Commercial Buildings

Commercial buildings include, but are not limited to, stores, offices, schools, places of worship, gymnasiums, libraries, museums, hospitals, clinics, warehouses, and jails. The design, construction, operation, and demolition of commercial buildings impacts natural resources, environmental quality, worker productivity, and community well-being.

Patterns of Use

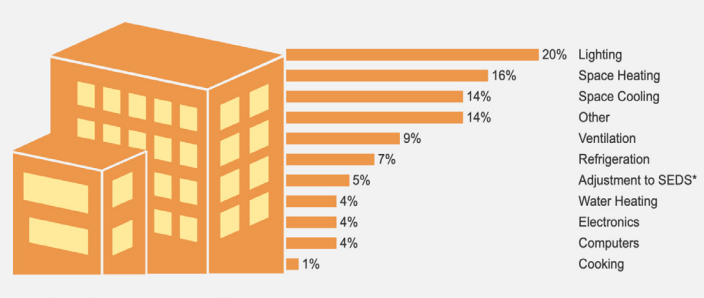
- In the U.S., 5.9M commercial buildings contained 96B ft^2 of floor space in 2018—an increase of 56% in number of buildings and 89% in floor space since 1979.[1,2] By 2050, commercial building floor space is expected to reach 124.6B ft^2, a 29% increase from 2022.[3]
- Education, mercantile, office, and warehouse/storage buildings make up 61% of total commercial floor space and 49% of buildings.[1]

Resource Consumption

Energy Use

- Commercial buildings used 17% of all energy in the U.S., and CO_2 emissions from the building sector accounted for one third of U.S. energy system emissions in 2022.[4,5]
- In 2023, the commercial sector used 16.1 quads of primary energy, a 52% increase from 1980.[4,6]
- In 2018, energy for U.S. commercial buildings cost over $140B, with space heating accounting for close to one-third of energy use.[7]
- Operational energy represents 80-90% of a building's life cycle energy consumption, vs. 10-20% for construction.[8]
- In under 2.5 years of operation, a UM campus building with an estimated lifespan of 75 years used more energy than material production and construction combined.[9]

U.S. Commercial Buildings Primary Energy, 2010[6]



*SEDS is an energy adjustment EIA uses to adjust discrepancies between data sources. Energy is attributable to commercial buildings, but not to a specific end-use.

Material Use

- Typical buildings contain materials including concrete, metals, drywall, asphalt, and wood products.[10] To make concrete, cement (a combination of ground minerals) is mixed with sand, water, gravel, and other materials.[11] Structural steel made up 46% of material market share in 2017 for non-residential and multi-story residential building, followed by concrete. While strong and durable, both concrete and steel require significant energy to create and have higher embodied emissions than other materials.[12]
- In 2011, the construction of new low-rise nonresidential buildings in the U.S. used about 1.2B board-feet equivalents of lumber, accounting for approximately 1% of all lumber used in the U.S.[13]

Water Consumption

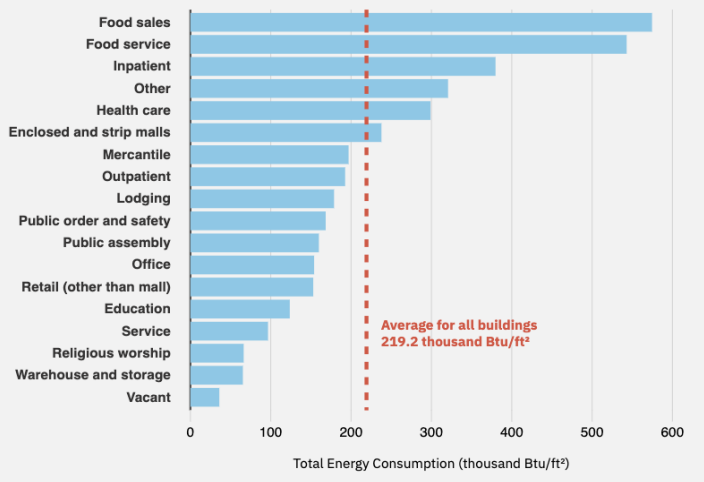
- The commercial and institutional sector is the second largest user of publicly supplied water in the U.S., accounting for 17% of withdrawals from public water supplies.[14]
- In 2005, commercial buildings used an estimated 10.2B gal/d of water, an increase of 23% from 1990 levels.[6]
- Domestic and restroom water is the largest use in commercial buildings, except in restaurants where 52% of water is used for dishwashing or kitchen use.[15]

Life Cycle Impacts

Construction and Demolition Waste

- In 2018, 600 Mt of construction and demolition (C&D) waste was generated.[10] This amounted to approximately 10 lbs per capita of municipal solid waste daily compared to the U.S. average of 4.9 lbs.[10,16] See the Municipal Solid Waste Factsheet.
- Approximately 38% of C&D waste was recovered for processing and recycling in 2014.[17] Most frequently recovered and recycled were concrete, asphalt, metals, and wood.[17]

Energy Use, U.S. Commercial Buildings, 2018[1]



Indoor Air Quality

- Volatile Organic Compounds (VOCs) are found in concentrations 2 to 5 times greater indoors than in nature. Exposure to high concentrations of VOCs can result in eye, nose, and throat irritation, headaches and nausea, and extreme effects, such as cancer or nervous system damage. VOCs are emitted from adhesives, paints, solvents, aerosol sprays, and disinfectants.[18]

Greenhouse Gas Emissions

- The combustion of fossil fuels to provide energy to commercial buildings emitted 725 Mt CO_2 in 2023, 15.4% of all U.S. CO_2 emissions that year.[19]
- As operational emissions drop with the adoption of energy efficiency and renewable energy, embodied emissions, which are attributed to the building materials and energy required for construction, may dominate new building life cycle emissions by 2050.[20]

Solutions and Sustainable Actions

Opportunities

- Before 2000, little attention was paid to energy use and environmental impact of buildings during design and construction.[21] For typical commercial buildings, energy efficiency measures can reduce energy consumption by 20-30% with no significant design alterations.[22]
- NREL found that 62% of office buildings, or 47% of commercial floor space, can reach net-zero energy use by implementing current energy efficiency technologies and self-generation (solar PV). By redesigning all buildings to comply with current standards, implementing current energy efficiency measures, and outfitting buildings with solar PV, average energy use intensity can be reduced from 1,020 to 139 MJ/m^2-yr, an 86% reduction in energy use intensity.[23]
- Energy Star's Portfolio Manager tracks energy and water consumption.[24] The tool includes nearly 25% of total U.S. commercial building space, making it the industry-leading database to benchmark building performance and provide transparency to building managers and tenants.[24]
- There is a movement to make the energy and water use of buildings more transparent to both building owners and tenants. For example, New York City passed Local Laws 84 (2009) and 113 (2016) requiring large building owners to publically report energy and water use.[25]
- U.S. office vacancy rates have climbed 47% since the start of COVID-19, suggesting potential for real estate repurposing.[26] Repurposing can cut emissions with retrofits potentially halving carbon output when compared to new construction.[27]
- Erosion and pollution from stormwater runoff can be mitigated by using porous materials for paved surfaces and native vegetation instead of high maintenance grass lawns. A typical city block generates 5 times more runoff than a woodland area of equal size.[28]

Design Guidelines and Rating Systems

- The U.S. Green Building Council developed the Leadership in Energy and Environmental Design (LEED) rating system. LEED is a tool for building performance, assigning points for design attributes that reduce environmental burdens and promote healthy, sustainable buildings.[29] As of July 2024, the U.S. has 86,140 buildings that are LEED certified.[30]
- Passive House Institute U.S. provides a climate-specific building standard to minimize energy use and emissions.[31] There are 4 principles of PHIUS buildings, mainly focused on insulation and airtightness.[32] As of July 2024, there are 454 certified PHIUS buildings.[33]
- The Living Building Challenge, an initiative by the International Living Future Institute, comprises seven performance areas, or 'petals': place, water, health and happiness, energy, materials, equity, and beauty.[34] As of 2021, there are 125 certified Living Buildings.[35]
- SITES certification for landscapes promotes nature-based solutions to protect ecosystems, while enhancing benefits to communities (e.g., climate mitigation and improving public health). As of 2024, 90 projects have SITES certification.[27,36]
- BREEAM certification measures sustainability across multiple categories that range from ecology to energy. As of July 2024, there are 159 projects that have achieved BREEAM Outstanding In-Use.[38,39]

Case Studies

- The Center for Sustainable Landscapes (CSL) was recognized by the American Institute of Architects (AIA) in its 2016 Commitment to the Environment Top Ten Projects, and was the first building to meet seven of the highest green certifications — the Living Building Challenge, LEED Platinum, SITES Platinum, WELL Building Platinum, BREEAM Outstanding In-Use, Zero Energy Certification, and Fitwel 3 Star green certifications.[40,41] CSL is a net-zero energy building, which significantly reduces its environmental impact during use, but a study revealed its materials had near equal embodied energy and 10% higher global warming potential than a conventional building.[42]
- Harvard's Science and Engineering Complex, an AIA COTE 2023 Top Ten Award Winner, achieved Living Building certification (materials, beauty, and equity petal requirements) and LEED Platinum certification. Solar shading, adaptable ventilation, water conservation and stormwater reuse, a heat recovery system, and an energy-saving air cascade system are all employed within the facility.[43]