

# Concrete and Cement

## Industry Description

Concrete is a ubiquitous and essential building material for much of modern infrastructure in the buildings, transportation, and industrial sectors. Although low-carbon substitutes for concrete exist in some applications (for example, wood for residential and other smaller types of buildings), concrete, in some form, will continue to be an essential building material even in a deeply decarbonized world.

Cement, the main binding agent in concrete, is typically produced from a feedstock of limestone, clay, and sand. Cement production requires large amounts of both thermal energy and electricity, which are typically produced from carbon-emitting fossil fuels. In addition to fossil fuel emissions, around two-thirds of CO<sub>2</sub> emissions from global cement production come from the calcination of limestone used as a raw material.<sup>1</sup> These emissions are inherent to the chemistry of current production processes, making full decarbonization of cement production technically challenging.

The concrete and cement industry's large carbon footprint, its importance to modern society, and the technical challenges involved in its decarbonization make it a poster child for "hard to abate" industries.<sup>2</sup>

## Greenhouse Gas Footprint

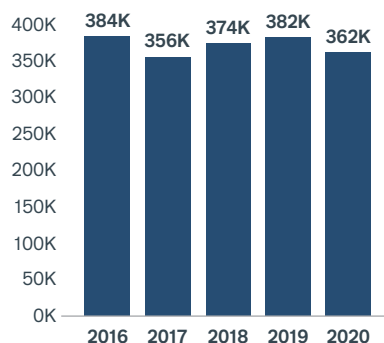
Globally, the production of cement contributes to around 7% of anthropogenic greenhouse gas emissions.<sup>3</sup> U.S. cement production stands out for having, on average, the highest carbon intensity in the world.<sup>4</sup> This is partly due to the high ratio of clinker used at U.S. cement plants (around 90%<sup>5</sup> of cement by mass, compared to 65%<sup>6</sup> globally). Clinker is the product of limestone calcination and is the material that gives cement its binding properties.

There are two concrete and cement facilities in Washington with over 10,000 metric tons in annual carbon dioxide equivalent (CO<sub>2</sub>e) emissions.<sup>7</sup> The state's one cement kiln is operated by the Ash Grove Cement Company in Seattle.<sup>8</sup> The other facility manufactures concrete products and is operated by

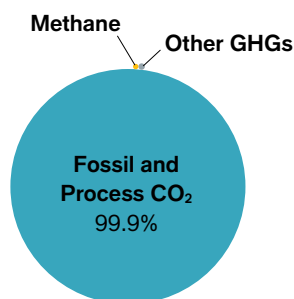
**Figure 1. Washington concrete and cement manufacturing direct reported emissions, 2016–2020**

### Annual Emissions

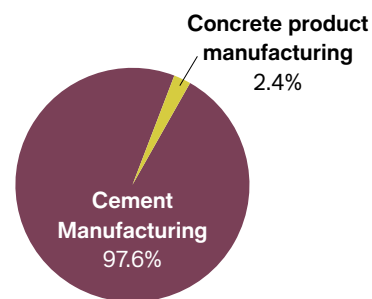
Metric Tons CO<sub>2</sub>e



### Emissions by Greenhouse Gas



### Emissions by Subsector



**Data Source:** Washington State Department of Ecology. "Facility Greenhouse Gas Reports." Accessed April 11, 2022. <https://ecology.wa.gov/Air-Climate/Climate-change/Tracking-greenhouse-gases/Greenhouse-gas-reporting/Facility-greenhouse-gas-reports>; NAICS codes for reporting facilities: 327310 (Cement manufacturing); 327390 (Other concrete product manufacturing)

**Note:** This figure shows direct reported emissions from facilities with over 10,000 metric tons CO<sub>2</sub>e in annual emissions. Direct reported emissions do not include electricity use.

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James Hardie Building Products in Tacoma. Producing cement is much more energy-intensive than manufacturing concrete products and contributes to nearly 98% of the industry's emissions in Washington, as seen in Figure 1.

The carbon intensity of the Ash Grove plant in Seattle is considerably lower than the U.S. average – around 500 kg CO<sub>2</sub>e/tonne of cement, compared to 800 kg CO<sub>2</sub>e/tonne nationally.<sup>9</sup> This is likely because its fuel mix between 2017 and 2019 consisted of a combination of natural gas and used tire combustion.<sup>10</sup> Prior to 2017, Ash Grove relied to varying extents on coal, like many other U.S. cement producers.<sup>11</sup> The Ash Grove plant is also energy efficient; it has been consistently recognized as an ENERGY STAR certified facility by the U.S. Environmental Protection Agency.<sup>12</sup>

### Industrial Process and Decarbonization

The production of cement involves four sequential production processes.<sup>13</sup> First, the raw materials (limestone, clay, sand, or other materials) are quarried. Second, the raw materials are crushed and ground into a mixture, either as a dry process, in which the product is a fine dry powder, or in a wet process, where the crushed material is mixed into a slurry prior to grinding. The Ash Grove plant in Seattle uses a dry process.<sup>14</sup>

Displacing clinker with other supplementary cementitious materials (SCMs) can lower the overall carbon intensity of cement.

Third, the fine powder or slurry is heated in a kiln, which first transforms the ground limestone (CaCO<sub>3</sub>) into lime (CaO) and releases CO<sub>2</sub> in a process called calcination, and then into solid pellets called clinker. In Washington, Ash Grove operates a rotary kiln, which in conjunction with using a dry preparation process, is relatively energy efficient compared to older technologies involving “vertical shaft” kilns and/or a wet process. Improved thermal and electrical energy efficiency measures at cement plants offer some of the most cost-effective near term greenhouse gas emissions abatement opportunities.

Lastly, clinker is mixed and ground in mills with other ingredients to produce cement. Standard “Portland cement” consists of about 90-95% clinker, with only about 5-10% gypsum and/or

Carbon capture, utilization, and storage (CCUS) will likely contribute to significant emission reductions in the cement and concrete sector.

fine limestone added.<sup>15</sup> Blending Portland cement with other supplementary cementitious materials (SCMs) can significantly lower overall carbon intensity by displacing clinker. Unlike in other parts of the world, however, most blending in the United States occurs at concrete mixing plants rather than at cement plants. This highlights the importance of working with the concrete industry in Washington on any decarbonization strategy.

Other blended cements can be made by mixing in other materials with cementitious properties, especially byproducts from other industries, such as fly ash from coal power plants or blast-furnace slags.<sup>16</sup> Aside from energy efficiency measures, increased blending of cement with SCMs is easily the most cost-effective and immediate way to reduce the carbon intensity of concrete and cement production.

Although efficiency and use of low-carbon cement blends could significantly lower emissions, large thermal energy demands for making cement are unavoidable since cement kilns must typically heat raw materials to over 2,500°F. Achieving these temperatures is (currently) not practical using electrical energy sources, so fully decarbonizing cement production will likely require alternative fuels or technologies to replace the use of fossil fuels.

Additionally, even if thermal energy were fully decarbonized, cement production would still have a substantial carbon footprint due to process emissions from calcination. Therefore, unless radically new cement chemistries are developed and deployed, a core measure in any deep decarbonization strategy will be to capture CO<sub>2</sub> produced during cement production. Most studies suggest that carbon capture, utilization, and storage (CCUS) will contribute a majority of expected emission reductions in the concrete and cement sector.<sup>17</sup>

Additional decarbonization strategies include targeting emission reductions in transportation of concrete and cement, which could reduce up to 7% of the industry's total carbon footprint,<sup>18</sup> and enhancing the carbon-absorbing properties of concrete.

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Downstream cement “demand management” strategies like improving material efficiency in buildings and infrastructure, recycling concrete and cement, and substituting materials like wood for concrete in building construction, could have a significant impact on the industry’s greenhouse gas emissions. There is significant potential for emissions reductions from material efficiency alone. In a study on commercial and multifamily residential buildings in Europe and the United States, researchers found that there was typically twice as much structural material (primarily concrete) compared to what would be needed to comply with building codes. Because cement is so inexpensive, there is not a huge incentive for building projects to use less.<sup>19</sup>

## Workforce

The concrete and cement manufacturing industry directly supports over 4,000 workers in Washington, the vast majority of whom are employed in concrete and concrete product manufacturing. The Teamsters Union represents a portion of Washington concrete and cement workers.<sup>20</sup>

Washington’s two reporting concrete and cement facilities are in Seattle (Ash Grove Cement) and Tacoma (James Hardie Building Products). Additional employment data in the concrete and cement industry are at smaller facilities for ready-mix

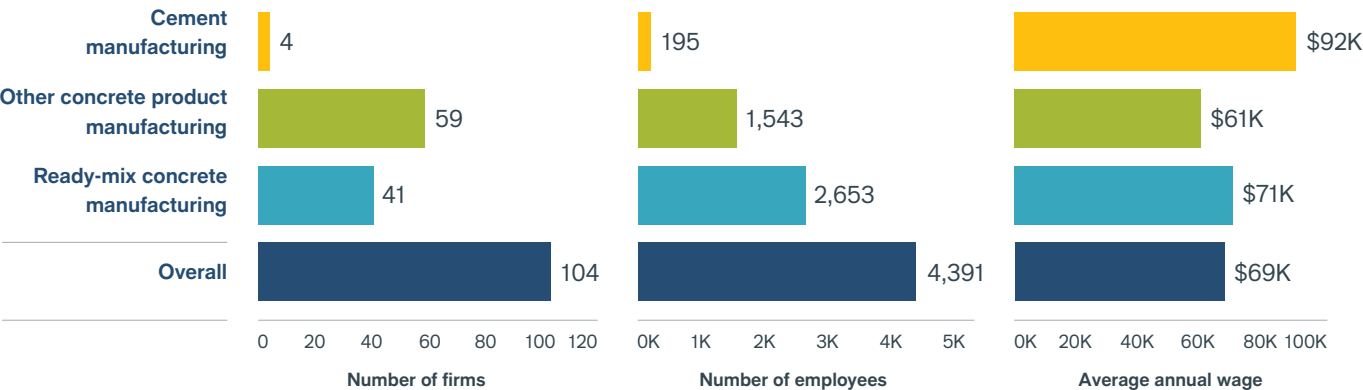
concrete manufacturing, concrete block and brick manufacturing, and concrete pipe manufacturing, which are not required to report emissions if they emit less than 10,000 metric tons of CO<sub>2</sub>e annually.

In contrast to many other manufacturing industries, U.S. concrete and cement manufacturing is not a highly trade exposed industry due to high long-distance shipping costs. Interstate trade remains a factor, however, especially in states that do not have a cement plant.<sup>21</sup>

Decarbonizing process-based emissions will likely require innovative technologies, which in turn could require workers to develop new skills. Additionally, as procurement policies such as Buy Clean<sup>22</sup> drive demand for low-carbon materials, opportunities arise for local manufacturers to create new products and new jobs to meet that demand.<sup>23</sup>

In the North American Industry Classification System (NAICS), the concrete and cement manufacturing industry falls under the Nonmetallic Mineral Product Manufacturing subsector, which also includes glass manufacturing and other industry groups. Nationwide, about 40% of the positions in this manufacturing subsector require a high school diploma or equivalent.

Figure 2. Washington concrete and cement manufacturing workforce snapshot, 2020



**Data Source:** Washington State Employment Security Department. Covered Employment (OCEW). 2020, <https://esd.wa.gov/labormarketinfo/covered-employment>. NAICS codes: 327310 (Cement manufacturing); 327320 (Ready-mix concrete manufacturing); 327331 (Concrete block and brick manufacturing); 327332 (Concrete pipe manufacturing); 327390 (Other concrete product manufacturing).

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Notably, over half of the occupations in this manufacturing subsector are truck drivers (transportation of cement likely accounts for a large portion). Of the remaining half, there is a range of education needed and on-the-job training required (see Figure 3).

Workforce training research and analysis are required at a state level to address the specific needs of Washington's concrete and cement manufacturing workers. The occupations and education pathways data displayed in Figure 3 are only available at a national level and not at the specific subsector level for concrete and cement manufacturing.

**Figure 3. U.S. nonmetallic mineral product manufacturing: occupations and education pathways, 2021**

Occupation	Percent of industry	Typical education needed for entry	Work experience in a related occupation	Typical on-the-job training needed to attain competency
Truck drivers, heavy and tractor-trailer	52.7%	Postsecondary nondegree award	None	Short-term on-the-job training
Molders, shapers, and casters, except metal and plastic	17.6%	High school diploma or equivalent	None	Long-term on-the-job training
First-line supervisors/managers of production and operating workers	10.7%	High school diploma or equivalent	Less than 5 years	None
Laborers and freight, stock, and material movers, hand	10.5%	No formal educational credential	None	Short-term on-the-job training
Extruding, forming, pressing, and compacting machine setters, operators, and tenders	8.5%	High school diploma or equivalent	None	Moderate-term on-the-job training

**Data Sources:** "Industries at a Glance: Nonmetallic Mineral Product Manufacturing: NAICS 327," accessed May 5, 2022, <https://www.bls.gov/iag/tgs/iag327.htm>; "Education and Training Assignments by Detailed Occupation: U.S. Bureau of Labor Statistics," accessed April 18, 2022, <https://www.bls.gov/emp/tables/education-and-training-by-occupation.htm>.

**NOTE:** This manufacturing sector overview is based on CETI and SEI-US research conducted in the summer of 2021. For the full report, please see ["Washington Industrial Emissions Analysis."](#)

For more information, please see [Washington State Clean Materials Manufacturing](#) on the Clean Energy Transition Institute website.

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## Endnotes

- <sup>1</sup> International Energy Agency and Cement Sustainability Initiative, "Technology Roadmap: Low-Carbon Transition in the Cement Industry" (Paris, France: International Energy Agency, March 2018), <https://www.iea.org/reports/technology-roadmap-low-carbon-transition-in-the-cement-industry>.
- <sup>2</sup> Max Åhman, "Perspective: Unlocking the 'Hard to Abate' Sectors" (World Resources Institute, March 2020), <https://files.wri.org/expert-perspective-ahman.pdf>.
- <sup>3</sup> Energy Transitions Commission, "Mission Possible Sectoral Focus: Cement" (Energy Transitions Commission, January 2019), <https://www.energy-transitions.org/publications/mission-possible-sectoral-focus-cement/>.
- <sup>4</sup> Ali Hasanbeigi and Cecilia Springer, "California's Cement Industry: Failing the Climate Challenge" (San Francisco, California: Global Efficiency Intelligence, February 4, 2019), <https://www.climateworks.org/report/californias-cement-industry-failing-the-climate-challenge/>.
- <sup>5</sup> Hasanbeigi and Springer.
- <sup>6</sup> International Energy Agency and Cement Sustainability Initiative.
- <sup>7</sup> Washington State Department of Ecology, "Facility Greenhouse Gas Reports," accessed April 11, 2022, <https://ecology.wa.gov/Air-Climate/Climate-change/Tracking-greenhouse-gases/Greenhouse-gas-reporting/Facility-greenhouse-gas-reports>.
- <sup>8</sup> Ash Grove Cement, "Fact Sheet on Ash Grove Seattle Plant," ca 2018, [https://static1.squarespace.com/static/5f39b10071a9b67f78f74a82/t/5fb962099876b8736cac88d1/1605984777890/2020-AG\\_FACT\\_SHEETS-SEATTLE.pdf](https://static1.squarespace.com/static/5f39b10071a9b67f78f74a82/t/5fb962099876b8736cac88d1/1605984777890/2020-AG_FACT_SHEETS-SEATTLE.pdf).
- <sup>9</sup> Calculated from Ash Grove reported 2019 CO<sub>2</sub>e emissions of 366,000 tonnes (obtained from: <http://ghgdata.epa.gov/ghgp/main.do>) and reported clinker production of 750,000 tons per year (from: Ash Grove (ca. 2018)). Electricity-related emissions assumed to be zero based on Seattle City Light resource mix. U.S. average obtained from Hasanbeigi et. al (2019).
- <sup>10</sup> "EPA Facility Level GHG Emissions Data," United States Environmental Protection Agency, 2021, <http://ghgdata.epa.gov/ghgp/main.do>.
- <sup>11</sup> "EPA Facility Level GHG Emissions Data."
- <sup>12</sup> U.S. Environmental Protection Agency, "List of Certified Plants," 2021, [https://www.energystar.gov/industrial\\_plants/earn-recognition/plant-certification/list\\_certified\\_plants](https://www.energystar.gov/industrial_plants/earn-recognition/plant-certification/list_certified_plants).
- <sup>13</sup> Erickson, Peter, Michael Lazarus, Janice Adair, Justin Brant, Eli M. Levitt, Hauke Hermann, Tim Larson, Bill Ross, and Amy Wheelless. "Issues and Options for Benchmarking Industrial GHG Emissions." Stockholm Environment Institute (SEI), 2010. <https://www.sei.org/publications/issues-options-benchmarking-industrial-ghg-emissions/>.
- <sup>14</sup> Puget Sound Clean Air Agency, "Statement of Basis for Ash Grove Cement Company, Inc.," June 13, 2018, <https://pscleanair.gov/DocumentCenter/View/216/Statement-of-Basis-PDF>.
- <sup>15</sup> International Energy Agency and Cement Sustainability Initiative.
- <sup>16</sup> Erickson and Lazarus.
- <sup>17</sup> MPA UK Concrete, "UK Concrete and Cement Industry Roadmap to beyond Net Zero" (London, United Kingdom: UK Concrete / Mineral Products Association, 2020), <https://www.mineralproducts.org/Sustainability/Net-Zero-Carbon.aspx>; International Energy Agency and Cement Sustainability Initiative; Energy Transitions Commission.
- <sup>18</sup> MPA UK Concrete.
- <sup>19</sup> David Roberts, "Volts," Rebecca Dell on Decarbonizing Heavy Industry, n.d., <https://www.volts.wtf/p/volts-podcast-rebecca-dell-on-decarbonizing>.
- <sup>20</sup> Washington State Labor Council. "Directory of Labor Organizations in Washington State." Washington State Labor Council, December 15, 2020. [https://www.wslc.org/wp-content/uploads/2020/12/WSLC-2021-Directry\\_20Dec15.pdf](https://www.wslc.org/wp-content/uploads/2020/12/WSLC-2021-Directry_20Dec15.pdf). Exact union membership numbers are not publicly available.
- <sup>21</sup> Derik Broekhoff, Silvia Ulloa, and Jason Veysey. "To Decarbonize U.S. Industry, Look to Federal and State-Level Partnerships." Leadership Group for Industry Transition. Accessed March 28, 2022. <https://www.industrytransition.org/insights/decarbonize-us-industry-federal-state-level-partnerships/>.
- <sup>22</sup> Buy Clean is a type of procurement policy that addresses greenhouse gas emissions from building materials purchased with government funding.
- <sup>23</sup> Rebecca Dell, "Build Clean: Industrial Policy for Climate and Justice" (San Francisco: ClimateWorks Foundation, December 2020), <https://www.climateworks.org/report/build-clean-industrial-policy-for-climate-and-justice/>.