Washington State Manufacturing Sector Overview

Aluminum

Industry Description

After steel, aluminum is the second most used metal in the world.[1] Aluminum is made either through primary production (making new aluminum from bauxite ore) or secondary production (recycling existing aluminum into pure metal). Primary production consists of two main steps: alumina refining, in which aluminum is chemically extracted from mined bauxite, and smelting, which converts alumina into pure aluminum.

Greenhouse Gas Footprint

There were three aluminum facilities in Washington with over 10,000 metric tons in annual carbon dioxide equivalent (CO_2e) emissions between 2016 and 2020.[2] Of these three, one is a manufacturer of aluminum sheet, plate, and foil (Kaiser Aluminum in Spokane), while the two others were aluminum smelters.

One of the aluminum smelters, Alcoa Wenatchee Works in Malaga, was officially decommissioned at the end of 2021 after five years of being idle (the last year of reported emissions was 2016). The other aluminum smelter (and the only U.S. aluminum smelter west of the Mississippi at the time), Alcoa Intalco Works in Ferndale, was idled in 2020. This closure explains the emissions reductions seen between 2019 and 2020 in Figure 1. There are currently efforts underway to reopen the Alcoa Intalco plant.[3]

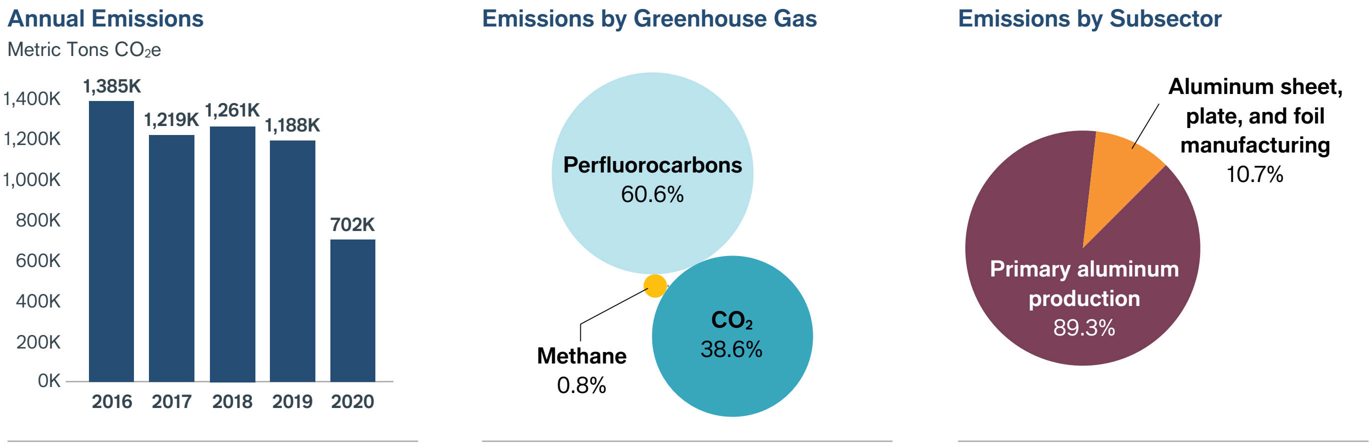
Note: Figure 1 shows only direct reported emissions and does not include emissions from electricity, which account for approximately two-thirds of the aluminum industry's global emissions.

Industrial Process and Decarbonization

In primary production, the raw material for aluminum is most often bauxite ore. The aluminum within the bauxite is chemically extracted into aluminum oxide (alumina) through the Bayer process.[5] Next, the Hall-Héroult[6] process uses electrolysis to smelt the alumina into pure aluminum.

In the Hall-Héroult smelting process, an electric current runs through a high-temperature bath of molten cryolite between a carbon anode and cathode. The alumina is added to the bath and is reduced to aluminum as the current passes through.

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



Data Source: Washington State Department of Ecology. "Facility Greenhouse Gas Reports." Accessed April 11, 2022. https://ecology.wa.gov/Air-Climate/Climate-change/Tracking-greenhousegases/Greenhouse-gas-reporting/Facility-greenhouse-gas-reports; NAICS codes for reporting facilities: 331312 (referring to 331313: Primary aluminum production); 331315 (Aluminum sheet, plate, and foil manufacturing). **Note:** This figure shows direct reported emissions from facilities with over 10,000 metric tons CO_2e in annual emissions. Direct reported emissions do not include electricity use.

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The pure aluminum can then be removed from the bottom of the bath. The liquid aluminum is then poured into molds or saved to refine further or combine with other metals to form alloys.

Smelting is responsible for 77% of the aluminum industry's CO_2e emissions, a large portion of which arise from electricity consumption due to running the electrolysis process on an industrial scale.[7] Because the production process is electricity-intensive, aluminum smelters have historically been located in regions with lower electricity prices.

The confluence of low-cost hydropower and Boeing's production of warplanes for World War II led to the Pacific Northwest emerging as an aluminum production hub in the mid-20th century. The region's facilities accounted for 40% of the nation's smelting capacity in the 1950s, but by the 1990s struggled to stay competitive in the global market.[8]

Overall, emissions from electricity use account for between 64%[9]–70%[10] of total (direct and indirect) global aluminum emissions. Therefore, decarbonizing electricity used by aluminum smelters worldwide is a key strategy, and it must address both electricity on the grid and onsite electricity generating facilities, which often use coal.[11] Worldwide, coal-fired electricity accounted for nearly 60% of the industry's total carbon emissions in 2019.[12]

In addition to emissions from electricity usage, the electrolysis process also causes a chemical reaction that produces CO_2 and perfluorocarbons (PFCs). These PFCs have a global warming potential between 6,500–9,200 times as strong as CO_2.[13] Decarbonization strategies therefore must involve technological innovations and methods that would attempt to eliminate these process emissions.[14]

> A key strategy is decarbonizing electricity used by aluminum smelters.

Secondary production of aluminum (recycled aluminum as the raw material) uses only 5% of the energy needed in primary production.[15] Aluminum is infinitely recyclable and does not lose its strength or durability during the recycling process. When

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using recycled aluminum, the scrap material is first collected and sorted. Sorting by chemical grade produces more valuable aluminum than if the aluminum is composed of a mix of alloys.

The scrap is then melted in a furnace that heats to 1300–1400 degrees Fahrenheit. Achieving these temperatures is (currently) not practical using electrical energy sources, so full decarbonization will likely require alternative fuels or technologies to replace the use of fossil fuels for thermal energy. The molten aluminum is then ready to be cast into semi-finished products, such as large slabs called ingots, which can then be used to create finished products.[16]

Due to its significantly lower energy use, using more recycled aluminum instead of primary aluminum is a key decarbonization strategy. However, there is a limited supply of available aluminum since it is a durable material that can last in construction or transportation for over 20 years. Recycling, therefore, must be paired with other decarbonization strategies as the availability of scrap metal may not be able to meet the growing demand for aluminum.[17]

While recycled aluminum accounts for only one third of aluminum production, recycling rates are already quite high—around 80% of scrap aluminum was collected and recycled in 2018.[18] Still, effort should be made to increase the amount of recovered scrap aluminum by diverting more aluminum from landfills; improving separation techniques; collaborating among businesses on closed-loop recycling; and designing products that are more easily separated and recycled.[19]

Aluminum demand is expected to grow due to increased urbanization; use of aluminum as a lightweight vehicle material for electric vehicles; use in construction in the expansion of the electric grid; and potential use as replacement for single-use plastics. Aluminum is also a key material for the growing fields of renewable energy technologies, such as solar photovoltaic cells and energy storage technologies.[20]

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Workforce

Aluminum is an increasingly important material for clean energy technologies, which means that demand for low-carbon aluminum will continue to grow and likely increase demand for aluminum manufacturing workers.

Washington employment numbers in the aluminum manufacturing industry have fluctuated as smelting plants closed during the past five years. According to 2020 employment data, the aluminum manufacturing industry was directly supporting over 250 workers in Washington. However, the real number is much higher; as seen in Figure 2, employment data are not available for individual employers, such as the Alcoa aluminum smelter.

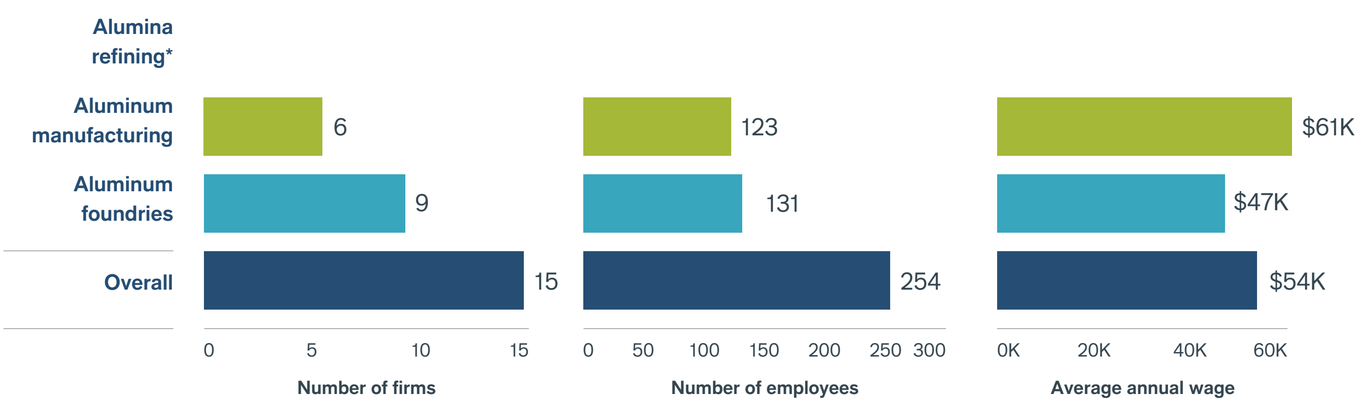
The curtailment of Alcoa Intalco Works in 2020 led to layoffs of approximately 700 workers;[21] however, there are efforts to reopen the plant and restore those jobs.[22] The International Association of Machinists and Aerospace Workers (IAMAW) Union represents a portion of Washington aluminum manufacturing workers.[23]

Decarbonizing process-based emissions will likely require new technologies, which in turn could require workers to develop new skills. For aluminum manufacturing in Washington, it could be worthwhile to determine whether there are workforce implications for primary versus secondary aluminum manufacturing.

In the North American Industry Classification System (NAICS), the aluminum manufacturing industry falls under the Primary Metal Manufacturing subsector, which also includes iron and steel mills, steel product manufacturing, nonferrous metal production, and foundries. The workforce in this manufacturing sector is skilled relative to other industries. Nationwide, all primary metal manufacturing positions require a high school diploma or equivalent and additional moderate-term on-the-job training (more than one month but less than one year), or some experience in a related occupation (see Figure 3).

Workforce training research and analysis are required at a state level to address the specific needs of Washington's aluminum 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 aluminum manufacturing.

Figure 2. Washington aluminum manufacturing workforce snapshot, 2020



Data Source: Washington State Employment Security Department. Covered Employment (QCEW). 2020, https://esd.wa.gov/labormarketinfo/covered-employment for NAICS codes: 331313 (Alumina refining, primary aluminum production)*; 331315 (Aluminum sheet, plate, and foil manufacturing)*; 331318 (Other aluminum rolling, drawing, and extruding); 331524 (Aluminum foundries, except die-casting).

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

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Figure 3. U.S. primary metal 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
First-line supervisors/managers of production and operating workers	20.5%	High school diploma or equivalent	Less than 5 years	None
Rolling machine setters, operators, and tenders, metal and plastic	17.8%	High school diploma or equivalent	None	Moderate-term on-the-job training
Molding, coremaking, and casting machine setters, operators, and tenders, metal and plastic	17.4%	High school diploma or equivalent	None	Moderate-term on-the-job training
Cutting, punching, and press machine setters, operators, and tenders, metal and plastic	15.6%	High school diploma or equivalent	None	Moderate-term on-the-job training
Metal-refining furnace operators and tenders	14.4%	High school diploma or equivalent	None	Moderate-term on-the-job training
Inspectors, testers, sorters, samplers, and weighers	14.3%	High school diploma or equivalent	None	Moderate-term on-the-job training

Data Sources: "Industries at a Glance: Primary Metal Manufacturing: NAICS 331," accessed April 18, 2022, https://www.bls.gov/iag/tgs/iag331.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

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