RESILIENT NATURE & PROPERTIES OF GREEN BUILDINGS

USGBC EDUCATION PARTNER

GBES™ GREEN BUILDING EDUCATION SERVICES

INTRODUCTION

According to the National Oceanic and Atmospheric Administration (NOAA), 2018 the U.S. experienced 14 events, ranging from hurricanes and winter storms to drought and wildfires. The cost of those events: $91 billion [1]

The frequency of these severe weather conditions and the huge associated costs have made resilience planning increasingly important for the building and construction industry. Going beyond sustainability, green building certifications, like LEED and RELi, encourage and drive resilience-enhancing designs, technologies and methods.

Emphasizing resilience within buildings and interior spaces can help businesses and communities cope with local environmental challenges. These challenges might look and seem different depending on one's location, but the effects can be equally devastating, personally and economically. Over the years, the work of USGBC members, partners, and LEED users has underscored a collective commitment towards building back better in a manner that helps communities plan, prepare, absorb, recover from, and adapt to adverse events.

Sustainable buildings are the cornerstone to enhancing community resilience. They are driving resilience-enhancing designs, technologies, materials, and methods. To support these efforts, green buildings have incorporated practices like the use of durable materials, thoughtful site selection, rainwater collection, demand response, grid islanding, maximal energy efficiency, on-site renewable energy generation, and more.

BUILDING RESILIENCE, RESILIENT BUILDING DESIGN PRINCIPLES & STRATEGIES

Building Resilience

USGBC defines resilience as the ability to prepare and plan for, absorb, recover from, and more successfully adapt to adverse events. It also means- Proactive design planning and construction for potential impacts of reasonably expected natural disasters with minimal damage.

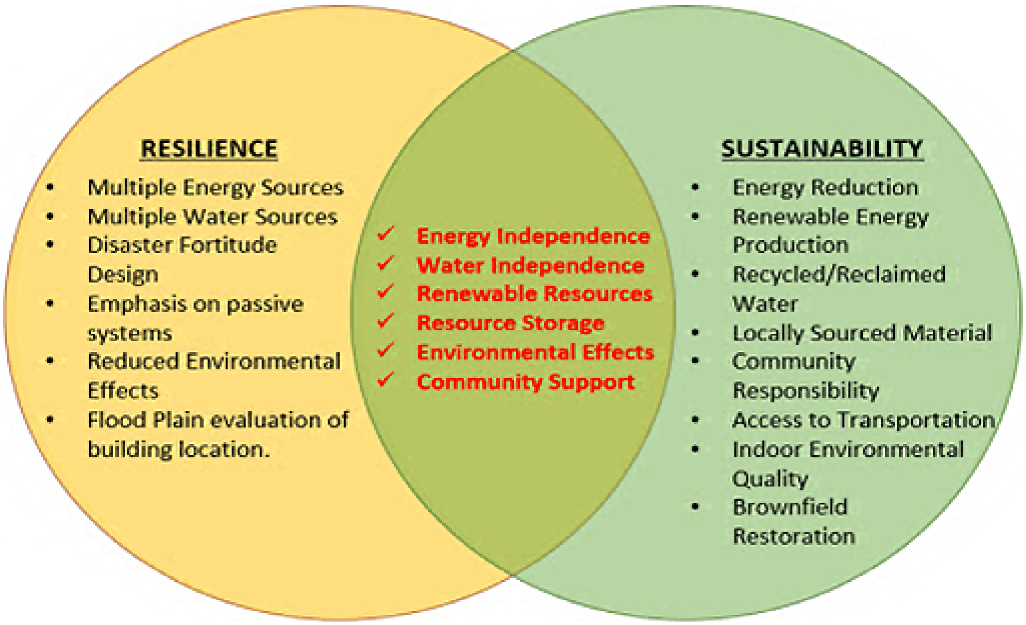
Building resilience is becoming increasingly important as the earth's climate changes and deviates from historical climate data. Due to this, some regions are predicted to experience increased precipitation and related flooding, while others may experience more severe and prolonged droughts. In addition, natural disasters like hurricanes, tornadoes, and blizzards are expected to occur more frequently and become even more severe. Again, regions that were not historically affected in the past would start experiencing such strange and terrible weather events.

The SuDS Manual, published by CIRIA in 2015, defines climate resilience as the capacity of a system to cope with a hazardous climate event, trend, or disturbance, responding or reorganizing in ways that maintain (or recover) its essential function, identity, and structure while also maintaining the capacity for adaptation.

Encouraging resilient assets using BREEAM defines resilience as the capacity of built assets and infrastructure to endure acute shocks and chronic stresses while successfully adapting to long-term changes.

In terms of the built environment, resilience can involve refining designs, stress-testing solutions, designing adaptable and flexible structures, and developing stronger infrastructure.

Resilience is more than physically withstanding major natural disasters. It is an important factor and criteria in surviving weather extremes, economic disruption, and resource depletion. Ultimately, it is about a community's ability to unite after an extreme event. The ability of a community to bounce back ultimately benefits everyone. Green buildings are one of the best ways companies and communities can future-proof, support climate action, improve quality of life, and make an immediate impact.



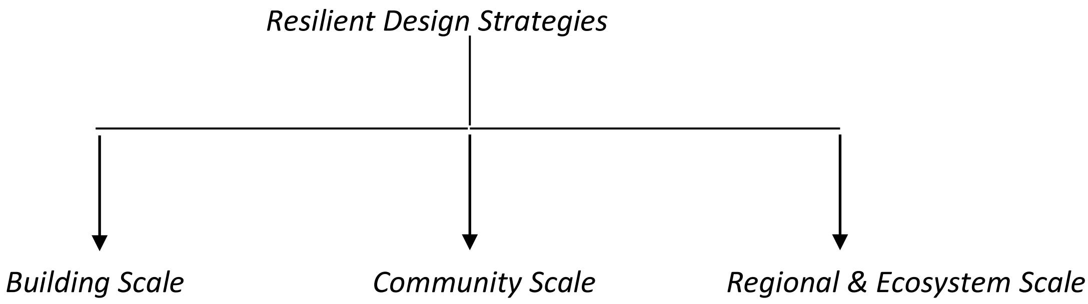
Culled - https://www.echotape.com/blog/why-building-resilience-is-the-future-of-sustainable-building/

Resilient Building Design Principles

- Predevelopment and planning phase: resilience measures that should be analyzed and incorporated at this stage include hazard identification, vulnerability assessment, analyzing scenarios and impacts, establishing performance targets, assessing how resilient interventions can create value in terms of underwriting building operations and mitigating harm, balancing costs and long-term value over the intended service life, and developing lines of communication about potential hazards to building resilience between owners, operators, and users.
- Resilience transcends scales -Strategies to address resilience apply at scales of individual buildings, communities, and larger regional and ecosystem scales; they also apply at different time scales—from immediate to long-term.
- Providing basic human needs - Resilient systems are meant to provide for and meet basic needs, including potable water, sanitation, energy, livable conditions (temperature and humidity), lighting, safe air, occupant health, and food; these should be equitably distributed.
- Building in diversity - More diverse communities, ecosystems, economies, and social systems are better able to respond to interruptions or change, making them inherently more resilient. While sometimes in conflict with efficiency and green building priorities, redundant systems for such needs as electricity, water, and transportation improve resilience.
- Designing simple, passive, and flexible systems- Passive or manual-override systems are more resilient than complex solutions that can break down and require ongoing maintenance. Flexible solutions can adapt to changing conditions in the short- and long-term.
- Designing for durability- Strategies that increase durability enhance resilience. Durability involves building practices, design (beautiful buildings will be maintained and last longer), infrastructure, and ecosystems.
- Making the most of locally available, renewable, or reclaimed resources - Reliance on abundant local resources, such as solar energy, annually replenished groundwater, and locally available construction materials, provides greater resilience than dependence on nonrenewable resources or resources from far away.
- Anticipating interruptions and a dynamic future - Adapting to a changing climate with higher temperatures, more intense storms, sea level rise, flooding, drought, and wildfire is a growing necessity. Non-climate-related natural disasters, such as earthquakes and solar flares, and anthropogenic actions like terrorism and cyberterrorism also call for resilient design. Responding to change is an opportunity for a wide range of system improvements.
- Finding and promoting resilience in and through nature - Natural systems have evolved to achieve resilience; we can enhance resilience by relying on and applying natural lessons. Strategies that protect the natural environment enhance resilience for all living systems.
- Building strong and culturally diverse communities - Strong, culturally diverse communities where people know, respect, and care for each other will fare better during stress or disturbance. Social aspects of resilience can be as important as physical responses.
- Resilience is not absolute- Recognize that incremental steps can be taken and that total resilience in all situations is impossible. Implement what is feasible in the short term and work to achieve greater resilience in stages.

Resilient Design Strategies

Resiliency is not any singular solution nor a concept or perspective. Rather, resiliency is a multifaceted lens that balances proactivity and reactivity to inform solutions to disruptions. Resilient Design is an approach that involves taking that lens and using it to rethink the built environment. Under resilient design strategies, we shall look at achieving resilience at the building, community, and regional/ecosystem scales.



Achieving Resilience at the Building Scale

Resilient design strategies at the building scale include:

- Designing and building structures that can accommodate the anticipated impacts of change.
- Strengthening critical systems to withstand extreme weather.
- Using future climatic conditions to model design solutions rather than relying on past data
- Designing structures that will remain habitable in power or energy loss.
- Building in manual overrides to reduce dependence on complex building controls and systems.
- Optimizing on-site renewable energy supply
- Rainwater harvesting
- Composting toilets and water-less urinals
- Selecting materials and components that will not present a hazard in the event of damage.
- Combining tested vernacular design practices with modern materials and techniques.
- Design and construct (or renovate) buildings to handle severe storms, flooding, wildfire, and other impacts expected to result from a warming climate.
- Locate critical systems to withstand flooding and extreme weather events.
- Model design solutions based on future climatic conditions as much as possible rather than relying on past data.
- Create buildings that will maintain livable conditions in the event of extended power or heating fuel loss through energy load reductions and reliance on passive heating and cooling strategies (passive survivability).
- Create durable buildings using such features as rainscreen details, windows that can withstand hurricane winds, and interior finish materials that can dry out if they get wet and not require replacement.
- Create beautiful buildings that will be loved and maintained.
- Carry out water conservation practices and rely on annually replenished water resources, including potentially harvested rainwater, as the primary or backup water supply.

- Provide redundant water supplies or water storage for use during emergencies. For deep-well pumps, provide either stand-alone solar electricity or hand pumping options where possible. Where there is no option for on-site water, consider water storage that can supply water under gravity to the building.
- Consider an option for human waste disposal in the event of non-operating municipal wastewater system.
- Use locally available materials for construction, products, and skill sets.
- Specify products and materials that will not off-gas or leach hazardous substances in the event of flooding or fire damage.
- Rely on vernacular design practices that were prevalent before the advent of air conditioning and central heating. Combine these design strategies with modern materials to optimize resilient design.
- Provide redundant electric systems with minimal backup power capacity, such as a solar-electric system with islanding capability.
- Maintain on-premises, non-perishable food supply that could provide residents with adequate staples for a 3-to 6-month period. Non-perishable foods include canned goods, dehydrated foods (dried fruits, vegetables, meats in sealed bags), dried beans, grains, rice, flour and cornmeal, salt, and vegetable oils. Some such foods may be stored in a freezer for a long shelf-life, but they will remain relatively durable out of a freezer. Most foods should be stored in sealed glass jars for protection against insects and rodents.

Achieving Resilience at the Community Scale

Resilient design strategies at the community scale include:

- Building social structures that strengthen the community, such as gathering spaces, communal gardens, etc.
- Minimizing reliance on fuels sourced from a distance.
- Reducing the urban heat island effect
- Managing stormwater.
- Designing resilience into communications infrastructure.
- Encouraging community education programs to instill greater understanding.
- Build or facilitate social structures that strengthen the fabric of the community. These could include community gathering places, dog parks where residents get to know their neighbors, central mailbox locations, and community bulletin boards with rideshare notices and other postings. The Japanese “Koban” may provide a useful model.
- Design communities to minimize dependency on transportation fuels sourced from far away; provide human-powered transportation options to access key services.
- Design vegetated roofs and rainwater bioswales to reduce the urban heat island effect and manage stormwater.
- Design and build (or rebuild) physical infrastructure, such as culverts, storm sewers, roadways, and bridges, to handle increased stormwater flows.
- Rely on green infrastructure and low-impact development strategies - natural, biological erosion-control solutions that will grow stronger over time.
- Create community facilities (resilience hubs) that can serve as gathering places during emergencies and service interruptions. Outfit such facilities with access to key services, including water, electricity for charging cell phones, etc. Such capabilities could be integrated into schools and other existing community facilities.

- Work to ensure the resiliency of cell phone towers so that communications can be maintained during times of emergency. Educate residents about the benefits of texting rather than calling during emergencies to use less bandwidth.
- Consider potential extreme weather events and climate change in determining locations of critical facilities and systems.
- Foster strong community education programs that will increase understanding of energy, water, and other natural resource systems and the functioning of buildings and community infrastructure. Build such capacity in public education systems.

Achieving Resilience at the Regional and Ecosystem Scales

- Resilient design strategies at the regional and ecosystem scales include:
- Encouraging reliance on regional construction materials and manufactured goods.
- Adopt policies that recognize and value ecosystem services and protect or restore the capacity to rely on those services (e.g., water filtration, protective buffers at coastlines, natural erosion control along streams and rivers, healthy forests that purify and replenish air).
- Maintain and protect aquifers—prohibit withdrawals that exceed recharge annually and provide strict regulations to protect against contamination.
- Develop or strengthen regional transportation networks that can transport not only people but also food and other critical needs, and that can function during emergencies.
- Develop regional, renewable power-generation systems to ensure a more stable, distributed electrical grid. Pursuing community ownership of utility-scale renewable power systems to garner regional support, s has been done very successfully in Germany and Belgium with energy co-ops.
- Work to achieve a more diverse regional economy.

CONTRIBUTIONS OF THE GREEN BUILDING INDUSTRY TOWARD MAKING GREEN BUILDINGS MORE RESILIENT

Through LEED and other programs and initiatives, USGBC promotes and advocates for design, construction, operation, and maintenance that address and emphasize resilience in buildings, landscapes, power systems, and communities.

LEED advocates for resilience-enhancing strategies that include durable materials, thoughtful site selection, rainwater collection, demand response, grid islanding, energy efficiency, and more. Communicating the impact of that work is also a vital part of ensuring people are ready in the face of a serious event. USGBC recently released a Living Standard Action Toolkit to help guide companies and individuals and engage them in talking more about this work's impact on human beings.

For the past 20 years, LEED has provided a proven path to designing, building, and operating spaces that conserve resources, reduce carbon, prioritize safer materials, and improve indoor environmental quality for those using such spaces. Factoring resilience into these plans is a clear extension of that work and has been a part of USGBC’s ongoing development of LEED.

USGBC actively works with policymakers on resilience strategies, including the Resilient Cities Summit, and has highlighted several examples of resilient design in the Profiles of Resilience resource. One of those projects was GAF’s headquarters in Parsippany, New Jersey, the first building to earn a LEED pilot credit for resilient design. GAF wanted to ensure the building’s resilience during a severe hurricane, like the area experienced during Hurricane Sandy in 2012.

The building’s features that contributed to its hurricane readiness include:

- Flood preparations and backup capabilities to enable operations during long-term outages.
- Roofing that meets FEMA Wind Zone II velocities.
- An assessment of floodway mapping to understand flood-prone areas.
- A disaster recovery plan that outlines how to communicate with occupants during a disaster.

LEED Climate Resilience Screening Tool

The LEED Climate Resilience Screening Tool for LEED v4 Projects provides a practical framework to identify climate sensitivities and prioritize opportunities to promote enhanced resilience through the green building outcomes rewarded in LEED credits. The tool applies to all LEED v4 rating systems and complements the resilience pilot credits adopted in November 2015. This resource is an update to a LEED v2009 version of the tool.

Culled - https://www.usgbc.org/resources/leed-climate-resilience-screening-tool-leed-v4-projects

PEER

PEER stands for Performance Excellence in Electricity Renewal. It is the nation's first comprehensive, consumer-centric, data-driven system for evaluating power system performance and modeled after LEED.
It is the certification program that measures power system performance and electricity infrastructure while also working to improve their sustainability, reliability, and resilience. PEER includes guidance for cities, utilities, campuses, and transit to help ensure reliable electricity delivery, reduce emissions, improve safety and security, and more.
The PEER rating system helps fill a major gap in the smart grid movement. It allows power systems to gain a competitive advantage by differentiating their performances and demonstrating meaningful outcomes. In the process, the metrics serve as a tool to accelerate transformation in the marketplace.
A growing number of stakeholders, electricity suppliers, and utilities are exploring how quality can help ensure the success of smart grid efforts. PEER is the only measurement tool to help the industry apply quality principles to grid modernization.
PEER is administered by the Green Building Certification Institute. It looks at power systems across four outcome categories and allows all stakeholders to evaluate and set the standard for system performance that best meets customers' needs. and includes:

Enabling customer action -This category aims to assess customer participation as a resource in grid improvements and enable private investment and innovation.

Operational efficiency -The intent of this category is to assess spending practices and assist in the identification and elimination of wasteful spending through performance benchmarks.

Reliability, power quality and safety-The intent of this category is to assess the quality of power delivery and reduce negative impacts on the customer.

Energy efficiency and the environment -The intent of this category is to assess the environmental impact of electricity generation and transmission and encourage the adoption of clean energy.

Culled - https://www.usgbc.org/sites/default/files/2021-03/Webinar%20Slide%20Deck_Final.pdf

SITES

Again, SITES is the sustainable land development and management program that aims, in part, to create regenerative systems and foster resiliency. SITES provide a green infrastructure framework for landscapes of virtually any type. Because SITES was modeled after LEED, the system optimizes resilience efforts by enabling some projects to concurrently pursue both certifications.

LEED For Cities

Culled - http://coab.us/818/LEED-for-Cities

LEED for Cities supports progress towards better, more resilient cities. Available through the Arc performance platform, LEED for Cities provides solutions for measuring and managing energy and water use, human experience, waste production, and transportation usage on a city scale.

Measuring resilience - A guide to measuring community resilience with LEED v4.1* for Cities and Communities is designed for local leaders seeking guidance on using LEED v4.1 to measure and improve existing community resiliency. This guide can measure local resilience, recognize connections among community systems, learn about best practices, and set your path toward becoming a more resilient and sustainable community. The guide utilizes a resilience framework developed by the Federal Emergency Management Agency (FEMA) and the National Oceanic and Atmospheric Administration (NOAA). LEED for Cities and Communities' community-wide approach to sustainability mirrors FEMA's whole community approach to resilience, in which hazard and vulnerability identification and solution development must go beyond the local government to include residents, local community groups and organizations, non-profits, and private organizations. Local efforts to measure and achieve the goals embedded in resilience should incorporate substantial community input, as resilience is a multi-faceted concept, and concerns and vulnerabilities will vary widely from community to community. The metrics and information in this guide present a solid foundation from which to begin understanding and measuring community resilience but should ultimately be tailored by community members to address local context. Low-income neighborhoods and communities of color are frequently the most vulnerable to shocks and stressors and, thus, should be thoroughly engaged throughout the process.

RELi Resilience Rating System

The RELi resilience rating system is rising as the new leadership benchmark for resilient buildings and neighborhoods. RELi focuses on resilience by requiring assessment and planning for acute hazards, preparedness to mitigate against them, and designing and constructing for passive survivability. It is a rating system and leadership standard that takes a holistic approach to resilient design. It is used by companies, developers, city planners, architects, bond insurers, and more to assess and plan for all the acute hazards that buildings and communities can face during unplanned events, prepare to mitigate against these hazards, and design and construct buildings to maintain critical life-saving services in the event of extended loss of power, heating fuel or water.

Administered by GBCI, RELi's comprehensive approach lays the groundwork for resilient, regenerative, and healthy outcomes that support quality of life. The rating system includes 15 requirements and 43 credits across 8 categories, including panoramic design, hazard preparedness and adaptation, community vitality, productivity, health, and diversity, energy, water, and food, materials and artifacts, and applied creativity.

UNDERSTANDING HOW LEED V4 RATING SYSTEM GIVES GREEN BUILDINGS THE NEEDED RESILIENT EDGE

In 2015, USGBC introduced some pilot credits bordering on resilient designs. In 2018, some revisions were made on the credits to improve effectiveness, reflect feedback, and harmonize them with RELi. The credits are available to all new construction projects looking to certify through LEED v4 or LEED v4.1 and they include:

Assessment and Planning for Resilience

To earn this credit, teams must identify risks and potential vulnerabilities related to the effects of climate change. Risks that must be considered include sea level rise, extreme heat, and more intense winter storms.

The intent is to encourage designers, planners and building owners/operators to proactively plan before design commences for the potential impacts of natural disasters or disturbances as well as address issues that impact long-term building performance such as changing climate conditions.

Requirements includes to complete a Hazard Assessment prerequisite plus at least one of two options – bordering on Climate Related Risk Management Planning or Emergency Preparedness Planning.

The Hazard Assessment prerequisite and either Planning option shall be initiated and substantially completed in pre-design. Historical climate records as well as future projections for precipitation, storms

and temperature should be used for this assessment. The assessment may be used for projects within the same location or campus but must be less than six years old at the time of submission.

Designing for Enhanced Resilience

The intent is to design and construct buildings that can resist, with minimal damage, reasonably expected natural disasters and weather events that includes flooding, hurricanes/high winds, tornadoes, earthquakes, tsunamis, drought, wildfires, landslides, extreme heat, and winter storms.
The requirements are to carryout for any two of the top three hazard-related risks identified in the Hazard Assessment Prerequisite, IPpc98 - Assessment and Planning for Resilience, and implementing the recommended mitigation strategy processes. If more than two hazard-related risks are identified, project teams have the leverage to choose to include more than two in this whole process. Outside the United States, project teams may use the U.S. standards if applicable or local equivalent standards, whichever are more stringent, and document their equivalence. If the project team completed the Climate Related Risk Management Planning Option 1 in IPpc98, they are to incorporate any agreed-upon parameters into the hazard mitigation strategies.

Passive Survivability and Back-Up Power During Disruptions

This centers around the concept that buildings should be able to safely shelter occupants during a power outage, as well as be able to provide backup power.
The intent has two options, with the first one having to do with ensuring that buildings will maintain safe thermal conditions in the event of an extended power outage or loss of heating fuel or provide backup power to satisfy critical loads. The second option is concerned with ensuring that electricity needed by a building to maintain a reasonable level of functionality during an extended power outage will vary greatly, depending on building function.
The requirements include:
Option 1 - Provide for Passive Survivability (thermal safety): Demonstrate through thermal modeling or Passive House certification that a building will passively maintain thermally safe conditions during a power outage that lasts four days during peak summertime and wintertime conditions of a typical meteorological year. This performance will be achieved through a combination of design measures that could include careful building orientation, a highly insulated building envelope, natural ventilation, cooling-load-avoidance measures, passive solar heating, and integration of thermal mass.
Option 2 - Provide Backup Power for critical loads: Demonstrate that adequate emergency power will be available to provide for critical loads that have been identified by the design team as being necessary for the building. It is important to note that these critical loads will differ by project.

Other approaches provided by LEED V4 that aids building resilience includes:

Water Efficiency in Green Buildings; Water efficiency, gives green buildings an edge to be more resilient and able to stand the test during periods of severe draught, while at the same time making less demands on our aquifers. LEED uses the water efficiency approach to reduce water demands from green buildings and associated grounds. Water consumption, portable water use, water recycling and energy used for treating/heating/cooling water is drastically reduced through this process. For outdoor water use, LEED makes it mandatory for projects to reduce the water consumption to 30% for landscapes and rewards project with credit points up to a maximum reduction of 100%. For indoor water use, LEED makes it mandatory for projects to reduce indoor water use by 20% and rewards projects with credit points up to a maximum reduction of 50%.

Rainwater Management: Rainwater management not only helps to provide the needed resilience against flooding, but also provides an alternative water source that can be utilized for various indoor and outdoor water uses. LEED V4 aims to manage rainwater, with the intent of reducing runoff volume and improving water quality by replicating the natural hydrology and water balance of the site, based on historical conditions and undeveloped ecosystems in the region. It actualizes this through two major approaches which includes percentile of rainfall and natural land cover.

Culled - https://theconstructor.org/water-resources/rain-water-harvesting/

Energy Efficiency and Demand Response; The energy demands or consumption rate for green buildings is far lower when compared to conventional buildings. It is a mandatory requirement in LEED V4 rating system for green buildings to reduce the environmental and economic harms of excessive energy use by achieving a minimum level of energy performance for buildings and its systems. It uses three different approaches to achieve this, which includes whole building energy simulation, ASHRAE 50% advanced energy design guide, and advanced buildings core performance guide.
For whole building energy simulation, projects need to achieve a 5% improvement for new buildings, 3% improvement for renovations, and 2% for core and shell projects based on energy costs and with respect to the baseline building performance rating that is calculated using the updated ASHRAE 90.1-2010 standard. ASHRAE 50% Advanced Energy Design Guide is a prescriptive approach with different guides based on different types of buildings. For example, offices less than 100,000 square feet, are required to use ASHRAE Advanced Energy Guide for Small to Medium Office Buildings. There are other guides for medium to large, big box retail, K-12 schools, and large hospitals. Projects must comply with the applicable criteria based on the building's specific climate zone.
Advanced Buildings Core Performance Guide is used for buildings less than 100,000 square feet (9,290 meters). Healthcare, warehouses, and lab projects are ineligible for this option.
To optimize energy performance to achieve further reduction in energy demands beyond the mandatory prerequisite requirements, LEED V4 uses the whole building energy simulation and ASHRAE Advanced Energy Design Guide to achieve this.
Whole building energy simulation allows energy reductions and savings beyond the prerequisite of 5% for new buildings, up to a maximum of 50%.
ASHRAE advanced energy design guide is the prescriptive path that can also be used to optimize energy performance, though projects using this are rewarded with lower credit points as compared to whole

building energy simulation approach for LEED projects. Projects are required to follow the appropriate ASHRAE design guide based on the project type and climate zone. This also requires that project must have earlier achieved the Minimum Energy Performance Prerequisite requirement using the ASHRAE design guide as well.
Also, LEED v4 through the demand response approach provides a system that allows a minimum reduction of 10% of the building's estimated peak load electricity usage at critical periods. Overall, this gives residential, commercial, and industrial consumers the ability to voluntarily trim their electricity usage at peak periods, during high electricity prices, or during emergencies in a bid to preventing blackout.

Renewable Energy Use for Less Reliance on Grid Power; Onsite renewable energy systems offset building energy costs, reduces reliance on grid power and reduce GHG emissions. Buildings with this system are more resilient and able to stand firm when there are challenges with power supply from the grid. LEED V4 encourages the use of renewable energy in buildings by awarding credit points to projects that have a certain percentage of their energy from renewable sources. Its sole intent is to reduce the environmental and economic harms associated with fossil fuel energy by increasing self-supply of renewable energy.

Culled - https://www.pexels.com/photo/alternative-alternative-energy-clouds-eco-energy-433308/

Strong and Robust Building Envelopes; The building envelope of green buildings are normally built to withstand extreme weather and environmental conditions. This usually comes with increases in insulation levels, air tightness, long-term performance, and most recently, mold resistance. The building envelope acts as a thermal barrier between the enclosed conditioned space and the outside environment through which the thermal energy is transferred. By minimizing the heat transfer through the building envelope, the energy used for space heating and cooling can be reduced drastically. LEED V4 uses envelope commissioning credit requirement to validate that the design and performance of materials, components, assemblies, and systems achieve the objectives and meet the requirements of the owner. The building envelope commissioning process achieves this through experience, expertise,

modeling, observation, testing, and documentation. Also, it carries out verification of materials, components, assemblies, and systems to validate that both their use and installation meet the owner's requirements.

Material Reuse/Recycling/Waste Reduction and Use of Eco-Friendly Materials*;* Green buildings approach of encouraging reuse and recycling of construction materials, places less demand on virgin materials which in-turn brings about sustainability and resilience. LEED V4 favors reuse of existing building materials found onsite or salvage building materials from off-site. Typical reused materials on LEED projects include structural elements like floors and roof decking, enclosure materials, and permanently installed interior elements like walls, doors, floor coverings, ceiling systems. Windows and other hazardous materials are mandatory excluded from the list of items that can be reused. The minimum percent of reused materials in terms of surface area is 25%, with increasing increments of 50% and 75%. Also, for LEED V4, Products meeting materials reuse criteria are valued at 100% of their cost for the purposes of credit achievement calculation. Reusing materials reduces waste generated & the number of materials deposited in landfills.

Recyclable materials, components and assemblies particularly post-consumer recycled content plays a significant role in ensuring limited and depleting resources are conserved, while also ensuring that waste is diverted from landfill. Extended producer responsibility, closed-loop recycling, and 'take back' programs are gaining wide acceptance in the industry. Most carpet manufacturing companies in the US practice the take back program. Also, Steel, glass, and metals are exceptionally durable, and they can be recycled again and again. LEED V4 encourages recycling of materials by ensuring products meeting recycled content criteria are valued at 100% of their cost for the purposes of credit achievement calculation, while extended producer responsibility is as well valued at 50% of the cost. For LEED V4 Recycled content must meet the definition set by ISO 14021-1999 for environmental labels and declarations. Recycled content is the sum of postconsumer recycled content plus one-half the pre-consumer recycled content, based on cost.
Eco-friendly literally means earth-friendly or not harmful to the environment. This term most commonly refers to products that contribute to green living or practices that help conserve resources like water and energy. Eco-friendly products also prevent contributions to air, water, and land pollution. Eco-Friendly materials used in green building projects include bamboo, straw bale, stone, earthen materials (adobe bricks, rammed earth), stone etc.

Culled - https://www.pinterest.com/pin/386183736800759014/

Reduction of Greenhouse Gas Emissions; A 2014 UC Berkeley study found that by building to LEED standards, buildings contributed 50% fewer GHGs than conventionally constructed buildings due to water consumption, 48% fewer GHGs due to solid waste and 5% fewer GHGs due to transportation. LEED rewards thoughtful decisions about building location, with credits that encourage compact development and connection with transit and amenities, helping lower GHGs associated with transportation. When a building consumes less water, the energy and GHGs otherwise required to withdraw, treat and pump that water from the source to the building are avoided. Additionally, less transport of materials to and from the building cuts associated fuel consumption. All these strategies significantly reduce the carbon footprint of buildings.

Indoor Environmental Quality*:* Green buildings provides better indoor air quality as compared to conventional buildings. Indoor Environmental Quality, or IEQ, refers to the quality of a building's environment in relation to the health and well-being of people in the space. LEED has set standards to ensure better IEQ in buildings, and they include, minimum internal air quality performance standards, enhanced indoor air quality strategies, environmental tobacco smoke control, construction indoor air quality management plan, indoor air quality assessment, use of low emitting materials, thermal comfort standards, standards for internal lighting, green cleaning, acoustic performance for school projects etc.

UNDERSTANDING HOW LEED NET ZERO CERTIFICATIONS DRIVES RESILIENCE IN GREEN BUILDINGS

LEED Zero highlights the achievements of exemplary projects in areas that are critical to the goal of reaching a regenerative future. Projects can complement their existing LEED certification or LEED O+M registration with one or more of the following LEED Zero.
certifications include LEED Zero Carbon, LEED Zero Energy, LEED Zero Water, and LEED Zero Waste.

LEED Zero encourages a more holistic and comprehensive approach to buildings and places to enhance the health and well-being of building occupants and the natural environment. This is even more critical as we face issues arising from climate change. The Climate Change (IPCC) report from October 2018 describes the impacts of global warming of 1.5°C to 2°C above pre-industrial levels on environmental, human health, and economic systems. In general, climate change requires fundamental shifts to human society's structure and consumption habits and adaptive and integrated carbon reduction, sustainable development, and resilience strategies deployed at all scales.

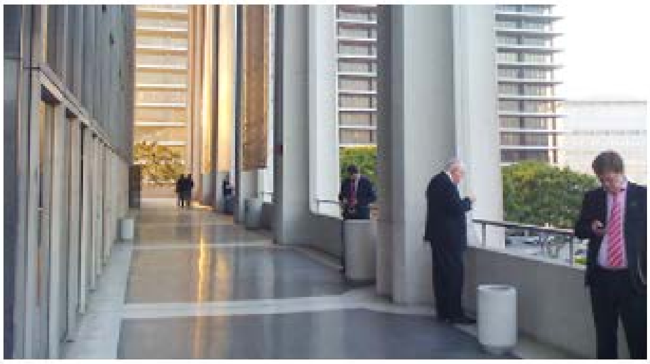
LEED has guided and pushed projects to aim for higher performance and reduce greenhouse gas emissions through integrated building strategies that impact energy, transportation, water, waste, and materials for more than two decades. The built environment is critical in accelerating the transition to a low-carbon society and enhancing the health of natural and human ecosystems.

LEED Zero Energy Certification

LEED zero energy certification helps to provide the needed resilience against power outages during periods of emergencies and absolute reliance on grid power.
To obtain LEED Zero Energy certification, a project must achieve a source energy use balance of zero for the past year. The net zero energy balance is based on the quantity of source energy delivered and the quantity of renewable energy that displaces non-renewable energy on the grid. Renewable energy generated and used on-site reduces the amount of energy delivered.

Source Energy Balance = (Total Source Energy Delivered) – (Total Non-Renewable Source Energy Displaced)
To calculate source energy delivered to the project, use the national average ENERGY STAR Source-Site Ratios for each building energy source from the Energy Star Portfolio Manager Technical Reference: Source Energy for projects in the U.S. and Canada.

International projects may use the U.S. source-to-site ratios or published ratios for the country or multi-country region where the project is located. The same source energy conversion factors should be used to calculate energy delivered and non-renewable energy displaced.
Environmental benefits of all renewable energy generation or procurement must be retained by the project.



Entegrity Partners Head Quarters Building – The second in the World & first in the United States to earn LEED Zero Energy Certification.
Culled - https://www.usgbc.org/articles/first-10-leed-zero-projects

LEED Zero Water Certification

LEED zero water certification helps to provide the needed resilience in times of drought and water shortages while contributing greatly to the preservation of our aquifers.

A net zero water building, whether constructed or renovated, is designed to:

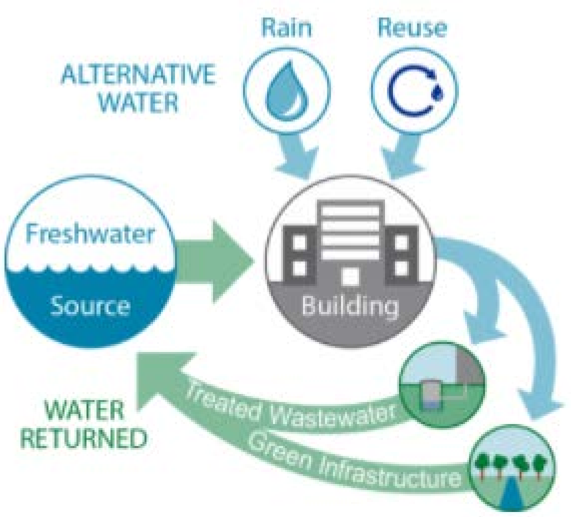
- Minimize total water consumption.
- Maximize alternative water sources.
- Minimize wastewater discharge from the building and return water to the original water source.

Net zero water creates a water-neutral building in which the amount of alternative water used and returned to the original water source equals the building's total water consumption.

The goal of net zero water is to preserve the quantity and quality of natural water resources with minimal deterioration, depletion, and rerouting by utilizing potential alternative water sources and water efficiency measures to minimize the use of supplied fresh water. This principle can be expanded to the campus level.

Ultimately, a net zero water building (or campus) completely offsets water usage with alternative water plus water returned to the original water source.

To obtain LEED Zero Water certification, a project must achieve a potable water use balance of zero for the past year.
Water Balance = Total Potable Water Consumed – (Total Alternative Water Used + Water Returned to Original Source)
An overview of the water balance: "Water returned to its original source" includes rainwater stored and infiltrated or evapotranspirated via green infrastructure and wastewater treated and returned to the local watershed or aquifer via decentralized wastewater treatment systems. Calculations for rainwater retained and infiltrated on-site must be based on the calculation methodology outlined under LEED v4 Sustainable Sites Credit Rainwater Management.



Culled - https://www.energy.gov/eere/femp/net-zero-water-building-strategies

LEED Zero Waste Certification

LEED Zero waste certification drives waste reduction, material reuse, and recycling for constructing green buildings. This, in turn, reduces the burden arising from the demands of virgin raw materials, exploitation of natural resources, and new materials for construction while at the same time providing the needed resilience in periods of material scarcity and shortages. Overall, our forest and other natural resources are preserved.

To obtain LEED Zero Waste certification, a project must achieve GBCI's TRUE Zero Waste certification at the Platinum level. The TRUE Zero Waste program requires projects to have a zero-waste policy in place, achieve an average of 90% or greater overall diversion from landfill, incineration (waste-to-energy), and the environment for solid, non-hazardous wastes for the most recent 12 months, and fulfill five other minimum program requirements.

A project team submits their TRUE Zero Waste Platinum certification for GBCI review to earn LEED Zero Waste Certification.

LEED Zero Carbon Certification

Climate change today is one of the major causes of extreme weather conditions, such as flooding, droughts, extreme heat and cold, etc., that could negatively affect and destroy buildings and other infrastructural facilities.

Again, carbon emissions are a major contributor to climate change. LEED Zero Carbon Certification for green buildings is an approach that addresses these challenges, which could affect a building's resilience (climate change-related issues—flooding, extreme heat, extreme cold, drought, damages to the building envelope, etc.), from their root cause.

To obtain LEED Zero Carbon certification, a project must achieve a carbon-dioxide equivalent (CO2E) balance of zero for the past year: Carbon Balance = Total Carbon Emitted - Total Carbon Avoided

Carbon Emitted is calculated from delivered energy and occupant transportation. Carbon Avoided includes on-site renewable energy generated and exported to the grid, off-site renewable energy procured, and the purchase of carbon offsets. Renewable energy generated and used on-site reduces the amount of energy delivered.

Environmental benefits of all renewable energy generation or procurement must be retained by the project.

If purchasing Energy Attribute Certificates (EACs), also known as Renewable Energy Certificates (RECs), the EACs must be Green-e Energy certified or equivalent. Carbon offsets must be Green-e Climate certified or equivalent. Projects must purchase EACs or carbon offsets annually during the three-year period when the certification is valid. On-site renewable energy generation and enough will vary based on weather and operating conditions, so the required purchase will vary yearly. For LEED Zero certification review, it is sufficient for the project owner to provide a written commitment to purchase EACs or carbon offsets, as applicable, each year during the three-year period when the certification is valid to maintain the net zero carbon balance.

**LEED v4.1 is not a balloted LEED rating system, and the rating system may change. The information for this course was taken from the version published on July 2023. Participants should check www.usgbc.org for the most recent version.*

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