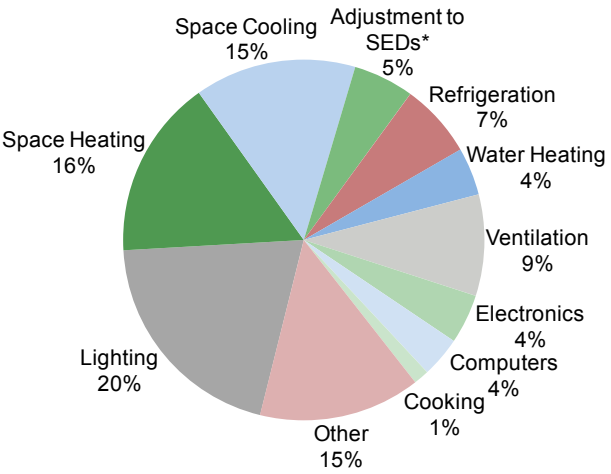
Commercial Buildings

Commercial buildings include, but are not limited to, stores, offices, schools, churches, 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 covered 87 billion square feet of floor space in 2012—an increase of 46% in number of buildings and 70% in floor space since 1979.[1,2]
- By 2040, commercial building floor space is expected to reach 109 billion square feet, a 32% increase over 2013 levels.[3]
- Education, mercantile, office, and warehouse/storage buildings comprise 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 19% of all energy in the U.S. in 2016.[4]
- In 2010, the commercial sector consumed 18.3 quadrillion Btu of primary energy, a 73% increase from 1980.[5]
- Lighting and indoor climate control consumed 51% of commercial sector primary energy in 2010.[5]
- Operating phase 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 concrete, metals, drywall, and asphalt. One demolished non-residential building was 82% concrete by weight.[8]
- 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.[9]

Water Consumption

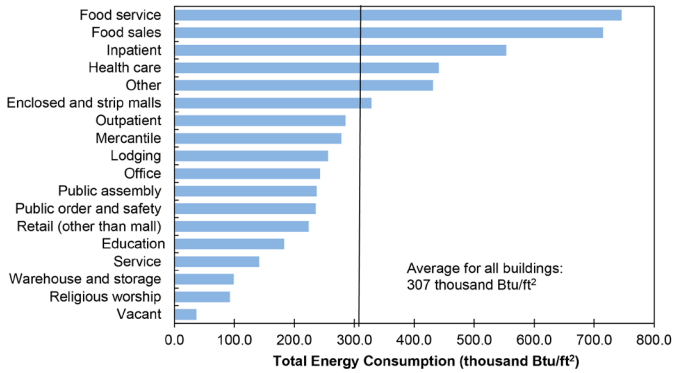
- In 2005, the commercial sector used an estimated 10.2 billion gallons of water per day, an increase of 23% from 1990 levels.[5]
- Domestic/restroom water is the largest end use in commercial buildings except in restaurants where 52% of the water is used for dishwashing or kitchen use.[10]

Life Cycle Impacts

Construction and Demolition Waste

- In 2003, the EPA estimated that construction, renovation, and demolition of non-residential U.S. buildings generated 103 million tons of waste.[12] This amounts to 1.94 lbs per capita per day, compared to the U.S. average of 4.72 lbs per capita per day of municipal solid waste.[12,13]
- Between 20% to 30% of non-residential building waste was recovered for processing and recycling in 1996. Most frequently recovered and recycled were concrete, asphalt, metals, and wood.[14]

Total Energy Consumption, U.S. Commercial Buildings, 2012[11]



Indoor Air Quality

- Volatile Organic Compounds (VOCs) are found in concentrations 2 to 5 times greater indoors than naturally occurs in the environment. Exposure to high concentrations of VOCs can result in eye, nose, and throat irritation; headaches, loss of coordination, and nausea; and extreme effects, such as cancer or nervous system damage. VOCs are emitted in commercial buildings through carpet adhesive, paints, solvents, aerosol sprays, cleansers, disinfectants, and dry-cleaned clothing.[15]

Greenhouse Gas Emissions

- The combustion of fossil fuels to provide energy to commercial buildings emitted 918 million metric tons of carbon dioxide (CO_2) in 2015, approximately 17% of all U.S. CO_2 emissions that year.[3]

Solutions and Sustainable Alternatives

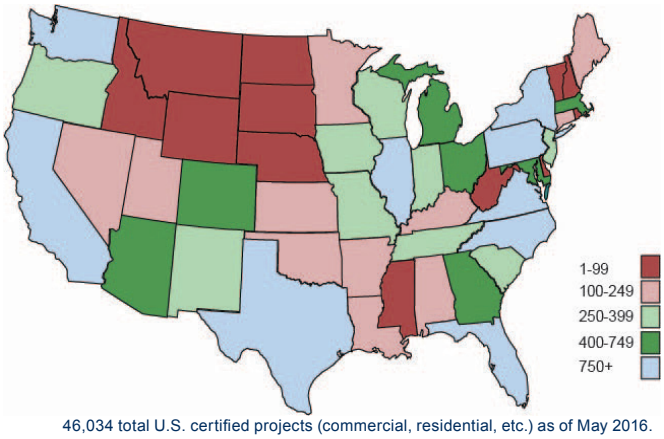
Opportunities

- An estimated 72% of current buildings are more than 20 years old and were built with little concern for energy savings.[16] For typical commercial buildings, current energy efficiency measures can reduce energy consumption by 20-30% with no significant design alterations.[17]
- 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 panels, average energy use intensity can be reduced from 1020 to 139 MJ/m^2-yr, an 86% reduction in energy use intensity.[18]
- Energy Star's Portfolio Manager tracks energy and water consumption.[19] The tool includes over 300,000 commercial buildings, and could serve as a national database to benchmark building performance and provide more transparency to building managers and tenants.[20]
- 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 more runoff than a woodland area of equal size.[21]

Design Guidelines and Rating Systems

- The U.S. Green Buildings Council developed the Leadership in Energy and Environmental Design (LEED) rating system. LEED is an evaluation metric for overall building performance, assigning points for design attributes that reduce environmental burdens and energy use.[22]
- The Better Buildings Alliance is an industry network focused on advancing commercial energy efficiency. Members that accept the Better Buildings Challenge commit to 20% energy savings over ten years.[23]
- The U.S. EPA Energy Star buildings program recognizes and assists organizations that have committed to energy efficiency improvement.[24]
- The Living Building Challenge, a building initiative by the International Living Future Institute, comprises seven performance areas, or 'petals': place, water, health and happiness, energy, materials, equity, and beauty.[25]

LEED Registered Green Building Projects, New Construction[26]



46,034 total U.S. certified projects (commercial, residential, etc.) as of May 2016.

Case Studies

- The Samuel Trask Dana Building, a 100-year-old structure located on University of Michigan'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.[27]
- The Center for Sustainable Landscapes (CSL), recognized by the American Institute of Architects (AIA) in their 2016 Commitment to the Environment Top Ten Projects,[28] was the first building to meet these four green certifications: Living Building Challenge v1.3, LEED Platinum, SITES certification for landscapes, and WELL Building Platinum.[29]
- Comparing the materials used in CSL to those of a conventional building reveals a 10% higher global warming potential and near equal embodied energy, due mainly to solar panels and inverters, concrete, steel, and gravel. Embodied energy savings come from 40% flyash replacement in cement and the use of recycled steel.[30]

The Edith Green - Wendell Wyatt Federal Building
AIA Top Ten Plus Green Project, 2016[31]

- The AIA awarded the Edith Green - Wendell Wyatt Federal Building in Portland, Oregon the 2016 Top Ten Plus winner. This 512,474 square foot building achieved a 55% reduction in energy consumption, a 65% reduction in water consumption, and improved occupant satisfaction.[31]
- The Energy Star buildings program sponsors a "Battle of the Buildings" each year. The 2015 team winner, Energy Service Company (ESCO) Project at Texas A&M University, reduced average energy usage by 35.5% in six buildings, which saved $548,900 and avoided 1,726 metric tons of greenhouse gas emissions. The top building winner was Woodville Chapel, which reduced energy usage by 89%.[32]

1. U.S. EIA (2015) "2012 Commercial Buildings Energy Consumption Survey."
2. U.S. EIA (1981) "1979 Nonresidential Buildings Energy Consumption Survey."
3. EIA (2016) Annual Energy Outlook 2016.
4. Energy Information Administration (EIA) (2016) Monthly Energy Review April 2016.
5. U.S. DOE, Energy Efficiency and Renewable Energy (EERE) (2012) 2011 Buildings Energy Data Book.
6. Ramesh, et al. (2010) Life cycle energy analysis of buildings: An overview. Energy and Buildings, 42(2010): 1592-1600.
7. Sheuer, C., et al. (2003) Life cycle energy and environmental performance of a new university building: modeling challenges and design implications. Energy and Buildings, 35: 1049-1064.
8. Cochran et al. (2007) Estimation of regional building-related C&D debris generationand composition: Case study for Florida, US. Waste Management, 27 (2007): 921–931
9. USDA Forest Service (2013) Wood and Other Materials Used to Construct Nonresidential Buildings in the United States, 2011.
10. U.S. EPA (2016) "WaterSense: Commerical-Types of Facilities."
11. US EIA (2016) 2012 Commercial Buildings Energy Consumption Survey.
12. U.S. Environmental Protection Agency (EPA) (2003) Estimating 2003 Building-Related Construction and Demolition Materials Amounts.
13. U.S. EPA (2015) Advancing Sustainable Materials Management Facts and Figures 2013.
14. U.S. EPA (1998) Characterization of Building-Related Construction and Demolition Debris in the United States.
15. U.S. EPA (2007) "An Introduction to Indoor Air Quality – Organic Gases (Volatile Organic Compounds - VOCs)."
16. The American Institute of Architects and Rocky Mountain Institute (2013). "Deep Energy Retrofits: An Emerging Opportunity."
17. Kneifel, J. (2010) Life-cycle carbon and cost analysis of energy efficiency measure in new commercial buildings. Energy and Buildings, 42(2010): 333-340.
18. Griffith, B., et al. (2007) Assessment of the technical potential for achieving net zero-energy buildings in the commercial sector. National Renewable Energy Laboratory.
19. Energy Star (2016) "Portfolio Manager."
20. Cox, M., et al. (2013) Energy benchmarking of commercial buildings: a low-cost pathway toward urban sustainability. Environmental Research Letters, 8(2013): 1-12.
21. U.S. EPA (2003) Protecting Water Quality from Urban Runoff.
22. U.S. Green Buildings Council (USGBC) (2013) "About LEED."
23. U.S. DOE (2017) "Better Buildings Alliance."
24. Energy Star (2013) "Buildings & Plants."
25. International Living Future Institute (2016) Living Building Challenge 3.0.
26. USGBC (2016) "Project Directory."
27. School of Natural Resources and Environment, University of Michigan (2003) The Greening of Dana.
28. American Institute of Architects (2017) COTE Top Ten Awards.
29. Phipps (2016) Center for Sustainable Landscapes.
30. Thiel et al. (2013) A Materials Life Cycle Assessment of a Net-Zero Energy Building. Energies 2013, 6, 1125-1141.
31. American Institute of Architects (2016) The Edith Green - Wendell Wyatt Federal Building.
32. U.S. EPA (2016) Battle of the Buildings: EPA's National Building Competition, 2015 Wrap Up Report.

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