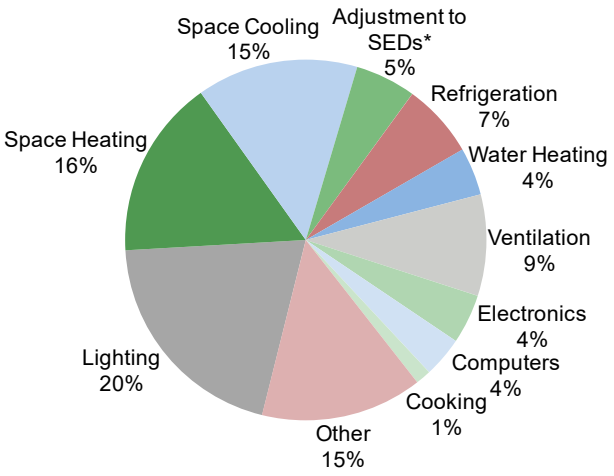
Commercial Buildings

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., 5.6 million commercial buildings contained 87 billion square feet of floor space in 2012—an increase of 46% in number of buildings and 71% in floor space since 1979.[1,2]
- By 2050, commercial building floor space is expected to reach 124.7 billion square feet, a 34% increase from 2019.[3]
- Education, mercantile, office, and warehouse/storage buildings make up 60% of total commercial floor space and 50% 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 2019.[4]
- In 2019, the commercial sector consumed 18.18 quadrillion 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]

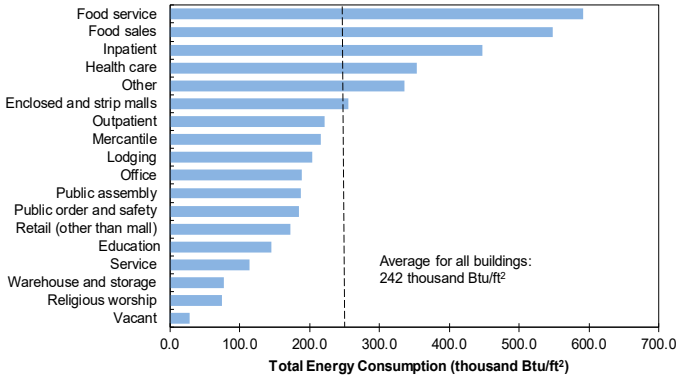
Material Use

- Typical buildings contain materials including concrete, metals, drywall, and asphalt.[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 the structural building material market share, 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 non-residential buildings in the U.S. consumed about 627 million board feet 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/restroom water is the largest end use in commercial buildings, except in restaurants where 52% of the water is used for dishwashing or kitchen use.[12]

Total Energy Consumption, U.S. Commercial Buildings, 2012[1]



Life Cycle Impacts

Construction and Demolition Waste

- In 2017, 569 million tons of construction and demolition (C&D) waste was generated.[13] This amounted to approximately 9.6 lbs per capita daily compared to the U.S. average of 4.5 lbs per capita per day of municipal solid waste.[13,14,15]
- Approximately 38% of C&D building 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 826 million metric tons of carbon dioxide (CO_2) in 2019, 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, those 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

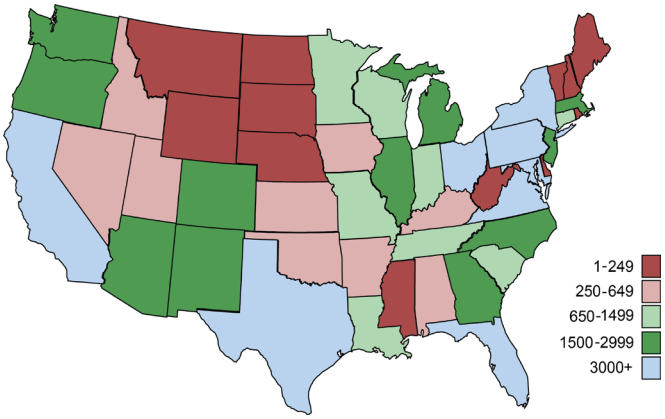
Opportunities

- 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/m²-yr, an 86% reduction in energy use intensity.[20]
- Energy Star's Portfolio Manager tracks energy and water consumption.[21] The tool includes over 300,000 commercial buildings, and could serve as a national database to benchmark building performance and provide transparency to building managers and tenants.[22]
- 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.[23]

Design Guidelines and Rating Systems

- The U.S. Green Buildings 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.[24]
- Passive House Institute US provides a climate-specific building standard to minimize energy use and emissions. There are 5 principles of passive building, mainly focused on insulation and airtightness.[25,26]
- The U.S. EPA Energy Star buildings program recognizes and assists organizations that have committed to energy efficiency improvement.[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]

LEED Registered Green Building Projects, New Construction[29]



95,382 total U.S. certified projects (commercial, residential, etc.) as of June 2020

Case Studies

- The Samuel Trask Dana Building, a 100-year-old structure located on UM's Ann Arbor campus, was renovated in 2004 to improve energy and environmental performance. Design features include photovoltaic electricity generation, natural lighting, radiant cooling, composting restrooms, and selective materials use and reuse. The renovation attained a LEED Gold rating.[30]
- The Center for Sustainable Landscapes (CSL) was recognized by the American Institute of Architects in its 2016 Commitment to the Environment Top Ten Projects,[31] and was the first building to meet the Living Building Challenge, LEED Platinum, SITES Platinum, WELL Building Platinum, and BREEAM Outstanding In-Use green certifications.[32]
- 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.[33]
- The Tashjian Bee and Pollinator Discovery Center in Chaska, MN was an AIA COTE 2019 Top Ten Award winner. This facility achieved a 51% reduction in operating costs, a 71% reduction in energy consumption, and uses native vegetation to support local and migratory wildlife.[34]
- 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.[35]

Tashjian Bee and Pollinator Discovery Center
AIA COTE Top Ten Award, 2019[34]

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