VIEW POINT

UNDERSTANDING BUILDING DECARBONIZATION WITH NET ZERO CARBON BUILDINGS

Abstract

There is a need to decarbonize the world's-built environment by 2050 to meet global climate change goals. This point of view aims to address and provide clear pathways by which buildings can achieve net zero. It presents core definitions of zero carbon buildings as well as ways to classify carbon emissions. It also looks at aspects related to the building's energy demand and supply to reduce operational emissions to zero. It addresses ZCB components and the hierarchy of use for these strategies. Energy efficiency comes first, followed by using on-site renewable energy. Off-site renewable energy is the next choice, with carbon offsets as the final strategy to compensate for the remaining carbon emissions that cannot be avoided through efficiency measures and carbon-free renewable energy supply.

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Climate change poses a significant threat to our planet and our way of life. Already experiencing the consequences of a rapidly warming planet, we are seeing a massive loss in biodiversity, volatile weather-related disasters, stress on food production and water scarcity. According to the Intergovernmental Panel on Climate Change (IPCC), we have time until 2030 to reduce carbon emissions to limit the overall temperature increase to below 2°C, which is in line with the Paris Agreement. Carbon dioxide (CO_2) emissions must fall to net zero by 2050 to meet the goals of the Paris agreement.

The built environment is a major energy user and is responsible for a staggering one-third of global energy consumption and energy-related carbon emissions.

Classifying carbon emissions

There are two most common ways to classify carbon emissions:

1. **Operational carbon emissions:** Electricity generated from fossil fuels, use of diesel-powered backup generators play an important role in energy provisioning and emit CO_2 in the atmosphere. The carbon emissions associated with a building's energy use are called operational carbon emissions as they emerge from activities associated with the building's operations.

2. **Embodied carbon emissions:** Carbon emissions, resulting from the use of construction materials (right from their extraction, manufacture, and transport to site), and the machinery and equipment used on or near the site (fuel) during construction of buildings are known as embodied carbon emissions. On average, embodied carbon emissions represent a quarter of a building's total lifecycle emissions, and in case of low energy consuming buildings, the embodied emissions represent as much as 40-60%. As countries continue to add new buildings, the aggregated embodied carbon emissions associated with materials can be considerable.

Applied net zero concepts

It is important to note the prevalent commonly applied net zero concepts:

1. **Nearly zero energy building:** An energy efficient building that uses most (but not all) of its annual energy needs through renewable energy sources.

2. **Net zero energy building:** An energy efficient building that produces enough renewable energy to meet energy needs for the building operations' annually on a net basis. The building delivers at least the same amount of renewable energy to the grid than is used from the grid annually. (Note: Not all renewable energy is carbon-free in its generation.)

3. **(Net) zero carbon building (ZCB):** An energy efficient building that produces or procures enough carbon-free renewable energy to meet energy needs for the building operations' annually and over its lifecycle, compensating for the embodied carbon during the building's construction.

Solutions, though not perfect, already exist for decarbonization, and these solutions can be framed as pathways to accomplish zero carbon buildings. Zero carbon buildings (ZCB's) integrate several measures within and outside the building/s, and consider measures that relate to the specific characteristics of the building design and the intent of use. These measures also consider tradeoffs that need to be made between costs, desirability, and practicality of what can be implemented.

The built environment decarbonization measures also encounter trade-offs between different building types. Decisions on whether to focus on new buildings by implementing and enforcing codes and standards or on the existing building stock through retrofits, as well as between buildings catering to different market segments (commercial, residential, or municipal buildings, etc.) are critical to creating ZCB pathways. The best mix of measures to arrive at ZCBs and the best scale (individual buildings versus a city, municipal, or portfolio approach) would differ based on area, market conditions and policy environment. This approach will serve as the first critical step in defining the ZCB policy roadmap.

For ZCB's, energy efficiency is typically considered as a first step before using carbon-free renewables. The energy efficiency ecosystem is complex. Hence, there needs to be a careful balance between the cost and effort invested to ensure significant energy savings (because of deep retrofits) in business-as-usual scenarios and directing the same efforts and resources on other decarbonization efforts. Decarbonization measures include greening the electricity from the grid and promoting on-site renewable power generation. The use of these measures can, however, be limited by the building types and local conditions. Renewable energy can be effectively developed at the scale of districts, cities, or entire regions, rather than at the level of individual buildings. These decisions and the availability of renewable power considerably influence the adoption of renewable energy in building operations.

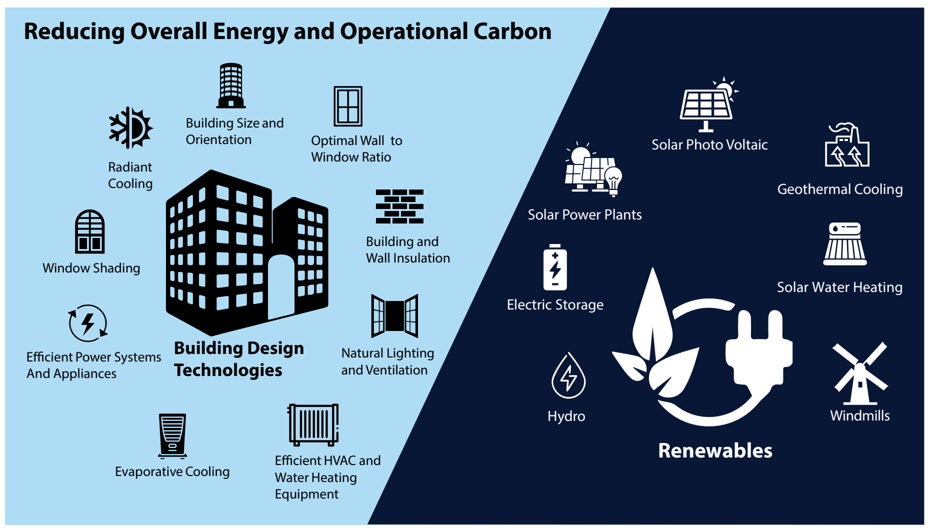
ZCB pathways primarily target operational carbon emissions in the net zero journey. Some of the aspects that relate to the building's energy demand and supply and that can help reduce the operational emissions to zero are:

1. **Energy efficiency (EE):** Measures to reduce the building's energy consumption using passive design strategies and advanced energy performance mechanisms (including efficient equipment and deep green retrofits) to reach the required EE levels while ensuring compliance with the local codes and standards.
2. **Renewable energy (RE):** Incremental reduction in building emissions can be achieved using carbon-free renewable energy sources. The options include on-site RE generation, off-site RE purchase, or off-site RE generation. RE costs for generation and storage have dropped drastically over the years and are comparable with conventional grid energy, making renewable energy a more attractive option.
3. **Carbon offsets:** The use of energy conservation mechanisms combined with the generation or purchase of renewable energy may not eliminate a building's operating carbon emissions. It may not always be possible to completely reduce carbon emissions in buildings that use fossil fuels for cooking or hot water heating. Carbon offsets (investment in energy efficiency measures or carbon-free renewables) is another pathway to achieve net-zero.
4. **Use of hydrogen:** Zero-carbon hydrogen can be used as an alternative to reduce emissions from fossil fuels and emissions from various feedstocks. Hydrogen is a versatile energy carrier and can be produced from low-carbon electricity or carbon-abated fossil fuels.
5. **Carbon capture and storage:** Carbon capture technologies can collect CO2 produced by fossil fuels in electricity generation, and appropriate storage can prevent CO2 from entering the atmosphere.

Building decarbonization through design and technology interventions

While action on combating climate change, particularly interventions in the built environment, is increasing, progress has been slow. The solutions (technologies), though not perfect, already exist and can be framed as pathways to accomplish zero carbon buildings. These solutions cater to different climates, budgets, and existing levels of expertise.

Reducing operational carbon is possible both during the design and the operational stages in a building. Use of passive design technologies that include but not limited to building size and orientation, building and wall insulation, optimal wall to window ratio, window shading, natural lighting and ventilation, evaporative cooling, radiant cooling, use of efficient HVAC equipment, LED lighting, use of efficient water heating systems, efficient power systems and efficient appliances are available technologies that assist in the net zero journey as well as reducing the overall energy consumption. Solar photovoltaic, solar water heating, electric storage, geothermal cooling, solar power plants, windmills, hydro and geothermal power plants are renewable energy sources used in the net zero journey. The decision on net zero or near-zero depends on considerations around deep efficiency measures that will influence the overall energy consumption.



Advancements in digital technology, such as the Internet of Things (IoT), blockchain, digital twins, and AI-enabled energy-management platforms, also promise to boost efficiency and drive costs down across both conventional and renewable energy value chains. They also present a unique transformation opportunity of the built environment. As decarbonization drivers (need, policy, and cost across value chains) intensify and converge, organizations are officially announcing goals related to reducing emissions, utilizing renewable energy, and addressing climate-related risks.

Net zero energy buildings can be part of the path to more sustainable and livable cities. While regulation will undoubtedly play an increasing role, the choice we make for our buildings today will continue to impact our planet. How we build today will define the course of our future.

About the Author

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Swapnil Joshi is with the Smart Spaces and Sustainability Centre of Excellence (ENCAS-IoT) at Infosys. He has a solid technology background in automation, IoT for buildings and application engineering for HVAC and building controls. Swapnil has led various aspects of building sustainability and delivered infrastructure to the highest standards of green.

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