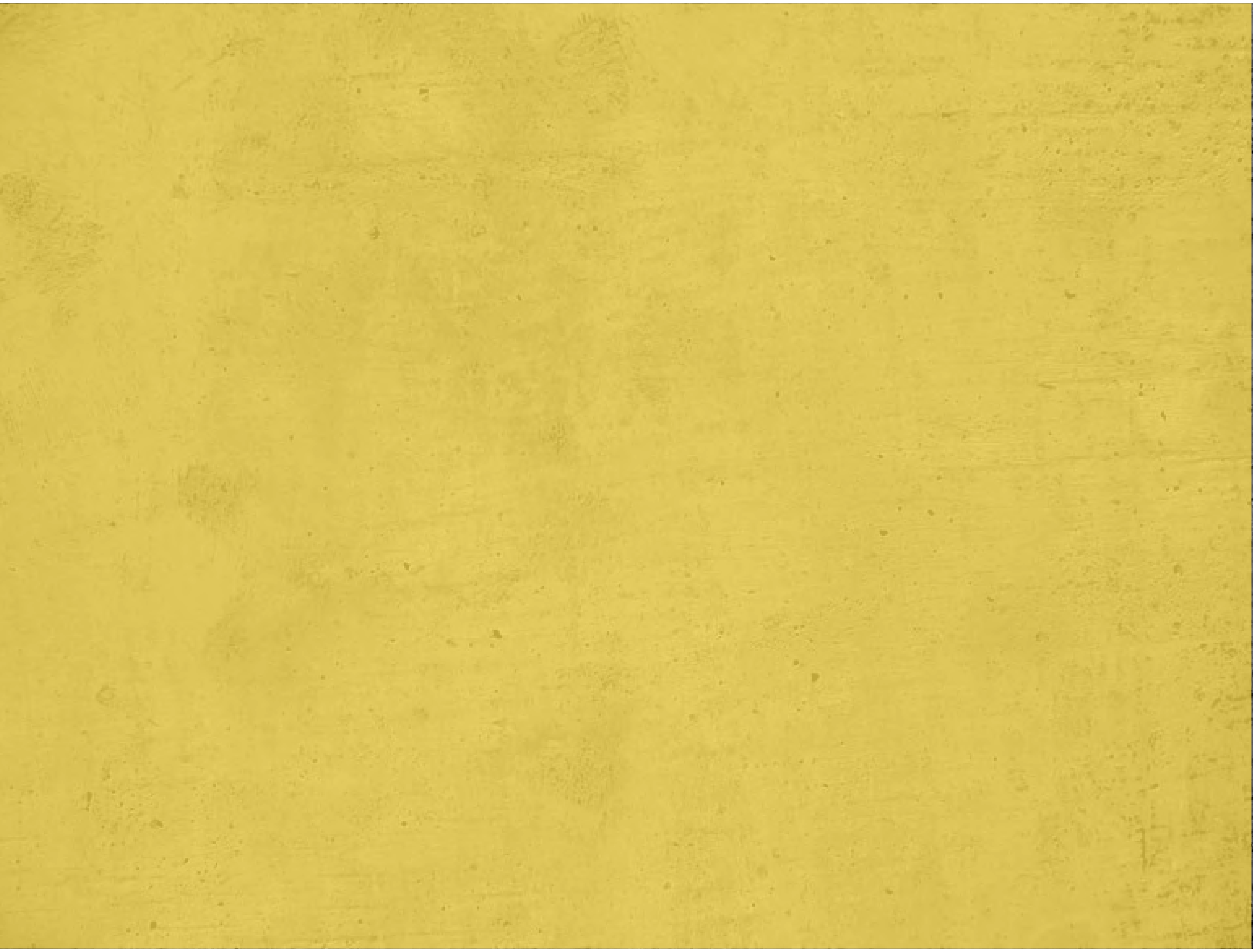
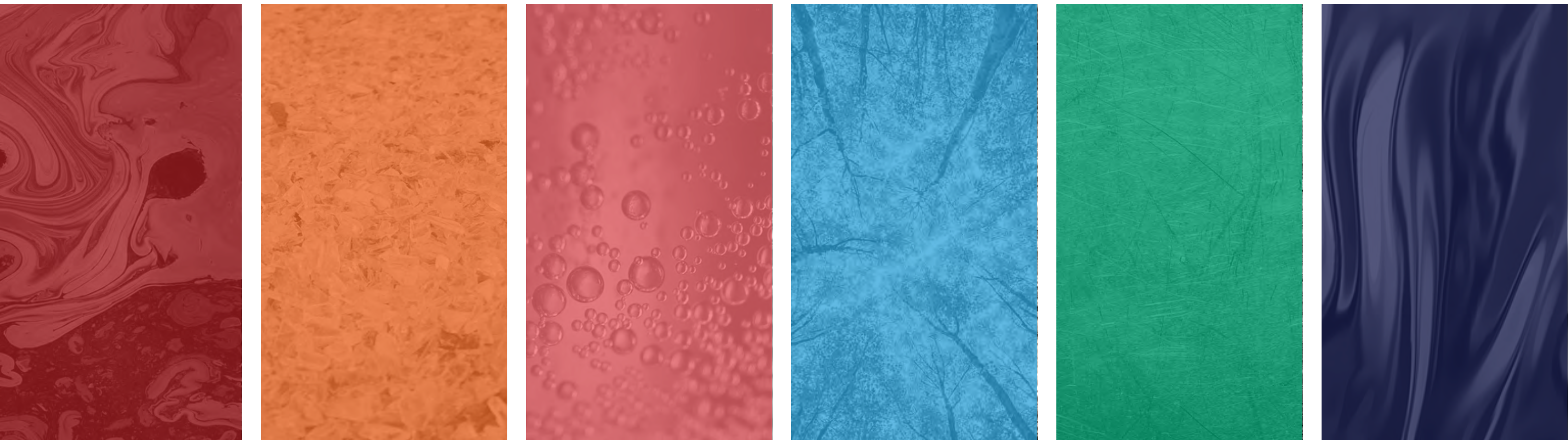
Cement





3.4 Cement

In 2020, the United States produced about 89 million metric tons of cement at 96 plants in 34 states and two plants in Puerto Rico. Texas, Missouri, California, and Florida (in descending order) account for nearly 45 percent of all U.S. cement production. The total value of cement produced in the United States is $12.7 billion and the industry employs 12,500 workers across 34 cement producing states. The majority (70–75 percent) of cement that is produced is used by ready-mix concrete producers, 10 percent by concrete product manufacturers, and the remainder is used by contractors and other customers. The United States is the fourth-largest producer of cement worldwide after China, India, and Vietnam.[346, 347]

Cement manufacturing is energy intensive and a major source of GHG emissions. In 2018, cement manufacturing comprised roughly 8 percent of the manufacturing sector's direct (onsite) emissions.[348] The cement sector emits around 66 MMT CO_2e/year (including emissions from offsite generation), with process emissions and process heating accounting for the most direct emissions (***Figure 19***).[349] Lifecycle assessment of the cement manufacturing process indicates that GHG emissions impacts are primarily driven by energy use (electricity and thermal fuels) during the pyro-processing of limestone to produce clinker (40 percent) and the calcination process itself which releases carbon dioxide (60 percent). The amount of clinker present in cement therefore defines the emissions profile of the final cement product. The greater the clinker content, the higher the emissions. After clinker, the second largest contributor to emissions is raw material extraction followed by raw material transportation.[350]

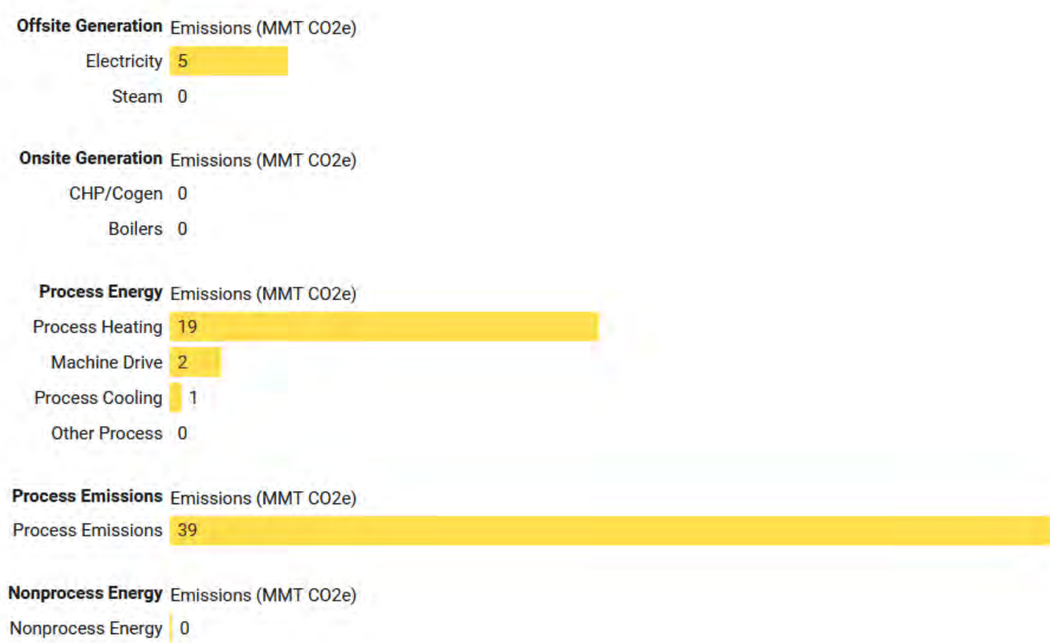
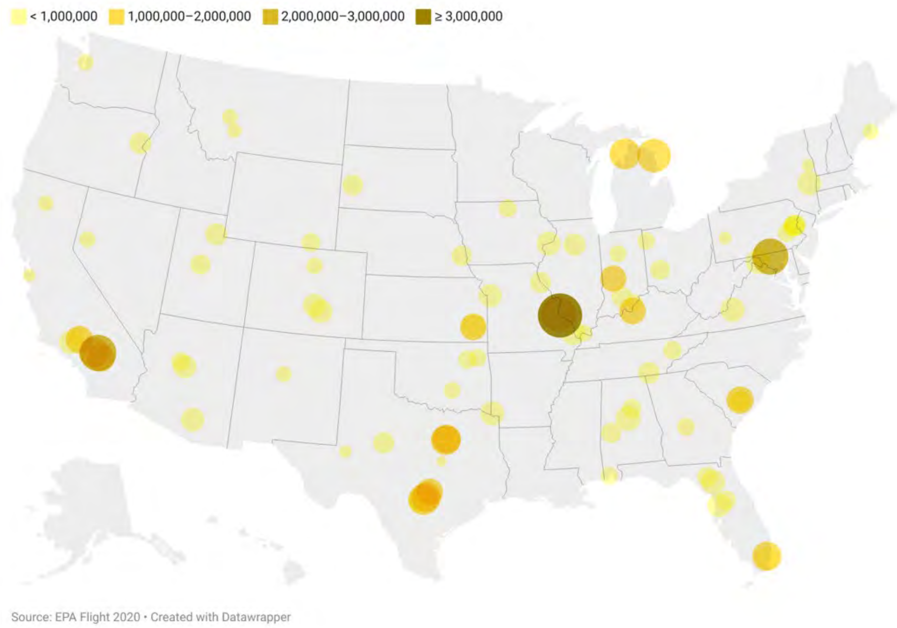


Figure 19: Cement sector sources of GHG emissions in 2018, by major end use. Source: U.S. DOE, Manufacturing Energy and Carbon Footprint: Cement Sector.

Figure 20 shows the distribution of cement facilities across the United States.[351]



State	Total GHG Emissions	Facilities
TX	9,198,706	11
CA	7,542,301	9
MO	7,247,143	5
FL	4,684,844	7
MI	3,185,504	2
PA	2,898,599	8
MD	2,506,244	2
AL	2,397,871	4
IN	2,388,556	4
SC	2,200,545	3

Figure 20: Location and total reported emissions (metric tons CO_2e) of cement manufacturing plants in the United States (left). Top 10 states by total GHG emissions from cement facilities (right table). Size and darkness of bubbles scale with level of emissions. Source: U.S. EPA, FLIGHT.

The majority (about 90 percent) of cement produced in the United States is Portland cement, with the remaining 10 percent distributed between masonry cement, blended-hydraulic cement, and Portland-limestone cement in decreasing order of quantities. As of 2019, most clinker (80–90 percent) in the United States is produced using a dry process with preheater and precalciner technology, which represents the most efficient technology currently available and in use. Because Portland cement represents the bulk of cement production in the United States, the remainder of this section provides energy and emissions data for this type only.

Maintaining the high combustion temperature in a cement kiln (1,100–1,500°C) to form clinker requires a primary fuel source with a high-energy output, like coal or petroleum coke coal (9,000–12,000 Btu/lb). This comes at a cost. A large volume of coal is required to maintain the high temperatures in the kiln, which comes with high transportation costs (typically train, truck, or barge, all of which rely on diesel and release their own carbon emissions). As a result, the industry has been supplementing coal with waste heat and burning of hazardous waste (e.g., waste oils, spent organic solvents, sludges from the paint and coatings industry, waste paints and coatings from auto and truck assembly plants, and sludges from the petroleum refining industry) with a similar energy output profile to offset the amount of coal/coke burned in the kiln.[352, 353] The cement manufacturing process also uses electricity to run crushing and grinding operations. ***Figure 21*** shows a breakdown of the cement sector's uses of energy sources.[354]

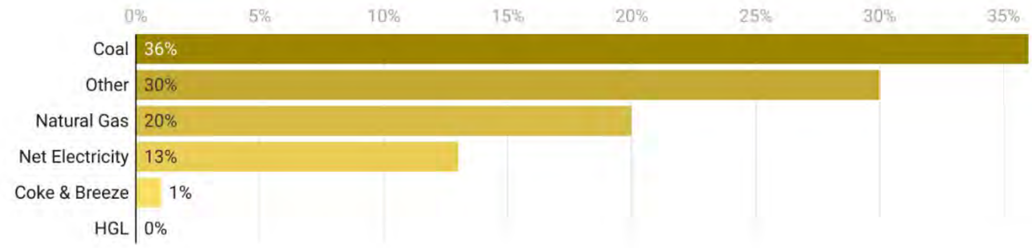


Figure 21: Cement sector fuel and non-fuel uses of energy in 2018 (as a percentage of total trillion Btu). Source: U.S. EIA, MECS 2018, Table 1.2.

In 2019, the U.S. EPA estimated the carbon intensity of U.S. cement plants ranged from 0.787 to 0.934 metric ton of carbon dioxide per metric ton of clinker produced, with 25 percent of plants at the high end of the range and 25 percent of the plants at the low end of the range. The median carbon intensity was 0.838 metric tons of carbon dioxide per ton of clinker produced. When considering the carbon intensity per metric ton of cement produced from clinker, the range was 0.886 to 0.722 metric ton of carbon dioxide.[355] The slight reduction in carbon intensity factor may be attributed to energy and material efficiency strategies applied in the production of cement from clinker.[356] However, according to the International Energy Agency (IEA), the direct carbon dioxide intensity of cement production increased 1.8 percent each year during the period 2015–2020 globally. The IEA recommends that to meet net-zero emissions goals by 2050, a 3 percent annual decline in carbon intensity is necessary, which may be achieved through a particular focus on reducing the clinker-to-cement ratio (by promoting greater uptake of blended cements) and deploying carbon capture technologies (CCUS). Thus, funding research, development, and demonstration efforts and adopting carbon dioxide emissions reduction policies offer two key policy approaches to achieve these goals.[357]

Several large cement companies have established sustainability targets or made significant efforts in improving their operations. Cement companies have announced new product lines, renewable energy use plans, decarbonization research initiatives, and other innovations aligned with the industry's overall commitment to sustainability. Many cement plants have also installed emissions reduction equipment to comply with the 2010 *National Emissions Standards for Hazardous Air Pollutants* (NESHAP). This has led to the shutting down, idling, or reducing use of some cement kilns (for compliance reasons) and associated reductions in cement production.[358]

Lafarge Holcim, the largest cement manufacturer in both the United States and the world, has established net-zero goals validated by the Science-Based Targets initiative (SBTi), such as:

- Until 2030, accelerating carbon dioxide intensity reductions to exceed 20 percent (compared to 2018 baseline)
- After 2030 establishing the first climate targets with SBTi for a 1.5°C future in the cement sector
- By 2050, committed to long-term targets for full scope of emissions
- Reduce scope 3 emissions by 90 percent compared to 2020 or 90 percent of total absolute emissions (as per SBTi net-zero requirements).[359]

Other large producers such as CEMEX[360] and Heidelberg Cement[361] have also issued sustainability targets.

Table 11: Decarbonization barriers and policy opportunities in the cement industry.

Challenge / Barrier	State Opportunities	Policy Connections
Energy efficiency	• Establish efficiency goals to decrease energy use while improving flexibility and resilience	• Support fuel efficiency standards • Support energy managers at small/medium cement/concrete plants • Encourage efficiency networks to leverage common efforts within/across industries (e.g., waste reduction/reuse) • Recognition/credit for industry reduction
Transition to low-carbon feedstocks and energy sources	• Promote coal and coke switch with other high-energy, lower-carbon sources like biomass and waste-derived fuels • Promote circular economy with other industries that can provide low-carbon fuel feedstock • Promote alternative fuels and other technologies	• Support air regulations to allow transition from heavy hydrocarbons to biomass and waste-derived fuels • Promote infrastructure and regulation to divert non-recyclable, solid, and hazardous waste streams from landfills to kilns for incineration where they reduce net energy and GHGs • Promote funding/investing in industrial hub zones and clusters to spur low-carbon technology adoption
Electrification: near-, mid-, longer-term time horizons	• Promote adoption of electric technologies in conjunction with greening of the grid.	• Support infrastructure to bring low-carbon electricity to industry • Incentivize renewables (i.e., solar, wind) in onsite generation, microgrid development, and main grid generation/storage • Promote reduction/elimination of grid interconnection fees for low-carbon energy and expand net energy metering rules • Use Tax exemptions for electricity use in industrial processes to spur adoption
Material efficiency	• Develop and expand markets and infrastructure for end-of-life reuse and recycling of concrete construction and demolition debris	• Support use of blended cements and cement mixes with alternative materials/additives/supplementary cementitious materials (SCM) • Reduce or eliminate minimum-clinker requirements in government procurement requests • Promote circular economy policies
Define current level of embodied carbon and developing new processes for products	• Promote low-embodied-carbon cement materials for state sponsored projects • Promote low-carbon alternative cements and concrete • When new or major plant upgrades proposed, tie incentives	• Engage on initiatives to preferentially purchase low-embodied-carbon products • Promote and adopt local green building codes and performance-based standards for building materials • Incentives for deployment of low-carbon process technologies

Challenge / Barrier	State Opportunities	Policy Connections
	to lower-embodied-carbon cement production	• Streamline regulation, siting, and permitting to modernize facilities • Support leakage protections for domestic manufacturers against less-regulated imports (border states)
Capture major direct emissions from plants and reduction in carbon dioxide	• Coordinate/integrate CCUS deployment with cement industry plants (co-location, industrial hubs) • Facilitate carbon sinks in public infrastructure	• Fund/invest in CCUS infrastructure and interconnections between industries for mitigation, transport, storage (including multi-state/regional initiatives) • Stipulate a reduction plan for facilities in future air permits • Consider market-based carbon price (e.g., cap-and-trade mechanisms) • Promote use of concrete in infrastructure (e.g., roadways) to enlarge carbon sink capacity • Support/incentivize development of cost-competitive, commercial-scale solutions to trap carbon
Workforce development	• Develop / expand capabilities of a diverse future workforce	• Initiate training programs, onsite internships, re-skilling (e.g., energy managers) for decarbonization in partnership with industry

Roadmaps for the Cement and Concrete Industry

- Portland Cement Association: Roadmap to Carbon Neutrality by 2050 (2021)
- CEMBREAU Cement Roadmap to 2050 (Webpage, Full Report)
- International Energy Agency (IEA) Cement Roadmap (2009 Report, 2021 Report)
- Japan Technology Decarbonization Roadmap and Transition Finance for Cement Industry (2022)
- Global Cement and Concrete Association 2050 Roadmap for Net Zero Concrete (2021 Report, Webpage)
- World Business Council for Sustainable Development - Cement Roadmap (2018)

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