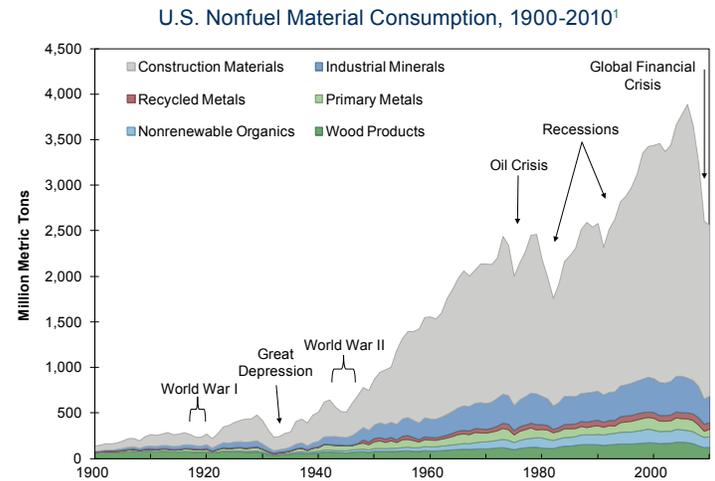




U.S. Material Use

Patterns of Use

Raw materials are extracted, converted to engineered and commodity materials, and manufactured into products. After use, they are disposed of or returned to the economy through reuse, remanufacturing, or recycling. Sustainability in materials use has three components: 1) the relationship between the rate of resource consumption and the overall stock of resources; 2) the efficiency of resource use in providing essential services; and 3) the proportion of resources leaking from the economy and impacting the environment. The first two topics reflect the sustainability of resource supply, while the third affects the sustainability of ecosystems. The United States is a primary user of natural resources, including fossil fuels and materials. The increased use of renewable materials (e.g., agriculture, wood products, primary paper) and nonrenewable materials (e.g., nonrenewable organic, primary metals, industrial minerals, and construction materials) during the 20th century is illustrated in the figure to the right.

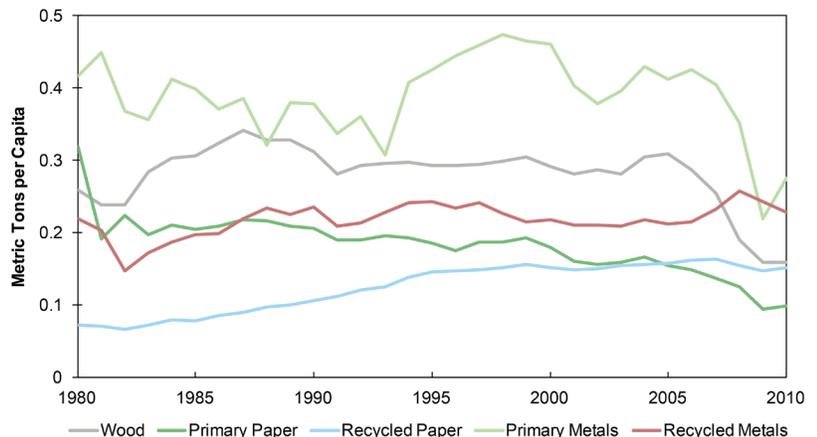


- U.S. raw material (non-fossil fuel or food) use rose 2.8 times more than the population from 1910 to 2010.^{1,2}
- Including fuels and other materials, total material consumption in the U.S. rose 57% from 1970 to 2000, reaching 6.5 billion metric tons.³
- In 2000, U.S. per capita total material consumption (including fuels) was 23.6 metric tons, 51% higher than the European average.³
- After increasing by 30% from 1996 to 2006, U.S. raw material use decreased 34% from 2006 to 2010 following the global financial crisis.¹
- Construction materials, including stone, gravel, and sand comprise around three-quarters of raw materials use.¹
- The use of renewable materials decreased dramatically over the last century—from 41% to 5% of total materials by weight—as the U.S. economy shifted from agriculture to industrial production.⁴
- The ratio of global reserve to production rate is an indicator of the adequacy of mineral supplies; it can range from over a millennium (aluminum), to a few centuries (lithium, platinum, phosphate rock), to several decades (chromium, indium, cadmium).⁵
- Several rare earth elements (REEs) and other minerals critical to producing solar panels, wind turbines, and electric vehicles could face supply shortages in the next five to ten years.⁶
- China controlled 85% of REE production in 2015. No readily available substitutes exist for most REEs.⁵

Intensity of Raw Material Use

- Material intensity of use refers to the amount of materials consumed per unit of economic output, generally measured by the total gross domestic product (GDP) of a country.⁷
- 44% of materials consumed in the U.S. economy are added to the long-term (+30 years) domestic stock, 2% remain in the stock between 2-30 years, 39% remain in the stock less than 2 years, and the remaining 15% are recycled back into the economy.³
- Of the materials remaining in the domestic stock less than 30 years, 73% are released into the atmosphere (mostly through fossil fuel combustion), 18% are disposed of in controlled areas (e.g., landfills, tailings ponds), and the remaining 9% are dispersed directly into the environment on land, in water, or through multiple paths.³
- There is an appreciable decline in the intensity of use of primary metals, except aluminum, while the use of plastics continues to grow.⁸
- Trends in the composition of materials used in the U.S. economy have changed from dense to less dense, i.e., from iron and steel to lighter metals, plastics, and composites.⁹
- The domestic processed output, or total weight of materials and emissions disposed of in the domestic economy, declined per unit of GDP by about 44% in the U.S. over the last few decades, similar to other industrialized nations.³

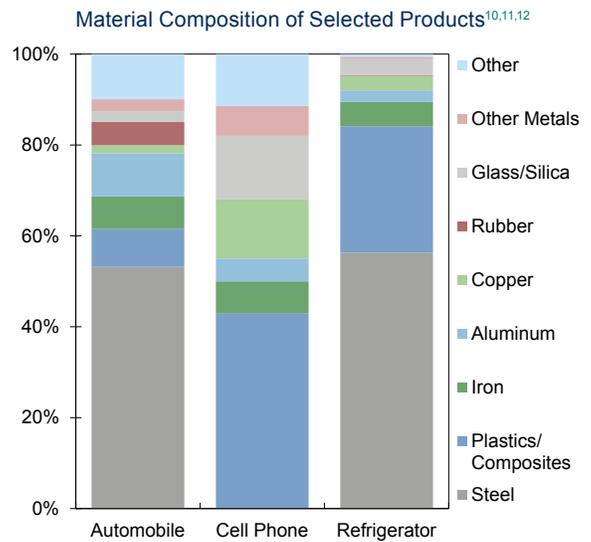
Intensity of Use of Selected Materials in the U.S., 1980-2010^{1,2}



Environmental Impacts

Raw material extraction and use can create significant environmental impacts.

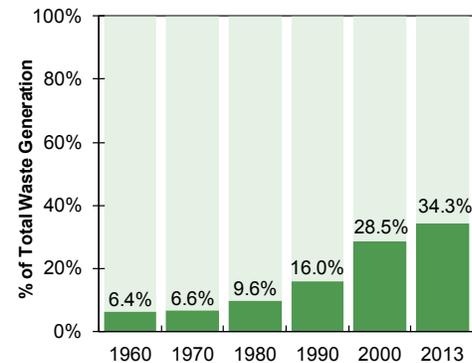
- Mines, including coal but excluding oil and natural gas, occupy 0.26% of the land area in the U.S., of which 60% is used for excavation and the rest for disposal of overburden and other mining wastes.¹³
- As higher grade reserves are depleted, the quality of metal is degrading, leading to greater energy needed to extract and process ore, and thus greater releases of gases that contribute to climate change and acid precipitation.¹⁴
- The primary metals and metal mining sectors accounted for nearly 55% of the total 3.9 billion pounds of toxic releases in 2014.¹⁵
- In 2011, more than 34 million metric tons of Resource Conservation and Recovery Act (RCRA) regulated hazardous waste were generated in the U.S. The largest sources were chemical manufacturing (56%) and petroleum and coal products manufacturing (20%).¹⁶
- In 2010, primary metal industries used 1.6 Quadrillion Btu (quads) of energy; nonmetallic mineral (stone, clay, glass, cement) manufacturing used 0.7 quads; chemical manufacturing used 5.0 quads; and petroleum and coal products used 6.7 quads (total U.S. consumption was ~97 quads).^{17,18}
- Energy-related carbon dioxide emissions from the industrial sector have fallen 15.5% since 1990, mainly due to a structural shift away from energy-intensive manufacturing in the U.S. economy.¹⁸
- Human health risks arise from emissions and residues over a material's life cycle. In many cases, pollutant releases have been substantially reduced from historical levels, e.g., mercury released by gold mining, fugitive volatile organic compound emissions from paints, and lead from the combustion of gasoline.¹⁹ However, in 2014, more than 370,000 tons of lead and lead compounds were released; 92% came from metal mining, while primary metal production and electric utilities accounted for 3.6% and <1%, respectively.¹⁵ New chemicals have been introduced that have been found to persist in the environment, bioaccumulate (move up the food chain), and/or are toxic, e.g., phthalates that are widely used in consumer products to make plastics soft and flexible.¹⁹



Solutions and Sustainable Actions

- **Conserve materials:** Follow the motto of “Reduce, Reuse, Remanufacture, and Recycle.” U.S. recycling and remanufacturing industries accounted for over 1.1 million jobs and more than \$236 billion in revenue in 2011.²¹ In 2013, 34.3% of municipal solid waste in the U.S. was recovered for recycling and composting, diverting more than 87 million tons of material from landfills and incinerators.²⁰
- **Change the material composition of products:** Create products using materials that are less toxic, easily recyclable, and less energy intensive during production and manufacturing. There are over 101 million commercially available chemical compounds.²²
- **Reduce material intensity:** Technological advances can help reduce the raw material intensity of products while making them lighter and more durable. Aluminum beverage cans are 36% lighter today than they were three decades ago, allowing more cans to be produced from the same amount of aluminum. Additionally, beverage cans are made with an average of 68% recycled aluminum, representing a huge decrease in energy requirements and greenhouse gas emissions compared to using virgin materials.²³
- **Promote product stewardship:** Appropriate policy and regulatory frameworks can help ensure product manufacturers' responsibility for the environmentally conscious management of retired consumer goods. The European Union's regulations on waste electrical and electronic equipment (WEEE) include a target of an 85% increase in proper WEEE collection and disposal by 2019.²⁴
- **Encourage renewable material use:** Increase the use of renewable materials within products and in packaging. Biobased materials such as polylactic acid (PLA), a biodegradable polymer derived from corn, can provide performance characteristics similar to petroleum-based plastics. Although manufacturing these renewable materials requires less energy and emits fewer greenhouse gases, the use of land and chemicals required to grow the feedstock may have adverse environmental consequences.²⁵

U.S. Recovery of Municipal Solid Waste, 1960-2013²⁰



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