equally devastating, including:

- Loss of life, displacement of communities, and migration
- Exacerbation of existing social inequalities
- Disruption of social networks and community cohesion
- Mental health impacts from witnessing destruction and displacement
- Increased social conflict
- Disruption of access to education and healthcare

The Opportunity: Transforming the Built Environment



While the challenges are vast, the good news is that the built environment also holds the key to a brighter future. By embracing sustainable practices, we unlock a \$43 trillion opportunity to grow the world economy by 2070.

The following chapters will explore some of the solutions that focus on:

- **Compact, mix-uses, walkable cities:** Densifying and diversifying cities with green spaces reduces reliance on cars and promotes alternative transportation and businesses.
- **Retrofitting existing buildings:** Improving energy and water efficiency in existing

buildings, often coupled with renewable energy sources, significantly reduces emissions.

- **Sustainable design and construction:** Implementing green building practices like optimized design, efficient systems, and renewable energy integration in new buildings leads to substantial energy savings and climate change mitigation. This includes selecting low-carbon and renewable materials.
- **Mandatory building codes:** Establishing worldwide minimum energy and water performance standards for buildings, with voluntary ratings for exemplary efficiency and net-zero performance.
- **Appliance standards and labels:** Implementing mandatory minimum energy performance standards and labels for appliances, equipment, and lamps, with voluntary standards for high-performance models.
- **Financial incentives:** Encouraging sustainable practices through tax reductions, lower loan interest rates, subsidies, and grants.

Beyond “Green” Buildings: A Systemic Shift

Building “green” is crucial but insufficient on its own. We need a systemic transformation encompassing:

- **Sustainable resource extraction:** Changing how we extract and process materials for construction.
- **Renewable energy production:** Creating cleaner and more sustainable energy sources.
- **Efficient transportation systems:** Developing less carbon-intensive transportation infrastructure and modes.
- **Deforestation reduction:** Minimizing land-use changes and protecting critical forest and water ecosystems.
- **Reduced methane emissions:** Addressing emissions from agriculture, the meat industry, and natural gas.



This collective effort demands collaboration across industries, governments, and individuals. The construction sector must take the lead, embracing these challenges and opportunities with urgency and ambition.

Let’s work together to transform the built environment into a force for good, mitigating climate change and creating a more sustainable future for us and future generations.



Part 1:

Fundamentals of Green Building

Green building practices are a fundamental cornerstone in pursuing sustainable development, embodying a commitment to balance our built environment's economic, social, and environmental dimensions. The benefits of green buildings extend beyond environmental preservation; they encompass enhanced occupant well-being, resource efficiency, and long-term economic advantages.

However, this noble endeavour has challenges, requiring a nuanced understanding of interdisciplinary complexities. It is imperative to recognize that the quest for sustainable buildings and cities demands intentional efforts from the outset of the design process, where economic, social, environmental, and technical considerations converge. Once a building has been designed, the opportunity to instil sustainability becomes limited, underscoring the critical importance of comprehensive planning and collaborative approaches.

As we delve into the fundamentals of green building, it becomes evident that achieving true sustainability necessitates foresight, innovation, and a collective commitment to fostering resilient and coherent urban landscapes.

Understanding Sustainability

In the exploration of sustainable practices within the built environment, we will examine key foundational concepts. Fundamental principles such as the Triple Bottom Line, Life Cycle Assessment, Embodied Carbon, and Interconnectedness of Systems, will guide responsible decision-making.

1. Triple Bottom Line (TBL):

The triple bottom line is a framework for measuring the success of a business or project by considering three pillars:

- **People:**
 - Social equity and resilience: Ensure buildings are accessible, inclusive, and adaptable to future challenges like climate change.
 - Human health, and well-being of stakeholders, including employees, communities, and occupants: Create healthy and comfortable indoor environments with good air quality, lighting, thermal comfort, and access to nature.
- **Planet:** Environmental impact, resource use, and contribution to climate change mitigation and adaptation. Reduce negative impacts on resources and ecosystems through energy efficiency, water conservation, and minimizing waste.

- **Profit:** Economic viability, financial performance, and long-term shareholder value increase.

TBL encourages businesses to think beyond the financial bottom line and consider their social and environmental responsibilities. Green buildings strive to optimize all three aspects, creating sustainable and liveable spaces while maintaining economic viability.

2. Life Cycle Assessment (LCA):

Sustainable buildings should be designed with their whole life in mind. LCA is a tool to assess the environmental impacts of a product, process, or service throughout its entire life cycle, from resource extraction and production to use, end-of-life, and disposal. It takes into account all stages, including

- Raw material extraction and processing
- Manufacturing and transportation
- Construction and installation
- Operation and maintenance,
- Demolition and waste disposal

By providing a holistic view of environmental impacts, LCA helps identify hotspots and potential areas for improvement, allowing designers and builders to make informed decisions for more sustainable buildings.



3. Embodied Carbon

Refers to the greenhouse gas emissions associated with the materials and construction of a building, excluding emissions from its operation (energy use). It includes:

- Emissions from extracting, processing, and transporting building materials
- Emissions from manufacturing and installing building components
- Emissions from demolition and disposal of building materials

Reducing embodied carbon is crucial for green buildings to combat climate change and achieve overall sustainability. Strategies include using low-carbon materials, locally sourced materials, and circular economy principles in construction.

4. Interconnectedness of systems

Our behaviours within a space ripple outwards, influencing the building, the city, and even the global ecosystem. Through design, we can manage behaviours and their impacts. By incorporating sustainable features like energy-efficient systems, water-saving fixtures, natural ventilation, and green spaces, architects and designers can create spaces that

encourage responsible behaviour, and energy conservation, facilitate waste reduction, minimize environmental impact, and create healthy environments.

Benefits of Green Buildings

Green Buildings: A Triple Win for Environment, Economy, and Society

The benefits of green buildings extend far beyond their impressive eco-friendly credentials. They offer a win-win-win scenario for the environment, economy, and society, positively impacting all stakeholders. Some of these benefits are

Environmental benefits:

- **Reduced energy consumption and greenhouse gas emissions:** Optimized design, energy-efficient systems, and renewable energy integration lead to significant energy savings and contribute to climate change mitigation.
- **Water conservation and protection:** Low-flow fixtures, rainwater harvesting, and greywater systems minimize water usage and strain on freshwater resources.
- **Improved air and water quality:** Enhanced ventilation, filtration systems, and responsible material choices lead to cleaner indoor and outdoor environments.
- **Minimized waste generation and pollution:** Construction waste reduction strategies and sustainable materials choices decrease the environmental burden and promote circular economy principles.
- **Biodiversity and habitat preservation:** Green roofs, permeable paving, and native landscaping provide valuable habitat for pollinators and other wildlife, promoting ecological balance.

Economic benefits:

- **Reduced operating costs:** Energy and water efficiency measures lead to lower utility bills, increasing building profitability and long-term financial savings.
- **Increased asset value:** Green buildings often command higher rental rates and property values due to their enhanced health, comfort, and operational efficiency. The lower the operating cost, the higher the profitability.
- **Job creation and economic growth:** The green building sector is rapidly growing, creating new jobs in construction, design, technology, and related fields.
- **Innovation and technological advancements:** The demand for green solutions drives innovation in sustainable materials, technologies, and design approaches, benefiting the entire industry.
- **Attracting and retaining talent:** Green buildings can attract tenants and retain employees who value environmentally responsible practices and healthy productive workspaces.



Social benefits:

- **Improved occupant health and well-being:** Enhanced indoor air quality, natural lighting, thermal comfort, and access to green spaces contribute to occupant well-being, reducing allergies, respiratory problems, and stress.
- **Increased productivity and satisfaction:** Comfortable and healthy indoor environments improve workplace productivity and employee satisfaction.
- **Community resilience and adaptation:** Green building principles can enhance buildings' resilience to climate change impacts like extreme weather events.
- **Social equity and inclusivity:** Accessible design, affordable housing options, and community amenities in green buildings can promote social equity and inclusivity.
- **Enhanced quality of life:** Green buildings contribute to cleaner air, quieter neighbourhoods, and more liveable communities for everyone.

Considering the environmental, economic, and social benefits, it becomes clear that green buildings are a good choice for the planet and a smart investment for building owners, occupants, and society.

The transition to green buildings is not just about individual projects, but about creating a sustainable future for everyone. By building greener, we can invest in healthier communities, a thriving economy, and a planet that can support future generations.

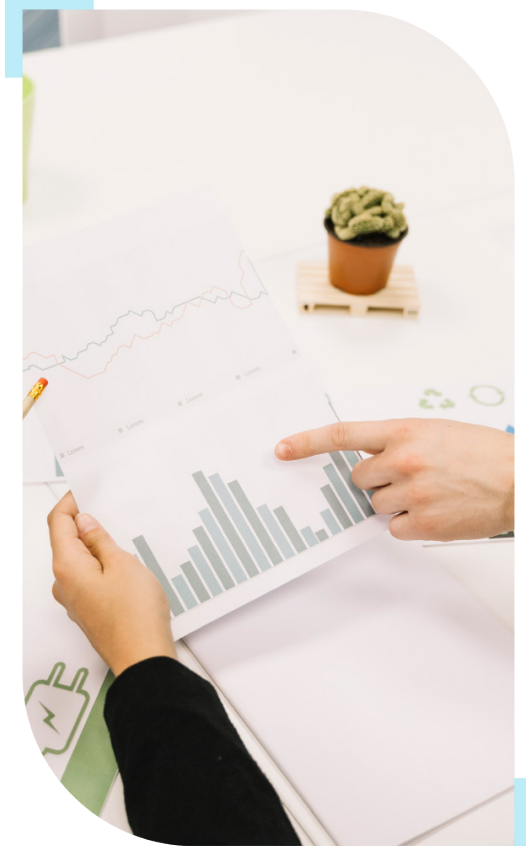
Challenges and Opportunities

While green buildings offer many benefits, implementing them has its fair share of challenges. Understanding these hurdles and identifying innovative solutions is crucial for advancing sustainable construction practices.

Challenges:

1. Technical:

- **Higher upfront costs:** Green construction often involves high-performance materials and technologies, initially impacting project budgets.
- **Limited availability of materials and skilled labour:** Finding specific sustainable materials and workers trained in green building techniques can be difficult in some regions.
- **Complexity of design and integration:** Optimizing energy efficiency, water conservation, and indoor environmental quality requires comprehensive planning and integration of systems.
- **Performance verification and monitoring:** Accurately measuring and verifying the sustainability performance of a building can be complex and resource-intensive.



2. Financial:

- **Lack of financial incentives:** While long-term savings are substantial, upfront costs can only deter investors and developers with adequate incentives like tax breaks or green finance mechanisms.
- **Split incentives:** When building owners and occupants are different entities, financial benefits and motivations for green features may not be aligned.
- **Limited access to green financing:** Traditional financing options may not consider the long-term value of green buildings, creating barriers to project funding.

3. Market:

- **Lack of awareness and demand:** Consumer and market awareness of green building benefits is still evolving, impacting demand for such properties.
- **Resistance to change:** Traditional construction stakeholders may be hesitant to adopt new technologies and practices, because it involves them doing things differently than they already do, or an effort to learn something new, creating inertia in market adoption.
- **Limited market data and transparency:** Lack of readily available data on green buildings' actual performance and financial returns hinders informed decision-making.

Opportunities:

1. Innovative solutions:

- **Modular construction:** Prefabricated green building modules can reduce cost, construction time, and material waste. They could be designed for durability, flexibility, adaptability and easy maintenance and repair while foreseeing the deconstruction and recyclability of the building.
- **Biomaterials and renewable resources:** Using rapidly renewable and low-carbon building materials like bamboo and bio-based resins can address material availability concerns.
- **Building information modelling (BIM):** Using BIM for design optimization, energy analysis, and collaboration can improve project efficiency and sustainability outcomes.
- **The 6 dimensions of a sustainable building:** the traditional 2D drawings have evolved into sophisticated 3D virtual representations, allowing us to evaluate how the building will perform, in this instance, the building's environmental design efficacy and its impacts. Time is considered as the 4D. The decisions' costs are viewed as the 5D. The 6D model, therefore, constitutes the as-built project information or post-construction project data accessible to the owner, facilitating the sustainable operation of the building.
- **Performance-based contracts:** Agreements based on guaranteed energy savings



or occupant health improvements can mitigate upfront cost concerns and share benefits across stakeholders.

2. Financial solutions:

- **Green financing mechanisms:** Public and private sector initiatives offering green loans, tax breaks, and subsidies can incentivize green building investments.
- **Life cycle cost analysis:** Demonstrating the long-term financial benefits of energy and water savings can attract investors and developers.
- **Green bonds and crowdfunding:** Innovative financing models can attract capital from environmentally conscious investors seeking sustainable returns.

3. Market development:

- **Education and awareness campaigns:** Increasing public understanding of green building benefits can drive market demand for sustainable properties.
- Implementation of mandatory building energy codes and incentivize high performance
- **Green building certifications and standards:** Implementing recognized certifications can differentiate green buildings, providing confidence for investors and occupants.
- **Data transparency and benchmarking:** Creating readily available databases on green building performance can inform decision-making and showcase the tangible benefits.

Overcoming these challenges and embracing innovative solutions and market development opportunities requires a collaborative effort from policymakers, investors, developers, architects, engineers, and consumers. By working together, we can navigate the hurdles and pave the way for a future where green buildings are the norm, not the exception.

Remember, the transition to green construction is not just about individual buildings, but about transforming the entire built environment. By addressing the challenges and seizing the opportunities, we can ensure that our cities and communities thrive in a sustainable future.



Part 2:

Design and Construction Strategies

A sustainable building employs strategies to, if not achieve complete autonomy, at least strive to reduce as much of the energy that it consumes as possible through a highly energy-efficient design and envelope, as well as generate more energy than it consumes with zero carbon emissions. Reduces its embodied carbon through a conscious choice of its materials. It focuses on minimizing water consumption and waste production, promoting the health of its occupants, and minimizing pollution. Sustainability also means creating durable buildings that adapt to changing needs and can be easily dismantled when required.

These strategies include:

• Site Planning and Development:

- **Sustainable site selection:** Choose sites with minimal environmental impact, prioritize reusing existing infrastructure or buildings, and avoid sensitive ecosystems, such as mangrove areas or biological reserves, for example.
- Avoidance of non-essential underground spaces
- **brownfield redevelopment:** Green buildings rise from the ashes of former industry, breathing new life into polluted and abandoned sites while showcasing environmentally mindful construction.
- Design for durability, flexibility, adaptability and easy maintenance and repair.
- Foresee deconstruction and recyclability of the building.
- **Green infrastructure:** Incorporate green roofs, permeable paving, and bioswales to manage stormwater and improve air quality. The incorporation of green roofs and landscaping reduces heat islands and provides insulation.
- **Landscape design for resilience:** Use native plants requiring minimal water to create natural habitats. Limit the use of turf or reduce to the maximum possible amount of traditional grass lawns surrounding the building by replacing traditional lawns with drought-tolerant landscaping using native plants. This has several environmental benefits, like water conservation, as it requires significant water for irrigation; reduced chemical use that harms the environment and pollutes waterways; enhanced biodiversity as replacing some or all of the turf with native plants, shrubs, and trees can increase biodiversity by providing habitat for pollinators, birds, and other

beneficial insects, requiring less maintenance than a traditional lawn; heat island mitigation as green spaces can help cool the surrounding environment and reduce energy consumption for cooling buildings; and improved soil health and drainage.

- **Optimized location:** Central location, diversity of uses and social amenities, reduced car parking, priority for the use of public transport, hybrid or electric vehicles, as well as universal accessibility, and alternative mobility infrastructure such as bicycles.



• Energy Efficiency

Passive design principles

Optimize building orientation, daylighting, and natural ventilation to minimize reliance on mechanical systems.

» Proper orientation

Take advantage of the sun's path and prevailing winds to maximize natural light and ventilation within the building.

» Daylighting and Passive Solar Design (Window placement and shading)

Building design to maximize natural daylight and passive solar heating when needed. Strategically placed windows can provide natural light and ventilation while reducing heat loss and heat gain. The use of shading elements, such as overhangs, louvres or screens, can reduce solar heat gain in the building in warm climate zones.

» Ventilation

Natural ventilation can be used to circulate fresh air throughout the building, reducing the need for mechanical ventilation systems.

Energy Efficient Systems

The building should be designed and constructed to minimize its energy consumption. Improving the building envelope and mechanical systems to reduce energy consumption. Optimized design, energy-efficient systems, and renewable energy integration contribute to significant energy savings and climate change mitigation.

» High-performance building envelope

- **Passive Solar Design:** Using the sun to heat, or protect, the building through appropriate orientation, insulation and shading.
- **Insulation:** Adequate insulation helps to reduce heat loss in winter and heat gain in summer, improving energy efficiency.
- **High reflectance roof:** Consider high reflectance in the roof to reduce heat gains and heat island effect. Cool roofing materials are typically made of reflective materials such as white or light-coloured coatings, reflective tiles or membranes to enhance solar reflectance and reduce heat absorption. Therefore, it contribute to reducing cooling energy requirements and contributes to better indoor air quality, especially in warm climates. Besides, it extends the lifespan of the roof by reducing thermal stress in it.
- **Solar Heat Gain coefficient (SHGC):** it represents the fraction of solar radiation entering a building through a window or other fenestration system. A lower SHGC is desirable in warm climates to minimize the amount of heat entering the building,

while a higher SHGC may be preferred in colder climates to utilize solar heat gain for passive heating. Low SHGC in fenestration can reduce heat gains through solar radiation, though a low SHGC sometimes means poor visibility in the window, this can be solved with better window technology or shading. Different types of glazing, coatings, and shading devices can be used to achieve specific SHGC values based on the desired energy performance and climate considerations. Some advanced glazing technologies offer dynamic SHGC control, allowing the adjustment of solar heat gain based on real-time conditions. Electrochromic or thermochromic windows can dynamically change their tint to modulate solar heat transmission. Dynamic shading elements are also available for façade protection, adapting its location depending on the time of day and orientation of the sun.

» Ventilation, Heating and Air Conditioning

- **Natural ventilation:** Natural ventilation can be used to circulate fresh air throughout the building, reducing the need for mechanical ventilation systems.
- **Geothermal Heating and Cooling:** Using the ground's constant temperature to heat and cool the building especially in buildings located in climate zones with heat and cooling needs in summer and winter respectively. Geothermal heat pumps or Provençal Wells are some alternatives.
- **Heat Recovery Ventilation:** Recycling the heat from the expelled air to heat the incoming air, for cold climate zones, or during winter
- **Radiant Floor Heating:** Heating system at a lower temperature that heats the floor, which in turn heats the space, for cold climate zones, or during winter.
- **Ground-Source Heat Pumps:** Consider heating spaces using heat pumps instead of electric or gas heaters. Use of constant ground temperature to heat and cool the building.
- **Chilled beams:** Consider the use of chilled beams, especially in climate zones with low humidity, to provide cooling at higher temperature with minimal use of energy to move the air. Chilled beams primarily use convection and radiation to cool indoor spaces. You could use the ones that rely solely on natural convection for cooling, or the ones that incorporate ventilation components for high-demand spaces. Chilled beams have the ability to operate with higher chilled water temperatures and reduced airflow rates, leading to lower energy consumption for the cooling process and air distribution.
- Consider HVAC systems with high efficiency indicators, such as Coefficient of Performance (COP), Seasonal Energy Efficiency Ratio (SEER), Energy Efficiency Ratio (EER), Integrated Energy Efficiency Ratio (IEER), Integrated Part Load Value (IPLV). Systems with high COP, SEER, EER, IEER and IPLV values consume less energy to provide the same heating or cooling output. This results in significant energy savings over the lifetime of the system.
- **Control systems:** Consider control systems to define schedules of lower or higher temperatures, and unoccupied or occupied spaces, among other control strategies
- **Thermal driven cooling:** Consider free or recovered thermal sources such as solar energy or Combined Heat and Power (CHP) systems to power thermal driven HVAC systems.

» Energy-efficient lighting

- **Daylighting:** Utilizing natural light through strategic window placement and design can significantly reduce reliance on artificial lighting.
- **Improved quality:** High lumen-to-watt ratio in lighting fixtures allows a lower energy consumption and reduced heat generation. Longer lifespan in lighting systems, and reduce life cycle impact of the building. LED bulbs are nowadays the most widely used and efficient, available in various types and colours.

- **OLED lighting (Organic LED):** Evolving technology providing superior light quality and efficiency, albeit at a higher initial cost.
- Improved controllability: Many energy-efficient lighting options, like LEDs, can be dimmed or controlled intelligently, reducing energy consumption.

» Energy Conservation Codes

The development of energy efficiency requirements adopted at national level, or even by certification programs such as LEED, is a task that is carried out by organisms that encompass the different disciplines involved in the building design and construction process.

Since requirements vary by location, market and even building typology it is necessary to have a clear breakdown structure of each one. We can take a look at the International Energy Conservation Code (IECC), which separates broadly in commercial and residential provisions. Each one is structured by topics, such as:

- Administration and definitions
- Climate zones and general materials requirements
- Energy efficiency requirements
- Existing buildings
- Reference standards

The 2021 IECC represents a crucial milestone in the global effort to enhance energy efficiency in building construction and operation. Released by the International Code Council (ICC), this updated code sets forth comprehensive guidelines and standards for the design and construction of energy-efficient residential and commercial buildings.

This code incorporates advancements in technology and building science to establish more stringent requirements for insulation, lighting, heating, ventilation, and air conditioning systems. By prioritizing sustainable practices and promoting the use of renewable energy sources, the code aims to reduce energy consumption and minimize environmental impact.



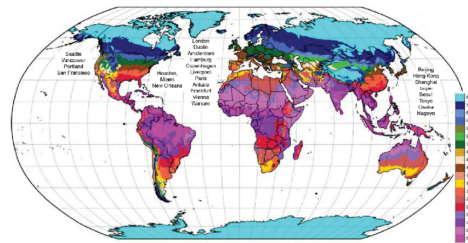
It is common that the Energy Conservation codes include an appendix listing typical values for standard material and equipment, as well as more detailed methodologies for showing compliance with the code. The organisms responsible for updating these codes keep review cycles that allow them to keep up with the ever-increasing need to maximize efficiency, alongside manufacturers' development of readily available commercial solutions to meet the intended goals.

It is important to notice that the implementation of these codes and their enforcement varies widely across the globe, some countries have been adopting them for several years and others are still in the process of adequate them to their specific needs and possibilities; however, consumers do have the opportunity to get involved through

optional certification programs or even just by gathering adequate specifications for their specific needs and invest in energy efficiency, which in turn provides them with several years of cost reductions in their energy bills.

Climate zones

One of the most critical things to do, is to identify the climate zone and moisture zone of your project. You can use [Table C301.3](#), to classify your project location into one of eight climate zones based on heating and cooling degree days (HDD and CDD), determining applicable energy efficiency requirements for the building envelope and HVAC systems.



The climate zones are used by the IECC to establish minimum energy efficiency requirements for buildings in different locations. Buildings in colder climates will have stricter heating requirements, while buildings in warmer climates will have stricter cooling requirements.

The climate zones are: Zone 0 - Extremely Hot, Zone 1 - Very Hot, Zone 2 - Hot, Zone 3 - Warm, Zone 4 - Mixed, Zone 5 - Cool, Zone 6 - Cold, Zone 7 - Very Cold, Zone 8 - Subarctic/Arctic.

The moisture zones are A for Humid, B for Dry, and C for Marine. You can determine the moisture zone if you have the monthly or annual average temperature and precipitation data of the location of your project.

If we were to have a deeper look at the Energy Efficiency requirements chapter, we would find there listed sections for items such as:

Building envelope

- **R-Value Method** ([Table C402.1.3](#)): Sets minimum R-values (thermal resistance) for opaque building components like walls, roofs, floors, and other opaque building components. Selecting materials with sufficient R-values ensures adequate insulation performance for your chosen climate zone, minimizing energy loss or gain.
- **U-Factor Method** ([Table C402.1.4](#)): Defines maximum U-factors (heat transfer rate) for opaque building assemblies. By choosing materials and construction methods that meet these U-factors, you minimize unwanted heat transfer through walls, roofs, and floors.
- **Fenestration** ([Table C402.4](#)): Establishes maximum U-factors and Solar Heat Gain Coefficients (SHGC) for windows and doors. Balancing these values ensures energy efficiency while allowing desirable daylighting.
- **Air Leakage** ([Table C402.5.4](#)): sets maximum air leakage rates for windows and doors. Minimizing uncontrolled airflow is crucial for airtightness, reducing energy loss and improving building comfort.

Building mechanical systems

- **Electrically Operated Unitary Air Conditioners & Condensing Units** ([Table C403.3.2\(1\)](#)): This table sets minimum efficiency requirements for stand-alone

air conditioners and their condensing units, measured by their Seasonal Energy Efficiency Ratio (SEER). Choosing units exceeding these minimums can significantly reduce cooling energy consumption.

- **Electrically Operated Air-Cooled Unitary Heat Pumps** ([Table C403.3.2\(2\)](#)): Similar to Table 1, this table specifies minimum SEER and Heating Seasonal Performance Factor (HSPF) for heat pumps, providing both heating and cooling functionality. Consider higher efficiency ratings and features like variable-speed compressors and desuperheaters for maximizing energy savings across seasons.
- **Water-Chilling Packages** ([Table C403.3.2\(3\)](#)): This table addresses larger, centralized water-chilling systems, setting minimum Energy Efficiency Ratio (EER) requirements. Consider advanced technologies like variable-speed drives, two-stage cooling, and integrated economizers for superior efficiency, especially in large buildings.
- **Packaged Terminal Systems** ([Table C403.3.2\(4\)](#)): This table covers various packaged units like room air conditioners and vertical air handlers, specifying minimum SEER or HSPF based on type and capacity. Look for units exceeding minimums and features like variable-speed fans and modulating controls for individual zone comfort and efficiency.
- **Warm-Air Furnaces & Boilers** ([Tables C403.3.2\(5\) & \(6\)](#)): These tables specify minimum Annual Fuel Utilization Efficiency (AFUE) for gas and oil-fired furnaces and boilers, respectively. Higher AFUE translates to lower fuel consumption. Consider advanced features like condensing furnaces and modulating burners for significant efficiency gains.
- **Heat Rejection Equipment** ([Table C403.3.2\(7\)](#)): This table addresses cooling towers and evaporative coolers, setting minimum EER or Total Energy Ratio (TER) requirements. Select equipment exceeding minimums and explore options like variable-speed drives and two-stage operation for optimal water-cooled system performance.
- **Variable-Refrigerant-Flow Systems** ([Tables C403.3.2\(8\) & \(9\)](#)): These tables cover VRFs, a versatile HVAC system using refrigerant for both heating and cooling. Minimums are specified for SEER, Integrated Energy Performance Ratio (IEPR), and COP (Coefficient of Performance). Explore variable-speed compressors, inverter technology, and multi-zone control for maximizing efficiency and flexibility.

Specialized Equipment

[Tables C403.3.2\(10-16\)](#) address specific equipment types with individual efficiency metrics:

- **Computer Room Air Conditioners** ([Table 10](#)): Minimum sensible heat ratio (SHR) ensures proper dehumidification.
- **Indoor Pool Dehumidifiers** ([Table 11](#)): Minimum COP for efficient moisture removal.
- **DX-DOAS Units (Direct Expansion Dedicated Outdoor Air System)** ([Tables 12 & 13](#)): Minimum EER with and without energy recovery for dedicated outdoor air systems.
- **Water-Source Heat Pumps** ([Table 14](#)): Minimum COP for efficient heat transfer in hydronic systems.

- **Heat Pump & Heat Recovery Chiller Packages (Table 15):** Minimum EER, COP, and integrated part-load value (IPLV) for combined systems.
- **Ceiling-Mounted Computer Room Air Conditioners (Table 16):** Minimum sensible heat ratio (SHR) for targeted cooling in data centers.

Service water heating

[Table C404.2](#) sets minimum performance standards for water heaters, including gas, electric, and heat pump models, guiding your selection for efficient hot water production.

Electrical power and lighting systems

- **Interior Lighting ([Table C405.3.2\(1\)](#)):** Establishes maximum allowable lighting power densities for various building types based on area, encouraging efficient lighting design and equipment selection.
- **Exterior Lighting ([Tables C405.5.2\(1-3\)](#)):** Define lighting zones and corresponding power allowances for exterior fixtures, encouraging responsible outdoor lighting design while considering security and aesthetics.

Additional efficiency requirements

To achieve additional energy efficiency, [section R408 of the IECC 2021](#) establishes additional efficiency package options you can follow to enhance the envelope performance, have a more efficient HVAC equipment performance, reduce energy use in service water-heating systems, have a more efficient duct thermal distribution system, improve air sealing and have a more efficient ventilation system.

Total building performance

Based on [section R405 of the IECC 2021](#), A total building performance analysis that includes heating, cooling, mechanical ventilation and service water-heating energy only, lighting, receptacle and process loads helps to comprehensively assess and track the energy consumption of the entire building, considering the interactions between different building systems, and their combined impact on energy use. This allows a more accurate prediction of actual building energy performance, it allows greater flexibility to designers to explore various combinations of systems and technologies to achieve desired energy performance goals, and it allows potential innovation and optimization by looking beyond individual systems with a holistic approach.

» Renewable Energy Generation

After the building has optimized energy consumption, through passive strategies, and it has energy-efficient systems, the building has reduced its energy demand, the building should generate its energy using renewable sources such as solar, wind or geothermal. Installation of on-site renewable energy systems, such as photovoltaic systems, wind turbines or combined heat and power systems. Photovoltaic (PV) panels have recently increased efficiency and decreased cost, which makes PV projects more affordable than in the past.

» Energy storage

The building should have a system to store excess energy generated during the day for use during periods of high demand. Stored energy can be thermal or electrical.

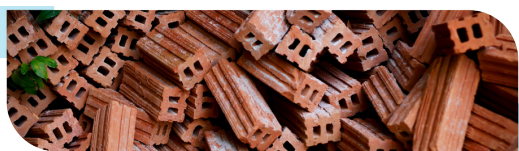
» Energy associated with mobility

Central location of the building, diversity of uses and social facilities around and nearby the building, reduced car parking, priority for use of public transport, hybrid or electric vehicles as well as universal accessibility, infrastructure for alternative mobility such as bicycles.



• Water Conservation:

- **Water management:** Implementing strategies such as rainwater harvesting, greywater recycling and low-flow fixtures can reduce the building's water consumption and associated environmental impact:
 - **Low-flow fixtures:** Use water-efficient toilets, faucets, and showerheads, also waterless urinals. Low-flow fixture requirements for toilets, faucets, and showerheads across different green building standards vary. Therefore, we suggest the following maximum water consumption: toilets (single or dual flush) 4.8 L per flush (lpf); urinals 1.9 lpf; public metering self-closing lavatory faucets 1 L per metering cycle; residential lavatory faucet 2 L per minute (lpm); showerheads 6 lpm, residential dishwasher 10 L per cycle, residential washing machine 35 L per cycle.
 - **rainwater harvesting:** Collect and utilize rainwater for irrigation, washing, or toilet flushing.
 - **wastewater treatment:** Consider greywater systems for non-potable uses, recycle lightly used water like shower or sink runoff for non-potable uses like irrigation, reducing strain on freshwater resources.
- Soil permeability for groundwater recovery
- If needed, consider all water saving technologies available for cooling towers, like makeup water filtration, water treatment, blowdown reduction and recovery, water-efficient cooling tower design such as counterflow and hybrid, floating covers for the basin to reduce water evaporation and contamination, water recovery systems such as condensate recovery or rainwater harvesting, variable frequency drives (VFD) controlled fans, smart monitoring and control systems that utilize sensors and real-time monitoring, and regular cleaning maintenance practices to prevent the build-up of scale, debris, and biological growth, maintaining optimal heat exchange efficiency and reducing the need for excessive blowdown.



• Material Selection and Management:

Using sustainable and low-impact building materials can reduce the environmental footprint of the building and improve indoor air quality. The building should use materials with a low carbon footprint, such as sustainably harvested timber or recycled materials.

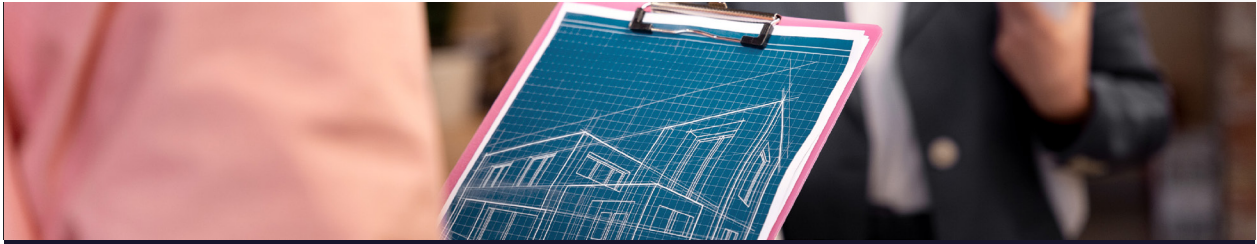
- **Recycled content, sustainably sourced materials, bio-based:** Prioritize recycled content, low-emission materials, and products with certifications like FSC from the Forest Stewardship Council for forest management certification, or Cradle to Cradle.
- **Local materials:** Reduce transportation emissions and support local economies by sourcing materials nearby.

- **Waste reduction strategies:** The building should minimize waste by reusing and recycling materials. Implement waste management plans to minimize waste generation and maximize recycling.



- **Indoor Environmental Quality:**

- **Ventilation and air quality control:** Ensure adequate ventilation, control pollutants, and provide access to fresh air.
 - Low volatile organic compounds (VOC) emission for cleaning and retrofit products
 - If needed, consider high performance air filters according to outdoor pollutants (PM10, PM2.5, Ozone)
- **Thermal comfort:** Maintain comfortable temperatures and humidity levels using natural ventilation and energy-efficient HVAC systems.
- **Lighting design:** Design for optimal daylighting and use high quality energy-efficient artificial lighting that minimizes glare and flicker.
- **Acoustic considerations:** prioritize acoustic design for occupant well-being, aiming to control noise pollution, enhance speech clarity, and create comfortable sound environments.



Part 3:

Construction Practices and Technologies

- **Green Building Materials and Products:**

Identify sustainable alternatives, certifications, and responsible sourcing practices. Green building materials and products need certifications or specifications that assure their environmental & health benefits, like recycled content, low emissions, sustainable sourcing, and certifications like FSC, Cradle to Cradle, or Declare, all while meeting performance and safety standards.

- **Prefabrication and Modular Construction:**

Benefits, challenges, and considerations for off-site construction methods: offer speed, reduced waste, quality control, and potential for low-carbon materials, but require upfront planning, efficient transportation, and integration with on-site elements. It can even reduce the cost of demolition, and at the same time recycle the different elements of the entire building, and use it for another.

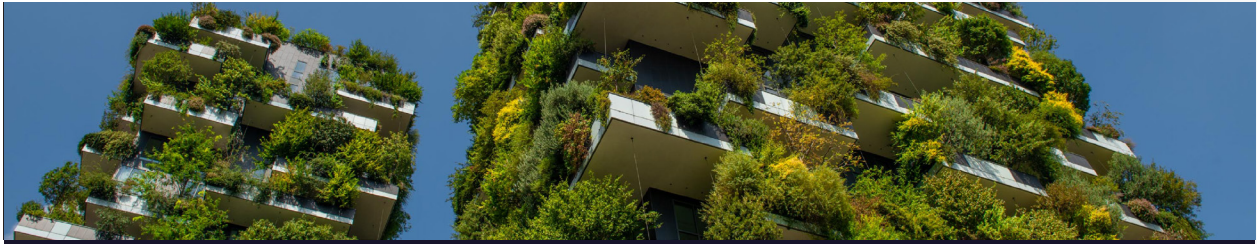
- **Building Information Modeling (BIM):**

Utilizing BIM for design optimization, energy analysis, and collaboration can improve project efficiency and sustainability outcomes. Also, for sustainability tracking. Building information modelling (BIM) is a digital process for creating and managing a building's entire life cycle, from design and construction to operation and maintenance. Imagine a 3D model that's not just a pretty picture, but also stores detailed information about each building element, like materials, performance, and maintenance schedules.

Think of it as a “brain” for your building, allowing different professionals like architects, engineers, and contractors to collaborate, optimize design, analyze energy performance, and even simulate construction phases, all within the same model. This leads to:

- **Improved coordination and reduced errors:** All parties are working from the same source of truth, minimizing miscommunication and costly mistakes.
- **Enhanced design optimization:** BIM allows testing different scenarios and materials virtually, leading to more efficient and sustainable buildings.
- **Streamlined construction and reduced waste:** Prefabrication and efficient resource management become easier with precise information from the model.
- **Better building performance and maintenance:** Detailed data on systems and materials helps optimize operations and predict maintenance needs.

- **Construction Waste Management:**
minimizes leftover materials through careful planning, sorting waste streams like concrete, metal, and wood (segregation), maximizing recycling where possible, and responsibly disposing of remaining waste to avoid landfills and pollution.



Part 4:

Green Building Certifications and Standards

- **Overview of Popular Certifications:**

Some of the renowned international green building certifications are LEED, EDGE, Passivhaus or Passive House, BREEAM, Living Building Challenge, and WELL.

Each certification has its strengths and weaknesses. EDGE is a good option for projects seeking a moderate-cost certification focusing on resource efficiency. While LEED, BREEAM, and LBC may have higher upfront costs due to their complexity, the potential benefits in terms of cost savings, environmental impact, and stakeholder engagement often make them worthwhile investments in the long run. Passivhaus is a great option for residential projects that are looking to achieve very high levels of energy efficiency. WELL is a unique certification focusing on human health and well-being, making it a good option for projects that create healthy and comfortable indoor environments.

Understanding their focus and benefits might help you decide which one is the best one for your specific project:



LEED

Source: usgbc.org

LEED, or Leadership in Energy and Environmental Design, is a widely recognized green building rating system with a broad focus on various aspects of sustainability.

This certification program has different rating systems:

- **Building Design and Construction (BD+C):** For new construction or major renovations. This could be the whole building project, including the interiors as “New Construction”, or only the “Core & Shell” for speculative developments, and also includes applications for Schools, Retail, Hospitality, Data Centers, Warehouses & Distribution Centers and Healthcare.
- **Interior Design and Construction (ID+C):** For complete interior fit-out projects. Includes Commercial Interiors, and also includes applications for Retail and Hospitality.
- **Building Operations and Maintenance (O+M):** For existing buildings undergoing improvement work or little to no construction. Includes Existing Buildings and

applications for Schools, Retail, Hospitality, Data Centers, and Warehouses & Distribution Centers.

- **Neighborhood Development (ND):** For new land development projects or redevelopment projects containing residential uses, nonresidential uses, or a mix. Projects can be at any stage of the development process, from conceptual planning to construction. Includes Plan and Built Project.
- **Homes:** For single family homes, low-rise multi-family (one to three stories) or mid-rise multi-family (four or more). Includes Homes, Multifamily Lowrise, Multifamily Midrise. Homes and residential buildings over four stories may also use LEED BD+C.
- **Cities:** For entire cities and sub-sections of a city. LEED for Cities projects can measure and manage their city's water consumption, energy use, waste, transportation and human experience.

LEED has evolved since its pilot version in 1998, the current version of LEED is v4.1 was released in 2019. LEED v5 is in Beta Version for existing buildings. Additionally, LEED offers different rating levels:

- **Certified:** Meets basic performance thresholds.
- **Silver:** Achieves higher levels of sustainability.
- **Gold:** Exceeds even stricter performance expectations.
- **Platinum:** Represents the highest level of green building achievement under LEED.

LEED primary categories are integrative process, location and transportation, sustainable sites, water efficiency, energy and atmosphere, materials and resources, indoor environmental quality, innovation, and regional priority.



Source: edgebuildings.com

EDGE

Excellence in Design for Greater Efficiencies (EDGE) was developed by the International Finance Corporation (IFC). EDGE focuses on resource efficiency and is well-suited for emerging markets like LATAM.

Additionally, EDGE offers different rating levels:

- EDGE certification focuses on achieving at least 20% savings in energy, water, and embodied carbon compared to a local baseline
- **EDGE Advanced:**
 - Requires at least 40% on-site energy savings compared to the baseline.
 - Ideal for projects aiming for higher energy efficiency without significant cost increases.
 - Recognized as “Zero Carbon Ready” if combined with renewable energy onsite or carbon offsets.
- **EDGE Zero Carbon:** This represents the highest level of carbon footprint reduction within the EDGE framework. Aims for net-zero carbon emissions through:
 - At least 40% on-site energy savings as in EDGE Advanced.
 - Remaining energy needs met through renewable energy sources on-site.
 - Any remaining emissions offset through certified carbon credits.



Passive House

Source: passivehouse.com

The first Passivhaus residences were built in 1990. The Passivhaus-Institut was founded in 1996.

The Passivhaus-Institut has three standards: Passive House, EnerPHit for Retrofit, and PHI Low Energy Building standard

The two first ensure:

- year-round comfortable and healthy indoor conditions
- an extremely high level of energy efficiency (as a prerequisite for cost-effective operation and climate protection)
- a high level of user satisfaction

EnerPHit: the first retrofit step has been implemented achieving at least 20 % energy savings.

PHI Low Energy Building: an alternative standard for buildings that do not completely meet energy efficiency and comfort objectives.

Passive House and EnerPHit have certification levels as classic, plus and premium.

Typically, the following five measures lead to the Passive House. The five key principles are:

- **Passive house windows:** In temperate and cold climates, triple-glazing and insulated window frames ensure heat gains in winter. In warmer climates, double glazing is usually sufficient.
- **Thermal insulation:** A well-insulated building keeps warmth in during winter and heat out during summer.
- **Adequate ventilation strategy:** Passive House buildings are supplied with consistent fresh air via the ventilation system. The heat exchanger ensures that air is supplied to rooms at nearly the room temperature without additional heating – cold and heat remain outside.
- **Airtightness:** A Passive House building has a continuous airtight outer shell. This protects the building structure, prevents energy losses and improves comfort.
- **Thermal bridge reduced design:** Passive House buildings are planned without thermal bridges, especially in temperate and cold climates. This ensures even lower heating costs and prevents building damage.

The low energy demand of buildings can be easily supplied with renewable energy. The lower the Renewable primary energy or PER demand, the less the effort and the space required for solar energy or wind power to supply the building. This way, the full renewable supply can be realized cost-effectively and environmentally friendly.



Source: bregroup.com

BREEAM

The Building Research Establishment Environmental Assessment Method (BREEAM), was first published in 1990 by the Building Research Establishment (BRE), in UK.

The BREEAM Standard has different ratings as well:

- BREEAM New Construction, for non-residential buildings in the UK,
- BREEAM International New Construction, for residential and non-residential buildings which takes account of circumstances in countries around the world, except UK and other countries with a national BREEAM scheme
- BREEAM In-Use, for existing buildings,
- BREEAM Refurbishment & Fit Out, for housing and non-housing refurbishment projects and retrofit.
- BREEAM Communities, for masterplanning of whole new communities and regeneration projects
- BREEAM Infrastructure, formerly CEEQUAL which was initiated at the UK's Institution of Civil Engineers and was acquired by BRE in 2015.

The BREEAM ratings range from Acceptable (In-Use scheme only) to Pass, Good, Very Good, Excellent to Outstanding, and it is reflected in a series of stars on the BREEAM certificate, from 1 to 5 stars.

BREEAM assessment categories are management, water, energy, transport, health & wellbeing, resources, resilience, land use & ecology, pollution, materials, waste, and innovation.



INTERNATIONAL
LIVING FUTURE
INSTITUTESM

Source: living-future.org

Living Building Challenge

The International Living Future Institute created in 2006 the international sustainable building certification program called the Living Building Challenge (LBC), a rigorous performance standard pushing boundaries for truly regenerative buildings. It sets the highest bar for green building, aiming to create structures that have a net positive impact on the environment and community. Buildings must operate for a year and demonstrate compliance with all requirements before certification.

The LBC's core principles are the "seven petals" exceeding typical codes and standards. Each petal has its imperatives. The seven petals are:

- **Place:** Reverence for ecology and biodiversity.
- **Water:** Net-zero water use through conservation and reuse.
- **Energy:** Net-zero energy use through renewable generation.
- **Health and happiness:** improving the source of health problems such as indoor air

quality, thermal comfort, visual comfort, and integration of nature to increase the quality of human health and productivity.

- **Materials:** Materials supporting human health and wellbeing, reducing adverse environmental and social impact simultaneously.
- **Equity:** Social and economic justice throughout the project lifecycle.
- **Beauty:** Inspire occupants and communities through design excellence.



WELL

Source: www.wellcertified.com

The WELL Building Standard is a performance-based system for measuring, certifying, and monitoring the features of the built environment that impact human health and wellbeing. It goes beyond traditional green building standards by focusing only on occupant health, comfort, and productivity within buildings.

WELL considers ten concepts: Air, Water, Nourishment, Light, Movement, Thermal Comfort, Sound, Mind, Community, and Materials.

It offers four certification levels: WELL Certified for individual concepts, Silver to those projects that meet core basic requirements, Gold for exceeding minimum requirements, and Platinum for projects that achieve ambitious targets.

Certification Selection and Application:

Ultimately, the best certification for your project will depend on your specific goals and priorities. You will need to navigate several factors and priorities for your projects, such as:

- **Project type:** Does the project represent a new construction or an existing building? Also, different certifications may be more suitable for specific building types (residential, commercial, school, hospital, hotel...)
- **Client and stakeholder preferences:** You must consider their values and priorities regarding sustainability and well-being.
- **Asset's market:** which market it belongs? Is it going to compete to other similar assets nearby?
- **Availability of expertise and resources:** Choose a certification supported by local professionals and resources.

Depending on these factors, you must assess if the priorities will be

- **Environmental impact reduction:**
 - **LEED:** Widely recognized, offers various levels (Certified-Platinum). Good balance of environmental impact and feasibility.
 - **EDGE:** Focuses on cost-effectiveness while significantly reducing environmental impact.
 - **Passivhaus:** Minimizes energy use through super-insulation and airtightness.
 - **BREEAM:** Similar to LEED in scope, with variations depending on region.
 - **Living Building Challenge:** Most stringent, aiming for net-zero impact and regeneration, suitable for ambitious projects, protagonism and market leadership.

- **Occupant health and well-being:**
- **WELL:** Exclusively focuses on occupant health and well-being, offering various certification levels.
- **LEED, BREEAM:** Include some aspects of indoor air quality and comfort.
- **Living Building Challenge:** Considers materials and practices for occupant health.
- **Budget and feasibility:** you will need to assess the costs of complying with requirements, and navigating the accreditation process.
- **EDGE:** Designed for cost-effectiveness and easier to achieve.
- **LEED:** Offers flexibility based on budget and ambition.
- **Passivhaus, BREEAM, Living Building Challenge:** This can be more expensive and complex to achieve, though with many more benefits.
- **Location and regulations:** Some certifications are widely recognized globally, with regional variations, others are less common or designed for different markets.

Benefits of Certification:

Some key benefits of green building certification are enhanced marketability, investor confidence and economic benefits, regulatory compliance, and performance verification.

1. Enhanced Marketability:

- **Attract tenants and buyers:** Certified buildings can command higher rents or sale prices due to perceived value and potential cost savings for occupants.
- **Stand out from competition:** Certification differentiates your building in a crowded market, attracting sustainability-conscious tenants and buyers.
- **Marketing and branding opportunities:** Use certification as a marketing tool to promote your commitment to sustainability and attract environmentally conscious customers.

2. Investor Confidence and Economic Benefits:

- **Reduced risks:** Certification demonstrates a commitment to energy efficiency, water conservation, and responsible resource use, potentially lowering the risks associated with these resources and long-term operating costs and improving return on investment.
- **Attract green investors:** Certification appeals to investors seeking sustainable investments aligned with their values and offering higher returns.
- **Reduced operating costs:** Energy and water efficiency strategies lead to significant cost savings over the building's lifecycle.
- **Increased property value:** Certified buildings may have higher valuations due to reduced future costs and potential rent premiums.
- **Enhanced productivity through improved occupant health and well-being:** Many certifications address indoor air quality, thermal comfort, and other factors leading to healthier and more productive occupants.
- **ESG reportability:** Environmental, Social, and Governance (ESG) reportability has become increasingly important for organizations, encompassing various practices related to sustainability and responsible business conduct. Green building certification, as we discussed earlier, plays a significant role in demonstrating and enhancing an organization's ESG performance. Green buildings contribute to reducing greenhouse gas emissions, conserving resources, and protecting the environment through quantifiable data, credibility and transparency, enhanced disclosure, benchmarking

and improvement, resulting in a more positive environmental impact report.

3. Regulatory Compliance:

- **Meet or exceed building codes:** Many certifications address current and anticipated regulations, helping you stay ahead of the curve and avoid future compliance issues.
- **Avoid penalties:** Some cities and regions offer incentives for certified buildings, while non-compliant buildings may face penalties.
- **Streamline approvals:** Certification can expedite permitting processes by demonstrating compliance with critical environmental standards.

4. Performance Verification:

- **Independent assessment:** Certification involves third-party verification of your building's sustainability performance, ensuring objectivity and credibility.
- **Ongoing monitoring:** Some certifications require ongoing monitoring and data collection, allowing you to track progress and identify areas for improvement.
- **Benchmarking and transparency:** Certification data provides benchmarks for comparing your building's performance with others and demonstrating transparency to stakeholders.



Part 5:

Operation and Maintenance

Green Building Operations Best Practices:

Green building operation best practices can be classified in: energy management, water conservation, waste reduction, indoor environment monitoring, and occupant engagement.

Efficient energy management is a cornerstone of green building operations. Building operations represent significant global energy consumption, contributing to greenhouse gas emissions and climate change. That is why this chapter delves into strategies for optimizing energy performance in green buildings, focusing on the powerful combination of energy audits and retro-commissioning.

By conducting regular energy audits, we identify areas for improvement in building systems and equipment. Retro-commissioning then implements corrective measures to ensure these systems operate at peak efficiency. This combined approach leads to significant cost savings, enhanced occupant comfort, and a reduced environmental footprint.

Energy management

Building operators should be aware that buildings decrease energy efficiency over time, and if not analysed, these increments in energy efficiency might be associated with other factors such as changes in weather or occupation. However, energy efficiency in buildings depends on several factors, from maintenance procedures to sequences of operation. Energy audits and retro-commissioning are processes that provide valuable information about building efficiency.

Energy Audits

This activity can be performed in-house or by a third party and consists of analysis and inspection of the building systems, especially those which consume most of the building energy. The outcomes of this process are an energy breakdown (metered or estimated energy consumed by different energy systems and sectors), an energy benchmark to compare building performance with similar buildings and energy conservation measures. Many energy audits are required by local code, and they are based on standards such as:

- ASHRAE 211-2018
- UNE-EN 16247-1:2023
- ISO-50002:2014

Retrocommissioning

This activity can be performed in-house or by a third party and consists in testing and adjusting the building systems, especially those which consume most of the building energy. Outcomes of this process are an updated sequence of operation, because sometimes building systems are not operated per the design intent, updated building system information (such as as-built drawings and operation manuals) and updated training to building operators. Typically, this process is based on ASHRAE 202-2018

Although these processes are focused on energy efficiency, outcomes may be beneficial for water and indoor air quality performance, for instance, a dirty filter affects both energy and IAQ performance, and control failure in a cooling tower affects both energy and water performance

Maintenance for Sustainability

While green building design and construction are crucial, ongoing maintenance is vital in upholding a building's environmental sustainability. By going beyond reactive repairs and adopting a proactive maintenance approach, we can optimize building systems, maximize resource efficiency, and minimize environmental impact.

The benefits of maintenance for sustainability are undeniable, leading to:

- **Reduced operating costs:** By optimizing equipment performance and preventing unnecessary repairs, proactive maintenance lead to significant cost savings. For example, studies show that regular HVAC maintenance can save up to 30% on energy bills.
- **Lower energy and water consumption:** Maintaining equipment efficiently prevents energy waste and leaks, minimizing resource consumption. Proactive measures like leak detection and repair programs can drastically reduce water waste.
- **Reduced greenhouse gas emissions:** By optimizing energy and water use, maintenance contributes directly to lowering greenhouse gas emissions and mitigating climate change.
- **Improved air quality:** Regular cleaning and filter changes ensure efficient ventilation and eliminate harmful pollutants, leading to cleaner and healthier indoor air for occupants. This can improve health, well-being, and even productivity.
- **Increased asset value:** Well-maintained buildings experience less wear and tear, extending their lifespan and increasing their market value.
- **Enhanced corporate image:** Demonstrating a commitment to sustainability through proactive maintenance sends a positive message to stakeholders and strengthens your brand image.

Building System Maintenance

- Regular inspections and preventive maintenance of HVAC, lighting, and other building systems ensure optimal performance and prevent energy waste.
- Automated building management systems can monitor equipment health and provide real-time insights for timely interventions.
- Implement predictive maintenance strategies that analyse historical data and sensor readings to anticipate equipment failures and schedule repairs before they disrupt operations.

Equipment Optimization

- Upgrade outdated equipment with energy-efficient models when replacements are necessary.
- Optimize equipment settings and configurations based on actual usage patterns to reduce energy consumption.
- Consider renewable energy sources like solar panels or geothermal systems to supplement your power supply.

Proactive Approaches

- Implement leak detection and repair programs to minimize water waste from plumbing systems.
- Utilize water-efficient fixtures and appliances to reduce water consumption throughout the building.
- Develop a comprehensive waste management plan that includes recycling, composting, and responsible disposal of hazardous materials.
- Invest in green cleaning products and practices to minimize harmful chemicals and protect indoor air quality, to promote human health

Continuous Improvement and Performance Tracking

Achieving long-term sustainability in buildings goes beyond initial design and construction. It requires a dedicated commitment to continuous improvement and performance tracking. This involves actively monitoring key metrics, analysing data, implementing improvement strategies, and measuring progress over time. By adopting this proactive approach, we can optimize building systems, minimize environmental impact, and ensure that our buildings perform at their best throughout their lifetime.

Continuous improvement and performance tracking are not just technical processes; they require a cultural shift within an organization. We can create a truly sustainable building operation by fostering awareness, collaboration, and a commitment to ongoing learning among all stakeholders. Regular communication, training programs, and recognition for improvement efforts encourage engagement and support the continuous pursuit of sustainability goals.

Some key elements of continuous improvement and performance tracking are:

Monitoring

- **Energy and water use:** Regularly monitor energy and water consumption through smart meters and building management systems. This data reveals patterns and helps identify areas for efficiency improvements.
- **Indoor environmental quality:** Track factors like temperature, humidity, CO2 levels, and pollutant concentrations to ensure occupants a healthy and comfortable indoor environment.
- **Waste generation:** Monitor waste generation and disposal by type to understand your waste profile and identify waste reduction and recycling opportunities.

Data Analysis

- Analyze the collected data to identify trends, anomalies, and areas for improvement.
- Utilize data visualization tools to present the information clearly and make it easily understandable for stakeholders.
- Benchmark your building's performance against industry standards and similar buildings to identify areas where you can improve.

Improvement Strategies

Based on the data analysis, implement targeted improvement strategies. This could involve:

- Upgrading equipment with energy-efficient models.
- Optimizing system settings and schedules based on occupancy patterns.
- Implementing behavioural change programs to encourage responsible resource use by occupants.
- Investing in renewable energy sources to supplement your power supply.
- Addressing leaks and inefficiencies in water systems.
- Adopting sustainable waste management practices like composting and recycling.

Measurement and Verification

- Continuously monitor the impact of your improvement strategies to verify their effectiveness and identify further opportunities for optimization.
- Use established measurement and verification protocols to quantify the environmental and economic benefits achieved through your initiatives.
- Communicate the results to stakeholders to demonstrate the value of continuous improvement and encourage ongoing commitment.



Part 6:

Emerging Trends and Innovation

Advances in Building Technologies:

The green building sector is continuously evolving, driven by innovation and the imperative for more sustainable built environments. Some key trends and technologies shaping the future of green buildings are:

- **Advanced Building Materials:**
 - **Smart Glass:** Dynamic transparency adjustment to reduce artificial lighting needs and minimize heat gain.
 - **Green Concrete:** Low-carbon formulations incorporating recycled materials or alternative binders.
 - **Biodegradable Building Materials:** Materials contribute to a circular economy by naturally decomposing.
 - **Bio-based Materials:** Utilize renewable resources like hemp, bamboo, and mycelium for lower environmental impact.
 - **Carbon Capture and Storage:** Materials that absorb and store CO₂ to mitigate the building's carbon footprint.
 - **Self-healing Materials:** Concrete and other materials are engineered to repair minor damage, reducing maintenance and waste.
 - **Nanotechnology:** Enables self-cleaning facades and energy-efficient coatings for improved performance and sustainability.
- **Renewable Energy Systems:**
 - **Building-Integrated Photovoltaics (BIPV):** Seamless integration of solar panels into building elements for on-site clean energy generation.
 - **Solar Windows:** Transparent solar cells in windows capture sunlight and convert it into electricity without obstructing views.
 - **Microgrids and Smart Grids:** Enable efficient management of energy generation, storage, and consumption, optimizing renewable energy use.
 - **Geothermal Energy:** Utilizes the Earth's heat for reliable and clean heating and cooling.
 - **Wind Turbines:** Generate electricity on-site for buildings with suitable wind resources.
- **Smart Building Technologies:**
 - **Building Energy Management Systems (BEMS):** Optimize energy consumption through real-time monitoring and control of building systems.
 - **Internet of Things (IoT) Sensors:** Provide continuous data on building performance for data-driven decision-making and improvement.
 - **Artificial Intelligence (AI):** Analyses data to predict energy needs, optimize

operations, and proactively identify potential issues.

- **Digital Twins:** Create virtual models of buildings to simulate performance and test solutions before implementation.
- **Circular Economy Strategies:**
 - **Building Deconstruction and Reuse:** Prioritizes salvaging and reusing materials from existing structures, minimizing waste.
 - **Cradle-to-Cradle Certification:** Ensures products and materials can be recycled or upcycled at the end of their life cycle.
 - **Modular and Prefabricated Construction:** Using prefabricated building components reduces waste and construction time.
 - **Design for Disassembly:** Enables easy disassembly and reuse of building materials at the end of their lifespan.
 - **Recycled and Reclaimed Materials:** Utilize salvaged materials and components to reduce reliance on virgin resources.
 - **Waste-to-Resource Systems:** Implement composting, greywater reuse, and other strategies to minimize waste and maximize resource recovery.
- Upgraded Green Roofing and Vertical Gardens with more capacity and density in new heights:
 - **Green Roofs:** Living roofs with vegetation provide insulation, reduce urban heat island effects, and contribute to biodiversity.
 - **Vertical Gardens:** Integrate vertical greenery on building facades for improved air quality, aesthetics, and thermal insulation. Do not mistake for green walls, as they do not contribute to biodiversity.
- **Water-Efficient Technologies:**
 - **Smart Irrigation Systems:** Optimize outdoor water use in landscaping by integrating sensors and weather data, minimizing water waste.
 - **Greywater Recycling:** Treats and reuses greywater for purposes like landscape irrigation, reducing demand for freshwater resources.
- **Biophilic Design or Nature-Inspired Spaces:** Integrate natural elements and functions through design, daylighting, and greenery to enhance occupant well-being, productivity, and connection to nature.
- **Hybrid and Net-Zero Energy Buildings:**
 - **Hybrid Systems:** Integrate multiple renewable energy sources, energy storage, and grid connectivity for efficient energy balance.
 - **Net-Zero Energy Buildings:** Design and technologies aim to produce as much energy as they consume over a year, promoting energy independence and sustainability.

Future of Green Construction

As we inch closer to the pivotal year 2030, the race towards net-zero energy and emissions in buildings continues to accelerate. New resources like the IECC appendix and Zero Code are emerging, guiding stakeholders towards stricter mandates for new and existing structures to indicate maximum Energy Utilization Intensity (EUI) values for different building typologies according to their climate zone.

The landscape is shifting, driven by the undeniable reality of climate change. Also the Zero Code, now linked to the 2021 IECC, lists a maximum procurement value for renewable energy, and references compliance with ASHRAE 90.1-2019 to set a limit for offsetting energy inefficiencies with renewables.

Choosing to adapt and mitigate its impact through sustainable practices is no longer just an option, but a necessity. Fortunately, the path forward is illuminated by established frameworks like LEED, EDGE, Passive House, BREEAM, Living Building Challenge, and WELL. These harmonized international standards offer a roadmap to a future where green construction isn't just mandatory, but a thriving choice by unlocking significant economic, social, and environmental benefits.

It's time to embrace a paradigm shift that prioritizes not just ecological health, but also the prosperity of our communities and economies.

Additional Resources

Here we provide a comprehensive list of relevant websites, organizations, publications, and tools for further learning and engagement.

Energy Efficiency:

- 2021 International Energy Conservation Code: <https://codes.iccsafe.org/content/IECC2021P1>
- Zero Code: <https://www.zero-code.org/>
- Cooling Technologies Institute: <https://www.cti.org/>
- The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE): <https://www.ashrae.org/>
- Environmental Protection Agency (EPA): <https://www.energystar.gov/buildings>
- New Buildings Institute: <https://newbuildings.org/>

From Architects Organizations:

- The American Institute of Architects (AIA) on Climate Action: <https://www.aia.org/design-excellence/climate-action>
- The Royal Institute of British Architects (RIBA) <https://www.architecture.com/>
- Architecture 2030: <https://www.architecture2030.org/>
- 2030 Palette: <http://www.2030palette.org/>

Product Transparency:

- The Health Product Declaration (HPD) Open Standard: <https://www.hpd-collaborative.org/>
- The Declare Label: <https://living-future.org/declare/>
- LBC Red List: <https://living-future.org/red-list/>
- Six Classes by the Green Science Policy Institute: <https://www.sixclasses.org/>
- Cradle to Cradle: <https://c2ccertified.org/>
- WaterSense Label: <https://www.epa.gov/watersense/watersense-label>
- U.S. Environmental Protection Agency: <https://www.epa.gov/>

Green Building Certifications:

- 2021 International Green Construction Code (IgCC): <https://codes.iccsafe.org/content/IGCC2021P2>
- Green Building Council: <https://www.usgbc.org/>
- EDGE: <https://edgebuildings.com/>
- Passive House Institute: <https://passivehouse.com/>
- BREEAM: <https://bregroup.com/products/breeam/>
- Living Building Challenge: <https://living-future.org/>
- International WELL Building Institute: <https://www.wellcertified.com/>

Some tools:

- EN-ROADS Simulator: <https://www.climateinteractive.org/en-roads/>
- Coastal Risk Screening Tool: <https://coastal.climatecentral.org/>
- Building Resilience Index: <https://www.resilienceindex.org/explore>

Bibliography

Architecture 2030. (n.d.). 2030 Palette – A database of sustainable design strategies and resources. <http://www.2030palette.org/>

ASHRAE and ACCA. (2018). Standard for Commercial Building Energy Audits. ashrae.org. <https://www.ashrae.org/technical-resources/bookstore/standards-180-and-211>

ASHRAE. (2018). ASHRAE 202-2018 Commissioning Process for Buildings and Systems (ANSI Approved; IES Co-sponsored). ASHRAE Store. https://www.techstreet.com/ashrae/standards/ashrae-202-2018?product_id=2025517

ASHRAE. (2022). Standard 90.1-2022—Energy Standard for Sites and Buildings Except Low-Rise Residential Buildings. ashrae.org. <https://www.ashrae.org/technical-resources/bookstore/standard-90-1>

BRE Group. (2023). BREEAM. <https://bregroup.com/products/breeam/>

Climate Interactive. (2023). En-ROADS. <https://www.climateinteractive.org/en-roads/>

Deloitte. (2022, June 20). The turning point. <https://www.deloitte.com/global/en/issues/climate/global-turning-point.html>

GlobalABC/IEA/UNEP (Global Alliance for Buildings and Construction, International Energy Agency, and the United Nations Environment Programme) (2020): GlobalABC Roadmap for Buildings and Construction: Towards a zero-emission, efficient and resilient buildings and construction sector, IEA, Paris. https://globalabc.org/sites/default/files/inline-files/Global%20Roadmap_FINAL.pdf

GlobalABC/IEA/UNEP (Global Alliance for Buildings and Construction, International Energy Agency, and the United Nations Environment Programme) (2022). 2022 Global Status Report for Buildings and Construction: Towards a Zero-emission, Efficient and Resilient Buildings and Construction Sector. Nairobi. Globalabc. https://globalabc.org/sites/default/files/inline-files/2022%20Global%20Status%20Report%20for%20Buildings%20and%20Construction_3.pdf

Intergovernmental Panel on Climate Change. (2022). Climate change 2022: Mitigation of climate change. IPCC. <https://www.ipcc.ch/report/ar6/wg3/>

International Code Council (ICC). (2021). 2021 International Energy Conservation Code (IECC). Digital Codes. <https://codes.iccsafe.org/content/IECC2021P2>

International Code Council (ICC). (2021). 2021 International Green Construction Code (IgCC). Digital Codes. <https://codes.iccsafe.org/content/IGCC2021P2>

International Finance Corporation. (2021, October 26). EDGE User Guide Version 3.0.a. EDGE Buildings. <https://edgebuildings.com/wp-content/uploads/2022/04/211026-EDGE-User-Guide-for-All-Building-Types-Version-3.0.A.pdf>

International Finance Corporation. (2024). APEX green cities. APEX Green Cities. <https://www.apexcities.com/#/>

International Living Future Institute. (2019). Living Building Challenge 4.0. <https://living-future.org/lbc/>

International WELL Building Institute. (2023). The WELL Building Standard version 2. WELL Standard. <https://v2.wellcertified.com/en/wellv2/overview/>

ISO. (2019). ISO 50002:2014 Energy audits: Requirements with guidance for use. <https://www.iso.org/standard/60088.html>

Lengen, J. V. (2011). Manual del arquitecto descalzo.

New Buildings Institute (NBI). (2022, August 23). 2021 IECC national model energy code (Base codes). New Buildings Institute. https://newbuildings.org/code_policy/2021-iecc-national-model-energy-code-base-codes/

Passive House Institute. (2022, August). Building Certification Guide. Passivhaus Institut. https://passiv.de/downloads/03_building_certification_guide.pdf

Passive House Institute. (2023, January 20). Criteria for Buildings: Passive House - EnerPHit - PHI Low Energy Building. Passivhaus Institut. https://passiv.de/downloads/03_building_criteria_en.pdf

RIBA Enterprises. (2015). 101 rules of thumb for sustainable buildings and cities. RIBA Publishing.

U.S. Green Building Council. (2023, July). LEED v4.1 Building Design and Construction. USGBC. https://build.usgbc.org/bd+c_guide

U.S. Green Building Council. (2023, September 25). LEED v5 for operations and maintenance: Existing buildings draft. USGBC <https://www.usgbc.org/resources/leed-v5-operations-and-maintenance-existing-buildings-draft>

UNE. (2023). UNE-EN 16247-1:2023 Auditorías Energéticas. Parte 1: Requisitos Generales. Normalización Española. <https://www.une.org/encuentra-tu-norma/busca-tu-norma/norma?c=norma-une-en-16247-1-2023-n0071160>

United Nations Human Settlements Programme (UN-Habitat). (2020). The new urban agenda illustrated handbook. UN-Habitat. https://unhabitat.org/sites/default/files/2020/12/nua_handbook_14dec2020_2.pdf

Universidad de Azuay. (2020). 33+1 Claves para un nuevo modelo de vivienda colectiva sostenible en el Ecuador. <https://publicaciones.uazuay.edu.ec/index.php/ceuazuay/catalog/view/143/118/811>

Sustainable construction isn't just a trend. It's a necessity. While the challenges are vast, the good news is that the built environment also holds the key to a brighter future. This is the premise of "Building Our Future: A Guide to Sustainable Practices for the Built Environment", a comprehensive guide by COHERENTIAZERO CARBON aimed at empowering professionals across the built environment to embrace sustainable practices. Packed with over 10 years of experience and insights from the authors, the book offers actionable strategies and leverages established international frameworks like LEED, EDGE, Passive House, BREEAM, Living Building Challenge, and WELL.

The guide in its first edition is a valuable resource for professionals across the built environment who want to understand and implement sustainable practices. Its accessible language, actionable strategies, and alignment with established frameworks make it a practical guide for beginners and experienced professionals.

