ANALYSIS TO ESTABLISH ADDITIONAL SUBCATEGORIES OF ELIGIBLE MATERIALS WITH MAXIMUM ACCEPTABLE GWP EMISSION LIMITS

BUY CLEAN MARYLAND ACT OF 2023

JUNE 2025

MARYLAND DEPARTMENT OF GENERAL SERVICES | MARYLAND GREEN BUILDING COUNCIL

US CLIMATE ALLIANCE PROJECT (C-20435) | PREPARED BY GREENPLUMSTREET LLC

Analysis to Establish Additional Subcategories of Eligible Materials with Maximum Acceptable GWP Emission Limits
Maryland Buy Clean Technical Assistance c/o US Climate Alliance Project (C-20435)
June 2025

For: Maryland Department of General Services (DGS) and Maryland Green Building Council
Author: GreenPlum Street LLC (typ@greenplumstreet.com, ndp@greenplumstreet.com)

PURPOSE

This Analysis reports the possible construction materials to add as "eligible materials" to the Procurement of Construction Materials Act (Buy Clean Maryland) of 2023.

SCOPE

This document identifies the most carbon-intensive construction materials used or manufactured in Maryland aside from cement and concrete:

- Structural Steel
- Asphalt
- Precast Concrete
- Insulating Glass
- Aluminum
- Wood

FOCUS ISSUES

The 2025 updated Maryland High Performance Green Building Program *(*HPGBP) incorporated input from the Maryland Green Building Council (MGBC) members, Department of General Services (DGS) staff and the Maryland Attorney General. This Analysis recognizes the requirement of the Maryland General Assembly session 2024, Chapter 423 (SB 258) requirements "to ensure that all new buildings and major renovations subject to the Program align with the state's goal of achieving net zero greenhouse gas emissions by 2045."

In addition, the DGS has published the framework and methodology to establish acceptable global warming potential (GWP) limits for cement and concrete per the Buy Clean Maryland Act. The DGS may expand the policy to other high-impact materials. This Analysis will review common construction materials for the continued application of the Buy Clean procurement policy per Buy Clean Section [4-903] (D):

> "The Department may: (1) Establish additional subcategories within each category of eligible material with distinct maximum acceptable global warming potential limits".

The analysis will consider:

- construction materials and their applications
- local Maryland industries and businesses
- carbon intensive processes
- the availability of environmental data

1. INTRODUCTION

Maryland is required to reduce statewide greenhouse gas (GHG) emissions 60% from 2006 levels by 2031 and achieve net-zero emissions by 2045[i]. Net-zero emissions means that the total GHG emissions from Maryland's economy will be equal to the GHGs removed from the atmosphere through natural and technological systems annually. The Maryland's Climate Pollution Reduction Plan[ii] outlines opportunities to implement a sustainable path where incentives are provided but are also practical and methodical. Key elements related to decarbonization of the building industry include the Buy Clean program which requires manufacturers to submit Environmental Product Declarations (EPD) to the state and for the state to establish a maximum acceptable global warming potential values for each category of eligible materials.

As a central instrument of the Maryland strategy to achieve its emissions goal, the Buy Clean Maryland Act (Act) o 2023 considers the role of public procurement in driving the decarbonization of construction materials. Beginning July 1, 2026, state agencies would be required to specify in each solicitation for a government-funded construction project the cement or concrete mixture that would be used in the building materials and prioritize proposals with the lowest carbon dioxide (a.k.a. carbon) footprint. Through the Act, the cement and concrete industry has been the focus for industrial decarbonization but without considering the contributions from all construction materials, this will not be enough to achieve the large-scale reductions needed.

For details on the referenced methodology for cement and concrete, see "Determining Initial Acceptable GWP Limits for Cement and Concrete" from Maryland DGS.

The Act states that DGS may: "Establish additional subcategories within each category of eligible material with distinct maximum acceptable global warming potential limits". Having multiple eligible materials creates a level playing field where low carbon products can compete on an equal footing with less cost-intensive conventional products. In this study we analyze the possible embodied carbon (EC) contribution of other construction materials manufactured and used in the state to achieve the Maryland's climate goals. Embodied carbon refers to the carbon emissions associated with the extraction and manufacture, construction, maintenance, refurbishment and demolition of a building. Having the EC information available for these materials in a cohesive format such as EPDs provides a solid base for industry professionals to make informed decisions to reduce embodied carbon of all construction materials.

2. COMMON CONSTRUCTION MATERIALS

The most common construction materials in Maryland aside from cement and concrete are identified below. The following highlights the market value of the materials, example Maryland businesses, the processes that involve carbon-intensive production which produce significant greenhouse gas emissions and readiness of transparent documents such as EPDs.

Ideally, the project teams will apply a whole-building lifecycle assessment (WBLCA), a widely accepted method for assessing embodied, to identify carbon "hot spots"—materials or systems that contribute the most to a building's embodied greenhouse gas emissions. This way, project teams can prioritize the materials that make the most difference and can start finding solutions that have the biggest impact. Caution should be exercised as materials should not be compared across product categories as they have differing functional uses, life cycles, underlying assumptions and performance requirements to avoid misleading conclusions.

2.1. Structural Steel

The U.S. steel market is projected to reach US$ 108.4 billion in 2025[iii]. This includes imports valued at approximately 26.2 million metric tons of steel which valued around US$ 32.99 billion. The construction sector is the largest consumer of steel in the U.S., accounting for over 50% of total steel consumption. Steel is a crucial and versatile material in the construction industry, valued for its strength, durability and flexibility.


Photo by Jason Richard on Unsplash

Maryland has a history of steel production and shipbuilding capabilities, producing steel used in iconic structures like the Empire State Building and the Golden Gate Bridge, but capacity has diminished with the closing of the Bethlehem Steel at the Sparrows Point facilities in 2012. Nevertheless, Maryland's Redbird Steel, Marlin Steel Wire, Sungate Unlimited Inc, Caldera Manufacturing Group, Durrett Sheppard Steel Co., Inc. currently fabricate engineered products. Current notable contracting companies including Titan Steel and Boldmark Steel fabricates and erects steel structures. In addition, the state has a returning focus on steel manufacturing for the offshore wind industry. US Wind's partnership with Haizea Wind Group is reestablishing production at Sparrows Point and plans to see the facility begin putting out its first components in late 2025. Crystal Steel Fabricators, is a structural steel fabricator headquartered in Delmar, DE but with agreements with offshore wind turbine companies to manufacture at their facility in Federalsburg, Maryland[iv].

It is estimated that steel products are responsible for 11% of all carbon dioxide emissions globally[v]. The International Energy Agency (IEA) estimates that direct CO_2 emissions due to crude steel production is approximately 1.4 tons CO_2 per ton steel produced[vi]. Steel production is highly polluting due to its reliance on coal-based processes such as iron ore extraction, coking and blast furnace operations. The industry is making a shift towards electric arc furnace (EAF) technology which has a significantly lower carbon footprint. Because of its impact, the Buy Clean policies in the U.S. General Services Administration, California, Oregon, Colorado, Washington as well as New York City (NYC EO 23) all require construction managers to submit EPDs for capital projects.

EPDs are readily available for various steel construction products quantifying the environmental impacts of its manufacturing process. Several associations, such as the American Institute of Steel Construction (AISC), the Steel Joist Institute (SJI), the Steel Deck Institute (SDI), the Metal Construction Association (MCA), the Metal Building Manufacturers Association (MBMA), the Steel Recycling Institute (SRI) and the Concrete Reinforcing Steel Institute (CRSI), actively support the transparent reporting of environmental impacts associated with their respective product categories. Many rating systems (e.g. LEED), standards (e.g. ASHRAE), green building codes (e.g. IgCC), public policies and private developers require the submission of EPDs for steel products delivered to the project site. EPDs for steel products can be found in Building Transparency's EC3 database as well as platforms like EPD International.

2.2 Asphalt

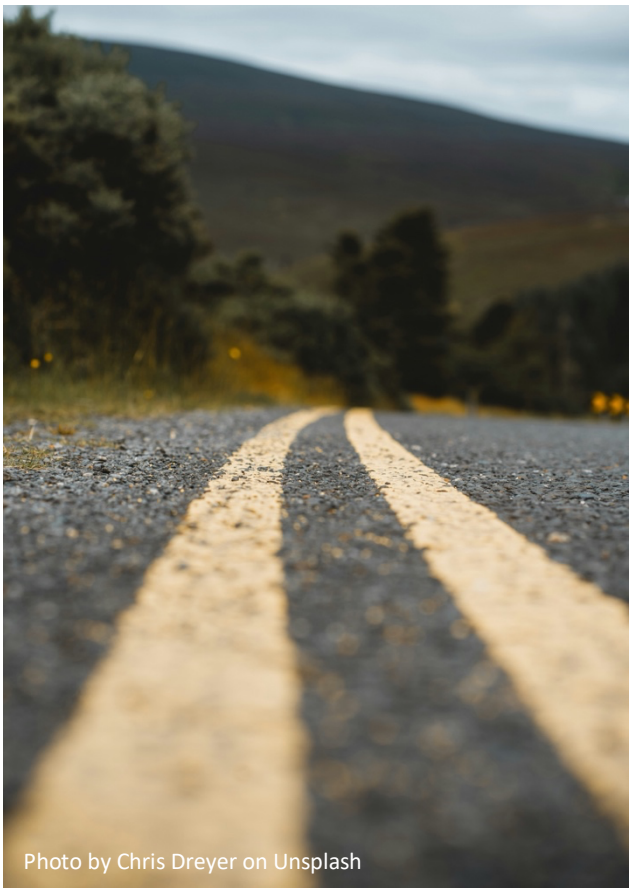
Photo by Chris Dreyer on Unsplash

The U.S. asphalt industry is a large and vital sector, heavily reliant on road construction and maintenance. In 2025, the industry's revenue will reach US$ 36.7 billion, climbing by 1.7% from 2024[vii]. The asphalt manufacturing industry relies heavily on crude oil as a critical input in production and transportation. Several companies operate asphalt plants throughout Maryland including Allan Myers, C. William Hetzer, C.J. Miller LLC, F.O. Day Co., David A. Bramble, Fort Myer Construction Corp., Gray & Son, Holcim-MAR Inc., Laney Companies, P. Flanigan & Sons and M Luis Construction with many more operating plants outside the state borders. These plants produce hot mix asphalt (HMA) for various paving needs, including roadways and commercial surfaces. Additionally, some companies specialize in recycled asphalt products. Some companies have both concrete and asphalt production facilities.

Asphalt pavement material is a combination of approximately 95 percent aggregate (stone, sand, or gravel) bound together by approximately 5 percent asphalt binder[viii]. Asphalt material is produced at a manufacturing facility where the aggregates and asphalt binder are heated, mixed according to precise engineering formulas and loaded into trucks for transport to the paving site. The high temperatures used in traditional asphalt production, along with the energy needed for raw material extraction and processing, contribute to carbon emissions. The EC footprint of asphalt typically ranges from 40kg to 75kg per tonne[ix], but this can vary based on factors like the type of asphalt, raw materials and transportation methods. The asphalt industry boasts a high recycling rate (around 95%)[x], which significantly reduces the environmental impact by minimizing the need for virgin materials. The asphalt industry is actively working to reduce its carbon footprint through measures like warm-mix asphalt (WMA) and the use of recycled materials.

There are a growing number of EPDs in the asphalt industry as road owners, agencies and contractors are increasingly seeking quantifiable metrics of sustainability to demonstrate environmental responsibility and meet regulatory requirements. The National Asphalt Pavement Association (NAPA) has developed a tool called the Emerald Eco-Label to help asphalt producers generate EPDs[xi]. It is important to remember that these disclosures relate to the production stage of the asphalt life cycle. Lifecycle assessments of pavements as well as buildings should consider emissions across the entire lifespan, including construction, use, maintenance and end-of-life. The use phase, for example, can be a significant contributor to lifecycle emissions of pavement, particularly regarding fuel consumption and potential air quality impacts. Colorado, New York, Oregon and Minnesota's Buy Clean programs require disclosure for asphalt products.

While the Buy Clean Maryland Act is directed at public buildings meeting the HPGBP, the inclusion of asphalt to optimizing paving and transportation infrastructure is vital in reducing the environmental impact of the built environment. In addition, in 2024, the Maryland Department of Transportation (MDOT) had requested significant funding from the Federal Highway Administration's (FHWA) Low-Carbon Transportation Materials (LCTM) program to advance its Low-Carbon Transportation Materials program. The purpose of this program is to advance the

utilization of construction materials, products and treatments that have substantially lower levels of EC associated with the production stage as compared to the estimated industry averages of similar materials. This aligns well with the Buy Clean Maryland directive to address embodied carbon of eligible products.

2.3 Precast Concrete


Photo by Johnathan Burger on Unsplash

The U.S. precast concrete market size was estimated at US$ 19.77 billion in 2023[xii]. Structural beams and slabs are two of the most common precast products used in construction projects. These standard products are essential components for building foundations, beams, floor slabs and other structural elements. Precast concrete is also used for infrastructure projects such as catch basins, highway barriers, sound walls and bridge decks. Precast concrete is popular in structural alternative to site-cast due to some advantages. The quality control, speed of construction and cost-effectiveness of precast elements make it an attractive option for many construction projects. The durability and flexibility of precast concrete also make it a reliable and versatile building material. However, precast concrete has several disadvantages, including transportation and installation challenges, potential environmental impact and unique maintenance requirements.

Several companies, including Nitterhouse Concrete, Gillespie Precast, Maryland Concrete Inc, Contractors Precast Corp., Environmental Precast and Nelson Precast, produce precast concrete products in Maryland. Other companies manufacture and supply concrete masonry unit (CMU) blocks for various construction projects. Nitterhouse Masonry Products, Ernest Maier and Maisel Brothers are examples of companies in Maryland that produce CMU.

Precast concrete's classification[xiii] is included in the overall EC calculation for concrete products which supports the importance of reducing its carbon footprint in achieving Maryland's sustainability goals. Research on the carbon emissions of prefabricated versus site-cast buildings is limited and few studies have conducted on the calculation of carbon emissions from prefabricated components[xiv]. Similar to cast-in-place concrete, cement is the most carbon-intensive component of precast concrete products. Precast concrete has the potential for a lower carbon footprint than cast-in-place concrete due to its more efficient production process in a controlled environment, installation on-site and potential for reduced waste. However long-distance transportation increases emissions, particularly for heavy precast components, significantly influences its carbon footprint.

There are extensive facility-specific EPDs for CMU including many in Maryland. The Precast/Prestressed Concrete Institute (PCI) and National Precast Concrete Association (NPCA) also provides industry-wide EPDs and guidance for various precast products, including architectural, insulated and structural precast concrete. Some precast concrete manufacturers provide facility specific EPDs with ASTM and NSF International as the program operator that publishes EPDs.

2.4 Insulated Glass

The glass manufacturing market in the U.S. in 2021 was valued at US$ 20,535.4 million and is expected to reach a projected revenue of US$ 31,875.7 million by 2030[xv]. Glazing is essential to building façades- it provides natural light, a connection to the outdoors and contributes to the management of heating and cooling. The increasing demand for energy-efficient building materials drives the demand for insulated glass. Furthermore, the growing need for acoustic insulation also contributes to the demand for effective sound transmission reduction. Considering this demand there is a need to consider not only operational carbon but also embodied carbon of insulating glass.

There are several commercial glass fabricators in Maryland, including Custom Glass Services, Inc., Kensington Glass Arts, Inc., Glass & Mirror Services, Inc, Maryland Glass Company, Central Glass Inc, Baltimore Glass Company, S. Albert Glass and General Glass Corporation.

Most of the embodied carbon in glass originates with the energy-intensive process of heating the melting furnace to 3,000 degrees Fahrenheit to convert a blend of silica, soda ash, dolomite, metal compounds and recycled cullet glass to flat glass. The processes of adding energy-efficient low-e coatings, tempering, laminating and fabricating flat glass into insulating glass units (IGU) also contribute to the glass's GWP – but to a lesser degree. It is estimated that of an IGU remaining embodied carbon, 12% comes from the fabrication process itself and just 10% comes from the process of adding low-e coatings and heat treatment processes. Energy efficiency in the manufacturing process plays a critical role in reducing GHG emissions[xvi]. Improving furnace insulation, using heat recovery systems and optimizing energy balance can minimize energy consumption and related emissions. Utilizing recycled glass (cullet) significantly reduces the need for virgin raw materials and lowers the energy required for melting, as cullet melts at a lower temperature. This reduces both process emissions and energy-related emissions. In one study[xvii], the percentage contribution of glass to the embodied carbon of the wall envelope ranges from 26 to 60 percent. The GHG emissions contribution of glass is influenced by the amount of glass in the façade and the emission factors associated with other materials.

There are limited EPDs for insulated glass products. Leading glass manufacturers like Guardian Glass, Vitro Architectural Glass and Cardinal Glass Industries publish EPDs for their products. These manufacturer EPDs often cover a range of IGU types, including double and triple-glazed units and units with various coatings and treatments. California, Colorado and New York's Buy Clean programs require disclosure from glass products used in their public projects.

2.5 Aluminum


Photo by Keith Dodrill on Unsplash

The emissions of the building envelope cannot be reduced without considering aluminum. Aluminum is a widely used material in the U.S. construction industry, particularly in non-residential (commercial) buildings. Its properties like strength, lightweight and corrosion resistance make it ideal for applications like siding, roofing, windows and doors. Non-residential construction made up more than 60 percent of the 2.5 billion pounds of aluminum used in building and construction applications in 2022[xviii]. Extruded aluminum profiles make up the highest share of aluminum building products mainly because of high demand for aluminum window frames. Non-residential windows and cladding are the key drivers of market growth through 2027, followed by solar installations and nonresidential doors.

The aluminum industry comprises three segments: upstream, secondary (or recycled) and downstream. The upstream sector consists of mining bauxite, refining it to produce alumina and smelting it to yield primary aluminum. Secondary aluminum is derived from recycled scrap metal. The downstream sector uses both primary and secondary aluminum to produce a variety of products. In 2023, the U.S. produced 860 thousand metric tons of primary aluminum and 3.4 million tons of secondary aluminum. While its share of global primary production is less than 2%, the U.S. is a major player in secondary aluminum, accounting for 81% of its total aluminum production[xix].

There is downstream aluminum manufacturing in Maryland, particularly in the Baltimore area and elsewhere in the state. Companies like Hydro Extrusion, Modern Aluminum Castings and Roberson Machine Company offer aluminum fabrication and extrusions services in Maryland. Additionally, Petersen Aluminum has a branch in Annapolis Junction, Maryland.

While aluminum constitutes a smaller percentage of global emissions compared to materials like steel or cement, it has a higher carbon footprint per unit weight. The embodied carbon of U.S. aluminum varies significantly based on whether it's primary or secondary production. Primary aluminum, produced from alumina, has a higher EC footprint (14.52 mt CO_2e/mt) due to the energy-intensive electrolysis process and reliance on electricity. Secondary aluminum, produced from recycled scrap, has a much lower footprint (average of 3.46 mt CO_2e/mt for all U.S. unwrought aluminum)[xx]. The electricity source for primary aluminum production is a major factor, with hydroelectricity helping to reduce the impact. For primary aluminum, the carbon footprint has been reduced 49 percent since 1991 and for recycled aluminum, the carbon footprint has been reduced 60 percent since 1991.

The availability of EPDs for aluminum products is limited. Several organizations, including the Aluminum Association, the Aluminum Extruders Council (AEC) and individual companies like YKK AP and Hydro Extrusion are actively developing and publishing EPDs for various aluminum products certified by UL Solutions, an EPD program operator in North America.

2.6 Wood

Wood is the only significant building material that is grown. While the primary structure of public buildings is not typically built with wood, there is growing interest in its environmental benefits. The forest products industry contributes significantly to the U.S. economy, with annual sales exceeding US$ 200 billion and employing around 950,000 people[xxi]. The industry produces hundreds of varieties, classifications and grades that make some woods better than others for certain projects.

While States like Oregon, Washington and Georgia are leading producers of softwood and hardwood lumber, Maryland has a significant forestry industry, with sawmills and mills processing wood into lumber, timber, plywood and veneers. Maryland forestry contributes to 8,800+ jobs and US$ 2.63 B in economic output[xxii]. The Eastern Shore of Maryland has a highly integrated forestry industry that contributes significantly to the state's economy and also supplies materials for the marine construction industry and agriculture[xxiii].

Photo by Khara Woods on Unsplash

The manufacturing sectors of the forestry industry includes primary and secondary manufacturing. Primary manufacturing is the processing of trees harvested from the forest into the basic products used by other manufactures, such as lumber, posts, piling and pulp. These Maryland companies include but are not limited to Kokinda and Sons LLC, Garman Brothers Inc., Urban Wood Milling, Timberline Farm Sawmill, Millville Lumber Co., Paul M. Jones Lumber, Wood Products, Inc. and Sisler Lumber Company, Inc. Secondary manufacturing uses outputs from primary manufacturing for further processing into finished products such as envelopes, firewood, roof trusses, fences and other products. These include but are not limited to Eastern Shore Forest Products, Coastal Wood Industries and Terry's Custom Milling.

The environmental benefits of using timber are not straightforward. There is ample global supply for the foreseeable future, but there is a worldwide trend towards deforestation. The carbon footprint of timber products is complex, involving both carbon storage and emissions. While timber harvesting and processing release carbon, the stored carbon in wood products offsets these emissions, making timber a potentially carbon-beneficial building

material. However, the scale of timber harvesting to meet global demand can contribute significantly to overall carbon emissions. Large-scale carbon emissions from industrial logging can be a major source of CO_2 emissions. Importantly, only a portion of the carbon of a tree is actually stored if it is cut and converted into wood products. Less than a third of the original carbon in an individual tree is carried through to the end of its life cycle – the rest is "slash" that rots and releases previously stored carbon into the atmosphere in the short term[xxiv], or is burned as "biomass" in power plants as an energy source. Other important considerations are carbon loss from soil disturbance[xxv] and biodiversity with habitat loss[xxvi] from clearcutting. However, with increased sustainable forestry management systems, wood use can claim climate advantages.

In 2020 American Wood Council (AWC) and Canadian Wood Council (CWC) issued industry-average EPDs for many North American structural wood products. However, product-specific EPDs are still limited with some available for mass timber, sheathing and engineered wood products. Typically EPDs describe the environmental performance from the cradle-to-gate of products. However, the wood industry recognizes the importance of GHG emissions of its products at the "end-of-life" stage and have developed a "Reuse Wood Directory"[xxvii] to expand wood products recovery.

3. CONCLUSIONS

As the momentum behind the Buy Clean Maryland Act and the demand for sustainable materials intensifies, Maryland businesses that proactively align with these shifts by embracing low-carbon, circular processes will not only help mitigate climate change but also capture competitive advantages in the evolving market. By highlighting construction materials in which the state can be most effective in meeting its long-term climate goals through construction procurement, this analysis provides a jumping-off point for discussions across value chains. The overall pollution from these materials underscores the importance of adding to the categories of eligible materials to reduce its embodied emissions.

Key findings:

- Steel production is highly polluting due to its reliance on coal-based processes such as iron ore extraction, coking and blast furnace operations
- Steelmaking which uses recycled steel and renewable energy, offers lower emissions compared to traditional blast furnace methods.
- The refining process for asphalt, derived from crude oil, contributes significantly to air pollution and greenhouse gas emissions.
- Asphalt paving activities release VOCs and particulate matter during application and mixing processes.
- Precast concrete has the potential for a lower carbon footprint than cast-in-place concrete due to its production process, installation on-site and potential for reduced waste.
- Glass manufacturing is energy-intensive, primarily due to high-temperature melting, which relies on fossil fuels.
- Aluminum has a higher carbon footprint per unit weight than cement or steel. The embodied carbon of U.S. aluminum varies significantly based on whether it's primary or secondary production.
- The environmental benefits of using timber are not straightforward.
- Only a portion of the carbon of a tree is stored to the "end-of-life" if it is cut and converted into wood products.

Demand for low-carbon construction materials in Maryland is expected to grow through 2050 and emissions will increase along with the demand without immediate action. Ultimately, the competitiveness and innovation driven by Buy Cean Maryland are two sides of the same coin. Innovation to find low carbon solutions and efficiencies fuels a company's competitive advantage by creating new products, services or processes that differentiate it from rivals. Conversely, competition acts as a catalyst for innovation, pushing design teams to constantly improve, adapt and find new solutions for public projects.

REFERENCES

i Maryland General Assembly, "Climate Solutions Now Act of 2022", Article II, Section 17(b) of the Maryland Constitution - Chapter 38 (8/3/2022)
ii S. McIlwain, et. al., "Maryland's Climate Pollution Reduction Plan", Maryland Department of the Environment, (December 28, 2023)
iii https://www.grandviewresearch.com/horizon/outlook/steel-market/united-states#:~:text=U.S.%20steel%20market%20highlights,terms%20of%20revenue%20in%202030, accessed June 2025
iv https://business.maryland.gov/news/crystal-steel-fabrications-open-manufacturing-facility-caroline-county, accessed June 2025
v https://www.weforum.org/stories/2024/04/technologies-cleaner-steel-industry/#:~:text=Steel%20production%20contributes%20around%2011,across%20some%20of%20the%20world's, accessed June 2025
vi International Energy Agency (IEA), "Iron and Steel Technology Roadmap", Energy Technology Policy Division, IEA Publications (2020)
vii https://www.ibisworld.com/united-states/industry/asphalt-manufacturing/450, accessed June 2025
viii "The Asphalt Pavement Industry: Fast Facts", National Asphalt Pavement Association (2023)
ix Day G., "The Road to Net-Zero Asphalt", Quarry Management (30 January 2024)
x Williams, B., et. al., "Asphalt Pavement Industry Survey on Recycled Materials and Warm-Mix Asphalt Usage", IS 138, National Asphalt Pavement Association (2019)
xi https://www.asphaltpavement.org/programs/napa-programs/emerald-eco-label, accessed June 2025
xii https://www.grandviewresearch.com/industry-analysis/us-precast-concrete-market-report#:~:text=U.S.%20Precast%20Concrete%20Market%20Size%20&%20Trends,U.S.%20over%20the%20forecast%20period, accessed June 2025
xiii Construction Specifications Institute (CSI), MasterFormat, Division 03, CSI (2020)
xiv Xu A., et. al., "Carbon Emission Calculation of Prefabricated Concrete Composite Slabs During the Production and Construction Stages", Department of Civil Engineering, Xi'an University of Technology, Xi'an, 710048, Shaanxi, China (21 October 2023)
xv https://www.grandviewresearch.com/horizon/outlook/glass-manufacturing-market/united-states, accessed June 2025
xvi Colangelo, S., "Reducing the Environmental Footprint of Glass Manufacturing", International Journal of Applied Glass Science, DOI: 10.1111/ijag.16674 (28 May 2024)
xvii Dodd, G., et.al., "Carbon Footprint of Façades: Significance of Glass", Arup and Saint-Gobain Glass (July 2022)
xviii The Aluminum Association, "Commercial Applications, Clean Energy Shift to Drive Aluminum Building Material Growth Through 2027", The Aluminum Association, Press Release (August 14, 2024)
xix Watson, C., "U.S. Aluminum Manufacturing: Industry Trends and Sustainability", US Congressional Research Service, R47294 (October 26, 2022)
xx Wang, J., "The Environmental Footprint of Semi-fabricated Aluminum Products in North America", The Aluminum Association (January 2022)
xxi https://research.fs.usda.gov/forestproducts, accessed June 2025
xxii "The Impact of the Forestry Industry on the Maryland Economy", Maryland Agricultural & Resource-Based Industry Development Corporation (2022)
xxiii https://lesmd.net/agriculture/forestry, accessed June 2025
xxiv Sierra Club, "Forest, Wood and Climate", Forest Climate Trust, Sierra Club (2019)
xxv Kosiba, A., Understanding Forest Soil Carbon, Northern Woodlands Magazine (Summer 2023)
xxvi Heimpel, E., "How does deforestation impact wildlife and biodiversity? What you need to know", Ecologi (3 March 2021)
xxvii https://reusewood.org/organizations, accessed June 2025