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USGBC EDUCATION PARTNER

DECARBONIZING THE BUILT ENVIRONMENT

Operations & Maintenance

Sustainable design and construction are the first steps towards achieving Net Zero Energy or low carbon emissions in buildings. During the design stage, the building blocks for a building lifecycle that supports decarbonization are established, and construction strategies turn the design into a reality that supports minimizing greenhouse gas (GHG) emissions. Once the building is ready for occupancy, the decarbonization strategy moves into the next stage, which is operations and maintenance. Strategies for sustainable operations and maintenance for new and existing buildings include conducting energy audits, adopting a Building Management System, developing green purchasing policies, implementing waste management systems, and implementing sustainable maintenance practices.

ENERGY EFFICIENCY AND MANAGEMENT

Once a building is occupied, the operations and maintenance policies and procedures become the focus. The ideal building's architectural design and engineering make it possible to reduce GHG emissions, but over the long term, the operations and maintenance of the building are instrumental in optimizing energy consumption. Events like poorly operating or aging equipment can significantly impact GHG emissions levels.

Keeping new building energy consumption in line with original plans requires strategies for maintaining operational emissions at a level that meets sustainability goals. Existing buildings can be retrofitted to reduce current carbon emissions. Operations and maintenance play significant roles in decarbonizing a new or retrofitted building. Some of the strategies for maintaining optimal carbon emissions or for reducing them include energy audits and the integration of renewable energy systems.

"Image Source: https://www.greentechmedia.com/articles/read/guest-post-operational-efficiency-a-hidden-energy-efficiency-opportunity-"

Energy audits –

An energy audit is a systematic process for identifying energy-saving opportunities and inefficiencies. It is a periodic assessment and analysis of building energy assets and operations that identifies:

1. Operational and maintenance opportunities to reduce energy consumption
2. Retrofit recommendations for energy efficiency
3. Code compliance issues
4. Opportunities to better adhere to energy standards
5. Potential capital investments
6. An action plan for short or long-term energy improvements
7. Energy cost and consumption patterns for purposes of improving operations and planning

Some cities like Atlanta, New York City, and Los Angeles require energy audits of commercial buildings meeting a certain square footage threshold. [1] The American Society of Heating, Refrigerating and Air-conditioning Engineers (ASHRAE) established auditing standards for energy consulting engineers, LEED professionals, building owners and managers, and others. The energy audit establishes a baseline energy consumption, identifies elements and practices that may unnecessarily increase energy usage, and recommends ways to reduce energy consumption.

"Image Source: https://chateaues.com/difference-between-ashrae-level-1-2-3-audits/"

ASHRAE ENERGY AUDITS

LEVEL 3:
Detailed Survey and Analysis
- Refined Analysis
- Additional Measurements
- Hourly Simulation

LEVEL 2:
Energy Survey & Analysis
- End-Use Breakdown
- Detailed Analysis
- Cost & Savings for ECMs
- Operations & Maintenance Changes

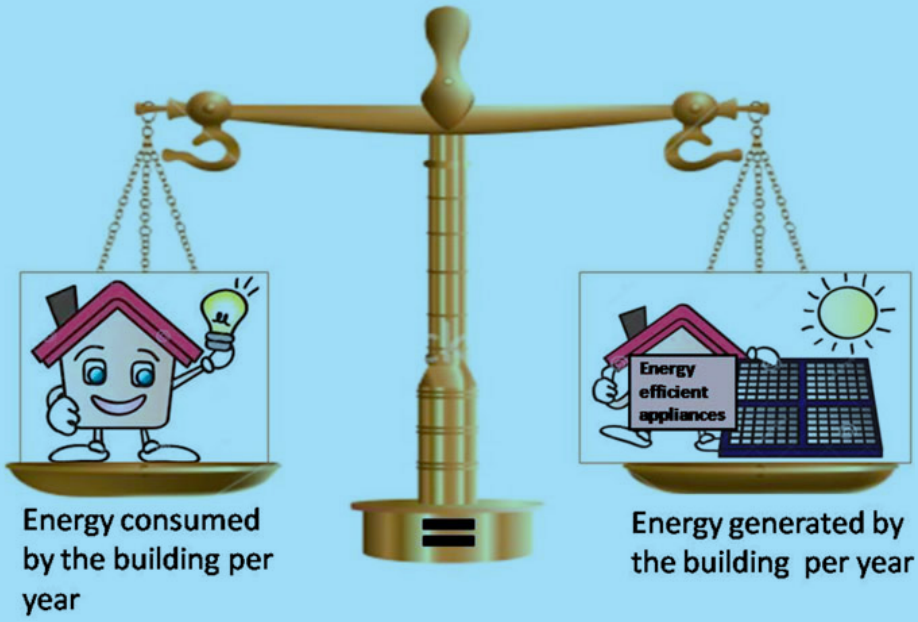
LEVEL 1:
Walk-Through
- Rough Costs & Savings for ECMs
- Identify Capital Projects

There are three levels of ASHRAE energy audits for commercial buildings, and levels 2 and 3 build on the prior level. Level one is a walk-through analysis to get a general overview of building energy performance in relation to similar properties. It establishes a baseline of energy consumption. Level 2 is a much more detailed energy analysis of operations and systems and how they interact. This detailed analysis normally means an energy modeling program is used, which can identify areas for improvement and unexplained energy use. The energy audit level 3 is the most comprehensive audit that collects detailed data on specific systems and equipment for capital projects. It may include making cost estimates of potential energy-saving measures. Targeted energy audits are also defined by need and customization rather than a particular level.[2]

The International Organization for Standardization (ISO) 50001 Energy Management System certification and 50002 energy audit procedures are also available. The standard establishes the requirements for improving energy performance. It is a detailed analysis of equipment, systems, processes, or the organization to improve energy efficiency. These standards are designed for global use.[3]

Renewable Energy Integration -

Renewable energy integration refers to incorporating energy from renewable sources, such as solar photovoltaic systems or wind turbines, into existing power systems. It involves connecting renewable energy sources to the grid and managing the energy flow to ensure it is used efficiently and effectively. Achieving Net Zero Energy status is often the ultimate goal because renewable energy sources may produce as much energy as the building consumes.



"Image Source: https://www.frontiersin.org/files/Articles/1028793/fenvs-10-1028793-HTML/image_m/FENVS_fenvs-2022-1028793_wc_abs1.jpg"

An academic building was retrofitted to convert it to a Net Zero Energy building. A solar PV system was integrated to meet the reduced energy demand the retrofit made possible. Retrofits can embrace various building changes, including insulating the building envelope, applying window shading, and replacing lighting with energy-efficient ones. The academic project included these measures, plus replacing appliances with energy-efficient products and replacing conventional air conditioners with inverter technology-based air conditioners. After electrical retrofitting, a BIM analysis was completed to determine how much solar photovoltaic-based energy was needed to supply the building's remaining energy needs to reach Net Zero Energy. Eighty PV panels were installed on the roof. The carbon dioxide emissions were reduced from 26.5 metric tons to 17.9 metric tons due to the retrofits. The integration of solar systems eliminated 25.2 metric tons of CO_2 emissions. The building was rated according to LEED v4.1 O+M and qualifies for LEED Silver. [4]

"Image Source: https://www.nrel.gov/grid/renewable-energy-integration.html"

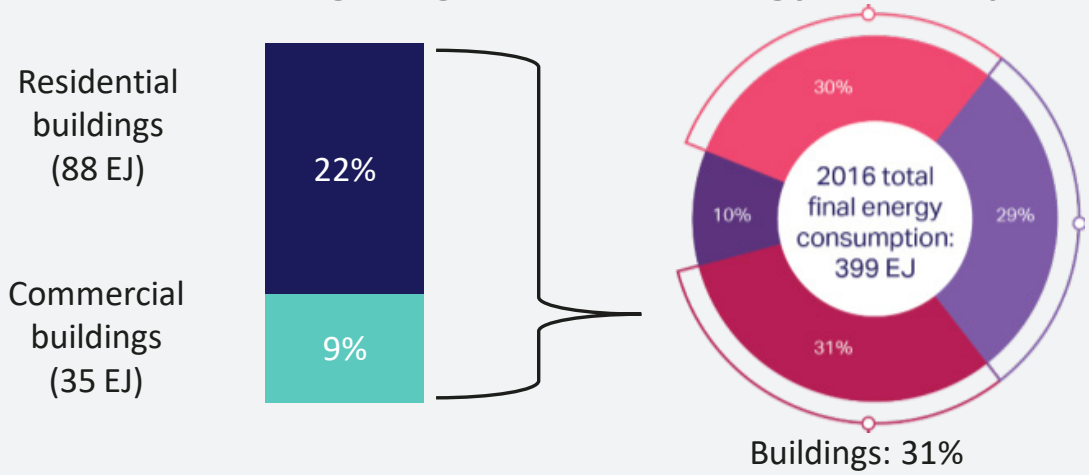
Building Energy Management Systems (BEMS) –

The Building Energy Management System is comprised of hardware, like controls and sensors, and software that monitors and controls energy consumption for optimized energy use. BEMS supports managing energy-consuming systems like the HVAC system, lighting, and hot water. It offers real-time monitoring and data analysis, automated control and scheduling, optimized lighting, and efficient HVAC systems. BEMS identifies wasteful energy consumption patterns and supports the integrated operation of energy-consuming systems to support efficiency and improve productivity. The system can control air quality and indoor temperature, which improves occupant comfort.[5] In addition, BEMS can be integrated with renewable energy systems.

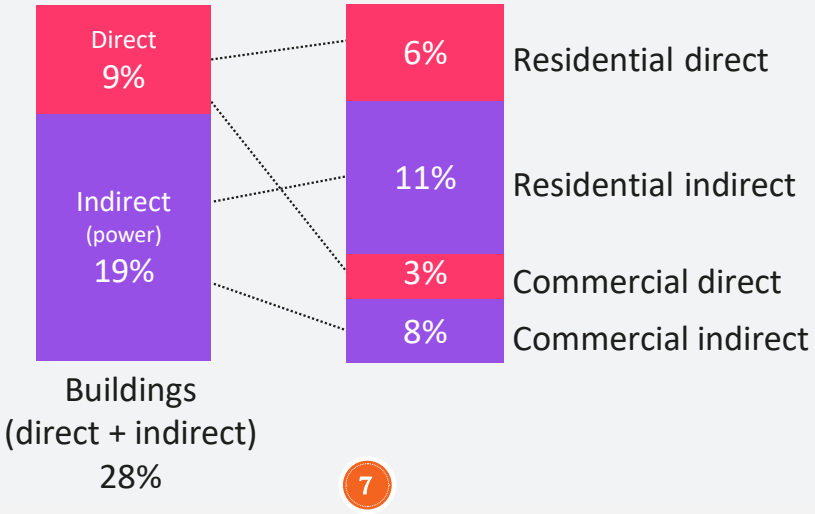
"Image Source: https://www.thermodial.ie/building-energy-management-system-bems-controls-service-maintenance/"

Energy consumption of buildings

Share of buildings in global final energy consumption[1]



Share of buildings in global energy-related CO_2 emissions[2]



"Image Source: https://wbcsdpublications.org/wp-content/uploads/2020/07/WBCSD_Business_Case_BEMS.pdf"

ADVANCED TECHNOLOGY IN BUILDING OPERATIONS

"Image Source: https://www.planradar.com/sa-en/modern-construction-technologies/"

BMS and AI

Advanced and emerging technologies are merging as innovations for increasing operational efficiency and generating energy savings. Building Management Systems (BMS) are computer-based systems that control and monitor the building's systems and functions, like electrical systems, and assist management with data analysis. Typically, control panels are wired to various building elements like valves, sensors, and switches. A BEMS has an emphasis on energy conservation and can be integrated into a BMS.

BMS relies on sensors and controllers for data collection from building systems and equipment and enables building managers to monitor and control the systems in real time. The BMS stores and analyzes the data so that building managers can optimize operations and maintenance.

Artificial intelligence (AI) is increasingly being integrated into BMS because it can optimize the use of the data for decision-making. Machine learning algorithms are able to manage vast amounts of data and analyze and learn from historical data patterns. AI can also utilize predictive modeling and recommend ways to reduce energy consumption.

Though BMS does data analysis, AI adds learning and predictive functions. The International Energy Agency calls energy and AI the “new power couple” because of AI’s ability to manage enormous data amounts as electricity demand increases and decarbonization efforts need adjusting. In a building’s renewable energy integrated system, AI supports a variable energy supply, allowing better grid integration. The ability to predict energy peak usage means a company like Google can better manage energy consumption by shifting heavy energy loads to avoid needing to buy additional power from the market. Another advantage of integrating AI is that it can use data to predict when maintenance is needed. [6]

The SWISS manufacturer, ABB, developed an AI-enabled energy demand forecasting app (Energy Forecasting and Smart Alerts) that allows commercial building managers to avoid peak charges.[7] Grid Edge, a UK-based company, developed the AI-based system called Flex2X. It combines data from the current energy management system with other data, like weather data. It uses AI algorithms to optimize building energy use and can predict energy use 24 hours in advance. Grid Edge has reduced carbon reduction in use cases by up to 40% through load-shifting and efficiency measures. [8]

“Image Source: https://new.abb.com/news/detail/41194/abb-uses-ai-to-revolutionize-energy-management”

“Image Source: https://sustainability.mit.edu/article/ai-pilot-programs-look-reduce-energy-use-and-emissions-mit-campus”

MIT is in the process of developing ways to utilize machine learning to increase heating and cooling efficiency across the campus. It is a complex process as the following description indicates.[9]

The work to develop smarter building controls starts with a physics-based model using differential equations to understand how objects can heat up or cool down, store heat, and how the heat may flow across a building façade. External data like weather, carbon intensity of the power grid, and classroom schedules are also inputs, with the AI responding to these conditions to deliver an optimal thermostat set point each hour — one that provides the best trade-off between the two objectives of thermal comfort of occupants and energy use. That set point then tells the existing BMS how much to heat up or cool down a space. Real-life testing follows, surveying building occupants about their comfort. Botterud, whose research focuses on the interactions between engineering, economics, and policy in electricity markets, works to ensure that the AI algorithms can then translate this learning into energy and carbon emission savings.

IoT and Smart Sensors

BMS and BEMS rely on sensors and other technologies for system monitoring and data collection. The Internet of Things (IoT) and smart sensors enable data streams that BMS and BEMS can use to optimize energy consumption. Some of the ways these technologies support reducing energy consumption include: [10]

This is just a sample of how IoT and smart sensors can significantly reduce energy consumption or CO2 emissions.

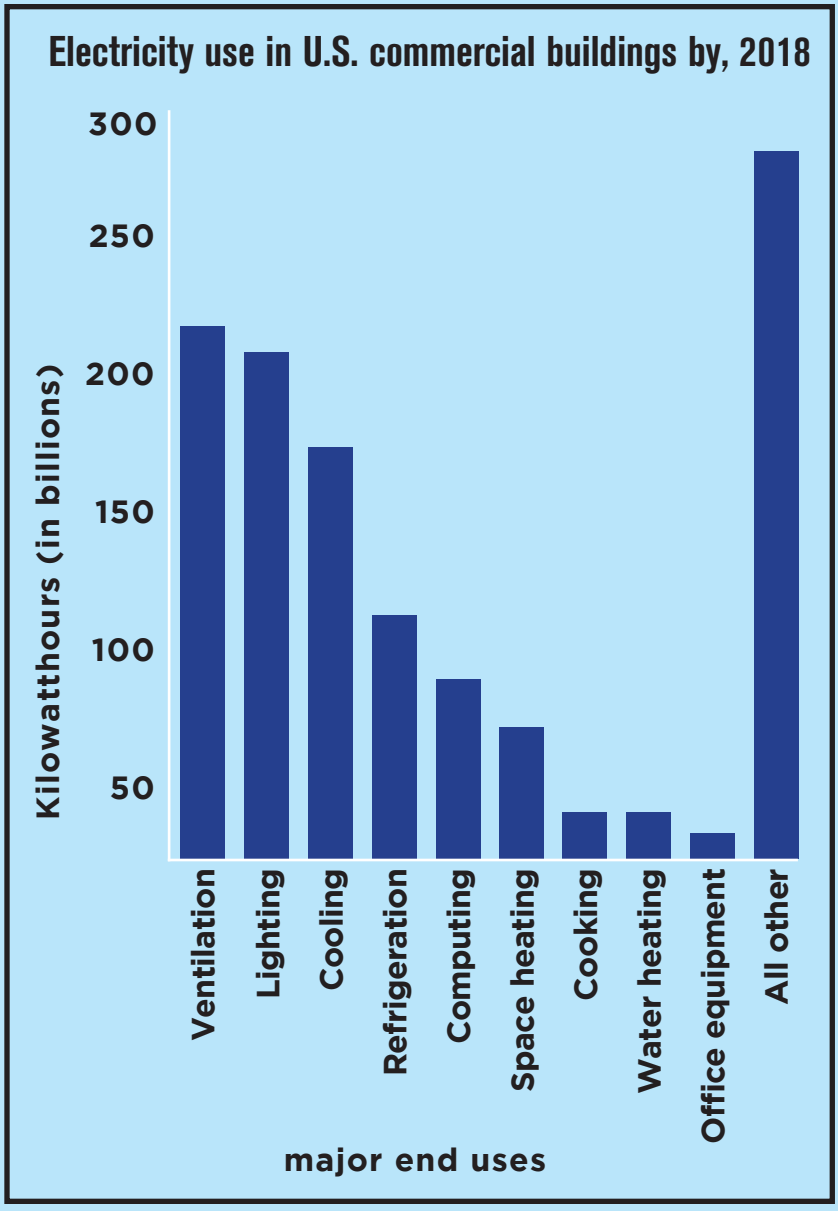
1. Turning off lights in unocwcupied rooms
2. Auto dimming of windows on sunny days or controlling smart window blinds equipped with sensors
3. Reducing airflow on weekends when the building is unoccupied
4. Automatically adjusting the HVAC system based on humidity, temperature, and weather conditions
5. Managing the energy consumption of appliances
6. Monitoring and control of renewable energy sources integrated with the electrical grid
7. Collecting real-time data collection on equipment performance for predictive maintenance based on identifying potential failures or inefficient operation
8. Learning from building user behaviors, driving decisions about things like workforce scheduling and identifying employee training needs

"Image Source: https://energy5.com/leveraging-internet-of-things-iot-for-smart-renewable-energy-management-in-electrical-infrastructures#anchor-3"

SUSTAINABLE MAINTENANCE & WASTE MANAGEMENT

Sustainable Maintenance Best Practices

Routine and ongoing maintenance and waste management provide essential opportunities for maintaining environmentally sustainable buildings. Utilizing IoT devices, analytics, and energy audits are significant strategies and part of the big picture, but daily procedures and practices are just as necessary. They are the details that prevent unintentional contributions to carbon emissions.



"Image Source: https://pressbooks.lib.vt.edu/sustainablepropertymanagement/chapter/sustainable-building-maintenance-and-repair-practices/"

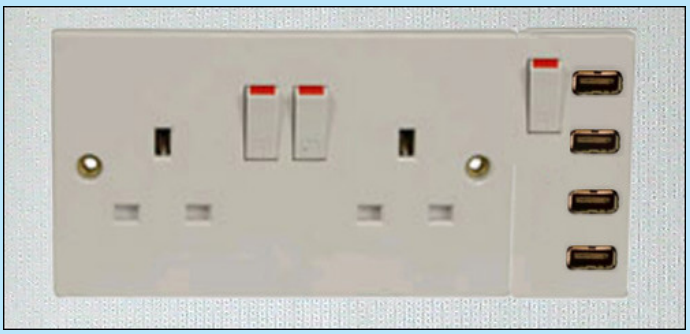
Following are some sustainable building maintenance practices. [11]

- Retrofitting aging or broken equipment or building elements with items that conserve energy or reduce emissions and are more durable
- Utilizing data-driven maintenance schedules instead of seasonal or scheduled plans so that energy consumption is not increased due to poorly functioning equipment in between routine maintenance events
- Conducting regular walk-throughs to identify malfunctioning equipment needing repair (think of ASHRAE Energy Audit Level 1)Adding motion sensors or timers for lighting control and replace incandescent light bulbs with smart LED lightbulbs

- Replacing windows at the end of their lifecycle with energy-efficient ones
- Regularly checking for air leaks around windows, doors, ductwork, etc.

"Image Source: https://pressbooks.lib.vt.edu/sustainablepropertymanagement/chapter/sustainable-building-maintenance-and-repair-practices/"

- Replace aging appliances with energy-efficient ones



- Training the workforce on daily practices for reducing energy consumption
- Replacing traditional water faucets with automatic shutoff products and older toilets with low-flushing models

- Checking for plumbing leaks and promptly repairing them

If retrofitting a building, it can be the ideal time to add a renewable energy system. An environmentally sustainable building maintenance program considers more than just carbon emissions. For example, testing indoor air quality for pollutants and replacing landscaping plants as they die with native plants are also important maintenance items that support lower carbon emissions.

Waste Management

"Image Source: https://safetyculture.com/checklists/waste-audit/"

Waste is a major source of greenhouse gases, and office building waste is considered municipal waste. Municipal waste does not include waste from building construction and demolition. [12] Globally, a staggering amount of municipal solid waste is generated annually. The current estimate is that two billion metric tons are generated, which is expected to increase by 70 percent by 2050. [13]

Waste management reduces carbon emissions in several ways. It reduces the greenhouse gases emitted by landfills. Landfill gas is primarily methane and CO2 in equal quantities and is the third largest source of atmospheric heat-trapping gases. Municipal solid waste landfills accounted for approximately 14.3% of these gas emissions for 2021.[14] Waste management also reduces the energy used for extracting resources and manufacturing and transporting finished materials and goods. Another way GHG emissions are reduced is by reducing the amount of waste hauled in fuel-burning trucks.

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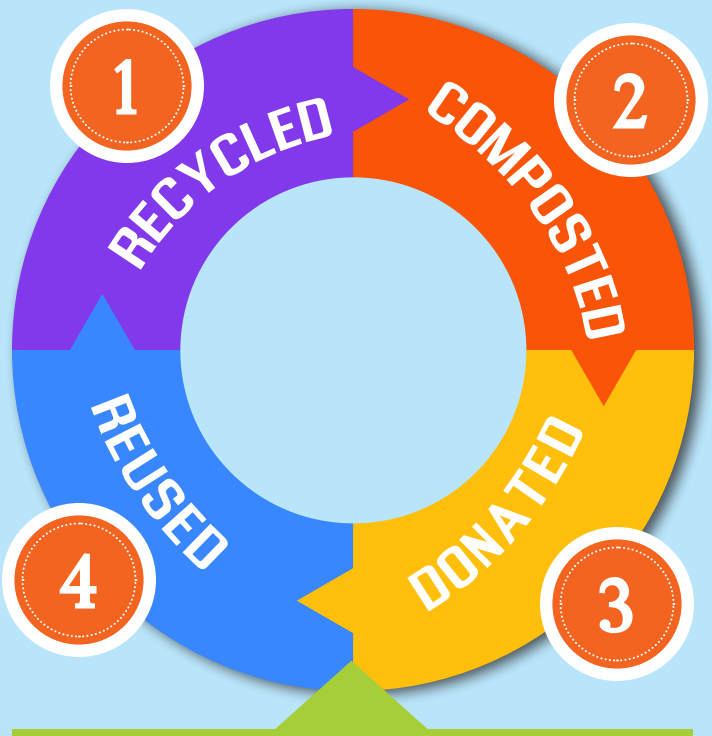
Commercial waste includes paper, packaging, wood, cardboard, glass, printer cartridges, scrap metal, plastics and plastic bottles, office furniture, solvents, steel cans, food, and more. Identifying the sources of business waste through a waste audit enables the development of a waste reduction and recycling strategy. A waste audit is then conducted periodically to stay on track. Tracking waste is critical to improving environmental sustainability and preventing GHG emissions. The ideal goal is to send Zero Waste to landfills.

The Environmental Protection Agency offers a benchmarking resource called Energy Star Portfolio Manager, which can track waste by 29 types and four categories within each type. The four categories are: [15]



Disposed in landfills, by incineration, as waste to energy. All types of waste can be disposed of, but many types can be donated, reused, or recycled. For example, plastics can be disposed of or recycled; furniture can be disposed of or donated/reused; and electronics can be disposed of, donated/reused, or recycled.

After identifying the types of waste, developing strategies to reduce the amount of waste by type so less is sent to landfills has a direct impact on GHG emissions. Waste reduction approaches include encouraging employees to change their behaviors to do things like reducing printing, which reduces paper and ink cartridges going to waste. Waste minimization is possible by making operational changes. For instance, substituting hazardous chemicals with non-hazardous cleaning supplies reduces waste. Procurement can choose products with minimal or biodegradable packaging. A waste management plan can include avoiding carrying excess inventory and can also address supply chains. A good example is asking suppliers to deliver materials on returnable pallets reduces operational waste.

Recycling is another effective strategy for reducing operational waste. Waste recycling is the process of transforming materials by changing their physical or chemical properties so the material can be used in new products or as new materials. Just by recycling office paper for 12 months, a building of 7,000 workers could reduce greenhouse gas emissions by 570 metric tons of carbon equivalent (MTCE) compared to throwing the paper in a landfill. [16]

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Waste diversion through recycling is an important source of GHG emissions reduction. Begin with planning for materials flows through a building to determine the strategic placement of recycling bins that separate paper, plastic, and glass. Partnering with a waste management company offering recycling services can strengthen the recycling program's results.

Recycle all materials. To illustrate, used electronics and batteries are important to recycling efforts. TVs, computers, phones and other electronics are made with valuable materials that can be recaptured and that should not end up in landfills, like mercury, lead, and brominated flame retardants. The EPA recommends using certified electronics recyclers who reuse components or refurbish equipment and ensure the destruction of all data on used electronics. There are two accredited certification standards in the U.S. called e-Stewards and R2. [17]

"Image Source: https://e-stewards.org/"

The e-Stewards Certified Recyclers destroy all residual data, conform to the law, and recycle and repair retired electronic assets. The e-Stewards Standard complies with ISO 14001 or RIOS Environment Management Systems and stops the export of illegal hazardous e-waste to developing nations. [18]

SERI is the ANSI-accredited Standards Development Organization for the R2 certification program and is focused on the whole lifecycle of electronics and reaching zero waste. R2 stands for Responsible Recycling and was created by SERI (Sustainable Electronics Recycling International). Facilities with R2 certification are trained to ensure electronics and their components are handled safely at the end of their lives. There is guaranteed data destruction, full tracking of recycling, and end-to-end legal compliance. [19]

Depending on the business, other items that can be recycled include oils, food waste, and plastic bags.

Recycling in manufacturing is another topic. In open-loop recycling, the material used in sustainable manufacturing processes eventually ends up in a landfill when the material degrades to the point where it is no longer useful after being reused or recycled multiple times. In a closed-loop recycling system, only bio-degradable materials that are not harmful are returned to the environment. The closed-loop recycling system supports the circular economy. There is a long way to go to develop a closed-loop manufacturing industry because of the complexity of the process. Challenges include developing product take-up programs, balancing economic needs with environmental sustainability, and developing initial sustainable products that support the closed-loop process.

"Image Source: https://info.mayeralloys.com/ewaste-blog/5-reasons-to-always-use-an-r2-certified-e-waste-recycler"

Two notes about waste. Building operations can reduce fuel usage because unnecessary fuel usage is a type of waste. Planning for fewer deliveries, for example, through more efficient ordering and inventory management, is a fuel waste reduction plan.

Second, the waste management company chosen can impact an organization's carbon footprint. Waste Management, Inc. is North America's largest waste management company and has a Climate Change Plan. It provides environmental solutions to customers, recycles post-consumer materials, reuses landfill gas, and has a network of renewable natural gas plants and gas-to-electricity plants. Waste Management offers customer solutions like helping organizations create new products for recycled products and recycling services for materials that provide the greatest GHG reduction benefits, can turn food waste into energy or compost, and can purchase products made with recycled content.[20]

GREEN PURCHASING AND SUPPLY CHAIN IMPACT

Green purchasing refers to procuring products and services that have a reduced impact on the environment and human health compared to other products and services. Researchers have found that purchasing professionals who include environmental criteria in the procurement process reduce waste, environmental impacts, and costs. “Buying 100 percent recycled-content paper can reduce energy use by 44 percent, decrease greenhouse gas emissions by 37 percent, cut solid waste emissions in half, decrease water use by 50 percent, and practically eliminate wood use,” says the University of Louisville Procurement Services. [21]

“Image Source: https://www.intechopen.com/chapters/72772”

Following is a sample of green purchasing practices.

- Buy recyclable goods and equipment that can be repurposed or has recyclable parts
- Buy recycled products
- Upgrade hardware or software instead of buying a brand new product
- Buy energy-efficient vehicles
- Add environmental sustainability requirements in procurement Request-For-Proposals (RFPs) sent to suppliers
- Buy products free of toxins and pollutants
- Buy from vendors with environmental sustainability programs they follow in their procurement and production processes and that produce green products that reduce waste, energy use, and/or chemical use

Procurement functions can also showcase green vendors to encourage internal buyers to choose green products and suppliers. The total impact of recycling on reductions in greenhouse gasses and environmental sustainability depends on advanced technologies to increase the type of recyclable materials.

Unfortunately, many cases of recycling only help postpone permanent waste generation. This happens if an original material gradually loses its quality while being recycled and cannot return to the same manufacturing process. It has to be reprocessed to lower-grade products, which are not necessarily recyclable. For example, recycling of polyester soda bottles results in obtaining polymer fibers, which may be supplied to a carpet manufacturer. Carpet, however, is not easily recyclable since it is a more complex product. Polymeric fabrics are combined with other organic products and adhesives to make the final product. Separation of pure components after its use is not feasible; hence, the used carpet becomes a landfill material. This way of recycling, when a material lives a few lives but becomes less and less usable or pure or safe along its way to the landfill, is often termed "downcycling". In terms of sustainability, it means being "less bad", but still not good enough. [22]

Green supply chain management best practices can significantly influence corporate sustainability performance, but it involves more than just procurement. Product design often drives materials, components, goods, and services within the organization. SAP defines a green supply chain as including “product design, materials sourcing, manufacturing, logistics, and end-of-life product management.” [23] SAP goes on to explain that sustainable supply chains depend on collaboration, leveraging of available technologies, setting consistent standards and targets, and communicating successes. Procurement should participate in product design to provide input on the impact of designs on GHG emissions and environmental sustainability, availability of green options, and green suppliers.

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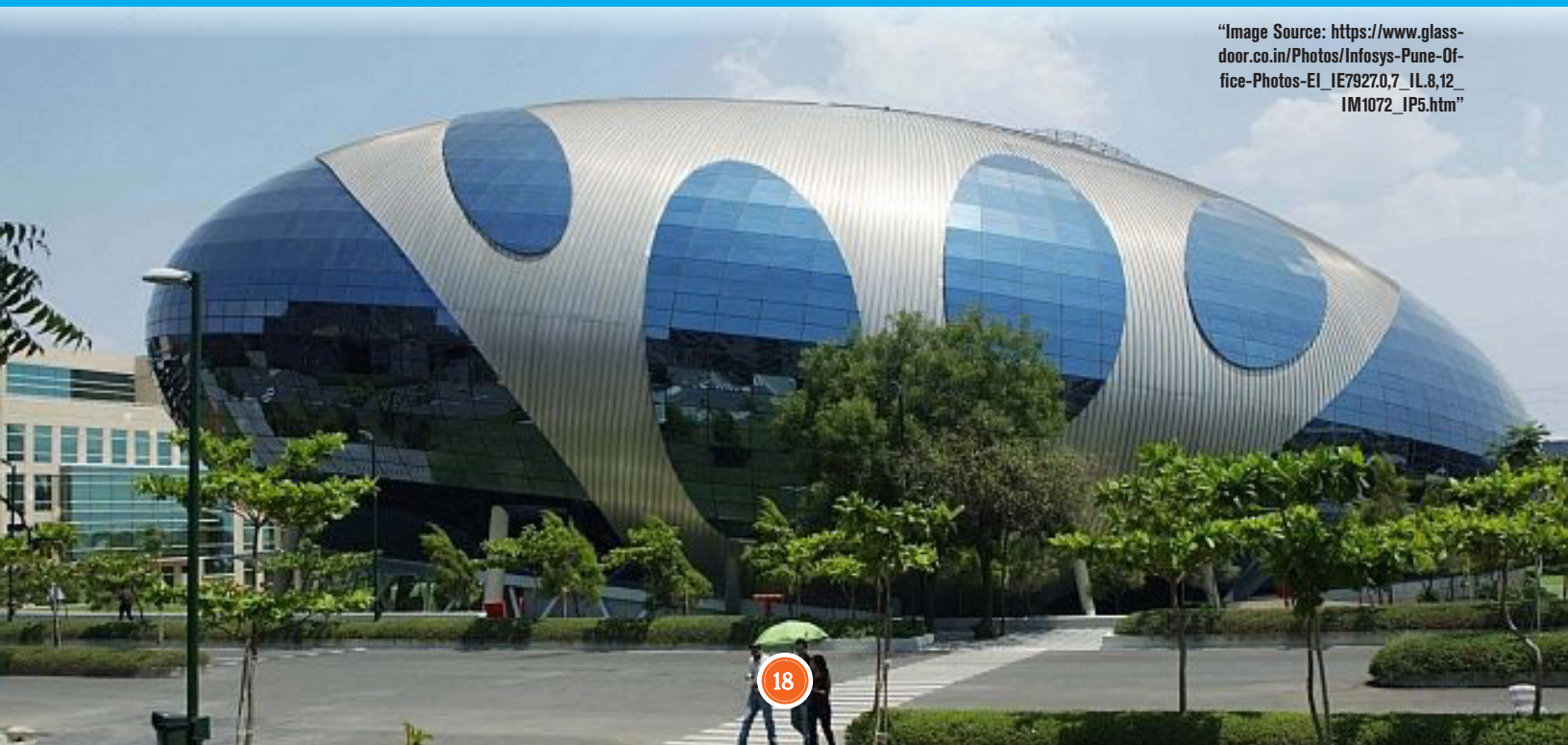
CASE STUDY:
INFOSYS EARNS LEED PLATINUM

Infosys earned LEED Platinum for its entire Pune Phase-2 Campus in Hinjewadi, India. This is the largest campus in the world to achieve LEED – Existing Building Operation & Maintenance (EBOM) Platinum certification. The campus was started in 2004 and has 114 acres. Numerous buildings include office buildings, food courts, multi-level parking, residential training facilities, and fitness facilities. To make the campus more environmentally sustainable, it has been constructing new buildings to meet the highest operational standards in environmental sustainability and has been doing retrofits on existing buildings.[24]

As the Infosys news release explained, three new buildings in the Phase-2 campus earned a LEED Platinum rating. The retrofitted buildings included 10 office buildings, three food courts, an employee training center, a guest house, and sports complexes. Retrofits focused on energy-intensive areas:

- **Re-engineered chiller plants and air handling units**
- **Retrofitted the Building Management System (BMS)**
- **Retrofitted lighting**
- **Retrofitted the Uninterruptable Power Supply (UPS)**

The impressive results over the last eight years are a 47% reduction in per capita energy consumption and a 38% reduction in per capita water consumption. There is also now 77% green power used for electricity generation on the campus.



"Image Source: https://www.glassdoor.co.in/Photos/Infosys-Pune-Office-Photos-EI_IE7927.0,7_IL.8,12_IM1072_IP5.htm"

Developing environmentally sustainable buildings and campuses is an intentional Infosys journey, and the organization is recognized as a trailblazer in achieving carbon-neutral status, which it did in FY 2020. The journey began in 2008 and has been optimizing energy efficiency across its campuses, like the one in Hinjewadi. The company chose to adopt integrative design in building designs, first focusing on optimizing the building envelope's energy efficiency and then integrating high-energy-efficient systems. Infosys uses a data-driven approach to validate results for new and retrofitted buildings.

As of 2022, the company has retrofitted 15 million square feet of office buildings and achieved carbon neutrality three years in a row. It added 30 mw of solar PV in Sira, Karnataka, implemented radiant colling in 5 million square feet, and deployed smart automation in 30 million square feet of office space, to name a few achievements. In 2023, the company adopted a lifecycle-based approach for building decarbonization.

The eBook ***The Infosys Journey – Pioneering Net Zero Buildings*** offers these facts and describes the journey in detail. [25]

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"Image Source: https://autocomponentsindia.com/30-mw-solar-project-in-karnataka/"

LEADING THE CHARGE IN OPERATIONAL DECARBONIZATION

The persons who must lead the way in operational decarbonization are the building owners and facilities managers. They are the people who make carbon emissions reductions and social and environmental sustainability priorities. The International Facility Managers Association describes the managers' various roles beyond building operations, and one is sustainability planning.[26] The building owner and facility manager are the two people who implement and promote sustainable practices throughout the building. The building owner and organizational executives empower company leaders to proactively support operational decarbonization and sustainability initiatives.

One way to support ongoing operational decarbonization is to develop a sustainability team that is led by the building owner and includes the facility manager, procurement professional, supply chain manager, engineer, and building staff representatives from different functional areas or who are environmentally conscious, like cleaning staff, IT staff operating high energy consumption computer equipment, and HVAC equipment maintenance staff. The team is not assembled based on reporting lines but rather on the people most influential on sustainability success. The sustainability team needs to have the right to execute change. [27]

CREATING THE FUTURE

Gro Harlem Brundtland, former Prime Minister of Norway, said, “Sustainable development is the development that meets the needs of the present without compromising the ability of future generations to meet their own needs.” Managing buildings so they are operationally efficient based on principles of decarbonization is important to present and future generations. It could be seen as a question of what comes first: operational efficiency or decarbonization. The answer is they are interdependent. Pursuing reduced energy consumption in buildings promotes innovation, creates more comfortable and safe interiors for occupants, supports economic development in communities through supplier selections, drives the purchase of green products that are good for people and the environment, and leads to continuous improvement and the adaptation to evolving technologies and practice. These benefits drive operational efficiencies, and operational efficiencies can drive reduced carbon emissions.

“Sustainable development is the development that meets the needs of the present without compromising the ability of future generations to meet their own needs.”

Pursuing decarbonization also brings people on board with sustainability practices. Joe Kaeser, prior CEO of Siemens AG, understood the importance of people supporting sustainability. “Sustainability is not just about adopting the latest energy-efficient technologies or turning to renewable power sources. Sustainability is the responsibility of every individual every day. It is about changing our behaviour and mindset to reduce power and water consumption, thereby helping to control emissions and pollution levels.” When people embrace building decarbonization, they turn the lights off as they leave the room rather than waiting for the technology to recognize an empty room. They bring new ideas for reducing energy consumption, embrace operational policies that drive carbon emissions reductions, and join sustainability teams.

The next article in the series on decarbonizing the built environment explores the principle of Life Cycle Assessment (LCA) and its role in sustainability evaluation.

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