CENTER FOR SUSTAINABLE SYSTEMS
UNIVERSITY OF MICHIGAN

factsheets
Built Environment

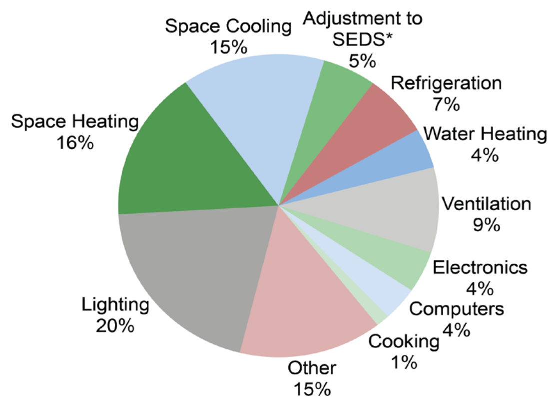
Commercial Buildings

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 impact natural resources, environmental quality, worker productivity, and community well-being.

Patterns of Use

- In the U.S., 5.9 million commercial buildings contained 96 billion square feet 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 124.6 billion square feet, 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]

U.S. Commercial Sector Primary Energy End Use, 2010[5]



*State Energy Database System (SEDS) is an energy adjustment that EIA uses to relieve discrepancies between data sources. Energy in this case is attributable to the commercial sector, but not to specific end uses.

Resource Consumption

Energy Use

- Commercial buildings consumed 18% of all energy in the U.S. in 2022.[4]
- In 2022, the commercial sector consumed 18.15 quads (1 quad = 10^{15} Btu) of primary energy, a 72% increase from 1980.[4,5]
- Operational energy represents 80-90% of a building's life cycle energy consumption.[6] In under 2.5 years of operation, a UM campus building with an estimated lifespan of 75 years consumed more energy than material production and construction combined.[7]

Material Use

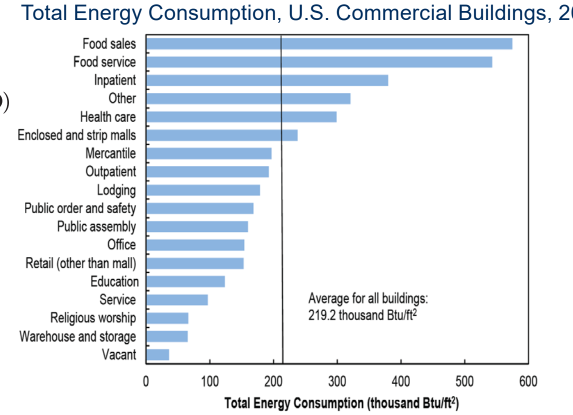
- Typical buildings contain materials including concrete, metals, drywall, asphalt, and wood products.[8] To make concrete, cement (a combination of ground minerals) is mixed with sand, water, gravel, and other materials.[9] Structural steel made up 46% of material market share for structural building, followed by concrete in 2017.[10] While strong and durable, both concrete and steel require significant energy to create and have higher embodied emissions than other materials.
- In 2011, the construction of new low-rise nonresidential buildings in the U.S. used about 1.2 billion board feet equivalents of lumber, accounting for approximately 1% of all lumber consumed in the U.S.[11]

Water Consumption

- In 2005, commercial buildings used an estimated 10.2 billion gallons of water per day, an increase of 23% from 1990 levels.[5]
- 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.[12]

Life Cycle Impacts

Total Energy Consumption, U.S. Commercial Buildings, 2018[13]



Construction and Demolition Waste

- In 2018, 600 million U.S. short tons (tons) of construction and demolition (C&D) waste was generated.[8] This amounted to approximately 10.0 lbs per capita daily compared to the U.S. average of 4.9 lbs per capita per day of municipal solid waste.[8,14]
- Approximately 38% of C&D waste was recovered for processing and recycling in 2014. Most frequently recovered and recycled were concrete, asphalt, metals, and wood.[15]

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.[16]

Greenhouse Gas Emissions

- The combustion of fossil fuels to provide energy to commercial buildings emitted 765 million metric tons (Mt) of carbon dioxide (CO_2) in 2022, approximately 16% of all U.S. CO_2 emissions that year.[3]
- 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, will likely dominate new building life cycle emissions by 2050.[17]

Solutions and Sustainable Alternatives

Opportunities

- Before 2000, little attention was paid to energy use and environmental impact of buildings during design and construction. In 2013, an estimated 72% of buildings were more than 20 years old.[18] For typical commercial buildings, energy efficiency measures can reduce energy consumption by 20-30% with no significant design alterations.[19]
- 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 1020 to 139 MJ/m^2-yr, an 86% reduction in energy use intensity.[20]
- Energy Star's Portfolio Manager tracks energy and water consumption.[21] 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.[21]
- 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 more than 5 times the runoff than a woodland area of equal size.[22]

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 measuring building performance, assigning points for design attributes that reduce environmental burdens and promote healthy, sustainable buildings.[23] As of June 2023, the U.S. has 82,121 buildings that are LEED certified.[24]
- Passive House Institute US provides a climate-specific building standard to minimize energy use and emissions.[25] There are 4 principles of PHIUS buildings, mainly focused on insulation and airtightness.[26] As of June 2023, there are 384 certified PHIUS buildings.[27]
- 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.[28] As of 2022, there are 333 certified Living Buildings.[29]
- The U.S. EPA Energy Star buildings program recognizes and assists organizations that have committed to energy efficiency improvement.[30]
- 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 2023, 86 projects have SITES certification.[31]
- BREEAM certification measures sustainability across multiple categories that range from ecology to energy. As of June 2023, there are 170 projects that have achieved BREEAM Outstanding In-Use.[32]

Case Studies

Harvard University Science and Engineering Complex, AIA COTE Top Ten Award, 2023[36]

- 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.[33,34] 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. As operational efficiencies continue to decrease the impact of a building's use phase, greater attention will be needed to address embodied energy requirements in the resource extraction and construction phases.[35]
- 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.[36]
- 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 report energy and water through the EPA's Energy Star Portfolio Manager. The information is analyzed by the New York City government and is also available to the public.[37]

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