retrofit

Climate Change Is a Big Challenge, and Many Believe Decarbonizing Buildings Is an Important Solution

TOPICS: Building TransparencyBuro HappoldCarbon EmissionsDanfoss North AmericaDecarbonizationEmbodied CarbonGreenhouse Gas EmissionsOperational CarbonSpacesmithThe Architectural Team

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In the past few decades, climate change has grown to become a major driver in how we approach the design, construction and operation of buildings. A sustainability movement, propelled forward by certification programs, like LEED, Passive House and the Living Building Challenge, drove manufacturers to innovate more environmentally friendly products and inspired architects and engineers to optimize their designs.

Although progress has been made, the specter of climate change has not subsided. If anything, the threat has grown, the stakes are higher and the time left to act is short. The world just experienced an unusually hot summer, even as the standard of “hot summers” continues to rise. According to the Copernicus Climate Change Service, an

agency supported by the European Union, June 2021 was the hottest June on record in North America and the fourth hottest worldwide.

Spacesmith designed the LEED Silver-certified NYPD Auto Pound Operations Building, which is run by the Property Clerk Division. The design is clean and direct, utilizing an aluminum composite panel cladding system, low-e glazing and a PVC roof membrane. PHOTO: Tanya Braganti

Led by groups, like the American Institute of Architects, the building industry is responding to the severity of the situation, and sustainability has become a greater focus than ever before. The concept of sustainability covers a wide array of strategies and is defined by different people in different ways. Is a sustainable building one that's built from environmentally friendly materials? Is it one that is energy efficient? Is it a space that is healthy for occupants? It can be all these things and more.

To deal with the core issue at the heart of climate change—the vast accumulation of greenhouse gases (GHGs) in the atmosphere—many designers and building professionals have begun to pursue what's known as the decarbonization of buildings. It's the next frontier in the fight against climate change.

"The building and construction industry is responsible for nearly 40 percent of global greenhouse gas emissions," explains Stacy Smedley, executive director of **Building Transparency**, a non-profit based in Washington state whose mission is to provide the open-access data and tools necessary to enable broad and swift action addressing embodied carbon's role in climate change. "It's critical that we begin to decarbonize the sector by focusing on reducing the two emission types associated with our built spaces: operational carbon and embodied carbon."

Decarbonization: Why and What

Where it relates to climate change, it's pretty clear that less carbon is what we want, but what exactly does decarbonization mean? How can greenhouse gases be minimized

or removed from the building equation? There are several thoughts and approaches, some focused on operation, others on materials.

“Operational carbon is defined as the greenhouse gases emitted during the use of a building,” Smedley continues. “Embodied carbon encompasses the carbon footprint of construction materials and considers all GHGs emitted throughout a product’s supply chain, manufacture, installation, use, replacement and end-of-life disposal. It’s critical that we reduce both emission types to decarbonize our buildings in our collective fight against climate change.”

“Decarbonizing means reducing the carbon used or embodied in the systems, construction and materials in a building,” adds Katy Flammia, design director of Hudson, N.Y.- based design firm **Spacesmith**. “This means making decisions from the start of the project to reduce the carbon the project will use. For example, reuse or adapt a building rather than tear it down and start new. Or consider clean energy choices and select materials with a lower carbon footprint.”

“To decarbonize buildings is generally defined as eliminating the direct emissions associated with the building,” says John Sheff, director of public and industry affairs for **Danfoss North America**. “Direct emissions are those produced onsite at the building, as op- posed to indirect emissions, which are produced upstream of the building by the power plant supplying the building’s electricity. In practice, decarbonizing buildings generally means electrifying its HVAC equipment, since they typically use fossil fuels. This could mean replacing gas-fired water heaters with electric ones or switching out boilers for heat pumps.”

“Some considerations may seem straightforward, like whether residential units will have natural gas or electric ranges, but decarbonization is a broad and holistic approach,” adds Jim Podesky, senior project manager with **The Architectural Team**, Chelsea, Mass. “It can also mean providing more electric car-charging stations or designing to reduce car trips altogether by offering more bicycle parking. A comprehensive approach will always consider long-term impacts and ongoing usage. Building systems that will be in use for years or decades have the potential to consume a lot of energy, so it’s critical to focus on heating, air conditioning, hot water, ventilation and lighting systems.”

10 Halletts Point is a two-tower mixed-use residential development on the waterfront of Queens, N.Y. Working closely with The Durst Organization and prime shell and core architects Dattner Architects, Spacesmith designed the public areas, including attended lobby, concierge desk, outdoor terraces, mail area, fitness center with yoga studio, resident lounge/party room, children's playroom and the leasing office. PHOTO: Eric Laignel

"Decarbonization effectively builds on more traditional ideas of sustainability and green building," Sheff adds. "Traditional green building tended to think of each part of a building—HVAC, lighting, exterior, water management—as a distinct system. Decarbonization takes those components and allows the building designers and operators to incorporate them into a single system."

"While historically green- building initiatives and standards might focus on energy, waste and water reductions or operational carbon emissions, decarbonization takes these traditional ideas a step further by including embodied carbon and low-carbon procurement requirements to incentivize carbon reduction across a building's value chain," Smedley says.

Optimize

A significant amount of a building's energy footprint comes from heating and cooling, so HVAC is a major part of the equation for any building looking to reduce its overall carbon impact. As a large contributor to the energy load of a building, the smallest improvements with HVAC can have a substantial impact.

"In most buildings you can get 20 percent reduction by optimizing the controls, operations, maintenance and behavioral elements," explains Ian Booth, partner with **Buro Happold** in New York. "It is not uncommon to see HVAC systems that are 20, 30 or sometimes even 40 percent overdesigned. This results in increased overall energy consumption and drastically reduces comfort. I am an advocate of correctly sizing the systems to ensure maximum comfort and efficiency—and agreeing the design criteria with the clients to avoid oversizing systems for extreme weather events. Part of the journey for us is working to make the systems we design as lean and efficient as possible."

“The best things you can do are to reuse what you can and create buildings that don’t require a lot of energy use,” Flammia says. “Have an insulated envelope, high-efficiency windows, lighting, heat pumps, and details that reduce thermal bridging and air leaks. These strategies are far superior to building conventionally and buying carbon offsets or having a huge solar field.”

“Simply replacing fossil fuel-powered equipment with electric components will only go so far toward reducing overall emissions,” Sheff says. “Adding more load to an electric grid that burns coal or natural gas to produce its power is not the ideal solution. Electric components must be added to an existing strategy to make the building as efficient and responsive as possible. Adding variable speed technology to pumps, fans and compressors and using controls technology to operate that system at peak efficiency is key to optimizing a decarbonized building and reducing upstream emissions, as well.”

For many examining the concept of decarbonizing buildings, the key is electric—specifically electric power that is generated by renewables, like wind and solar. A move away from sources that burn fossil fuels and toward renew- able electricity could change the game in the fight against climate change.

The Architectural Team currently is transforming 2.57 acres of parking next to the Massachusetts Bay Transportation Authority Mattapan Station into a development of 135 new, affordable, Passive House units. IMAGE: MASS Design Group

“The biggest trend lately has been to go fully electric as an energy source for heating and cooling in buildings,” Podesky says. “This is often done with variable refrigerant flow heat pumps. We are taking this approach on most of our building projects in Boston, where the city is pushing electrification. In one particular project, the one system in the building that is not electric is the domestic hot-water system, which is natural-gas fired. For larger multifamily developments, the technology isn’t there yet for large electric water heaters with short recovery times. Also, the operating cost for electric systems would be higher than gas at current utility rates.”

“It’s important to optimize and always question,” Booth says. “I question my own engineers and clients about HVAC. Do you need that much? Are we oversizing that? The usual approach is to oversize and say we’re better safe than sorry. That needs to change. I think it’s important to ask at every level, ‘Is this the right solution?’.”

Challenges

With the push to decarbonize the built environment, the momentum is not infinite and there are headwinds. The main one is economics. Although sustainable strategies can often deliver excellent return on investment, there are costs and, in the end, budget is still king in much of the design and construction industry. But as most climate scientists will agree, the situation doesn’t give us enough time to let the dollar be the driver. Action is needed now, along with some faith in the long-range economics.

“Initial cost is still a huge barrier to decarbonizing buildings,” Sheff says. “The paybacks on these projects are often quick, but their upfront cost can be significant. Even in new construction, where the best decarbonized designs are available, gas-fired equipment is still chosen because of upfront costs, especially in markets where policies are not in place to incentivize decarbonization.”

“Retrofitting HVAC systems in older buildings can be challenging, and first costs can sometimes be a drawback,” Flammia says. “Over time, though, most of the interventions will save money and work toward a safer, healthy environment.”

Initial investment is one hurdle, but another challenge comes from ongoing operation and the fact that our current balance of policy and power generally rewards doing things the way they’ve been done for years.

“Current utilities pricing does not incentivize decarbonization at a large enough scale,” Podesky notes. “As the hot-water system example demonstrates, in many cases natural gas is currently less expensive than electricity. That drives development decisions and ultimately influences how much the building team will focus on decarbonization. But as energy codes become more stringent, building envelopes are getting tighter and better insulated, so heating and cooling systems can be smaller as a result. Hopefully this will combine with technological advances to bring electrical costs more in line with natural gas.”

“Whilst many retrofit solutions cannot be justified on an economic basis purely in terms of energy savings, when you consider the avoided maintenance costs and end-of-life replacement costs in the analysis, there is a strong business case for these systems even considering that gas is currently a third of the cost of electricity,” Booth adds. “In

most cases we are very much advocates for optimizing the existing systems before replacement at the end of life or during major refurbishments. We also recommend deferring major equipment replacement until an audit has been carried out (chiller and boiler replacement) to avoid missing an opportunity to switch to a low-carbon solution for little to no additional investment cost."

Opportunities

The Architectural Team's approach for the Anne M. Lynch Homes at Old Colony draws on staples of Passive House design, including robust, heavily insulated walls and high-performance windows, along with passive solar design and an emphasis on compact, simple geometries to reduce thermal bridges. A highly efficient HVAC split system further ensures a healthy and comfortable indoor environment for tenants. IMAGE: The Architectural Team

In the end, there is great potential for long-term savings on buildings that pursue a path of decarbonization. Market forces, as well as new and evolving technologies continue to shorten the payback periods and make designing a less impactful building easier and more attractive. Improved sensors and building data also give engineers and building operators the tools to make vast improvements in building performance.

"Delving into building data is low-hanging fruit in terms of capital spend, but it does take time and smarts," Booth says. "Once you've optimized the building as far as you can, you may notice systems fighting with each other and being counter- productive. For example, you wouldn't believe how many buildings are heating and cooling simultaneously. We see a huge opportunity with retrofits."

"Heat pumps are emerg- ing as the No. 1 technology for replacing gas-fired boilers in buildings," Sheff says. "Not only do heat pumps reduce emissions, they also lend themselves to variable speed technology, allowing the building's HVAC system to ramp up and down to meet demand. When this happens, the building is capable of transitioning from an efficient building to a high-performance building."

“There are amazing new products and research going on in many areas,” Flammia says. “One is a building material made from mushrooms. There are concrete innovations that use fly ash, instead of cement. There are experimental 3D printed buildings made from Hempcrete, which is made of hemp. This is a time that is requiring innovation and a wholesale rethinking of the industry, how we make things and what we value. It is daunting, but it is doable.”