What Is Low-Carbon Development for Design and Construction?

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LEARN ABOUT THE TOOLS, MATERIALS, AND BENEFITS OF SUSTAINABLE BUILDING FOR FUTURE GENERATIONS.

Low-carbon development is a holistic approach to design and construction that comprises evolving, energy-efficient, and environmentally friendly practices used to build a better future. Broadly defined, it's development "that meets the needs of the present without compromising the ability of future generations to meet their own needs," according to the Brundtland Commission, a mid-1980s global conference that first defined core concepts for the renewable vision now embraced in principle by industry leaders worldwide.

As technology evolves and climate change reinforces the urgency of sustainable solutions, low-carbon development isn't just the future, it's the present. There's simply no way to achieve overall sustainability in the architecture, engineering, and construction (AEC) industry without radically changing the way projects are designed and built. Buildings account for 38% of annual carbon emissions worldwide - 28% from operational emissions via heating, cooling, and power and 10% from materials and construction. Reducing those numbers will be more challenging due to an expected wave of urbanization.

Why Is Low-Carbon Development Important?

The built square footage taking place between now and 2060 is expected to double, amounting to the equivalent of adding

one New York City every month for the next four decades. Decarbonization of new and existing buildings should be an immediate call to action. With that in mind, two of the United Nation's 17 Sustainable Development Goals for 2030 focus on the built environment: building resilient infrastructure and creating sustainable cities and communities.

To move forward means confronting a series of interlocking challenges. The built environment has to evolve in lockstep with the electric grid - while phasing out fossil-fuel infrastructure and kick-starting electric-transportation options. These transformations have been hindered by poor coordination and old-school thinking, but the technology and creativity needed to succeed exist.

These shifts present a massive opportunity for those willing to adopt a different approach. Low-carbon development could also be a smart money move: The International Finance

Corporation believes green buildings will be worth $24.7 trillion by 2030.

Elements of a Low-Carbon Development Strategy

Low-carbon development is a holistic vision and process, focusing on improving the environment and often adopting decarbonization, resilience, circularity, and equity. Done right, it requires coordination across architecture, engineering, and construction, with all teams sharing digital assets from the outset to eliminate waste from their own work and the finished product.

The initial picture of this process may not be data-rich, maybe even just a low-resolution image. But it's important to have a vision, however grainy, as more aspects come into focus. The shared vision and digital tools for any project need to consider every stage of a building's life, including embodied energy and the end-of-life impacts of the project. With this information, teams can commit to a comprehensive blueprint with the right sustainable materials and construction practices.

CAREFUL SITE SELECTION

Before a single wall is built, proper siting for a project can provide a significant head start to cut emissions. The real-estate axiom about location goes double for green design.

According to the Los Alamos National Laboratory Sustainable Design Guide, proper siting practices include:

- Using the site's topography, sunlight, shade, and wind to promote energy conservation
- Preserving existing vegetation
- Integrating the building architecturally into the surrounding landscape

Choosing a good location helps minimize disturbance: Consider retrofitting existing structures or reusing brownfield sites to shrink the environmental footprint, avoiding interference with watersheds and wildlife corridors, and landscaping with native vegetation. These measures maximize the site's value in relation to its carbon emissions. Choosing a walkable, urban location near amenities and public transit can also reduce transportation emissions.

Tools now exist to help architects design with energy efficiency and environmental optimization at the forefront of the project. Other artificial intelligence–based tools used in the initial stages of design, are even empowering real-estate professionals to think about the impact of their building location and orientation by using real-time, data-driven wind and daylight analysis and feedback.

This planning becomes especially important for renewable-energy infrastructure, such as wind farms and solar installations. Clean-energy generation is expected to see investment double in the next five years and will require smart planning to avoid potential ecological damage, especially to wildlife habitats.

Building owners are rethinking how they best use their portfolio of building assets to increase overall portfolio performance while also reducing the impact on the environment. By renovating and repurposing existing asset portfolios, owners can more quickly adapt to changing occupant demands and even expand into new markets as the real-estate market transforms.

CREATIVE, SUSTAINABLE ARCHITECTURE DESIGN AND ENGINEERING

It's important to meld creative visions and layouts with material selection. Planning for low-carbon development largely depends on production-process methods - for example, tapping into local supply chains that eliminate transport and shipping costs could help reduce embodied carbon. A carbon-light construction phase depends on sourcing correctly and implementing the right procedures.

Sourcing should reduce; renew; and, if all else fails, offset the carbon that comes with making, shipping, and using materials. For instance, in some cases, mass-timber construction can help cut a building's carbon footprint by storing carbon in the building's structure. Offering guidance early - for example, making sure the steel being used comes from a low-carbon supply chain and is highly recyclable - pays off over the lifetime of the building. Architects and engineers should also specify low-carbon construction materials in the proposal, specifying materials that require less water, energy, toxic chemicals, and cleaners. This approach also reduces maintenance costs over time.

LOW-CARBON CONSTRUCTION MATERIALS

Because as much as 80% of the embodied carbon in a building comes from the structural materials, sustainable development must rely on low-carbon options. Options for low-carbon construction materials may also include repurposed materials such as reclaimed wood and recycled steel content. (The construction industry is notorious for tossing unused materials.) Traditional concrete alone produces nearly 8% of the world's CO2 annually. Novel materials can be greener alternatives, including:

» Bricks made from recovered building materials

» Recycled concrete

» Concrete mixes that reduce carbon impact

Using new techniques and minimalist approaches to design - think sleek lines, exposed ceilings, and buffed concrete floors - also cuts down on the total amount of material used.

The Embodied Carbon Calculator - or EC3, which works with BIM (Building Information Modeling) software - works by mapping materials at an elemental level once a building design is detailed. It can provide quick insights into important metrics like embodied carbon; the estimated greenhouse gas emissions of all materials made, transported, and assembled for a project; and the materials' maintenance and end-of-life costs.

MINDFUL MATERIAL ASSEMBLY

Once the right materials are gathered, equal care should go into assembling them. Better BIM management and digital collaboration on the jobsite can save money, energy, hours required, and materials. Embracing more efficient methods, such as lean construction, eliminates waste and cuts down on embodied carbon through better project management. According to the Lean Construction Institute, 70% of construction projects come in late and over budget.

Prefab, modular, and industrialized construction can also speed up project timelines, codify construction, and cut waste for the lifecycle of the project. For instance, the city hall in the Dutch town of Venlo can actually be disassembled and reassembled elsewhere as a different structure altogether. Finally, a growing new generation of all-electric heavy equipment and trucks has forged a path toward renewably powered construction sites.

LOW-CARBON BUILDING OPERATIONS AND MAINTENANCE

Smart and sustainable buildings aren't finished when construction crews break down their jobsites. Building operations and maintenance are lifetime pursuits that offer ways to cut energy bills and, ultimately, pollution. UN researchers found that emissions from building operations hit their peak in 2019; better construction and smarter operations technology are becoming the new standard. Emissions from building operations need to decrease rapidly in order to meet the goals of the Paris Agreement.

Building owners can maximize the efficiency of heating, cooling, and HVAC systems using technology and data for building operations. This is done using sophisticated sensors and digital twins - a constantly updated digital simulation model of a building, powered by artificial intelligence and machine learning, that can monitor, maintain, and optimize performance of the physical model. These technological advancements also introduce predictive maintenance, where sensors and real-time monitoring can detect when something starts to wobble past a certain threshold and implement energy-, time-, and money-saving fixes before disruptions happen - keeping assets performing as close to peak efficiency as possible.

BUILDING DECOMMISSIONING AND END-OF-LIFE REUSE

Even soon-to-be-demolished or decommissioned buildings have sustainable value for smart, holistic developers. The 20th-century paradigm of selling or demolishing a site, with salvage companies stripping knocked-down buildings for parts, works to a certain degree. But digital solutions offer better recycling and reclamation solutions and a more thoughtful approach.

Leveraging digital twins, old buildings can become material banks. This way, used steel beams or bricks, tracked since they were installed, can be rescued and given a second life in another building facade. The more that's known about what's in the building before it's taken apart, the easier and cheaper it is to reuse those materials. Without a roadmap to deconstruction, much of an old building gets directed to the landfill.

When the design-data journey culminates in a digital twin, architects and designers are well-positioned to pursue

adaptive reuse. Using generative design, architects can use technology to help them rethink and redesign layouts that best use the space available. The material passport approach can also encourage creative designs for dead buildings. Better understanding of older or heritage sites lets architects, engineers, and builders reuse the core of existing structures or make recycled materials central to a new project's design. In Sydney, the brand-new Quay Quarter Tower reused 68% of an old '70s building, saving the embodied-energy equivalent of 10,000 flights from Sydney to Melbourne.

Benefits of Employing a Low-Carbon Development Strategy

Saving the planet, it turns out, also saves money - especially when it comes to a low-carbon development strategy. Low-carbon development strategies tend to speed up many phases of construction, which can dramatically lower the cost of a project. And building with high energy efficiency saves significantly on energy costs over the lifetime of a project. Focusing on energy efficiency through decarbonization, electrification, efficiency, and digitalization returns $3 for every $1 spent, according to the Three Percent Club. Many college and office buildings across the globe have saved millions with advanced, sustainable designs; Stanford University found aggressive whole-building retrofits saved an average of 24% a year.

There's also extensive research showing that sustainable buildings actually help workers perform better, too. Biophilic and biomimetic design are examples of how some architects are bringing nature from the outside to the inside, giving building occupants a bit of pep in their step. Using better materials, increasing airflow and daylighting, and eliminating fossil fuels and harmful chemicals all create an incredible sales pitch for office-building owners: pay less for energy and be more productive. The U.S. Green Building Council found employees were "happier, healthier, and more productive" in sustainable office buildings.

Ultimately, buildings are assets. While lower costs and better occupant satisfaction make them more attractive, the dramatic rise in ESG investment (investors focused on environmental, social, and corporate governance that demand sustainable construction and operation plans) means greener projects are magnets for capital investment. Sustainability is becoming normalized in financial systems, leading to thoughtful site planning, embodied carbon, and aggressive climate benchmarks. Literally trillions of dollars of capital with sustainable requirements are in play, turning the discussion of sustainability practices in the AEC ecosystem to both a financial and environmental imperative.

What Does Low-Carbon Building Design Look Like?

In practice, low-carbon buildings have created cutting-edge architecture with more value. The constraints of energy efficiency or reusing an old building can actually provide creative fuel for architects and designers, leading to more eye-catching outcomes.

In Epernay, France, architectural firm OuyOut designed a new space for the accounting association CDER, advising against demolishing an old eyesore of a building and instead retrofitting it and reworking the facade. The striking exterior, a double-thick facade with winding curves and pergola-like plantings, is a fitting aesthetic for the center of France's Champagne region. It also provided a thicker, more insulating exterior that slashed energy costs.

In Miami, a recently finished upscale residential project, Grove Central, boasts sustainable building materials and rooftop solar panels. Perhaps the most lasting environmental impact is the complex's siting and transit connections. Located near a light-rail stop, Grove Central facilitates car-free, multimodal transportation. It also has a walkable, on-site store and amenities such as a social hub, helping cut carbon emissions from commutes and shopping trips. Like the OuyOut design, this sustainable residential project doesn't demand lifestyle sacrifices. The creative and responsible design arguably adds more aesthetic value and user benefits than traditional designs.

A similar idea on a larger scale was adopted by Thailand's Magnolia Quality Development Corporation when designing WHIZDOM 101. The 17-acre campus and sustainable smart city are an integrated vision of work, life, and play. High-end

residential amenities include a jogging track, bike track, library, and copious green space. Created with digital design to cut the amount of building materials needed, the development planned outdoor microclimates to reduce heat and used smart system controls to monitor and decrease real-time energy consumption,. Overall, the project cut energy use by 30% and reduced water use by 40%.

In Atlanta, the Kendeda Building for Innovative Sustainable Design is pursuing full certification from the Living Building Challenge and is currently recognized as one of the most innovative and sustainable buildings in the Southeast United States. The Kendeda Building, located at the Georgia Institute of Technology, is a 37,000-square-foot educational space built using mass timber; it has a green roof, cisterns for rainwater collection and reuse, and a solar-panel canopy, among other sustainable features. The building itself is regenerative: It gives back more to the environment than it takes from it.

What's the Future of Low-Carbon Development?

The path forward for low-carbon development is circular. Accenture studied the circular economy and estimated that, globally, $4.5 trillion could be saved by a shift toward reusing what is usually cast away and wasted. Better-informed reuse and recycling operations, committed to slashing carbon emissions, would help developers find creative and cost-saving ways to reuse materials from the built environment. Cities, which produce 50% of global waste (per the Ellen MacArthur Foundation), can become testing grounds for a more evolved, nature-inspired design movement.

The future may look like White Arkitekter, a Swedish firm that introduced the White ReCapture process in 2020. By laser-scanning an existing structure, the process relies on Autodesk BIM 360, Revit, and ReCap to determine the value of every item and how it can be reused. The firm recently used the process to save $1 million on furniture alone for a new municipal building.

Every step in the sustainable construction pathway uses data and technology to connect architects, engineers, and construction workers, as well as manage material flow: how things are procured; assembled; and, ultimately, retired and recycled. As it becomes easier and less expensive - and more status quo - to reuse, the bricks and beams of older buildings become more valuable assets. As new skylines and urbanization continue to rise around the globe, sustainable, low-carbon development will ensure they can truly stand the test of time.

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About the Article

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