

Glass

Industry Description

Four main types of glass are manufactured in the United States: flat glass (e.g., windows); container (hollow) glass; fiberglass; and specialty glass. Glass is made from silica sand, combined with lime, potash, soda, cullet (recycled glass), and other ingredients. The mixture is melted together at a high temperature, then formed and finished.

Greenhouse Gas Footprint

Washington is home to three major glass manufacturing facilities: Cardinal Glass, a flat glass manufacturer in Winlock; Ardagh Glass, a glass bottle manufacturer (and major glass recycler and supplier of wine bottles) in Seattle; and Owens-Illinois, a glass container manufacturer in Kalama. Together, these facilities emitted approximately 180,000 metric tons of carbon dioxide equivalent (CO₂e) in 2019.¹

Glass manufacturing is also a major source of local air pollution and water pollution in Washington. The Ardagh Group's glass recycling plant in South Seattle is the largest stationary source

of particulate matter and sulfur dioxide in King County² and has been cited for numerous violations by the Department of Ecology.³

Industrial Process and Decarbonization

Production methods can vary for different types of glass, but there are shared basic production steps.

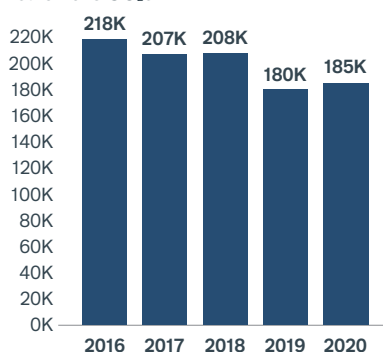
First, the raw materials are combined with stabilizers, including lime, magnesium oxide, and aluminum oxide. Materials are ground and mixed until a uniform mixture is obtained (the "batch" or "frit"), which is then melted in a furnace.

Second, during the melting and refining stage, which is the most energy-intensive phase, the raw material batch is fired in a furnace. In the United States, most glass furnaces are fired by natural gas, and some (especially container-glass furnaces) use electric boosters, as glass is a conductor at high temperatures. In such cases, electricity can represent up to 20% of the energy input to the furnace. Use of electric boost is less common in furnaces that produce flat glass.

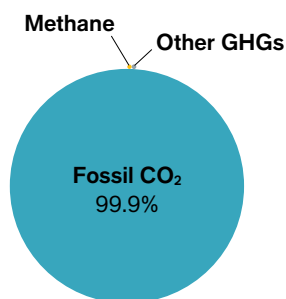
Figure 1. Washington glass manufacturing direct reported emissions, 2016–2020

Annual Emissions

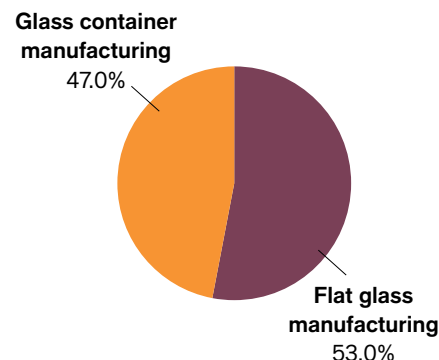
Metric Tons CO₂e



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: 327211 (Flat glass manufacturing); 327213 (Glass container manufacturing).
Note: This figure shows direct reported emissions from facilities with over 10,000 metric tons CO₂e in annual emissions. Direct reported emissions do not include electricity use.

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Third, the glass is transferred out of the furnace into a fore-hearth, where it is conditioned to have the desired temperature distribution, and then delivered to the forming equipment, where it is shaped. Lastly, during the finishing stage, various processes and treatments may be applied to affect glass characteristics.

The high temperatures required to melt raw materials cause glass manufacturing to be highly energy intensive and have a high share of energy-related CO₂ emissions.⁴ Glass manufacturing also has significant process emissions resulting from the melting of carbonate raw materials (limestone, dolomite, soda ash).

Therefore, decarbonization pathways for the glass industry will involve a combination of measures that reduce *energy-related* emissions, including fuel switching,⁵ electrification,⁶ waste heat recovery,⁷ and process intensification;⁸ and measures to avoid process emissions, such as material efficiency strategies.⁹

Carbon capture, utilization and storage (CCUS) could also be used to mitigate process emissions, but its potential use in the glass industry has not been widely investigated and could face numerous challenges, including the tendency for glass manufacturing facilities to be relatively small and distributed, the presence of acidic compounds, and relatively low CO₂ concentrations in flue gas.¹⁰

Workforce

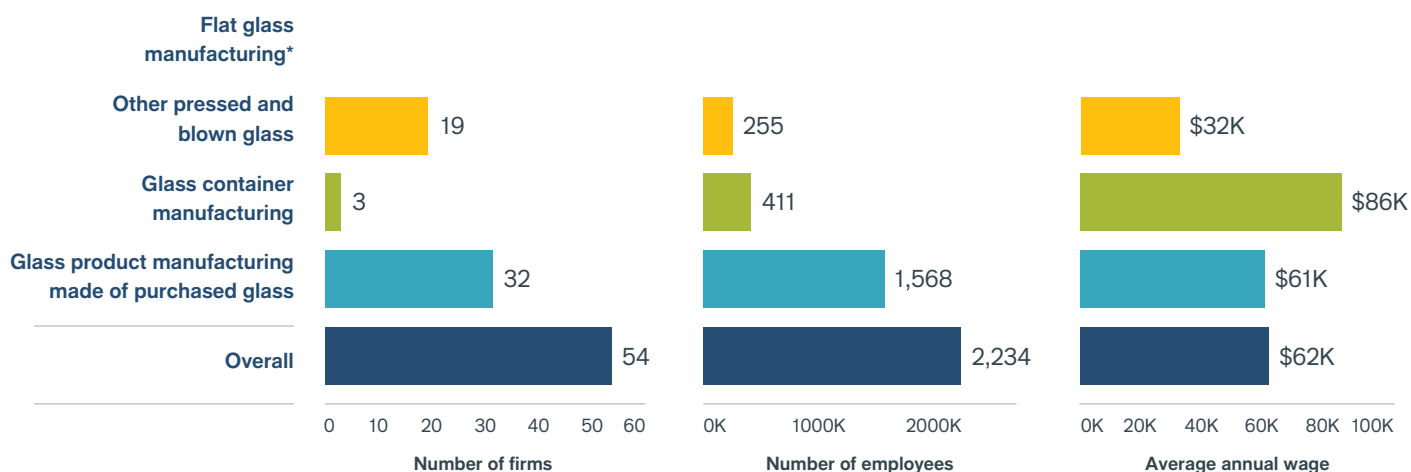
The glass manufacturing industry directly supports well over 2,000 workers in Washington (as seen in Figure 2, employment data are not available for individual employers, including the one flat glass manufacturing facility in Washington).

Unions including the International Brotherhood of Electrical Workers, the International Association of Machinists and Aerospace Workers, and United Steelworkers represent a portion of glass manufacturing workers.¹¹ In addition to workers directly employed in the industry, the glass industry supports jobs in downstream sectors such as construction, packaging, wind turbine manufacturing, and scientific equipment.

Ardagh Glass is located in South Seattle, while the other two large glass manufacturing facilities are located in smaller communities (Winlock and Kalama). Decarbonizing process-based emissions will likely require new technologies, which in turn could require workers to develop new skills. It will also be important to develop skills relevant to decarbonization and energy efficiency to ensure that workers are equipped to make improvements to existing processes.¹²

As the glass industry has become more mechanized, there has been increasing demand for highly skilled workers to do the remaining manual jobs, such as forming and molding.

Figure 2. Washington glass manufacturing workforce snapshot, 2020



Data Source: Washington State Employment Security Department. *Covered Employment (OCEW)*. 2020, <https://esd.wa.gov/labormarketinfo/covered-employment>. NAICS codes: 327211 (Flat glass manufacturing)*; 327212 (Other pressed and blown glass and glassware); 327213 (Glass container manufacturing); 327215 (Glass product manufacturing made of purchased glass).

* Employment and wages not available to avoid disclosure of data for individual employer

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Additionally, the glass industry faces challenges due to an aging workforce and low numbers of recruits.¹³

The glass industry is also highly dependent on trends in other sectors, relying in particular on demand for flat glass from the construction industry.¹⁴ The COVID-19 pandemic therefore disrupted many glass manufacturers as construction projects stalled; at the same time, there was increased demand for other glass producers to manufacture equipment for hospitals and pharmacies, such as those used for administering the COVID-19 vaccine.¹⁶ In the future, demand for glass will be affected by the growth of clean energy technologies (e.g., fiberglass used for wind turbines), which will increase demand for a skilled glass manufacturing workforce.¹⁶

In the North American Industry Classification System (NAICS), the glass manufacturing industry falls under the Nonmetallic Mineral Product Manufacturing subsector, which also includes

cement and concrete product manufacturing and other industry groups. Nationwide, about 40% of the positions in this manufacturing subsector require a high school diploma or equivalent.

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 glass 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 glass 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

- ¹ 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>.
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- ⁴ Michael Zier et al., "A Review of Decarbonization Options for the Glass Industry," *Energy Conversion and Management: X* 10 (June 1, 2021): 100083, <https://doi.org/10.1016/j.ecmx.2021.100083>.
- ⁵ IN4climate.NRW, "HyGlass," accessed July 6, 2021, <https://www.in4climate.nrw/en/best-practice/projects/2020/hyglass/>; "HyNet North West," HyNet North West, accessed July 6, 2021, <https://hynet.co.uk/>; "Kopernikus-Projekte," Kopernikus-Project: P2X, accessed July 6, 2021, <https://www.kopernikus-projekte.de/en/projects/p2x>.
- ⁶ Zier et al.
- ⁷ Zier et al.
- ⁸ Zier et al.
- ⁹ Ecofys, "Methodology for the Free Allocation of Emission Allowances in the EU ETS Post 2012: Sector Report for the Glass Industry" (European Commission, 2009), https://ec.europa.eu/clima/system/files/2016-11/bm_study-glass_en.pdf.
- ¹⁰ Glass Alliance Europe, "The European Glass Sector Contribution to a Climate Neutral Economy" (Glass Alliance Europe, 2019), https://www.glassallianceeurope.eu/images/para/gae-position-paper-on-decarbonisation-june-2019_file.pdf.
- ¹¹ 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-Directory_20Dec15.pdf. Exact union membership numbers are not publicly available.
- ¹² British Glass, "Glass Sector Industrial Decarbonisation and Energy Efficiency Roadmap Action Plan" (Department for Business, Energy & Industrial Strategy, October 2017), https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/652080/glass-decarbonisation-action-plan.pdf.
- ¹³ Nora Wintour, "The Glass Industry: Recent Trends and Changes in Working Conditions and Employment Relations" (International Labour Office, 2015), https://doi.org/10.1163/2210-7975_HRD-4022-2015081.
- ¹⁴ British Glass.
- ¹⁵ International Finance Corporation, "Strengthening Sustainability in the Glass Industry" (World Bank Group, July 26, 2021), https://www.ifc.org/wps/wcm/connect/5b253a67-c583-46a6-90bb-886a5a9b5838/FINAL_IFC_Glass_7-26-21.pdf?MOD=AJPERES&CVID=nldwExK.
- ¹⁶ British Glass.