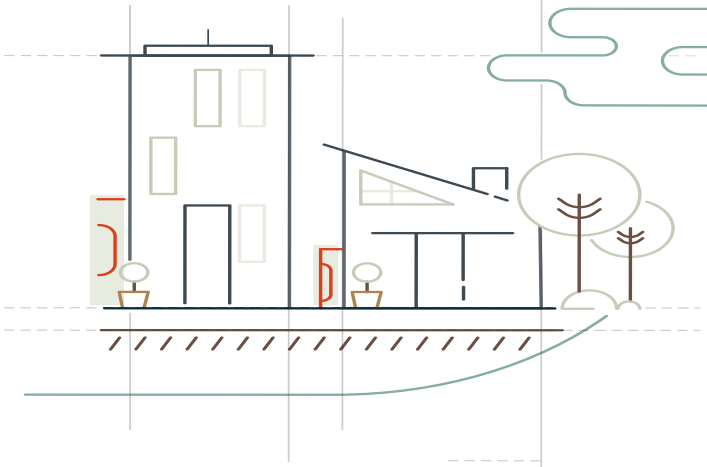
Home and Office



Buildings are a major source of global carbon emissions, **accounting for 28 percent** of global energy-related emissions in 2019 alone. Greener and healthier buildings rely on copper. These structures require smart-building design rooted in three key actions: decreasing energy demand, using efficient equipment and employing renewable energy.

Copper's **electrical and thermal conductivity** make it a secure, efficient and durable option for residential and commercial electrical installations. Copper's **128 uses in commercial building** construction help to achieve one-third of the 420+ credits, features and provisions recognized within LEED version 4, WELL version 1 and ASHRAE 189.1. Copper-enabled solutions play a central role in decarbonizing homes and offices to meet society's climate goals.

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DECARBONIZING HEATING

In the U.S., **43 percent of household energy** consumption comes from heating, most of which is powered by natural gas. In Europe, **31 percent of energy** consumed is used for space and water heating, and the vast majority of this heat is still generated from fossil fuels. In China, **20 percent of energy use** comes from buildings, largely powered by coal, 40 percent of which comes from space heating. Without deploying heat pumps running on renewable energy, it will be impossible to reduce carbon emissions to the level needed to keep global warming well below 2°C as put forward in the Paris Agreement.

- Switching from fossil-based heat to heat pumps not only reduces emissions but also improves the quality of indoor air by eliminating harmful particulate pollution. **Harvard research** has demonstrated that cleaner air inside buildings increases cognitive function and improves decision making. In Europe, approximately 50 percent of primary fine particulate matter emissions are related to heating, and over **400,000 premature deaths** every year are linked to air pollution. In China, this number is even higher with **11 percent** of deaths attributable to air pollution. Coal burning heating systems in China have **shortened lifespans by 5.5 years**. Electrification is an important strategy for improving air quality for cleaner air, increased productivity and a longer life.
- **Heat pumps** provide one market-ready solution for electrification. Climate-friendly and energy-efficient, heat pumps can produce four times the amount of heat energy consumed. Up to 21 kg/46 lbs of copper can be found in air source heat pump evaporators, condensers, compressors, piping, connection, control and sensor cabling.

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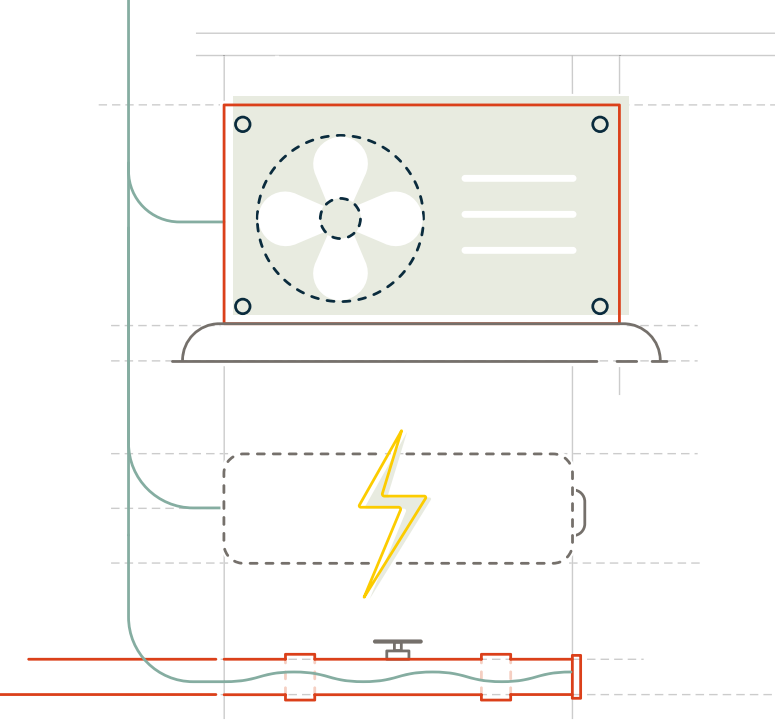

Decarbonizing Heating continued

- District heating also provides a solution that can potentially combine different sources of energy, such as excess heat from industry or solar thermal collectors. Deploying heat pumps on district heating can help provide a link to the renewable energy sector, contributing to demand flexibility due to the increased heat storage capacity.
- While most energy-efficiency efforts in homes currently focus on space heating, water heating is also important, comprising up to 45 percent of energy consumption in new buildings. Harvesting heat from shower drains in buildings is a simple and cost-effective way to save at least 40 percent of wasted energy and carbon emissions. Installing copper heat exchange pipes and heat exchange systems provide a practical solution to capture lost heat.
- Surface (underfloor, wall, ceiling) heating (and cooling) systems operate with low water temperatures and reduce heat demand and resulting cost for the consumer. Unifying surface temperatures that emit heat through radiation reduces the need for heat generation, allowing the overall air temperature in the room to be lowered by two to three degrees without sacrificing comfort. It is estimated that each 1°C reduction in temperature results in savings of around six percent in heating costs. By using heat pumps, the system becomes reversible in summer, i.e., it can be used for cooling and enables a reduction in temperature of two to three degrees. High-efficiency surface heating systems rely on copper tubes due to the metal's thermal conductivity.

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MAXIMIZING ON-SITE RENEWABLES WITH SMART BUILDING DESIGN

Incorporating renewable energy generation into building design is a key strategy for enabling building electrification and minimizing energy loss. Solar energy generation is often a practical option for residential and commercial buildings.

- Solar thermal systems collect solar radiation and use it to produce thermal energy by heating water or air, which can then be directly circulated throughout a building or stored for future use. These systems are long lasting, require little upkeep and maintain stable energy costs over a lifetime of 20 to 25 years. Copper is used in solar thermal collector and system piping, electrical and sensor cables, and pumping stations.

  According to a **2020 worldwide survey**, 99 percent of piping inside flat-plate collectors used in solar thermal systems is made of copper. Copper enables these systems to directly capture and transfer 70 percent of solar radiation for building use.
- Photovoltaic solar systems capture light and convert it to electricity. Panels can be placed in locations with high solar exposure, such as on rooftops. In Europe, deploying solar rooftop systems could save 680 TWh of electricity, the equivalent of 24.4 percent of current electricity consumption. Such systems contain 16 kg/35 lb of copper for a family home, which is found mostly in the cables.

SMART HOMES ENABLE SMART GRIDS

Digitalized energy-management systems can function as miniaturized smart grids, enabling buildings to intelligently direct energy use and reduce total consumption.

- Home automation systems optimize the use of energy in a building, preventing poor energy performance of the heating and cooling systems in individual buildings, as well as water conservation. Automation ensures continual energy performance monitoring, enables precise control and fault detection of heating and cooling systems and drives optimal user behavior.

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- Home automation systems are the missing links between near-zero energy buildings and the smart grid. They maximize the savings potential offered by smart meters, facilitate the use of renewable energy sources and provide buildings with load shifting and storage management capabilities.
- Load shifting is a critical component of energy-efficient buildings. At times of abundant electricity production from renewable sources, heat generated by a heat pump can be stored in the structure of the building or in a thermal energy storage tank. Heat can also be stored as hot water as a lower cost alternative to storing electricity. EV charging stations can also support load shifting through energy storage.

COPPER PROMOTES CONSERVATION

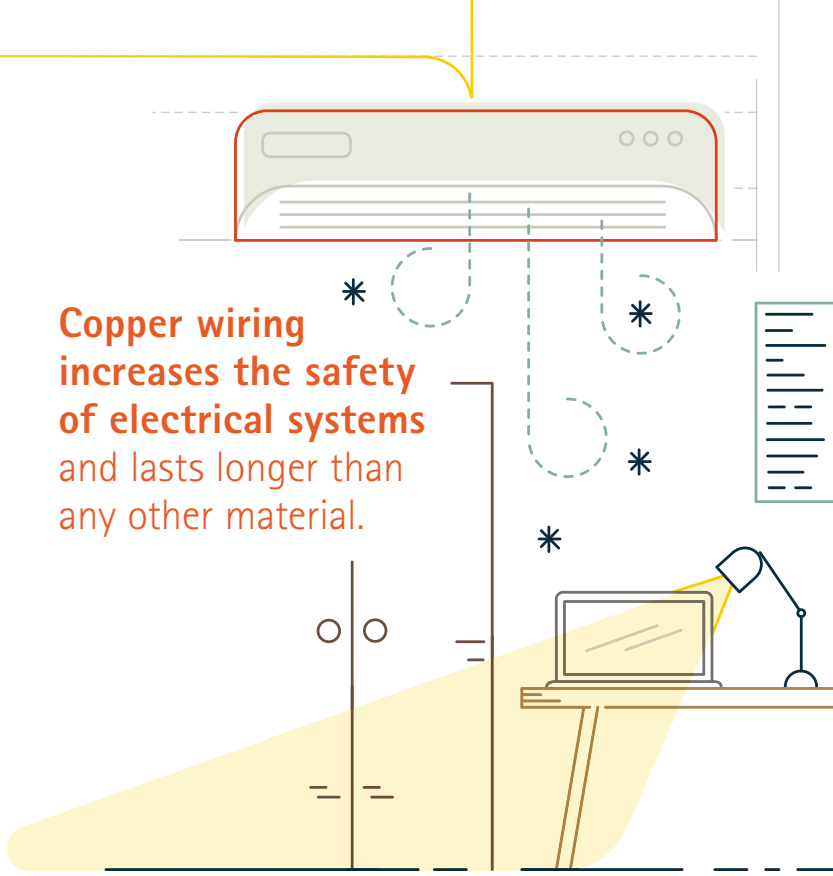
Smart design means maximizing resources, whether it be the broader conservation of natural resources or energy use in daily life.

- Forty percent of available clean water in developed countries goes toward industrial uses. Minimizing water loss means spending less money on water and wastewater treatment as well as on energy to heat, store and move water through buildings. Aging water infrastructure inevitably leads to rising costs in water and wastewater services when compared to more modern and efficient water systems. Nearly **80 percent of U.S. utilities choose copper** for water service lines because it is reliable, recyclable, resists corrosion and prevents contaminants from permeating tube walls, keeping treated water safe. Buildings made with copper pipes can **last up to 50 years**. In the U.S., cities like Flint, Michigan and Washington, D.C. are replacing outdated and unsafe lead water piping with copper.
- Standard appliances and motors used in homes and offices also need to maximize energy efficiency to enable smart design. Due to its electrical conductivity, copper enables energy efficiency, or for the same efficiency, more compact designs.

SAFE AND RELIABLE INFRASTRUCTURE

Copper enables smart and safe building development.

- An estimated **90 percent of homes globally** have unsafe electrical installations, and nearly 70 percent of building fires are caused by overheating electrical wires. Overloads, short circuits and faulty installations cause billions in property damage or losses each year. Copper wiring **increases the safety** of electrical systems and lasts longer than of any other material, making it the safest and most efficient option.



- Eighty percent of all deadly fires occur in homes, and according to the U.S. National Fire Protection Association, automatic fire sprinklers **increase the chance of surviving** a fire from 50 to 97 percent. Copper is not vulnerable to open flame, does not emit toxic fumes like plastic alternatives and can withstand heat up to 2,000°F/1093°C, securing copper as an ideal choice for fire sprinkler systems.
- Copper has **proven antimicrobial properties**. When used in the wet and humid environments of air conditioning units, **copper prevents mold, bacteria and fungi** from spreading through fans in homes and buildings.

SUSTAINABLE AND EFFICIENT MATERIALS

Sustainable materials in buildings are essential for circular and smart design. Copper is a truly circular material and can be recycled over and over without any loss to its physical properties. The average **120m² family house** contains 156 kg/343 lb of copper. After renovating for climate neutrality, the same house would contain an additional 88 kg/194 lb of copper distributed across various technological applications. Because recycling copper requires 85 percent less energy than primary production, its incorporation into products saves 40 million tonnes of carbon emissions globally, which is the equivalent of 100 million MWh of electricity or the emissions of 16 million cars.