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Sustainable Buildings

Designing, building, and operating to help create a greener future

Contents

Introduction

The engineering and construction (E&C) industry is focusing on sustainable development and energy consumption and greenhouse gas (GHG) emissions. Globally, the built environment accounts for 39% of gross annual carbon emissions.[1] This includes operational carbon — the ongoing carbon emissions from day-to-day use and embodied carbon — all the carbon emitted in producing, transporting, and disposing of construction materials.
The pursuit of net-zero emissions is placing pressure on E&C companies and suppliers to lower the carbon footprint of new and retrofit construction. According to a survey by Dodge Construction Network, over 90% of U.S. E&C companies receive requests from customers to lower the amount of embodied carbon used in construction projects.[2]

However, the capital expenditure required to realize this vision can be considerable. A new look at sustainable buildings may help offset the needed investment, either as new construction or a retrofit of an existing building. In 2019, the International Energy Agency (IEA) estimated that realizing the potential of sustainable buildings can save $1.1 trillion by 2050 but necessitates an increase of $270 billion in annual capital expenditure until 2030, with 70% of that for new construction and retrofits.[3]

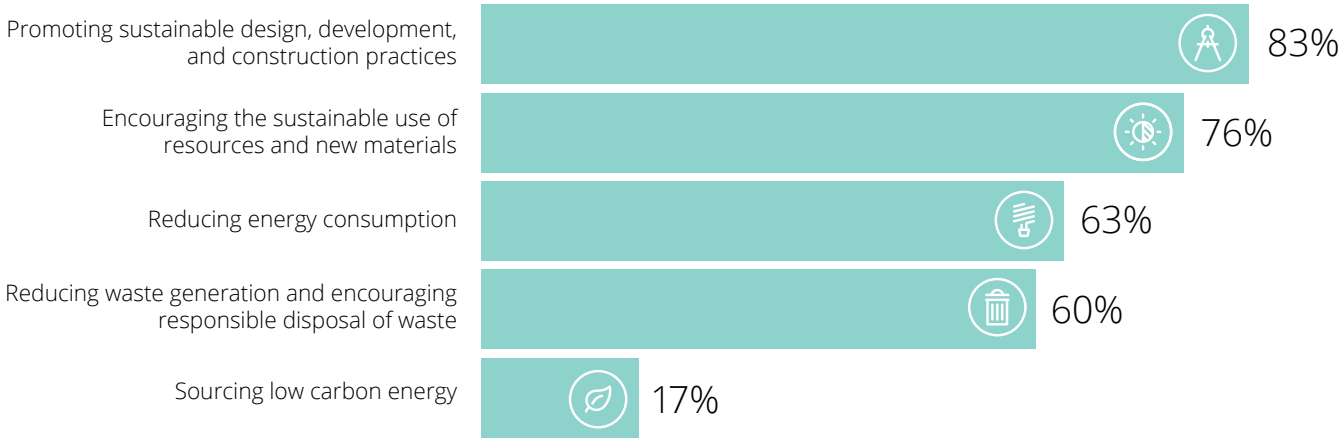
The industry's trifecta of potential solutions – sustainable materials, sustainable methods, and sustainable models – can help drive sustainable buildings. This article provides some approaches and recommendations for E&C companies to consider to help achieve the customer goals of lowering carbon footprint from buildings within the bounds of realistic capital expenditure.

A sustainable building can contribute to sustainable development when designed, built, and operated to minimize social and environmental impact.

Innovation, digital technologies, government incentives, and supportive regulation are helping facilitate progress toward emissions reduction

To reach net-zero emissions by 2050, some E&C, real estate, and building management services (BMS) companies have started integrating renewable energy and efficient construction into new builds. The 2021 World Green Building Trends report highlighted that commitments to boost green building efforts remain strong. For example, 34% percent of surveyed companies in the U.S. were focused on green buildings, and 46% reported that they would do so in the next three years.[4] The increasing global focus on climate change could incentivize construction companies to factor sustainability into their projects, construction processes, and designs (figure 1).

Figure 1. Top priorities of E&C companies to drive sustainability



Source: Deloitte Outlook Survey, September 2022.

Emissions Reduction - Innovation, Digital Technology, Government Regulation, and Policy Incentives

A typical building constructed today could still be in use in 2070 and beyond, but the climate that it will encounter would have likely changed significantly. So, there is a need to implement effective, low-carbon solutions to decarbonize buildings along their life cycle (figure 2). Innovation, digital technologies, policy incentives, and supportive regulation are some factors driving the industry's progress toward net-zero emissions.

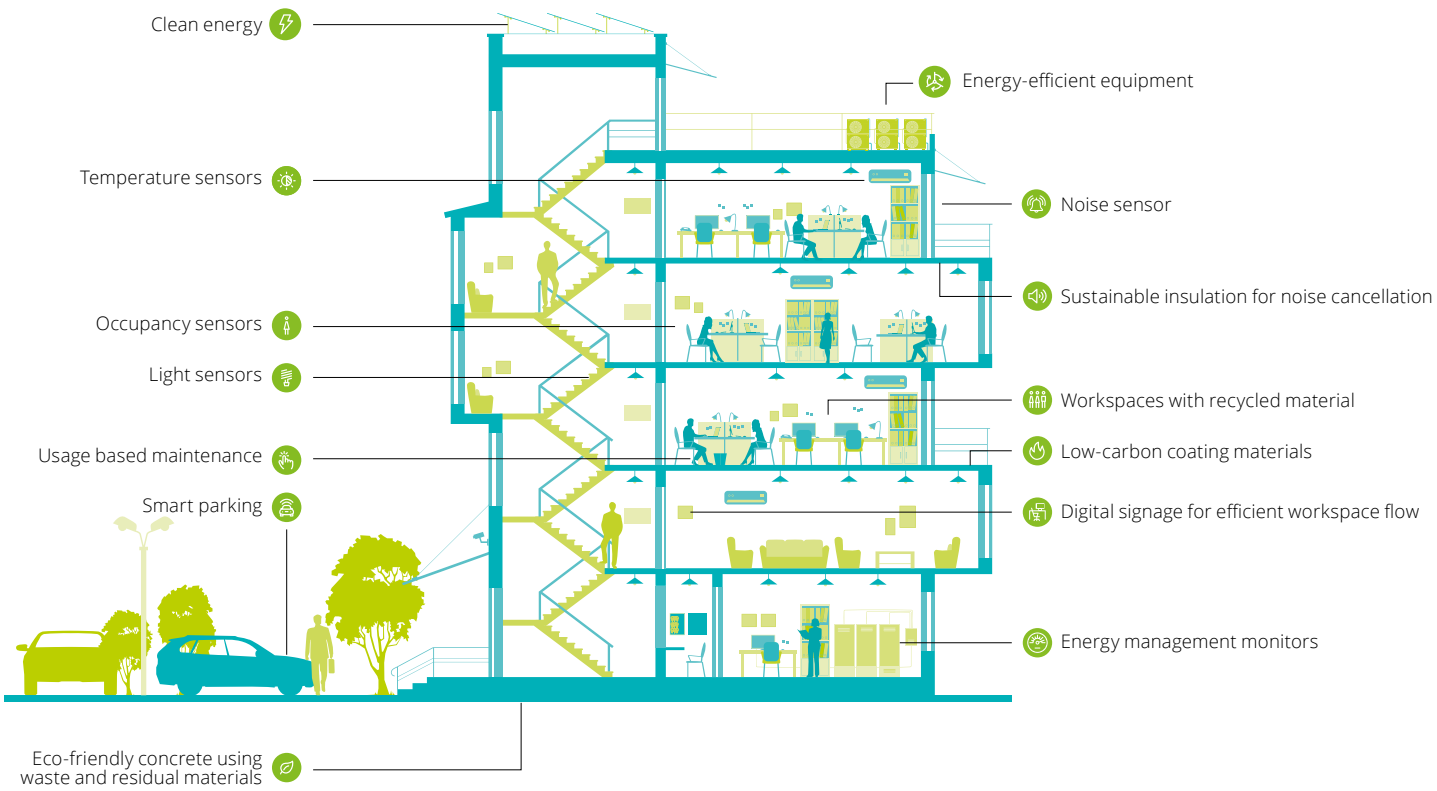
a. Innovation:

Substitutes and green building materials such as advanced concrete, organic admixtures, recycled glass, and plastic are gaining traction in the E&C industry. For example:

- Replacing lumber siding with polyvinyl chloride (PVC) or polypropylene resin resistant to water damage to reduce the need for frequent repainting and sealants.[5]
- Using treated wood to emulate plastic or glass. It is lightweight, stores heat, and reduces energy consumption.[6]
- Installing smart glass windows that can change heating capabilities based on the amount of heat and air conditioning present inside the building.[7]
- Using cement made with biologically grown (algae) limestone.[8]
- Leveraging low-carbon bricks that use 40% fly ash or green concrete substituted by fly ash and granulated blast-furnace slag. This can reduce emissions by around 46%.[9]

While these innovations are entering the market, regulation is still lagging. Companies may need the help of industry and engineering approvals for these material innovations to be adopted faster.

Figure 2. An example of a sustainable building that leverages innovative materials and advanced digital technologies



Source: Deloitte analysis.

b. Digital technologies:

Digital technologies such as IoT, sensors, connected devices, advanced analytics, generative design, and simulation software could drive emissions reduction and help developers conserve resources in energy usage, waste management, predictive maintenance, and other functions:

- Big data and AI/machine learning can help companies track and manage their overall carbon footprint.
- IoT sensors can increase data availability to track and monitor energy efficiency and enable more efficient operations and maintenance.
- Advanced controls, systems integration, data analytics, and energy optimization can actively reduce energy demand and consumption. Integration of digital capabilities like digital twin foundation and immersive integrated digital experience in smart equipment and appliances can offer benefits such as reduced downtime, increased utilization, improved reliability, remote management, and energy and emissions reductions.
- Generative design technologies enable optioneering capabilities on the building design options to evaluate different carbon footprint impacts.
- Simulation software for sustainable buildings allows developers and operators to conserve energy and resources while shortening project timelines.

c. Government incentives:

Global investment in the energy efficiency of buildings reached $180 billion in 2020, up from $129 billion in 2015, driven primarily by funding from European countries.[10] The European Commission introduced a strategy for a sustainable built environment in the E.U. to address construction products' sustainability. These measures include recycled content requirements for some products, promoting durability and adaptability of built assets in line with circular economy design principles, integration of lifecycle assessment, and more.[11]

In the U.S., the Infrastructure Investment and Jobs Act (IIJA) authorized $1.2 trillion for transportation and infrastructure spending, of which $550 billion was for new investments and programs, including energy and power infrastructure and water infrastructure.[12] Investments from the Inflation Reduction Act (IRA), such as tax deductions for energy-efficient commercial and public buildings and over $2 billion for procurement and use of low-embodied carbon materials in construction (new and retrofits) of General Services Administration (GSA) buildings, are helping to provide an impetus to sustainable construction.[13] Specifically, the IRA offers 50% cost rebates up to $400,000 for building retrofits that bring energy savings of at least 35% and up to $200,000 for retrofits that achieve energy savings of at least 20%.[14]

d. Supportive regulation:

Leadership in Energy and Environmental Design (LEED) continues to be a significant driving force behind the increased development of green buildings worldwide. For example, buildings can receive LEED credits for optimizing energy performance by analyzing efficiency metrics and focusing on load reduction and heating, ventilation, and air conditioning (HVAC)-related strategies during the design process.[15] Similarly, construction projects can earn LEED credits for building operations and maintenance by installing new or utilizing pre-existing energy meters or submeters that can be combined to produce data at the building level showing the overall energy usage of the building.[16]

The industry's trifecta of solutions to help drive sustainable buildings

To achieve the Paris Agreement goal of keeping global temperature rise to well below 2°C, the United Nations has set this target: *"By 2030, the built environment should halve its emissions, whereby 100% of new buildings must be net-zero carbon in operation, with widespread energy efficiency retrofit of existing assets well underway, and embodied carbon must be reduced by at least 40 percent, with leading projects achieving at least 50 percent reductions in embodied carbon. By 2050, at the latest, all new and existing assets must be net-zero across the whole life cycle, including operational and embodied emissions."*[17]

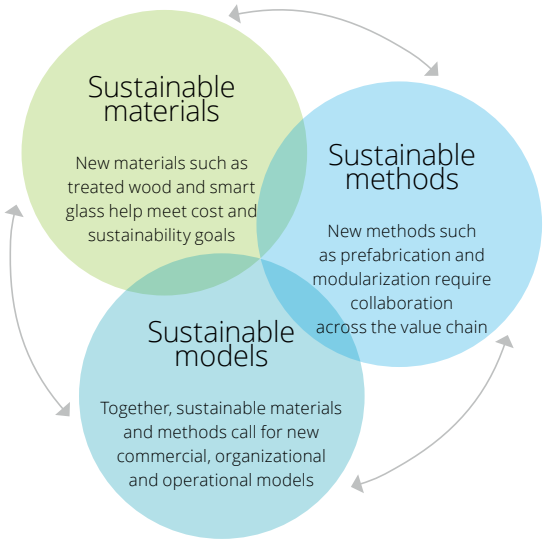
So, to help achieve the Paris Agreement goals, the global E&C industry, and its customers – the operating owners must completely decarbonize by 2050[18]. This may be difficult as global demand for energy services is expected to double by 2050 as developing economies experience growing demand for building floor space and economic activities.[19] The challenges of working to reach net zero and energy-efficient buildings are considerable, as 82 percent of the population expected to be added by 2030 will likely be living in countries without building codes or only voluntary codes.[20] One of the biggest challenges companies in the industry face when implementing sustainable practices is a lack of integrated visibility in their processes and with subcontractors.

The route to reduced emissions requires architects, designers, builders, subcontractors, suppliers, technology service providers, and operating owners to come together in new ways to solve for sustainability. It will likely also involve developers accurately measuring all carbon sources to reduce, reuse and recycle wherever possible, as well as considering many aspects of their business models.

Sustainable materials, methods, and models offer a route toward cutting embodied carbon and creating a zero-emissions construction industry (figure 3). Sustainable materials require end-to-end strategic sourcing capabilities, including cost, quality, and supplier management. Sustainable methods require effective supplier collaboration and development programs to manage cost and risk. And sustainable models require oversight across procure-to-pay processes and a high focus on spending compliance.

To achieve net-zero emissions by 2050, some construction and real estate companies have begun integrating efficient construction and renewable energy into new builds. However, millions of existing buildings that emit large amounts of carbon must be decarbonized first to help in the effort. This can be done by retrofitting. While retrofitting may be expensive initially, upon completion, owners may be able to recover their upfront costs through new technologies such as energy management systems. Renovation and reuse projects can save between 50-75% of the embodied carbon emissions compared to constructing a new building[21].

Figure 3. Industry leaders should consider focusing on sustainable materials, methods, and models to lower costs and scale sustainable solutions



Source: Deloitte analysis.

Sustainable construction does not necessarily have to be more expensive, especially when pricing strategies, program management, and environmental plans are incorporated from the beginning into the development process. While some of the sustainable construction materials may be more expensive initially, their usage lowers construction costs, and because of their durability, the finished construction requires less maintenance.[22] There has been a general trend of reduction in design and construction costs associated with sustainable buildings as building codes become stricter globally, supply chains for sustainable materials and technologies evolve, and the industry becomes more adept at delivering sustainable buildings.[23]

- *Sustainable materials:* Costs of sustainable or low-carbon construction materials will likely gradually decline compared to conventional materials due to lower ingredient costs of recycled or by-product materials. The higher upfront cost of sustainable buildings can be offset by a lower long-term life cycle cost, particularly for high-performance façades and energy-efficient systems.
- *Sustainable methods:* Prefabrication and modular construction, 3D-printing, advanced manufacturing, and material use optimization leveraging generative design can reduce the waste lifecycle of construction projects, thereby saving costs. Besides material costs, prefabrication and modularization can also help reduce labor costs, ensure better design and quality control, and shorten project schedules to help minimize budget overruns.[24]
- *Sustainable models:* Low-carbon business models and strategies can speed up many phases of construction and lower the costs of projects. For example, incorporating high energy efficiency in buildings helps save significantly on energy costs over their lifetime. A connected construction ecosystem can help ensure that developers and operators have a continuous flow of data and information. This can help processes remain compliant with building codes, worker safety standards, and other regulatory requirements. Enabling this new ecosystem may require companies to rethink their organizational, operational, and commercial models (i.e., revisiting talent structures and rethinking how companies buy, sell, and collaborate across the value chain).

The way forward: Considerations to help bring transformational changes

Emissions can be reduced along a building's entire lifecycle (for both new buildings and retrofits) from designing to building and operating/maintaining by focusing on these nine dimensions: (1) planning for sustainability and lowering emissions, (2) mandating minimum energy performance, (3) increasing the use of low-carbon materials, (4) driving the usage of energy-efficient and environmentally-friendly equipment, (5) encouraging efficient retrofits, (6) enhancing building operations and management, (7) building and operating a resilient supply chain for sustainable materials, (8) enhancing the health and safety and productivity profile of workers, and (9) attracting, hiring, and retaining top "sustainability" talent (figure 4).

Figure 4. Transformational changes that can help decarbonize buildings across construction stages

Consider the following ideas across the design, build, and operate/ maintain stages of construction:	Design Stage	Build Stage	Operate/Maintenance Stage
1. Planning for sustainability and lowering emissions	Evaluate requirements, design strategy, specifications, and each design choice using a whole lifecycle approach Integrate energy efficiency in buildings by developing decarbonization strategies and plans	Seek to minimize carbon impacts (e.g., lean construction, low-carbon materials, construction processes, etc.) Collaborate with developers to embed energy efficiency across projects	Have designs suitable to maximize the refurbishment of existing buildings Work with building operators to implement sustainable practices
2. Mandating minimum energy performance	Have a blueprint for reducing energy demand, achieving energy efficiency, and promoting the use of clean energy Focus on accelerating access to clean electricity	Prioritize high energy efficiency standards and use zero-carbon heating technologies Decarbonize the power supply and heat by electrification through renewable sources	Implement mandatory building energy codes and incentivize high performance (limiting the amount of energy used) to increase efficiency and provide longer lifetimes Use on-site renewable energy or green power
3. Increasing the use of low-carbon materials	Incorporate low-carbon materials early in the design process and leverage generative design solutions, to minimize a built asset's carbon footprint E.g., utilizing bricks made of concrete combined with plastic, which is hollow, allows airflow within buildings, absorbs pollution, and improves air quality Establish feedback and data-sharing loops between the supply chain, category management, and design groups for optimal material selection	Leverage blockchain technology to enable tracing materials as digitization of contracts, forms, and records of suppliers help streamline processes Deploy quick response (Q.R.) codes and radio frequency identification system (RFID) chips for material tracking Use automated drones, reality capture, visual intelligence, and AI that can check for material quality and identify potential defects	Use the life cycle assessment (LCA) technique to make more informed decisions through a better understanding of the health and environmental impacts of new materials Continuously evaluate air, water, land, and energy consequences of new materials and possible alternatives
4. Driving the usage of energy-efficient and environmentally friendly equipment	Utilize BIM methodologies and emerging technologies such as digital twin solutions to calculate energy usage, develop and test site logistics plans, and optimize water and lighting usage Deploy simulation software for sustainable construction, which allows for conserving energy and resources while shortening project timelines	Improve the average efficiency of equipment, appliances, and systems by leveraging the latest technologies – as the cost of new technologies declines over the long term and the asset value of low-carbon and sustainable buildings rises, developers can reduce expenses E.g., every $1 invested in efficiency upgrades such as heat pumps and LED alternatives could save $2 in electricity costs[25]	Deploy AI combined with big data-enabled advanced analytics to predict the amount of recyclable, reusable, and waste materials Aim to achieve economies of scale, narrowing the cost differential between maintaining code-compliant and near-zero energy-consuming buildings. E.g., lower heating and cooling expenditures
5. Encouraging efficient retrofits	Maximize the potential for renovation, future adaptation, and circularity Develop emissions reduction plans for refurbishment and retrofit	Upgrade buildings with sustainable alternatives such as smart lights according to the building occupancy rate, sensors to track and reduce energy consumption, composting and recycling waste Deploy robotics to help facilitate the disassembly of buildings as well as the sorting process of salvaged materials	Use 3D printing in retrofits to reduce material and water usage in development and minimize waste

Consider the following ideas across the design, build, and operate/ maintain stages of construction:	Design Stage	Build Stage	Operate/Maintenance Stage
6. Enhancing building operations and management	Plan to install automated building controls such as HVAC scheduling and optimal start, water and air temperature resets that help save energy	Deploy fault detection systems, including digital twin considerations that can identify, diagnose, and alert operators about faulty performance, which enables buildings to be finetuned routinely and cut energy consumption Install IoT sensors that can increase data availability to track and monitor energy efficiency, feed digital solutions for advanced analytics, and enable more efficient operations and maintenance	Continuously adopt energy performance tools, systems, and standards facilitating evaluation and monitoring of energy management
7. Building and operating a resilient supply chain for sustainable materials	Define new requirements with key stakeholders up front to drive effective strategic sourcing Build resilience by enabling interoperability throughout the supply chain and adopting an ecosystem approach to share data and real-time information Negotiate contract terms to include incentives and fines to ensure continuity in supply	Diversify supply sources (local, regional, and global) to ensure continuity of supply while reducing transportation costs and related emissions Work with suppliers to keep pace with trends in green architecture and building design, make continuous improvements for quality, and identify new use cases of materials to meet evolving demand	Establish continuous and regular vetting processes for suppliers to prevent losing time in the event an operator needs to switch suppliers Source materials for operations and maintenance within 500 miles that contribute to a building's LEED rating, boosting demand for domestically made products
8. Enhancing the health and safety and productivity profile of workers	Embrace learnings from programs such as "Prevention through Design (PtD)," a collaborative pilot between the National Institute for Occupational Safety and Health (NIOSH) and the U.S. Green Building Council to prevent occupational injuries, illnesses, fatalities, and exposures by minimizing risks and hazards to workers at all the stages of construction	Ensure adherence to Occupational Safety and Health Administration (OSHA) guidelines for worker safety standards. Specifically, concrete handling, exposure to fumes and dust, design and usage criteria for personal protective equipment (PPE), impact when using emerging technologies (e.g., new types of embedded sensors with built-in batteries), and others that apply to sustainable construction materials	Deploy measures such as having equipment rooms and recyclable storage areas, building exterior enclosures or daylighting systems, having safe operations and maintenance plans including recommendations for the use of PPE wherever applicable
9. Attracting, hiring, and retaining top "sustainability" talent	Create long-term plans to have access to a strong talent pool with skills in sustainability and green buildings E.g., according to the International Energy Agency, investing $1 million in energy-efficient building construction or retrofitting can result in the creation of up to 15 jobs[26]	Invest in training programs (both upskilling and retraining) to educate workers on the features and composition of alternative materials to facilitate better handling Provide specialized training to workers engaged in the installation of energy-efficient appliances	Use the new high-tech nature of materials as a branding opportunity to attract the talent required for operations and maintenance Develop and deploy sustained awareness programs that describe what sustainable buildings are to dispel the traditional view of construction as industrial and demonstrate the advanced nature of jobs

Source: Deloitte analysis.

Even as the E&C industry works toward driving lower-carbon solutions and enabling a greener future, it needs to continuously develop and bring innovative products and processes across the design, build, and operate phases. Industry players should work within their value chains and with end customers to ensure their solutions are positioned to support sustainability goals. However, no single company alone can address the emissions challenge. Construction ecosystems are an opportunity for reducing emissions as they enable industry players to deploy and activate assets and solutions they don't own and engage and mobilize a more significant number of value chain participants.

Arup, a British multinational professional services firm is updating 1 Triton Square in London, delivering twice as much office space and a BREEAM (Building Research Establishment Environmental Assessment Method) Outstanding sustainability rating, while retaining facades and superstructure.

Source: Arup, "Building retrofit: Transform and reuse - low carbon futures for existing buildings".

In Austin, Texas, a pilot project called "House Zero" was built using a proprietary 3D-printed cementitious material known as "Lavacrete", which is reinforced with steel and managed by software. This material is more resilient, uses fewer resources, and lowers energy consumption.

Source: Craftcloud, "3D Printed House Materials: What Are They Made of in 2022?", July 30, 2022.

Call to action

So, what are some things E&C companies can do to overcome current challenges and increase the successful implementation of sustainable buildings? E&C companies could consider four areas to scale new technologies and solutions needed to solve the challenges associated with reducing the adverse effects of climate change:

1. *Define a vision and develop a roadmap:* E&C companies should recognize that successful implementation often starts with a vision. This includes:
    a) Analyzing and selecting technological developments that bring value to all stakeholders
    b) Establishing technological guidelines to help suppliers meet the demand and achieve synergies and
    c) Developing an implementation roadmap

2. *Drive and prioritize sustainability-targeted construction and retrofitting projects:* To help ensure improved operational energy efficiency and carbon reductions, companies should consider encouraging and prioritizing sustainability-focused construction and retrofit/renovation projects through policies, regulations, penalties, or carbon taxes. These efforts should involve developers, real estate companies, and technology providers. Moreover, incentives can be created according to the building's useful purpose.

3. *Use incentives to promote alternate materials:* Industry players can help drive the usage of alternate low-carbon materials by building a strong ecosystem. For example, through initiatives such as the European Commission's Renovation Wave, companies can create collaboration and knowledge exchange opportunities that focus on sustainable materials[27].

4. *Promote data-sharing standards:* Generating data alone is likely not enough to successfully implement and scale sustainable buildings. Data should be combined with a thorough understanding of how developers and operators can use it. Information can be made actionable by enhancing interoperability and standards globally. For example, the European Commission's Digital Agenda is one of seven identified pillars for growth in the European Union that integrates information and communication technology in sustainable construction[28].

Achieving the vision for sustainable buildings and creating a zero-carbon built environment will likely require adopting transformational approaches, collaborating through global platforms, and working with governments for incentives that can take new solutions to a commercial scale.

E&C companies should prioritize how they identify, plan, and deliver on sustainability strategies that comply with regulatory requirements and investor demands, as well as benefit the communities in which they operate.

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