Chemical and Environmental Justice Impacts in the Life Cycle of Building Insulation

Case Study on Glass Fibers in Fiberglass Insulation

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ENERGY EFFICIENCY FOR ALL
energyefficiencyforall.org

PROJECT TEAM

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ABOUT ENERGY EFFICIENCY FOR ALL

Energy Efficiency for All unites people from diverse sectors and backgrounds to collectively make affordable multifamily homes energy and water efficient. We do this work so people in underinvested and marginalized communities—particularly Black, Latino, and other communities of color—can equitably benefit from the health, economic, and environmental advantages of energy and water efficiency. Reducing energy and water use in affordable multifamily housing will improve the quality of life for millions, preserve affordable housing across the country, reduce the energy burden on those who feel it most, and cut carbon pollution.

ABOUT HEALTHY BUILDING NETWORK

Since 2000, Healthy Building Network (HBN) has defined the leading edge of healthy building practices that increase transparency in the building products industry, reduce human exposure to hazardous chemicals, and create market incentives for healthier innovations in manufacturing. We are a team of researchers, engineers, scientists, building experts, and educators, and we pursue our mission on three fronts:

1) Research and policy—uncovering cutting-edge information about healthier products and health impacts;

2) Data tools—producing innovative software platforms that ensure product transparency and catalog chemical hazards; and

3) Education and capacity building—fostering others' capabilities to make informed decisions.

As a nonprofit organization, we do work that broadly benefits the public, especially children and the most marginalized communities, who suffer disproportionate health impacts from exposure to toxic chemicals. We work to reduce toxic chemical use, minimize hazards, and eliminate exposure for all.

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ABBREVIATIONS AND ACRONYMS

ACS: American Community Survey

CASRN: Chemical Abstracts Service Registry Number

EPA: U.S. Environmental Protection Agency

IARC: International Agency for Research on Cancer

LCA: Life Cycle Assessment

NIOSH: National Institute for Occupational Safety and Health

OSHA: Occupational Safety and Health Administration

PPE: Personal Protective Equipment

TRI: Toxics Release Inventory

EXECUTIVE SUMMARY

Product manufacturers, policymakers, and professionals in the building industry are paying more attention to the potential health and environmental impacts of building products during installation and use, but there has been less consideration of the important chemical impacts that may occur during other life cycle stages, including contributions to environmental injustice. To address this issue, we used the principles of green chemistry and environmental justice to develop a framework for understanding some of the important life cycle chemical impacts of products, considering the following criteria: avoid hazardous chemicals, prevent accidents, prevent pollution and waste, implement circularity and reduce end-of-life impacts, abide by environmental regulations, and prevent disproportionate and cumulative impacts.

In two separate case studies, we have applied this framework to example chemical inputs for building insulation. While insulation provides many benefits including comfort and energy efficiency, it can also have negative environmental and human health impacts throughout the product life cycle. As more insulation is being installed to improve the energy efficiency of buildings, we must ensure that materials that are safer along the entire life cycle are used. To expand understanding of the life cycle chemical hazards associated with insulation materials, we have examined the primary chemical inputs for two insulation materials: glass fibers in fiberglass insulation and isocyanates in spray foam insulation. We chose these inputs because they are the primary components of a preferred insulation material from a material health perspective (fiberglass) and a material that raises significant concerns during installation and use (spray foam).

In this case study, we consider glass fibers. The companion case study on the life cycle chemical impacts of isocyanates in spray foam insulation, as well as a fact sheet, are available on Healthy Building Network's website.[a] Our framework and case study findings can help inform decisions in product development, alternatives assessment, material selection, and policy.

Glass fibers are produced at fiberglass insulation manufacturing facilities as part of the process to

[a] https://healthybuilding.net/reports

make the insulation. This process involves a range of materials, primarily minerals and recycled glass that are melted at high temperatures. Some of the chemical inputs for glass fiber production are hazardous, and glass fiber manufacturing can release hazardous heavy metals. Though there were past concerns about possible carcinogenicity of glass fibers, authoritative organizations have determined that the glass fibers used in fiberglass building insulation do not have this associated hazard. They can, however, cause temporary eye, skin, and lung irritation.

This case study focuses on lightweight residential fiberglass batt and blown insulation manufactured in 22 facilities in the United States. Collectively, these facilities report a yearly average of 1,174,000 pounds of hazardous chemical waste associated with glass fiber production, most of it disposed off-site, with about 1,200 pounds released to the air on-site. Many fiberglass insulation manufacturing facilities have a history of noncompliance with U.S. Environmental Protection Agency regulations, with nine facilities having significant violations in the last three years.

The glass fiber manufacturing supply chain includes upstream facilities that process the recycled glass used to produce glass fibers and downstream landfills to dispose of the hazardous chemical waste generated during manufacturing. Many glass fiber manufacturing and supply chain facilities are sited in marginalized communities, such as those with a percentage (or percentages) of Black, Latino, Asian, and/or American Indian or Alaska Native populations greater than in the United States overall. Several of the communities also have a larger proportion of children than in the United States overall, and 21 facilities have at least one school located in close proximity, so children may be exposed to hazardous releases both where they live and where they learn. Some glass fiber manufacturing plants are located in cities with a large number of facilities that manage or release hazardous chemicals—six cities have 10 or more such facilities—contributing to cumulative impacts for surrounding communities.

Fiberglass insulation is intended to last the lifetime of a building, or about 75 years. At the end of life, glass fibers could be recycled into new products, but fiberglass insulation is currently disposed of in landfills.

Table 7 summarizes our findings regarding the life cycle chemical impacts associated with glass fibers, along with recommendations for reducing these impacts.

Manufacturers throughout the life cycle of insulation products should implement green chemistry and environmental justice principles. They should:

- Reduce waste and releases beyond regulatory requirements by optimizing process efficiency, using safer inputs (for glass fibers and other components of fiberglass insulation), and using best available technology to limit hazardous emissions;
- Develop standards for clean recycled glass inputs and increase the percentage of this input;
- Design for safe recycling and explore how to recover fiberglass insulation at its end of use;
- Avoid expanding or building new facilities that will increase hazardous chemical releases in already disproportionately impacted communities;
- Assess and improve the social equity impacts of their products and organizations; and
- Provide disclosure about material content, emissions, and location of manufacture.

Policymakers too should support the implementation of green chemistry and environmental justice principles. They should:

- Increase facility inspections and penalties for violations;
- Implement mandates on emissions reduction;
- Mandate a minimum amount of clean recycled glass inputs and offer incentives for higher levels;
- Increase recovery, reuse, and recycling through incentives and mandates; and
- Adopt policies that account for cumulative impacts in permitting decisions.

Building industry professionals can demand transparency about what is in a product, how it is made, and the hazardous releases that occur throughout its life cycle. As a starting point in considering the embodied chemical impacts of products, they should avoid products containing hazardous chemicals.

All these actions help support a more equitable and sustainable built environment.

INTRODUCTION

Purpose of Case Study and Framework for Analysis

Since the early days of the contemporary green building movement several decades ago, green building has been synonymous with improving building energy performance. Building material decisions are driven largely by energy efficiency and monetary cost considerations. More recently, building industry professionals have started including the embodied carbon of materials as an additional metric relevant to a building's climate change impacts; embodied carbon refers to the greenhouse gases emitted during life cycle stages outside of product use, such as raw material extraction, product manufacturing, transportation, and end of life.[1] However, human health and environmental impacts beyond carbon emissions can also occur at each life cycle stage. Unfortunately, this perspective is often missing or underrepresented when the green and sustainable building community considers building material impacts. Workers, building occupants, communities surrounding manufacturing facilities or extraction sites, and the broader environment can all be affected by hazardous chemicals during raw material extraction, chemical and product manufacturing, installation, use, and disposal or recycling, as illustrated in Figure 1. If we do not account for the effects of embodied chemicals, we won't understand the true impacts of materials on human and environmental health, and importantly, who is bearing the burden of these impacts. Buildings and products shouldn't be considered "green" unless they are green for all.

This case study aims to expand general understanding of the life cycle chemical hazards associated with building products using an example chemical and building material. The analysis is focused on health and environmental justice impacts related to chemical inputs and outputs in the context of the principles of green chemistry and environmental justice (Appendix 1).

The U.S. Environmental Protection Agency (EPA) defines green chemistry as "the design of chemical products and processes that reduce or eliminate the use or generation of hazardous substances" throughout the product life cycle. It defines environmental justice as "the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income,

FIGURE 1. Product life cycle
(adapted from UNEP "Life Cycle Management: A Business Guide to Sustainability"[2])

with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies."[3] Using these principles as a starting point, we identified six major criteria for considering chemical and environmental justice impacts: avoid hazardous chemicals, prevent accidents, prevent pollution and waste, implement circularity and reduce end-of-life impacts, abide by environmental regulations, and prevent disproportionate and cumulative impacts (Table 1). Several of these criteria are derived from both the principles of green chemistry and the principles of environmental justice. However, there are some environmental justice concepts that are not covered within the principles of green chemistry—in particular the idea of universal protection from toxics for all people.

If we do not account for the effects of embodied chemicals, we won't understand the true impacts of materials on human and environmental health, and importantly, who is bearing the burden of these impacts.

Table 1. Case study criteria for assessing chemical and environmental justice impacts based on selected green chemistry and environmental justice principles		
Principles of green chemistry*	**Principles of environmental justice***	**Case study criteria for assessing chemical and environmental justice impacts**
■ Designing chemicals, processes, and products with little or no toxicity to humans or the environment ■ Using inherently safer chemistry to minimize potential for chemical accidents	■ Ceasing the production of all toxics ■ Ensuring the right of all workers to a safe and healthy work environment	**Avoid hazardous chemicals**
■ Using inherently safer chemistry to minimize potential for chemical accidents	■ Ensuring the right of all workers to a safe and healthy work environment	**Prevent accidents**
■ Preventing pollution and waste	■ Protecting all people from extraction, production, and disposal of toxics and hazardous wastes that threaten the fundamental right to clean air, land, water, and food	**Prevent pollution and waste**
■ Using starting materials that are renewable instead of depletable	■ Protecting all people from extraction, production, and disposal of toxics and hazardous wastes that threaten the fundamental right to clean air, land, water, and food	**Implement circularity and reduce end-of-life impacts**
	■ Protecting all people from extraction, production, and disposal of toxics and hazardous wastes that threaten the fundamental right to clean air, land, water, and food	**Abide by environmental regulations**
	■ Basing public policy on mutual respect and justice for all peoples, free from any form of discrimination or bias ■ Affirming the fundamental right to self-determination for all peoples ■ Protecting all people from extraction, production, and disposal of toxics and hazardous wastes that threaten the fundamental right to clean air, land, water, and food	**Prevent disproportionate and cumulative impacts**

*See Appendix 1 for the full Principles of Green Chemistry and Principles of Environmental Justice.

Scope of Case Study

This case study supports the work of Energy Efficiency for All, which advocates for the use of safer materials for energy efficiency upgrades in affordable housing.[4] We chose to consider the life cycle chemical impacts of insulation materials because insulation is a critical component of almost all new construction and many energy-efficiency upgrades and helps provide comfortable and energy-efficient buildings.

While insulation provides many benefits, it may also introduce hazardous chemicals into buildings.[5] Given the large quantity of insulation used, material decisions can cumulatively affect the amount of toxic substances brought into building spaces and the embodied chemical impacts throughout the life cycle. Building insulation is a very broad product category that includes a variety of material types—such as cellulose, glass and mineral fiber, plastic foam, and natural materials—that are used in a range of forms: batt, blown, sprayed, and board. Our prior work evaluated use-phase chemical impacts of common insulation materials and found that, from this material health perspective, fiberglass ranks well while spray foam raises significant hazardous chemical concerns. Building on that work, we now

Playground next to CertainTeed facility in Kansas City, Kansas.

Photo: Beto Lugo-Martinez/ CleanAirNow

consider the life cycle chemical impacts of the primary chemical inputs for these two insulation materials: glass fibers in fiberglass insulation and isocyanates in spray foam insulation.

This case study expands the understanding of life cycle chemical hazards associated with glass fibers used in lightweight fiberglass batt and blown-in insulation for residential applications. We consider chemicals and materials that may be used in the production of glass fibers for fiberglass insulation and their health hazards, as well as potential exposures throughout the manufacturing supply chain in the United States. We also review the most common end-of-life scenarios for fiberglass insulation. We use publicly available information to compare how glass fibers in fiberglass insulation align with or diverge from our criteria for chemical and environmental justice impacts.

This report includes a brief discussion of some of the impacts on the communities where manufacturing takes place and equity implications within the supply chain, but it should not be considered a complete discussion of social or environmental justice issues related to the production of glass fibers or fiberglass insulation. This analysis does not include consideration of life cycle greenhouse gas emissions or other broad life cycle assessment (LCA) criteria. Nor does it address material cost, performance, or availability. For additional information on the range of chemical contents of building insulation materials including fiberglass insulation, potential impacts during installation and use, and recommendations for safer materials, see the Energy Efficiency for All report "Making Affordable Multifamily Housing More Energy Efficient: A Guide to Healthier Upgrade Materials."[6]

Background on Fiberglass Insulation

Fiberglass insulation comes in multiple forms including batt, board, blown-in, spray-applied, duct wrap, and pipe insulation and is used in residential, commercial, and industrial applications.[7] Lightweight residential fiberglass batt and blown-in insulation, the focus of this study, are used in walls, floors, and ceilings.[8] Blown-in insulation can be installed in either open or closed cavities and is often used in both new construction and retrofit applications.[9]

Glass fibers make up about 98 percent of blown-in fiberglass insulation and about 85–90 percent of fiberglass batt insulation, by weight. The remainder of the product includes additives such as antistatic agents, lubricants, de-dusting agents, and surfactants. Batts additionally have a binder component to hold the fibers together in a fixed form; they may also have a range of facing materials such as kraft paper applied with an asphalt-based adhesive. Spray-applied fiberglass insulation may include an adhesive component as well.[10]

Globally, fiberglass insulation is very common, accounting for an estimated 45 percent of the global insulation market in 2017 at an estimated worth of $3.9 billion (U.S. dollars). Residential applications account for the largest portion of use. The global value of insulation used in residential applications is expected to reach $5.1 billion by 2024, with commercial and industrial uses also expected to grow.[11]

According to a 2019 survey of U.S. home builders, fiberglass insulation accounted for about 71 percent of the square footage of insulation installed in new single-family homes (52 percent fiberglass batts and 19 percent blown fiberglass).[12] Surveys conducted by Energy Efficiency for All in 2019 identified fiberglass insulation as one of the most common materials used in affordable multifamily energy efficiency upgrades.[13]

Background on Glass Fibers as a Key Ingredient of Fiberglass Insulation

Glass fibers are used in a wide range of applications in the aerospace, automotive, sporting, and construction industries.[14] The building and construction industry accounts for the largest portion of the global glass fiber market.[15] Construction applications include fiberglass insulation, glass fiber–reinforced concrete, and glass fiber–reinforced plastics for bathtubs, shower stalls, doors, and window frames.[16] Estimates of the global glass fiber market in 2019 range from about $8 billion to $16 billion, with expected annual growth of about 4 to 6.8 percent in the coming years.[17]

Glass fibers have variable properties depending on their composition. Some specialty glass fibers, used in applications like batteries and filtration media, have been identified as possible carcinogens. The glass fibers used in fiberglass building insulation do not have this associated hazard because they are biosoluble (readily dissolved and cleared from the lungs if inhaled).[18] Still, there has been some confusion in the industry regarding the hazards of glass fibers in insulation because an older hazard designation, from 1988, identified mineral wool fibers (including glass fibers) as "possibly carcinogenic to humans."[19] A cancer warning label was required on fiberglass insulation in the United States for several years.[20] Since then, on the basis of additional research, authoritative organizations including the World Health Organization International Agency for Research on Cancer (IARC), the U.S. National Toxicology Program, and the California Office of Environmental Health Hazard Assessment have distinguished between biosoluble fibers and certain other glass fibers that are inhalable, persist in the body, and are possible carcinogens.[21] Agencies have consistently determined that the biosoluble glass fibers used in insulation are no longer considered carcinogens. They can, however, cause temporary eye, skin, and lung irritation.[22]

Glass fibers make up about 98 percent of blown-in fiberglass insulation and about 85–90 percent of fiberglass batt insulation, by weight. The remainder of the product includes additives such as antistatic agents, lubricants, de-dusting agents, and surfactants

CHEMICAL CONSIDERATIONS IN GLASS FIBER MANUFACTURING

Photo: Beto Lugo-Martinez/ CleanAirNow

Production

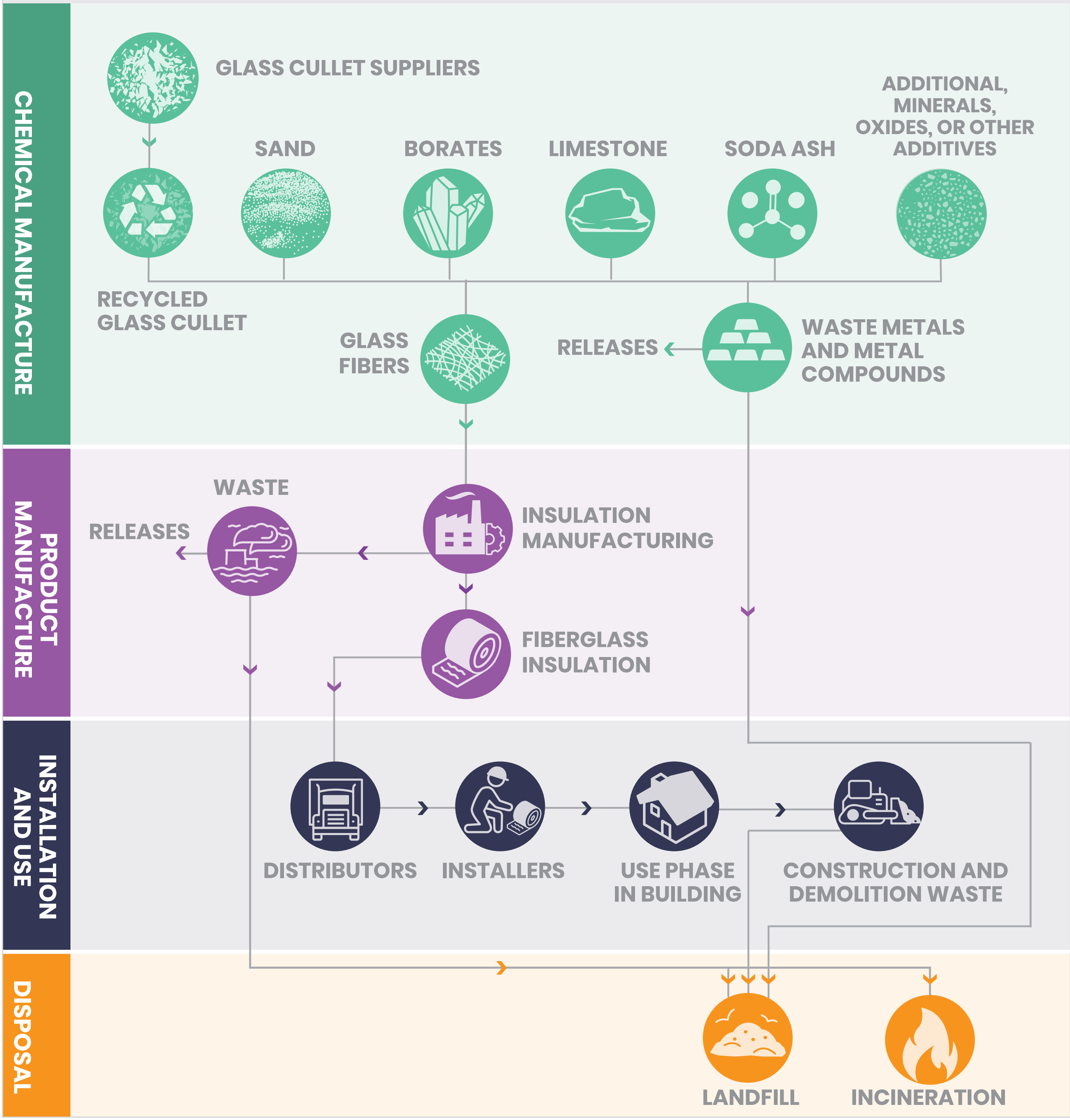
The ingredients used to make glass fibers for insulation are outlined in Figure 2. The raw materials are primarily crushed, furnace-ready recycled glass (known as cullet) and mineral-based materials including silica sand, borates such as borax, limestone, and soda ash. Additional ingredients that may be used are feldspar, dolomite, manganese dioxide, calcium oxide, nepheline syenite, calcium carbonate, sodium sulfate, and sodium nitrate. The amount of manganese dioxide, an oxidizing agent, varies depending on the quality of glass cullet.[23]

These materials are combined and melted in a high-temperature furnace and then formed into fibers. The percentage of recycled glass used in the glass fibers varies from about 25 to 80 percent.[24] The North American Insulation Manufacturers Association (NAIMA) says that fiberglass insulation "typically contains 40–60 percent recycled content, depending on manufacturer and specific facility."[25] The recycled glass may be from pre- or post-consumer sources including bottle glass, window glass, automotive glass, or other industrial sources.[26] Manufacturers may also incorporate production scrap back into the manufacturing process.[27] Overall, U.S. fiberglass insulation manufacturers reported using 2.2 billion pounds of recycled glass in residential, commercial, and industrial thermal and acoustic insulation in 2019.[28]

While not a focus of this case study, it is worth noting that even though most of the direct ingredients for fiberglass are mineral-based, fossil fuels typically supply at least some of the energy required to heat the furnaces to the high temperatures required in processing.[29] Several manufacturers report using both renewable and nonrenewable energy sources. The use of recycled glass leads to a decrease in the energy required during the glass melting process.[30]

Once the fibers are formed, binders and other contents are added.[31] Renewable feedstocks may be used for some of the binder components or additives.[32] These additional chemicals are outside the scope of this case study, which focuses on the production of the glass fibers themselves. It is worth noting, however, that residential fiberglass insulation manufacturers have previously responded to calls for safer products, phasing out formaldehyde from the binders used in this type of insulation.[33]

FIGURE 2. Life cycle of glass fiber production, fiberglass insulation manufacture, installation, use, and end of life.[34] Graphic shows elements of the life cycle discussed in this case study.



When hazardous chemicals are used, they can impact people and the environment throughout their life cycle.

Chemical Hazards

In this section we consider the chemical hazards of the inputs and releases related to glass fiber production. When hazardous chemicals are used, they can impact people and the environment throughout their life cycle. Workers who extract these materials, process them, and use them to manufacture products, as well as communities near facilities where each step of the process takes place, can be impacted. See the "Worker and Fenceline Community Impacts" section for some examples of impacts.

Silica sand is composed primarily of quartz, which is one type of crystalline silica.[35] Crystalline silica in the form of quartz dust is considered by IARC to be carcinogenic to humans.[36] Respirable crystalline silica (quartz dust) is identified as an occupational carcinogen by the U.S. Centers for Disease Control and Prevention and the National Institutes of Health.[37]

Multiple different borates may be used to supply boric oxide in the final glass fibers, including sodium tetraborate pentahydrate, borax, or boric acid. These chemicals are identified as reproductive toxicants by the government of Japan.[38]

Manganese dioxide is sometimes used as an additive in glass fibers. It is a suspected developmental toxicant, according to the government of New Zealand.[39]

Mineral-based materials, like sand and others used in the manufacture of glass fibers, may contain small quantities of naturally occurring metal impurities. Releases of antimony, barium, chromium, cobalt, lead, and mercury compounds reported by fiberglass insulation manufacturing facilities may come from glass fiber raw materials and be released during the high-temperature processing of the furnace.[40] Some of these reported releases may come from other sources or from other processes taking place on site. Most of these metals or metal compounds are considered hazardous.

Chromium, lead, and mercury could also be introduced from the glass cullet. If undesirable glass streams contaminate the cullet, such as cathode ray tubes (CRTs) from old TVs, which have high levels of lead, or fluorescent light bulbs, which contain mercury, these releases may be greater.[41] Cullet processing facilities typically have equipment to test for and remove such materials from the process, although a glass industry report indicates that some fluorescent tubes are recycled into fiberglass insulation.[42] In reporting to the EPA, one insulation company attributed lead releases to the cullet used.[43]

Chromium releases may originate from the refractory bricks used in glass-melting furnaces. The periodical rebricking of these furnaces (every six months to three years) leads to large quantities of chromium compound waste, although several facilities report recycling these materials.[44]

One input chemical, sodium nitrate, is considered highly reactive, but none are highly flammable. Highly reactive chemicals can spontaneously ignite or explode on their own or in contact with water, and flammable chemicals are easily ignited and capable of burning rapidly. Chemicals that are highly reactive or flammable can contribute to the potential for incidents that can impact workers and surrounding communities. None of the inputs used to make glass fibers are volatile chemicals, which easily evaporate at normal temperatures and may increase the potential for exposure.

A more complete list of the hazards associated with each of these chemicals and glass fibers used in fiberglass insulation is given in Table 2. Descriptions of each health hazard endpoint are provided in Table 3.

Table 2. Selected chemical hazards of primary chemicals, intermediates, and releases in the manufacture of glass fibers used in fiberglass insulation.[45]

CASRN	Chemical Name	PBT	Carcinogen, Mutagen, Reproductive or Developmental Toxicant, and/or Endocrine Disruptor	Respiratory Sensitizer	Acutely Toxic Chemical	Reactive Chemical	TRI Reportable Chemical	Reported as a TRI Release by Fiberglass Facilities in the Last 5 Years
Primary Chemicals and Intermediates								
	Glass cullet							
14808-60-7	Quartz (silica sand)		x					
	Borates†		x					
497-19-8	Sodium carbonate							
1317-65-3/471-34-1	Limestone/Calcium carbonate							
1305-78-8	Lime							
68476-25-5	Feldspar			x				
7757-82-6	Sodium sulfate							
7631-99-4	Sodium nitrate					x		
16389-88-1	Dolomite							
1313-13-9	Manganese dioxide		x				x*	x*
37244-96-5	Nepheline syenite							
Releases That May Be From Glass Cullet or Mineral Inputs								
	Antimony or antimony compounds‡		x				x	x
	Barium or barium compounds‡				x	x	x	x
	Chromium or chromium compounds‡		x	x			x	x
7440-48-4	Cobalt		x	x	x		x	x
	Lead or lead compounds‡	x	x				x	x
	Manganese or manganese compounds‡		x				x	x
7439-97-6	Mercury	x	x		x		x	x
Glass Fibers Used in Fiberglass Insulation								
65997-17-3	Fiberglass, biosoluble							

None of the listed chemicals are volatile or highly flammable. (See “Chemical Hazards” text box for more information.)

* Reportable as part of manganese compounds. Releases of manganese compounds were reported in the last 5 years.

† Several different borates may be used, depending on the manufacturer, including sodium tetraborate pentahydrate (CASRN 12179-04-3), borax (CASRN 1303-96-4), or boric acid (CASRN 10043-35-3). Listed hazards are associated with one or more of these options.

‡ Where metal compounds are reported to EPA’s Toxics Release Inventory (TRI) for glass fiber manufacturing, we associate the hazards of the metal itself with the metal compounds. In the case of chromium, we use the hazards of chromium (VI), representing the worst case.

Chemical Hazards

Hazard assignments in Table 2 are based on either a full hazard assessment or on a review of health hazard lists from the GreenScreen for Safer Chemicals.[46] Hazard indicators are included for chemicals assigned a high hazard for carcinogen, mutagen, reproductive or developmental toxicant, or endocrine disruptor; a high or moderate-to-high hazard for respiratory sensitizer; and a high or very high hazard for acute toxicity. Reactivity and flammability contribute to potential safety issues with the use of these chemicals so are also indicated for chemicals with a high or very high hazard. Descriptions of each hazard are provided in Table 3.

Table 3. Human health and physical hazards and descriptions

Hazard	Description
Carcinogen	Can cause cancer or contribute to the development of cancer.
Mutagen	Can cause or increase the rate of mutations, which are changes in genetic material in cells that in some cases may be transmitted to offspring. This can result in cancer and birth defects.
Reproductive Toxicant	Can disrupt the male or female reproductive system—changing sexual development, behavior, or functions; decreasing fertility; or resulting in loss of the fetus during pregnancy.
Developmental Toxicant	Can cause harm to the developing child including birth defects, low birth weight, and biological or behavioral problems that appear over time.
Endocrine Disruptor	Can interfere with hormone communication between cells (the endocrine system), which controls metabolism, development, growth, reproduction, and behavior. Linked to health effects such as obesity, diabetes, male and female reproductive disorders, and altered brain development, among others.
Respiratory Sensitizer	Can result in high sensitivity such that small quantities trigger asthma, rhinitis, or other allergic reactions in the respiratory system. These compounds can exacerbate current asthma, and some have been shown to cause the disease itself.
Acutely Toxic Chemical	Can be fatal on contact, ingestion, or inhalation for humans and other mammals.
PBT (Persistent Bioaccumulative Toxicant)	Persistent chemicals (P) do not break down readily from natural processes. Bioaccumulative chemicals (B) build up in organisms, concentrating as they move up the food chain. Toxic chemicals (T) are associated with one or more health hazards. Chemicals considered PBTs in this analysis are those listed on select authoritative hazard lists: the EPA's National Waste Minimization Program Priority PBTs or the European Union's European Chemical Substances Information System PBT List.[47]
Reactive Chemical	May spontaneously ignite or explode on its own or in contact with water.
Flammable Chemical	Can be easily ignited and is capable of burning rapidly.
Volatile Chemical	Volatility is an indication of how easily chemicals evaporate at normal temperature and pressure. For this case study, we use the European Union definition for determining whether an organic chemical is volatile. This definition is based on boiling point: Organic compounds with an initial boiling point below or equal to 250 °C at standard atmospheric pressure (101.3 kPa) are considered volatile organic compounds.[48] Because inorganic compounds that are volatile can also be hazardous and may also have increased potential for exposures when they are volatile, we use this boiling point cutoff to identify both organic and inorganic volatile compounds. Boiling point information was collected from REACH dossiers and "An Introduction to the Rock-Forming Minerals."[49]

Manufacturing Facilities and Surrounding Communities

Facility Locations

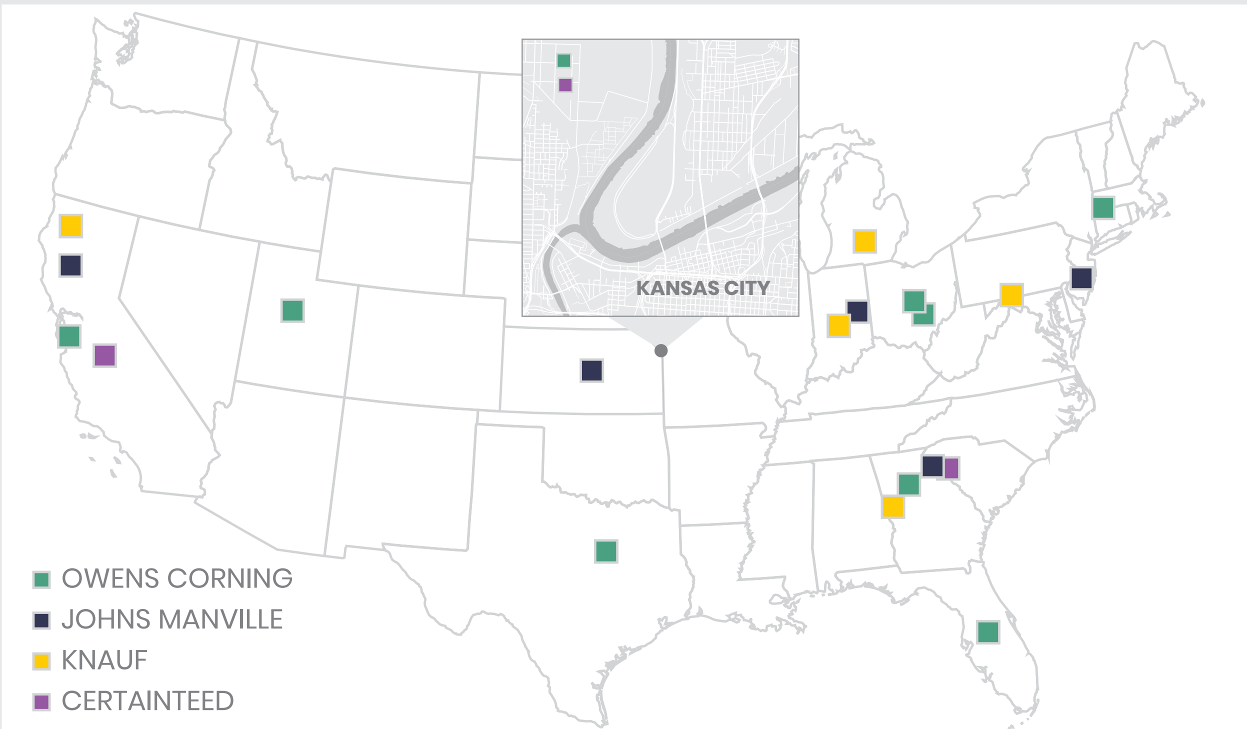
There are four major manufacturers of residential fiberglass insulation in the United States: CertainTeed, Johns Manville, Knauf, and Owens Corning.[50] We identified 22 facilities across the United States where these companies manufacture residential batt and loose fill insulation (Figure 3).[b,51] We were unable to locate publicly available information on the fiberglass or insulation production capacities of the individual manufacturers or facilities.

Community Demographic Information

A fenceline community or frontline community is a neighborhood that is located near a chemical plant, industrial facility, or distribution center and is directly affected by the noise, odors, chemical emissions, heavy duty diesel emissions, and operations of the company.[52] To understand who is living in the fenceline communities surrounding these fiberglass manufacturing facilities, we completed a demographic analysis using the EPA's EJScreen tool.[53] We considered demographic characteristics related to marginalization and biological vulnerability. Marginalized communities "are those excluded from mainstream social, economic, educational, and/or cultural life. Examples of marginalized populations include, but are not limited to, groups excluded due to race, gender identity, sexual orientation, age, physical ability, language, and/or immigration status."[54] Marginalized groups have the highest burden of chronic diseases due to the inequitable distribution of harmful environmental and social factors.[55]

For the purposes of this analysis, we considered those living within a three-mile radius of a facility to be within the fenceline zone.[c] Table 4 provides summary information on race, ethnicity, low-income population, linguistically isolated population, population under age 18, and number of schools in fenceline zones for the 22 fiberglass manufacturing facilities and for the United States overall.

FIGURE 3. Map of residential fiberglass insulation manufacturing facilities in the United States. Inset shows the two facilities located in Kansas City, Kansas.



[b] For mapping throughout this case study, facility locations are from EPA's Toxics Release Inventory and school locations are from EPA's EJScreen. Locations were mapped in Google Maps using latitude and longitude. For facilities not found in TRI, the street address was used. Report maps were generated in Illustrator based on the Google Maps. An interactive map with more exact locations is available here: https://www.google.com/maps/d/u/0/edit?mid=1tH6MyogUxH2brNou-UQx7Vwg37heD3hv&usp=sharing

[c] For fenceline demographic analysis, facility location was determined using latitude and longitude reported in the EPA's Toxics Release Inventory (TRI) for each facility appearing in the inventory. For facilities not found in TRI, the street address was used. Note that some facilities are large, and using a three-mile radius from a single point may not adequately capture the full population within three miles of all edges of the facility. There is no single recognized definition of "fenceline community," and others living, working, or going to school outside the three-mile radius may also be impacted by chemical releases. Releases to the environment may travel different distances depending on many factors, including properties of the chemical itself, wind speed, temperature, and whether it is released to air or water.

More on the EPA's EJScreen

Definitions:
Low-income population: The "population in households where the household income is less than or equal to twice the federal 'poverty level.' "

People of color: Individuals "who list their racial status as a race other than white alone and/or list their ethnicity as Hispanic or Latino."

Linguistically isolated population: People living in "a household in which all members age 14 years and over speak a non-English language and also speak English less than "very well" (have difficulty with English)."[56]

The EPA notes that there is "substantial uncertainty" in the demographic data, so this is intended as screening-level information.[57] For details on how EJScreen estimates demographics, see the EPA's EJScreen Technical Documentation.[58]

Table 4. Demographic information about residents within three miles of each glass fiber manufacturing facility compared with the United States overall

	Owens Corning									
	Fuera Bush, NY	Fairburn, GA	Newark, OH	Kansas City, KS	Santa Clara, CA	Waxahachie, TX	Mt. Vernon, OH	Lakeland, FL	Nephi, UT	U.S. Overall
Population	15,727	16,769	46,602	40,618	157,902	22,172	12,894	54,805	3,110	322,903,030
Percentage of Population										
Hispanic or Latino	2%	11%	1%	25%	19%	19%	1%	22%	7%	18%
White Non-Hispanic	91%	15%	92%	37%	32%	72%	96%	44%	89%	61%
Black or African American	2%	73%	3%	29%	3%	7%	1%	30%	0%	12%
American Indian or Alaska Native	0%	0.01%	0.05%	0.3%	0.1%	0.3%	0%	0.5%	1.0%	0.7%
Asian	3%	0.4%	1%	5%	42%	1%	0.3%	2%	0%	5%
Native Hawaiian or Other Pacific Islander	0%	0%	0%	0.02%	0.2%	0.05%	0%	0.02%	0%	0.2%
Other Race	0%	0.1%	0.04%	0.1%	0.2%	0.2%	0%	0.5%	0%	0.2%
Two or More Races	2%	1%	4%	3%	4%	1%	2%	1%	4%	2%
People of Color	9%	85%	8%	63%	68%	28%	4%	56%	11%	39%
Low-Income	9%	37%	45%	52%	18%	24%	36%	55%	24%	33%
Linguistically Isolated	0%	2%	0%	9%	9%	2%	1%	5%	4%	4%
Under 18 Years Old	22%	31%	22%	26%	18%	24%	23%	23%	34%	23%
Number of Schools	4	3	15	17	25	10	7	17	1	

Orange highlights in table 4 indicates where the percentage of historically marginalized populations in the fenceline zone is greater than in the nation as a whole. The ACS reports both on race (white, Black, Asian, American Indian or Alaska Native, Native Hawaiian or other Pacific Islander, other race, or two or more races) and on ethnicity (Hispanic or Latino). Hispanic or Latino individuals will also fall into one or more of the race categories. To avoid double-counting individuals, this table includes individuals reporting Hispanic or Latino in the row for Hispanic or Latino. Individuals reporting non-Hispanic or Latino are included in the subsequent rows. See text box, "More on the EPA's EJScreen," for definitions of people of color, low income, and linguistically isolated populations. *Sources: EPA's EJScreen and U.S. Census Bureau American Community Survey five-year estimates for 2014–2018.*[59]

Table 4. (continued) Demographic information about residents within three miles of each glass fiber manufacturing facility compared with the United States overall

	Knauf					CertainTeed			
	Shelbyville, IN	Shasta Lake, CA	Albion, MI	Lanett, AL	Inwood, WV	Athens, GA	Chowchilla, CA	Kansas City, KS	U.S. Overall
Population	21,936	19,330	10,326	14,036	11,748	25,520	9,493	47,242	322,903,030
Percentage of Population									
Hispanic or Latino	7%	10%	7%	4%	5%	16%	61%	30%	18%
White Non-Hispanic	88%	78%	62%	48%	84%	40%	28%	35%	61%
Black or African American	2%	1%	26%	44%	8%	41%	2%	27%	12%
American Indian or Alaska Native	0.2%	3%	1.0%	0.2%	0%	0.2%	1%	0.2%	0.7%
Asian	1%	2%	1%	2%	1%	1%	4%	5%	5%
Native Hawaiian or Other Pacific Islander	0%	0.01%	0%	0%	0%	0.03%	1%	0.1%	0.2%
Other Race	0.3%	0%	0%	0%	0%	0%	0%	0.1%	0.2%
Two or More Races	1%	5%	4%	1%	1%	2%	3%	3%	2%
People of Color	12%	22%	38%	52%	16%	60%	72%	65%	39%
Low-Income	36%	42%	57%	50%	26%	70%	43%	53%	33%
Linguistically Isolated	1%	0%	0%	1%	0%	6%	8%	10%	4%
Under 18 Years Old	24%	21%	24%	21%	23%	20%	29%	26%	23%
Number of Schools	8	11	3	6	1	5	6	21	

	Johns Manville					
	Berlin, NJ	McPherson, KS	Richmond, IN	Willows, CA	Winder, GA	U.S. Overall
Population	32,357	9,048	34,610	232	16,818	322,903,030
Percentage of Population						
Hispanic or Latino	8%	5%	5%	20%	9%	18%
White Non-Hispanic	63%	89%	82%	74%	72%	61%
Black or African American	21%	1%	8%	1%	10%	12%
American Indian or Alaska Native	0.02%	0.04%	0.1%	3%	0.1%	0.7%
Asian	5%	1%	1%	0%	5%	5%
Native Hawaiian or Other Pacific Islander	0%	0%	0%	0%	0%	0.2%
Other Race	0.1%	0%	0.1%	0%	0%	0.2%
Two or More Races	3%	3%	3%	2%	3%	2%
People of Color	37%	11%	18%	26%	28%	39%
Low-Income	19%	30%	46%	29%	38%	33%
Linguistically Isolated	1%	0%	1%	1%	2%	4%
Under 18 Years Old	24%	23%	22%	22%	26%	23%
Number of Schools	10	5	12	0	6	

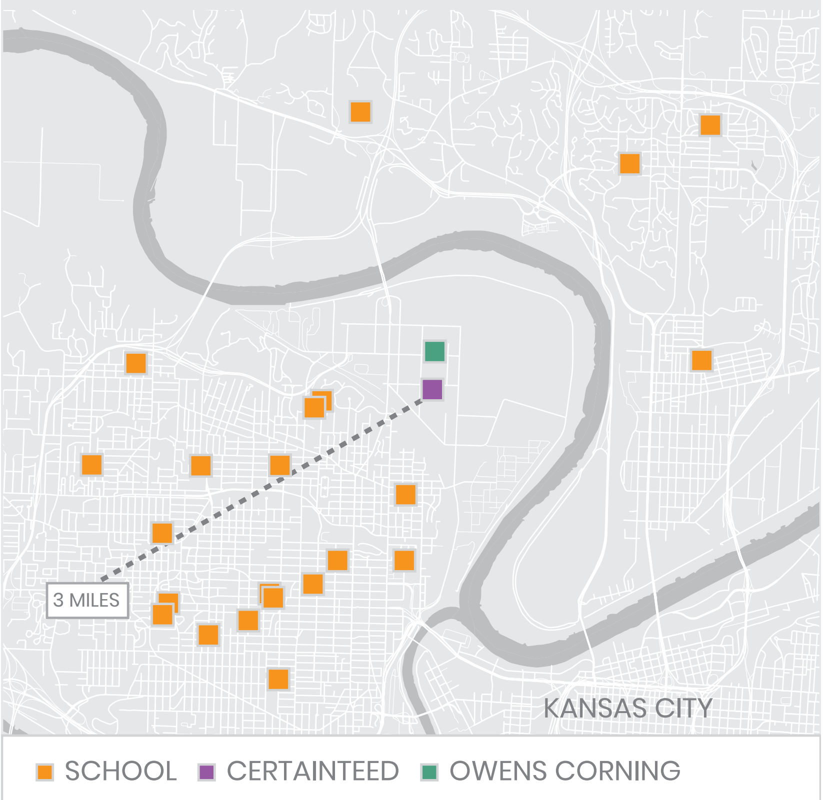
The majority of the glass fiber manufacturing facilities are located in or near communities with percentages of Black, Latino, Asian, and/or American Indian or Alaska Native populations greater than in the United States overall. Fourteen of the 22 facilities are in communities with a greater percentage of low-income people than the nation as a whole.

Nearly half of the fenceline communities also have a greater percentage of children than in the United States overall. This is a particular concern when hazardous chemicals are released; while we are all impacted by chemical exposures, children are biologically vulnerable—they are affected more than adults due to their smaller size and their still-developing bodies.[60] All but one of the 22 facilities have at least one school located in close proximity, so when hazardous chemicals are released, school-age children may be exposed both where they live and where they learn (Figure 4).

The 22 facilities are spread out over 13 states, and there can be significant regional variations in demographics among states and locales. Comparing fenceline zone demographics with more localized demographic data can highlight disparities in addition to those observed on a national level. For example, some states have a higher percentage of people of color than the national average, but fenceline communities within these states have even higher proportions of people of color. In other cases, a fenceline community has a percentage of people of color that is lower than the nation overall but much higher than the statewide average, indicating additional disparities not visible through the national perspective. See Appendix 2 for more information about state demographics.

We also compared the combined demographics of the fenceline communities across all 22 facilities with those of the United States overall to get a broader understanding of who may be impacted by glass fiber manufacturing. Because the two Kansas City facilities are so close together, some individuals are included in both fenceline zones; therefore the following information is approximate. Around 600,000 people live in the fenceline communities that surround the 22 facilities. In

FIGURE 4. Location of CertainTeed and Owens Corning facilities in Kansas City, Kansas, and of 22 schools within a three-mile radius of one or both facilities.



Source: EPA's EJScreen

The majority of the glass fiber manufacturing facilities are located in or near communities with percentages of Black, Latino, Asian, and/or American Indian or Alaska Native populations greater than in the United States overall. Fourteen of the 22 facilities are in communities with a greater percentage of low-income people than the nation as a whole.

total, these areas have a higher percentage of people of color (around 45 percent), low-income population (around 36 percent), and linguistically isolated people (around 5 percent) than the United States overall.

Manufacturing Releases, Waste, Pollution Prevention, and Compliance

During the glass fiber manufacturing process, facilities use and generate hazardous chemicals that may be emitted to air or discharged to water (i.e., released) or collected for recycling or waste disposal. For some of these chemicals, facilities must annually report the quantities that are released, recycled, or disposed of to the EPA through the Toxics Release Inventory (TRI) program.[61] Most of the primary materials used in glass fiber manufacture do not require reporting through TRI (see Table 2). The exception is manganese dioxide, which is not reported individually but must be reported as part of manganese compounds.[d] Several metal and metal compounds may be present as impurities in the raw materials and may be emitted during manufacturing; these too must be reported through TRI. The program also collects and records pollution prevention activities to identify effective environmental practices and highlight successes in reducing pollution.[62] TRI data are publicly available and were used for the following analysis.

Compliance with EPA regulations is also publicly reported for facilities and is discussed below as well. The amounts of hazardous chemical releases and waste, actions taken to reduce pollution, and whether a facility is in compliance with environmental regulations all contribute to the impacts these facilities have on neighboring communities and the broader environment.

Releases to Air and Water

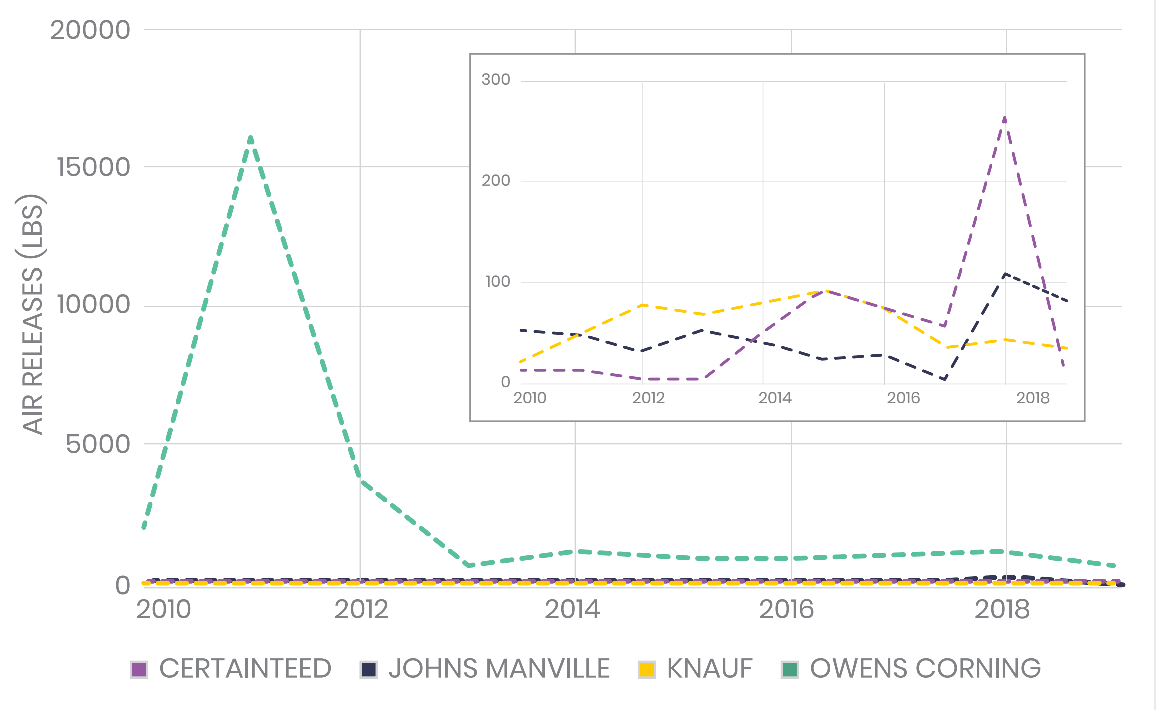
We analyzed the TRI releases reported by the 22 fiberglass insulation manufacturing facilities identified in Figure 3. Because these facilities produce other things in addition to glass fibers, their TRI reporting may include releases attributable to these other processes. To focus on impacts tied to glass fiber production specifically, we analyzed only those chemicals that are known to be an intentional part of glass fiber manufacturing or that may be present as impurities in the raw materials and released during processing—those listed in Table 2.

There are several limitations to this approach. First, it may not eliminate all the releases associated with other manufacturing processes at the facility. Second, TRI reporting requirements do not include all toxic chemicals used in the United States, and chemicals must be reported only when they are released above established thresholds. Consequently, there may be additional releases attributable to glass fiber manufacturing that are not included in our analysis. Also, releases are not directly comparable across facilities in terms of pollution per a given output of glass fibers because facilities may have different production capacities. However, greater amounts of hazardous releases, regardless of production volume, can still translate to greater overall impacts on surrounding communities and the environment. Finally, since releases are self-reported by facilities, there may also be variations in how different manufacturers account for and report releases.

The analysis in this section is focused on the production of glass fibers, but communities are also impacted by releases of hazardous chemicals related to other activity at the same facilities. We consider this in the "Communities and Cumulative Impacts" section below.

[d] TRI defines manganese compounds as "any unique chemical substance that contains manganese as part of that chemical's infrastructure."

FIGURE 5. Combined air releases for 10 glass fiber–related chemicals or chemical groups (antimony compounds, barium compounds, chromium, chromium compounds, cobalt, lead, lead compounds, manganese, manganese compounds, and mercury) reported to the EPA (2010–2019). Combined release amounts for Owens Corning facilities were significantly higher in 2011 and remain somewhat higher than other manufacturers' facilities, so are shown on a different scale. Release amounts are not directly comparable between facilities.



Source: EPA Toxics Release Inventory.

Only one pound of glass fiber–related releases to water was reported, so this analysis focuses on air releases. The total air releases of glass fiber–related chemicals from each manufacturer each year are shown in Figure 5. The chemicals and quantities of those chemicals released varied between facilities and from year to year. For CertainTeed, Johns Manville, and Knauf, the reported releases were typically below 100 pounds per year, with an occasional spike. Owens Corning reported more total annual releases than did the other manufacturers. A spike in releases from Owens Corning occurred in 2011, totaling just over 16,000 pounds. This included air releases of almost 4,000 pounds of lead from its Newark, Ohio, facility; almost 7,800 pounds of manganese compounds from its plant in Waxahachie, Texas; more than 2,600 pounds of manganese from its facility in Fairburn, Georgia; and more than 1,000 pounds of manganese compounds from its Santa Clara, California, plant. Owens Corning has reported lower releases over the past several years, around 1,000 pounds annually in total, but this is still higher than the amount reported by other manufacturers. The spike in lead releases may have been tied to glass cullet quality. It is not clear, based on publicly available data, whether the higher releases by Owens Corning were related to greater glass fiber production volume, other processes, variations in reporting, or other factors. From 2015 through 2019, the 22 facilities reported releasing a collective average of 1,200 pounds per year of glass fiber–related chemicals to air and water. See Appendix 3 for the reported releases of chemicals of interest in 2019 from each facility and for each manufacturer.

Figure 6 shows the summed releases over a five-year period for all facilities combined for the glass fiber–related chemicals with the highest releases. The largest releases to the air between 2015 and 2019 were manganese or manganese compounds—with more than 4,700 pounds released—followed by lead or lead compounds and chromium or chromium compounds. Less than 10 pounds each of antimony or antimony compounds, cobalt, mercury, and barium or barium compounds were reported within this time frame for all facilities combined.

Waste

The manufacture of glass fibers generates hazardous chemical waste.[e] Chemicals released on site to the air and water, discussed in the previous section, are considered waste because they are not used for their intended purpose. Waste reported through TRI also includes chemicals released to land (e.g., to landfills), recycled, or otherwise disposed of either on or off site. The above analysis highlights air and water releases specifically because there is a greater potential for exposure from these releases than from other on-site waste management practices, but all hazardous chemical waste can result in exposure and is an indication of inefficiencies within the system.

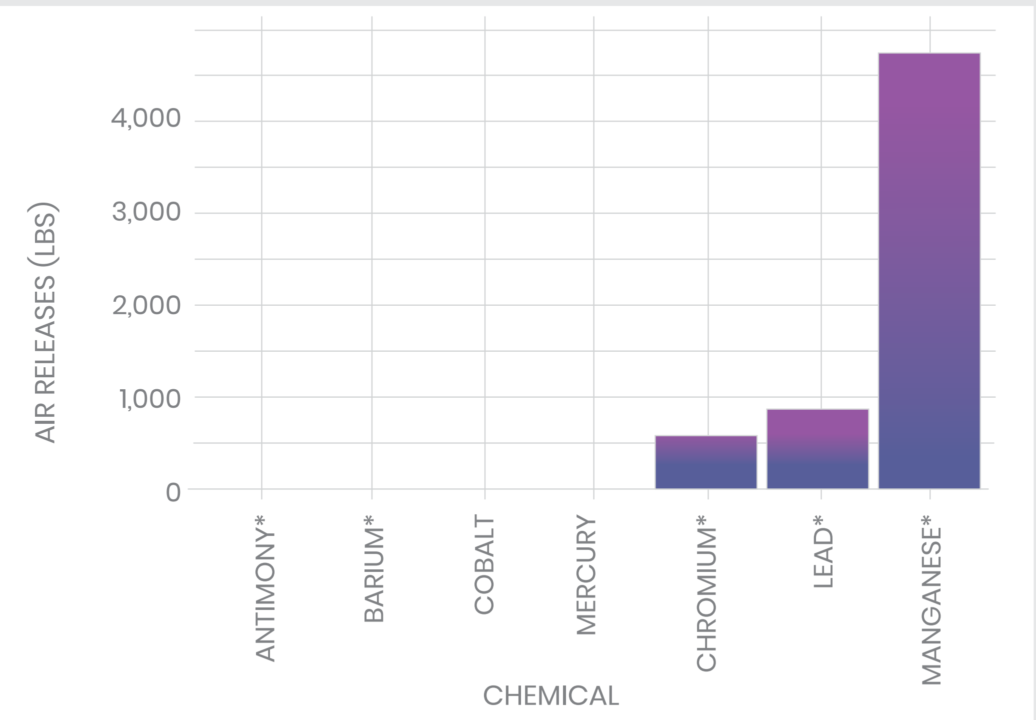
Releases and disposal of TRI-reportable chemicals must be disclosed to the EPA along with the type of release or disposal method. Disposal methods include landfill, injection into underground wells, energy recovery, and treatment.[63] *Energy recovery* means that the chemical is burned to generate heat or energy for use at the facility.[64] *Treatment* often means incineration, though it can include other methods meant to destroy the toxic chemical.[65] Burning of hazardous chemicals can lead to additional hazardous releases.[66]

The following analysis is based on waste data reported through TRI for the glass fiber–related chemicals listed in Table 2. Some of this waste may be attributable to other materials or processes; for example, lead and mercury waste may stem from the use of asphalt at some facilities.[67]

From 2015 through 2019, about 60–75 percent of the total hazardous chemical waste related to glass fiber production generated at the 22 facilities was reported as recycled on or off site. Figure 7 shows the average annual waste that was recycled, disposed of off site, or released or disposed of on site during this time period for all the facilities combined. Chemicals reported as recycled are excluded from the rest of this analysis, although some material sent for recycling may also end up as waste.

From 2015 through 2019, the 22 facilities collectively released or disposed of an average of more than 1,174,000 pounds of glass fiber–related chemicals every

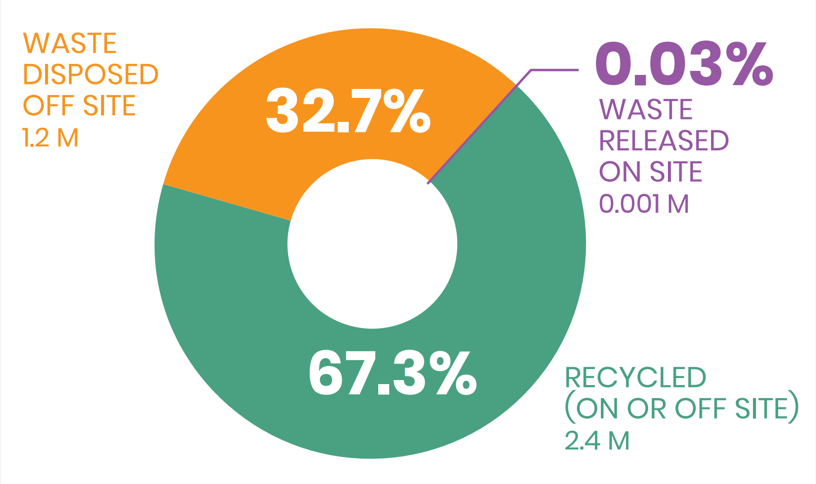
FIGURE 6. Total releases of glass fiber–related chemicals to air for all 22 facilities, 2015–2019. The chemicals with the highest releases are included. *Includes both the metal and its compounds.



Source: EPA Toxics Release Inventory.

e *Hazardous waste* is legally defined by the Resource Conservation and Recovery Act (RCRA). We use the term "hazardous chemical waste" to mean hazardous chemicals that are disposed of as waste. Some types of hazardous chemical waste may meet the legal definition of "hazardous waste"; others may not.

FIGURE 7. Average annual glass fiber-related chemicals recycled, disposed of off site, and released on site (including disposal) in millions of pounds for all 22 facilities, 2015-2019.



Source: EPA Toxics Release Inventory.

year. The facilities individually reported between zero and about 525,000 pounds of glass fiber–related waste in a given year. Most of this waste was transferred off-site for disposal, with an average of about 1,200 pounds per year being released or disposed of on site for all facilities combined. Almost all of the on-site releases or disposal (99–100 percent) were the releases to air reported in the prior section. No on-site injection well disposal, treatment, or incineration of the glass fiber–related chemicals was reported. See Appendix 3 for facility-specific waste information.

Almost all of the facilities reported transfers of glass fiber–related chemicals to waste facilities for disposal, extending the potential impact of chemical waste to communities surrounding these facilities. See the "Tracing the Supply Chain" section for more information on off-site transfers.

Pollution Prevention

Under the TRI program, the EPA also collects information on pollution prevention measures reported by facilities.[68] All of the facilities considered in this analysis have reported such measures, most with some pollution reductions since 2014. Many reported measures are related to increased recycling of materials containing lead compounds, manganese compounds, or chromium compounds that otherwise would have been scrap. This includes recycling of chromium-containing refractory bricks when furnaces are rebuilt.

Pollution prevention related to the binder used in fiberglass batt insulation was reported by all four manufacturers. For example, there was a reduction in releases of formaldehyde, a carcinogen, from these facilities as they switched binder formulations between 2002 and 2015.[69]

Compliance

The EPA reports data on facility compliance with environmental regulations related to clean air, clean water, and hazardous waste for the most recent 12 quarters (3 years).[f,70] Some of the fiberglass insulation manufacturing facilities show a history of noncompliance with one or more of these regulations in the 12 quarters as of July 2022. Nine facilities had significant violations during this period, as shown in Table 5. Of these nine facilities, seven are located in communities disproportionately made up of people of color, low-income populations, and/or those who are linguistically isolated, and three have disproportionately high percentages of all three of these marginalized populations. Two are located in Kansas City, Kansas, within about half a mile of each other. The community surrounding these Kansas City facilities has a percentage Black population more than twice that

f These regulations include the Clean Air Act, Clean Water Act, and Resource Conservation and Recovery Act. Noncompliance can only be discovered by EPA inspections and enforcement, but the EPA lacks resources to conduct these activities and cannot inspect all facilities. Therefore, quarters without violations may simply reflect a lack of inspection and do not necessarily mean a facility is in compliance. When violations are identified, they may be corrected by the facility without formal enforcement action; more serious or continuing violations may result in formal administrative orders, fines, or judicial cases.

of the United States overall and a percentage Latino population 1.5 times that of the nation overall. This community is also disproportionately low income (about 52 percent compared with 33 percent in the United States overall) and disproportionately linguistically isolated (about 9 percent compared with 4 percent in the nation overall). Twenty-two schools are located within a three-mile radius of one or both Kansas City facilities (Figure 4).

No noncompliance or violations were reported for the following facilities for the most recently reported 12 quarters at the time of analysis: Owens Corning in Mt. Vernon, Ohio, Delmar, New York, and Nephi, Utah; Knauf in Shasta Lake, California; and Johns Manville in McPherson, Kansas. Other facilities have some noncompliance, but no significant violations reported in the last 12 quarters.

EPA regulations can help protect communities, workers, and the environment from dangerous pollution and chemicals. Although the violations described above may or may not be related to glass fiber production specifically, they suggest a concerning pattern at these facilities of disregarding these important safeguards.

Worker and Fenceline Community Impacts

Facilities' use, release, and disposal of hazardous chemicals affect both workers and communities. Releases occur during regular manufacturing as well as during nonroutine events such as equipment failures or weather-related incidents. These events can lead to even higher levels of exposure for workers and communities and disrupt daily life for residents. The next sections consider some of the impacts of releases on workers and fenceline communities tied to glass fiber manufacturing.

Workers

Hazardous chemicals in manufacturing can expose workers on the job. As noted above, glass fibers used in fiberglass insulation are not themselves considered hazardous to humans, but exposure to glass fiber dust may cause irritation to the skin, eyes, nose, and throat and may cause difficulty breathing.

Some of the primary chemicals and intermediates used to produce glass fibers for insulation carry greater health hazards than others. As noted above, occupational exposure to quartz in the form of respirable crystalline silica through inhalation is associated with cancer; it may also cause silicosis, a lung disease.[72] An industrial hygiene survey of the Kansas City, Kansas, Owens Corning facility conducted by the National Institute for Occupational Safety and Health (NIOSH) in the early 1970s reported hazardous exposure to silica.[73] This does not imply that unsafe silica exposure is common at these facilities, but rather illustrates the potential for respirable crystalline silica exposure during glass fiber manufacturing. Personal protective equipment and engineering controls like ventilation may be employed to reduce worker exposures, but each of these measures can fail through user error or malfunction. Eliminating the use of hazardous chemicals is the most effective means of protection.[74]

Table 5. Facilities with significant violations of EPA regulations for the most recent 12 quarters as of July 2022[71]

Manufacturer	Location	Number of Quarters With Significant Violations
CertainTeed	Kansas City, KS	9 of 12
	Chowchilla, CA	12 of 12
Johns Manville	Richmond, IN	5 of 12
Knauf	Inwood, WV	12 of 12
	Lanett, AL	1 of 12
	Albion, MI	10 of 12
Owens Corning	Kansas City, KS	5 of 12
	Waxahachie, TX	4 of 12
	Santa Clara, CA	12 of 12

The risk-based regulatory system...fails to prevent the accumulation of substantial harms to communities.

Other potential occupational hazards during glass fiber manufacturing include dust exposure and dust explosion or fire, which are possible when dust is not controlled properly during insulation manufacturing. No instances tied to glass fiber manufacture itself were identified in this study, but there have been occasional dust fires or explosions related to binders or other insulation ingredients.[g, 75]

Overall, worker exposure to some hazardous chemicals is possible during manufacturing of glass fibers. We did not identify any worker incidents related to glass fiber manufacturing.

Communities and Cumulative Impacts
Consistent releases of hazardous chemicals to air and water, as discussed above, can impact communities neighboring facilities where they are released.

While the impacts of specific processes and facilities discussed above are important to consider, it is also imperative to understand the total, *cumulative impacts* experienced by communities near glass fiber plants—that is, the total harm resulting from a combination of stressors over time. U.S. policies have largely failed to evaluate, mitigate, or prevent cumulative impacts. In the United States, communities of color and low-income communities are disproportionately affected by environmental pollutants.[76] They often face hazards from multiple sources due to high concentrations of industrial facilities, contaminated sites, traffic, and other sources of pollutants near their homes. At the same time, these communities disproportionately experience other stressors tied to poor health outcomes, such as poverty, lack of access to adequate health care, racial discrimination, and additional factors related to the social determinants of health.[77] A community experiencing cumulative impacts may be identified as an overburdened, disadvantaged, and/or an environmental justice community in local, state, or federal policies. For example, New Jersey state law defines an overburdened community as a census block group in which a certain percentage of households are low income or have limited English proficiency, or a certain percentage of residents are minority or tribal members.[78]

The risk-based regulatory system generally considers one chemical at a time, or one facility at a time, in isolation from the real-world context in which it exists—such as proximity to many other sources of hazardous pollutants. This approach fails to prevent the accumulation of substantial harms to communities.[79]

In the following analysis, we consider additional environmental releases not related to glass fibers that affect the communities surrounding glass fiber manufacturing facilities to provide some information on cumulative impacts. However, we did not conduct a comprehensive analysis of the many other stressors that cumulatively affect community health.

First, the glass fiber manufacturing facilities themselves may release hazardous chemicals from other processes performed there. Eight of the glass fiber manufacturing facilities in this study each released more than 100,000 pounds of all TRI-reported chemicals, not just those related to glass fiber manufacturing, to the air and water in 2019 (see Appendix 3 for more details). All but one of these facilities are located in a community with a disproportionately high percentage of low-income people. Four are in communities with a percentage Black population 2 to 3.5 times that of the United States overall, and two have a greater proportion of American Indian or Alaska Native individuals than the nation overall.

Second, there may be releases from other facilities located in these communities, contributing to the overall environmental and health impacts for residents. Most of the cities where fiberglass insulation manufacturers are located are home to at least one other TRI-reporting facility (see Appendix 3 for more details). These facilities release up to a dozen chemicals that the EPA identifies as known or suspected carcinogens, including ethylbenzene, naphthalene, and ethylene oxide, in addition to lead compounds and chromium

[g] Dust explosions in the industry are very rare, but combustible dust may be a concern for fiberglass insulation manufacturers depending on the type of insulation produced and chemicals used. In 2003 an explosion at an acoustic and thermal fiberglass insulation plant (CTA Acoustics, Inc., in Corbin, Kentucky) killed 7 and injured 37 workers when combustible phenolic resin dust ignited. In 2016 Owens Corning's Delmar, New York, facility was cited by OSHA for what appears to have been a dust-related fire originating in the equipment that attaches facer materials to the insulation.

FIGURE 8. Glass fiber–related releases to air and water, all releases from glass fiber facilities to air and water, and all releases in the cities where glass fibers for fiberglass insulation are produced.*

* Some releases are not visible on this scale. See Appendix 3 for details. Source: EPA Toxics Release Inventory.

compounds, which are also associated with glass fiber manufacturing.

Kansas City, Kansas, has the most TRI facilities at 29 (two of which are the fiberglass manufacturing sites considered in this case study) and saw more than 1.2 million pounds of hazardous chemical releases to the air, water, and land in 2019. Athens, Georgia; Richmond, Indiana; Lakeland, Florida; Waxahachie, Texas; and Santa Clara, California, all have 10 or more TRI facilities and total releases ranging from nearly 6,000 pounds to almost 490,000 pounds. Figure 8 shows the reported releases to the air and water of glass fiber–related chemicals and all TRI-reportable chemicals from glass fiber facilities, as well as the total releases reported for TRI facilities in each city considered in this case study.

TRI data for the last five years generally show relatively stable total on-site releases for most of these cities. Inwood, West Virginia, and Willows, California, did see a dramatic increase of on-site releases in 2018 and/or 2019, and releases in Shelbyville, Indiana, have been trending upwards over time.

Spotlight: CleanAirNow, Kansas City

By: Beto Lugo-Martinez

CleanAirNow (CAN) is an environmental justice organization in Kansas City taking action to bring systemic change in industry and government policies and practices to protect health and to advance justice.[h] It brings attention to the environmental racism and inequity that perpetuates the unequal distribution of environmental pollution and health hazards in "fenceline" communities. The mission of CAN is to improve air quality in the Kansas City region, particularly in the overburdened communities suffering the greatest environmental health risks associated with cumulative pollution exposure. CAN is a community-driven organization building power through environmental health education, community-based participatory research, community-led solutions in public policy that bring a direct benefit to those most harmed by environmental injustices.

> "It all starts with the frontline communities—especially the people that have little to no income, people of color, women, children, and the elderly. People need to be aware of the environmental problems so they can hold people in power accountable. We as everyday people have to be able to say this is not right and have to call them out."
>
> — Magali Rojas, Kansas City, Missouri, community member

CAN's 2021 report, "Environmental Racism in the Heartland," outlines the multiple environmental health threats and cumulative impacts faced by the Kansas City community, including from the CertainTeed facility.[i] As a result of a legacy of systemic racism, communities of color and low-income communities in Kansas City face a greater risk of exposure to environmental hazards. These hazards are associated with myriad negative health outcomes including cancer, respiratory illness, and shorter life expectancy. The Kansas City community is experiencing cumulative exposures to hazardous pollutants from heavy freight and diesel-powered transportation and industrial emissions, and current policies are failing to keep people safe from harm. The local environmental justice movement, however, has been working to address these inequities through the establishment of an air monitoring network that provides real-time, local data that people can use to advocate for science-based protections. Local, state, and federal decisionmakers must take note of industry's environmental impacts throughout the city, engage the community in decision-making, and address systemic environmental justice concerns in Kansas City and across the country.

It is common for many members of overburdened communities to be employed by the same industries that are poisoning their families. Combined with a lack of economic resources and unjust policy making, these overburdened communities continue to face significant barriers to their overall health, livelihood, and sustainability.[80]

> "Decisionmakers should value community input and draw on local community-based solutions that are practical and effective. Taking into account community values and understanding the environmental impacts we face builds trust within the community. Once they have earned the community's trust and support, decisionmakers can start making meaningful change that is community-informed, rather than prioritizing their own agendas."
>
> — Atenas Mena, Kansas City, Missouri, CAN Co-Executive Director

[h] http://cankc.org/
[i] https://doi.org/10.47923/2021.14322

TRACING THE SUPPLY CHAIN

Chemical impacts can occur throughout the glass fiber and fiberglass insulation manufacturing supply chains. Though not the focus of this study, extraction and processing of mined or quarried materials can have significant impacts on surrounding communities.[81] Glass fibers are made as part of the fiberglass insulation manufacturing process, so there is no transfer of this material from one facility to another for production of insulation materials. Hazardous chemical waste generated in this process can be transferred to landfills or recycling facilities. At each stage of the supply chain, releases and impacts on surrounding communities are possible. In general, the lack of transparency and traceability within supply chains precludes a full understanding of these impacts. Below, we provide examples tracing the movements of an input material and of waste.

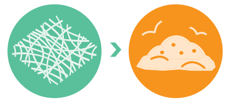
Feedstock for Glass Fiber Manufacture

One of the primary feedstocks for glass fiber manufacturing is glass cullet. Glass collected for recycling ends up at glass processing plants.[82] At these facilities, broken glass is sorted and washed to remove unwanted materials like dirt, metal, paper, and plastic.[83] It is typically also screened to separate out glass with high levels of heavy metals like lead, then crushed to the desired size.[84] There are 63 glass processing plants distributed across 30 states in the United States.[85] The largest cullet supplier is Strategic Materials, Inc., with around 40 facilities; most other cullet suppliers have only one or two locations.[86]

If a glass recycling facility processes materials with high levels of heavy metals, such as CRTs from old TVs (containing lead) or fluorescent light bulbs (containing mercury), dust from this processing can contaminate other types of glass that may be used for making glass fibers. Workers and local communities can also be impacted. For example, in 2012, OSHA cited Dlubak Glass Company in Upper Sandusky, Ohio, a facility that does process CRT glass, for 15 violations.[87] Many of these violations were related to worker lead exposure from processing CRTs and cleaning up debris, including "willful and repeat" violations and "failing to maintain a lunch room free from lead dust and residue."[88] OSHA also cited the company for not providing changing rooms with separate storage for street clothes and work clothes and for not providing shower facilities for workers to use at the end of shifts.[89] This means workers could also bring lead contamination home with them, exposing children and other family members.[90] Dlubak's website notes that it has inventories of automotive and window glass as well as container glass for use in fiberglass.[91] It is not clear whether any of the fiberglass manufacturers included in this report currently source glass cullet from Dlubak. The Upper Sandusky plant is the only Dlubak facility that reports recycling CRTs.[92] The population in the fenceline zone of this facility is primarily white, with a higher percentage of low-income population than in the United States overall. There are five schools within three miles of this plant (see Table 6, and for more detail see Appendix 3).

Ripple Glass supplies recycled glass from its processing facility in Kansas City, Missouri, to Owens Corning's fiberglass insulation plant in Kansas City, Kansas.[93] It does not accept televisions or light bulbs.[94] Ripple Glass was cited by OSHA for two serious violations in 2014, but none related to hazardous chemical or material exposures were identified.[95] The population within three miles of this glass processing facility has a larger percentage of Black and Latino individuals than in the United States overall, and also larger shares of low-income and linguistically isolated people.

Strategic Materials reports supplying recycled glass to all four U.S. fiberglass insulation manufacturers.[96] Many of the fiberglass insulation facilities in this case study likely source glass cullet from Strategic Materials, given that the company is the largest cullet supplier in the nation and has locations relatively close to most of the fiberglass plants.[97] Strategic Materials does not accept CRT glass or light bulbs.[98]



Waste Transfers From Glass Fiber and Insulation Manufacturing

All 22 fiberglass manufacturing sites report transfers of glass fiber–related chemicals for disposal and/or recycling. Landfills used for disposal are in a range of locations including Texas, Ohio, Oklahoma, and Alabama. When hazardous chemicals are transported and disposed of, additional releases are possible, and communities in proximity to landfills are impacted.[100]

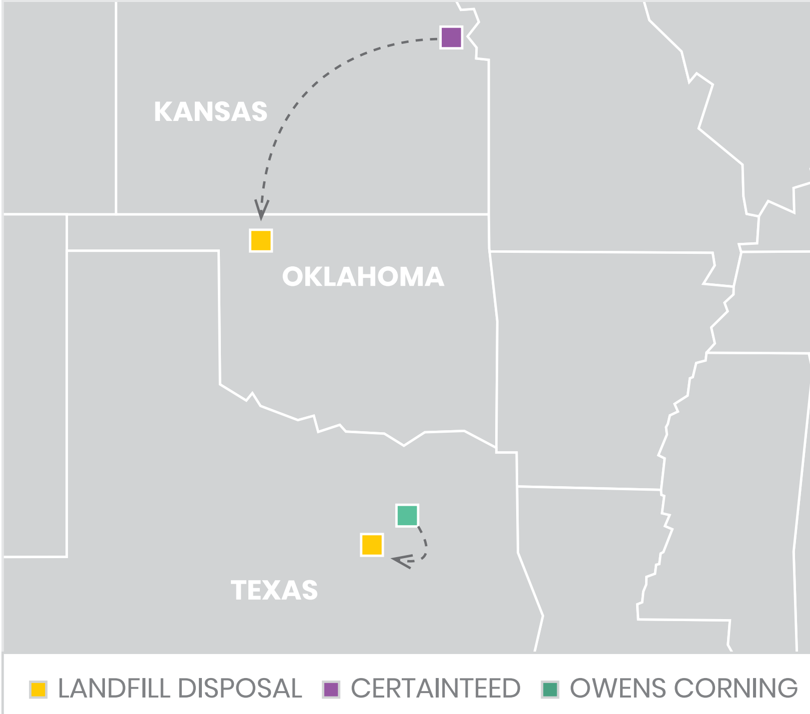
The two facilities that reported the largest quantities of glass fiber–related chemical waste in 2019 (excluding recycling) were CertainTeed in Kansas City, Kansas, and Owens Corning in Waxahachie, Texas. All or almost all of the waste from these facilities in 2019 was transferred off site for disposal. For example, the Waxahachie facility sent most of its glass fiber–related hazardous chemical waste—almost 296,000 pounds of it—to IESI Turkey Creek Landfill in Alvarado, Texas. The majority of this waste was manganese compounds, but it also included antimony compounds, chromium and chromium compounds, lead compounds, and cobalt. Most of the waste reported by CertainTeed in Kansas City in 2019—525,100 pounds

Table 6. High-level demographic information for residents within three-mile radius of example facilities that are part of the glass fiber life cycle, compared with the United States overall

	Dlubak Glass	Ripple Glass	Clean Harbors Lone Mountain	IESI Turkey Creek Landfill	U.S. Overall
Location	Upper Sandusky, OH	Kansas City, MO	Waynoka, OK	Alvarado, TX	
Function in Supply Chain	Glass Cullet Supplier	Glass Cullet Supplier	Landfill	Landfill	
Fenceline Communities					
People of Color	6%	64%	12%	19%	39%
Low Income	39%	63%	21%	29%	33%
Linguistically Isolated	1%	9%	0%	2%	4%
Number of Schools	5	20	0	2	

Orange highlights indicate percentages of historically marginalized populations that exceed national figures. See text box, "More on the EPA's EJScreen," for definitions of people of color, low income, and linguistically isolated populations. Demographic breakdown of race and ethnicity can be found in Appendix 3. *Sources: EPA's EJScreen and U.S. Census Bureau American Community Survey five-year estimates for 2014–2018.*[99]

FIGURE 9. Example movement of waste within the glass fiber supply chain.



Source: EPA Toxics Release Inventory

of chromium—was transferred to Clean Harbors Lone Mountain Landfill in Waynoka, Oklahoma. Only 25 people live within three miles of the Clean Harbors Lone Mountain facility. However, more than 2,700 people live within three miles of the IESI landfill, and the percentage of American Indians or Alaska Natives living near IESI is more than twice the proportion in the United States overall. There are two schools within three miles of this facility (Table 6 and Appendix 3). Figure 9 maps these examples of waste movement in the glass fiber supply chain.

Installation and Use Phase

While this case study is focused on chemical impacts outside of the use phase, chemical hazards and impacts also occur during installation and use. Installers may be exposed to glass fibers that can cause eye, skin, or lung irritation. Fiberglass insulation commonly contains a small amount of de-dusting oil to keep dust levels low. These oils can be carcinogens. Some types of fiberglass insulation may include additional hazardous content. For example, batts or boards with flame-retardant facings, such as foil-scrim-kraft (FSK) or all-service jacket (ASJ), can contain hazardous flame retardants including antimony trioxide and/or halogenated flame retardants.[101]

For additional information on a range of chemicals used in fiberglass insulation, their associated health hazards, and potential impacts during use, see the Energy Efficiency for All publication *Making Affordable Multifamily Housing More Energy Efficient: A Guide to Healthier Upgrade Materials.*[102]

INSTALLERS › USE PHASE IN BUILDING

END OF LIFE OF FIBERGLASS INSULATION

End-of-Life Scenarios

Fiberglass insulation products are intended to last the lifetime of a building, or about 75 years.[103] One manufacturer indicates that fiberglass insulation could be reused if it remains clean and dry; another acknowledges that there are currently no scenarios for reuse of these products at the end of life.[104]

In addition, no formal recycling programs for fiberglass insulation currently exist in the United States, and when removed from a building, fiberglass insulation materials are typically landfilled.[105] Since glass fibers used in building insulation are not hazardous, exposure during landfilling is not a concern, but other components of fiberglass insulation may be released when products are landfilled. These include polycyclic aromatic hydrocarbon impurities in asphalt-based adhesives that are sometimes used to adhere facing materials, and halogenated flame retardants that may be used in some flame-retardant facings. In addition, fires in landfills, or any other uncontrolled burning of halogenated flame retardants, can produce highly hazardous chemicals such as halogenated dioxins and furans.[106] Burning of binders may also release chemicals of concern (see "Building Fires" section, below).

Glass fibers could theoretically be recycled if fiberglass insulation were recovered at its end of use. This includes scrap generated during installation as well as insulation removed from buildings after use. Scrap from job sites can be used to fill corners or crevices so may not be discarded as waste.[107] A report from NAIMA and a life cycle analysis from the National Institute of Standards and Technology indicate that recycling of scrap material is possible in the production process, so in theory glass fibers from fiberglass insulation recovered at its end of use could potentially be recycled back into new fiberglass insulation, supporting a circular economy.[108]

Though not common, some fiberglass insulation may be incinerated if disposed of as part of municipal solid waste. Municipal waste incinerators have been associated with hazardous releases and adverse health impacts on surrounding communities.[109] Modern incinerators are equipped to capture some toxic pollutants that are generated, but these are effective only if regularly maintained and operating properly.[110]

Building Fires

Glass fibers do not pose a fire hazard; however, insulation binders, facings, adhesives, and other additives may burn and release combustion by-products in the event of a structure fire. The specific chemicals released will vary but may include hydrogen chloride, cyanides, ammonia, and volatile organic compounds.[111] These decomposition by-products can contribute to firefighters' exposure to hazardous chemicals while fighting fires. In a 2005 document, the South Dakota Department of Agriculture and Natural Resources lists styrene, acetone, methyl ethyl ketone, and phosgene as potential hazardous releases from open burning of fiberglass insulation.[112] Given the date of the source, this is likely based on older binder formulations; it may not be applicable to new lightweight residential batts and loose fill fiberglass insulation.

SUMMARY OF FINDINGS AND RECOMMENDATIONS

On the basis of available data, we have made several key findings. The manufacturing of glass fibers primarily uses recycled glass cullet and mineral-based inputs. Some of these inputs are hazardous. In addition, the production of glass fibers generates hazardous chemical waste and releases into communities that are disproportionately composed of people of color and low-income and linguistically isolated populations. Some of these communities are home to many other manufacturing facilities that also release hazardous chemicals, contributing to the cumulative chemical impacts experienced by the people who live there. Finally, there are many data gaps impeding our understanding of the impacts on workers and communities throughout the full life cycle of glass fibers in fiberglass insulation. Our findings are summarized in Table 7.

Below, we offer some recommendations based on the framework we developed using the principles of environmental justice and green chemistry.

Abide By Environmental Regulations

All of the companies in this report should comply with current environmental regulations. In addition, government agencies should increase facility inspections and penalties for violations.

Avoid Hazardous Chemicals and Prevent Pollution and Waste

Manufacturers should decrease emissions below regulatory limits, which are derived by considering only individual facility impacts and a limited number of hazardous chemicals. They should implement additional pollution prevention and hazard reduction activities with the goal of eliminating all hazardous releases and waste.

The European Commission determined that the best available techniques for reduction of metal emissions from glass melting furnaces are application of a filtration system and selection of inputs with low metal content (within the constraints of available raw materials).[113] Fiberglass manufacturers should invest in the best available technology for filtration systems to reduce emissions.

Regarding input materials, there are currently no standard requirements for glass cullet except those set by particular customers or by the cullet suppliers themselves.[114] This can lead to higher levels of metal impurities being present and therefore released during glass fiber production. Lower-quality cullet may also require greater use of manganese to process.[115] Improved industry-wide requirements for glass cullet could help increase the quality of recycled glass used in fiberglass insulation, which could in turn reduce hazardous releases.[116] Manufacturers who have their own requirements for glass cullet should publicly disclose their source(s) of recycled content and screening practices used to avoid or reduce contaminants.

The industry can also continue to expand recycling of chromium-containing refractory bricks used in glass-melting furnaces and investigate longer-lasting, less hazardous materials.

Governments should adopt policies that center on avoiding hazardous chemicals and supporting green chemistry innovations. In the case of glass fibers, for example, they should develop limits on hazardous impurities in glass cullet. In addition, jurisdictions should mandate emissions reductions.

Implement Circularity and Reduce End-of-Life Impacts

Using recycled glass inputs reduces the amount of other glass producing materials needed and can thereby decrease upstream impacts associated with glass fiber production. Manufacturers should increase the percentage of clean recycled glass inputs to glass fibers, and governments should act to mandate a minimum amount of clean recycled content, with incentives for increased levels.

Recovery of building materials at the end of a building's life or during renovation is not common practice in the United States; however, glass fibers in fiberglass insulation could potentially be recycled if recovered. Fiberglass insulation manufacturers should explore how to recover and recycle insulation at its end of use. This could include developing take-back programs and

Table 7. Summary of findings on glass fibers in fiberglass insulation and recommendations			
		Recommendations	
Case Study Criteria for Chemical and Environmental Justice Impacts	**Findings on Glass Fibers**	**For Manufacturers Throughout the Supply Chain**	**For Governments and Other Policymakers**
Avoid hazardous chemicals	About 35% of chemicals used as inputs for glass fiber production are hazardous to human health. One chemical is highly reactive or flammable. None of the chemical inputs used for glass fiber production are volatile. Releases of several heavy metal compounds are possible as a result of the process to make glass fibers. The glass fibers used in insulation are not considered hazardous.	Reduce hazardous chemical inputs. For example: ■ Develop standards for glass cullet to reduce metal impurities and emissions. ■ Investigate longer-lasting, less hazardous materials for refractory bricks.	Adopt policies centered on hazard avoidance. For example: ■ Develop limits on hazardous impurities in glass cullet.
Prevent accidents	No incidents related to glass fiber manufacturing were identified.		
Prevent pollution and waste	Facilities manufacturing glass fibers for residential fiberglass insulation in the United States report that they: ■ Generate almost 1.2 million pounds of hazardous glass fiber–related chemical waste on average each year (combined) ■ Release an average of 1,200 pounds of hazardous glass fiber–related chemicals into the air and water each year (combined)	Optimize process efficiency to reduce waste generation, and implement pollution control measures to reduce air and water releases, with the goal of eliminating all hazardous releases and waste. For example: ■ Use filtration systems to reduce metal emissions. ■ Expand recycling for chromium-containing refractory bricks.	Mandate emissions reductions.
Implement circularity and reduce end-of-life impacts	25 to 80% of inputs are recycled glass. Some recycled glass inputs may contribute to hazardous metal releases. Other inputs are primarily mineral based. In the context of use in insulation, glass fibers are reusable or recyclable at end of product life into similar or higher-value materials, though in practice they are neither reused nor recycled. Fiberglass insulation is primarily disposed of in landfills.	Increase percentage of clean recycled glass inputs. Explore how to recover and recycle fiberglass insulation at its end of use through initiatives such as take-back programs and development of collection infrastructure. Design fiberglass products for ease of reuse, recovery, and safe recycling. Disclose material content to support future reuse and recycling.	Mandate a minimum amount of clean recycled glass inputs with incentives for greater levels. Increase recovery, reuse, and recycling through incentives and mandates. Support transparency about material content as a part of circularity efforts.
Abide by environmental regulations	41% of glass fiber facilities had significant violations of EPA regulations within the last 12 quarters as of July 2022. 14% of facilities had significant violations in every quarter.	Abide by environmental regulations.	Increase facility inspections and enforcement actions.

Table 7. (continued) Summary of findings on glass fibers in fiberglass insulation and recommendations			
		Recommendations	
Prevent disproportionate and cumulative impacts	Compared with the United States overall, the combined communities surrounding fiberglass manufacturing facilities have a higher percentage of people of color (about 45% versus 39%), a higher percentage of low-income households (about 36% versus 33%), and a higher percentage of linguistically isolated people (about 5% versus 4%). Cities where fiberglass manufacturing is located are home to 1–29 facilities that release and/or manage hazardous chemicals. Reported cumulative on-site releases of hazardous chemicals from all these facilities were between 1 pound and about 1.2 million pounds in each city in 2019.	Pursue all of the above to help reduce disproportionate and cumulative impacts. Do not expand or build new facilities that will increase hazardous chemical releases in marginalized and overburdened communities. Use standard frameworks to assess and guide improvements related to broader social equity impacts. Disclose material content and emissions to support workers' and communities' right to know about hazardous chemicals that may impact them.	Pursue all of the above to help reduce disproportionate and cumulative impacts. Adopt policies that account for cumulative impacts in permitting decisions. Support transparency about material content, emissions, and location of manufacture.

collection infrastructure. Learnings from developing programs in Europe could be used to inform similar programs in the United States.[117] For example, one manufacturer has a take-back program for cut-off scrap from construction sites in Germany, converting the material into ceiling tiles.[118] This manufacturer also has a goal to develop programs to recycle insulation from building demolition in several European countries by 2025.[119] Manufacturers should design products for safe recycling, for example by employing binders that do not release hazardous breakdown products if heated during a recycling process.

Prevent Disproportionate and Cumulative Impacts

Abiding by environmental regulations, avoiding hazardous chemicals, preventing pollution and waste, and implementing end-of-life programs will all contribute to the reduction of disproportionate and cumulative impacts on marginalized and overburdened communities. Beyond considering glass fiber impacts, manufacturers should work to reduce the use of hazardous chemicals in other components of fiberglass insulation (binders, adhesives, facings, etc.) through implementing green chemistry principles for inherently safer chemistry. In the meantime, they should implement pollution prevention measures for any hazardous chemicals released from their facilities.

In addition, companies should not expand or build new facilities that will increase hazardous chemical releases in marginalized and overburdened communities.

Outside of reducing chemical impacts, manufacturers can strive to be good neighbors in the communities where they are located and along the supply chain, through activities such as hiring local workers and contributing to local economic development. Companies can use the Social Life Cycle Assessment methodology developed by the United Nations Environment Programme, or similar analysis, to assess the social equity impacts of their products and organizations and guide improvements.[120]

Beyond manufacturer actions, jurisdictions should adopt policies that account for cumulative impacts in their permitting decisions.[121]

Disclose Material Content and Emissions

We need a more complete picture of the chemical and material flows for glass fiber manufacturing, a better understanding of worker exposures at each stage of production, and a clearer view of the impacts on residents in the surrounding communities, including the combined impacts on communities from chemical and nonchemical stressors.

Manufacturers at each step of the supply chain of insulation products should provide transparency on material content and emissions, tied to location, to support the right of downstream manufacturers, workers, and communities to know about hazardous chemicals that may impact them. This would also support future efforts to reuse and recycle products.

CONCLUSION

The chemical impacts of a product extend in both directions from product manufacturing, from mineral mining and chemical production to the disposal of waste chemicals and products. Harm to people and the environment can occur at each of these steps, contributing to the embodied chemical impacts of a product. Through this case study, we have developed and applied a new framework for measuring some important chemical and environmental justice impacts. This framework can be used both to identify opportunities to reduce these impacts for a particular chemical or material and to compare the impacts of different chemicals or materials. It can be applied to any material, including those outside the built environment.

This case study is not inclusive of all potentially hazardous chemicals that may be used in the production of glass fibers or all the potential impacts on workers and communities. A more complete understanding of the embodied chemical impacts of fiberglass insulation requires additional data on upstream impacts such as those stemming from mineral mining, on chemical impacts of additives and binders used in fiberglass insulation materials, and on production volumes tied to quantity of releases and waste. This case study does, however, provide a view into some of the hazards and impacts as well as opportunities to reduce these impacts.

To support a more equitable and sustainable built environment, manufacturers throughout the life cycle of products should follow green chemistry and environmental justice principles. They should avoid hazardous chemicals; prevent accidents, pollution, and waste; implement circularity and reduce end-of-life impacts; and prevent disproportionate or cumulative impacts.

Governments (local, state, and federal) should increase enforcement, inspections, and penalties for violations of existing laws. At the same time, governments should advance policies that require facilities throughout the supply chain to reduce emissions; account for cumulative impacts in permitting decisions; set standards for glass cullet and minimum recycled content in fiberglass; and increase reuse, recovery, and recycling through incentives and mandates.

This case study can also help building industry professionals start to understand the embodied chemical impacts of materials. This awareness can then lead to demands for additional transparency on the part of manufacturers. Transparency about what is in a product, how the product is made, and hazardous emissions—beyond the reporting required by law—is critical. In the meantime, building industry professionals can work toward avoiding products that contain hazardous chemicals. As a starting point, this helps protect not only building occupants and installers but others impacted by those hazardous chemicals at other points in the supply chain. Healthy Building Network's product guidance can help professionals choose safer product types on the basis of what we know today as we work to expand our research into life cycle chemical impacts and to provide guidance on a broader range of materials.[j]

A similar case study considering isocyanates in spray foam insulation is available for comparison of these two inputs and types of insulation. A fact sheet summarizing the framework and offering recommendations is also available.[k]

j Healthy Building Network's product guidance is available here: https://healthybuilding.net/products.
k The case studies and fact sheet are available here: https://healthybuilding.net/reports.

APPENDIX 1: PRINCIPLES OF GREEN CHEMISTRY AND PRINCIPLES OF ENVIRONMENTAL JUSTICE

12 Principles of Green Chemistry[122]

1. **Prevention.** It is better to prevent waste than to treat or clean up waste after it has been created.
2. **Atom Economy.** Synthetic methods should be designed to maximize incorporation of all materials used in the process into the final product.
3. **Less Hazardous Chemical Syntheses.** Whenever practicable, synthetic methods should be designed to use and generate substances that possess little or no toxicity to human health and the environment.
4. **Designing Safer Chemicals.** Chemical products should be designed to preserve efficacy of function while reducing toxicity.
5. **Safer Solvents and Auxiliaries.** The use of auxiliary substances (e.g., solvents, separation agents, etc.) should be made unnecessary whenever possible and innocuous when used.
6. **Design for Energy Efficiency.** Energy requirements should be recognized for their environmental and economic impacts and should be minimized. Synthetic methods should be conducted at ambient temperature and pressure.
7. **Use of Renewable Feedstocks.** A raw material or feedstock should be renewable rather than depleting whenever technically and economically practicable.
8. **Reduce Derivatives.** Unnecessary derivatization (use of blocking groups, protection/ deprotection, temporary modification of physical/chemical processes) should be minimized or avoided if possible, because such steps require additional reagents and can generate waste.
9. **Catalysis.** Catalytic reagents (as selective as possible) are superior to stoichiometric reagents.
10. **Design for Degradation.** Chemical products should be designed so that at the end of their function they break down into innocuous degradation products and do not persist in the environment.
11. **Real-Time Analysis for Pollution Prevention.** Analytical methodologies need to be further developed to allow for real-time, in-process monitoring and control prior to the formation of hazardous substances.
12. **Inherently Safer Chemistry for Accident Prevention.** Substances and the form of a substance used in a chemical process should be chosen to minimize the potential for chemical accidents, including releases, explosions, and fires.

17 Principles of Environmental Justice[123]

1. Environmental Justice affirms the sacredness of Mother Earth, ecological unity and the interdependence of all species, and the right to be free from ecological destruction.

2. Environmental Justice demands that public policy be based on mutual respect and justice for all peoples, free from any form of discrimination or bias.

3. Environmental Justice mandates the right to ethical, balanced and responsible uses of land and renewable resources in the interest of a sustainable planet for humans and other living things.

4. Environmental Justice calls for universal protection from nuclear testing, extraction, production and disposal of toxic/hazardous wastes and poisons that threaten the fundamental right to clean air, land, water, and food.

5. Environmental Justice affirms the fundamental right to political, economic, cultural and environmental self-determination of all peoples.

6. Environmental Justice demands the cessation of the production of all toxins, hazardous wastes, and radioactive materials, and that all past and current producers be held strictly accountable to the people for detoxification and the containment at the point of production.

7. Environmental Justice demands the right to participate as equal partners at every level of decision-making, including needs assessment, planning, implementation, enforcement and evaluation.

8. Environmental Justice affirms the right of all workers to a safe and healthy work environment without being forced to choose between an unsafe livelihood and unemployment. It also affirms the right of those who work at home to be free from environmental hazards.

9. Environmental Justice protects the right of victims of environmental injustice to receive full compensation and reparations for damages as well as quality health care.

10. Environmental Justice considers governmental acts of environmental injustice a violation of international law, the Universal Declaration On Human Rights, and the United Nations Convention on Genocide.

11. Environmental Justice must recognize a special legal and natural relationship of Native Peoples to the U.S. government through treaties, agreements, compacts, and covenants affirming sovereignty and self-determination.

12. Environmental Justice affirms the need for urban and rural ecological policies to clean up and rebuild our cities and rural areas in balance with nature, honoring the cultural integrity of all our communities, and provided fair access for all to the full range of resources.

13. Environmental Justice calls for the strict enforcement of principles of informed consent, and a halt to the testing of experimental reproductive and medical procedures and vaccinations on people of color.

14. Environmental Justice opposes the destructive operations of multi-national corporations.

15. Environmental Justice opposes military occupation, repression and exploitation of lands, peoples and cultures, and other life forms.

16. Environmental Justice calls for the education of present and future generations which emphasizes social and environmental issues, based on our experience and an appreciation of our diverse cultural perspectives.

17. Environmental Justice requires that we, as individuals, make personal and consumer choices to consume as little of Mother Earth's resources and to produce as little waste as possible; and make the conscious decision to challenge and reprioritize our lifestyles to ensure the health of the natural world for present and future generations.

APPENDIX 2: STATE-LEVEL DEMOGRAPHIC INFORMATION

The 22 facilities considered in this case study are spread out over 13 states. The majority of the demographic analysis in this case study compares populations in the fenceline zones with that of the United States overall. Within the nation, there can be significant regional variations in demographics among different states and locales. Comparing fenceline zone demographics with more localized demographic data can highlight additional disparities beyond those observed at the national level. It is important to note that while fenceline demographics can sometimes mirror state-level data more closely than it mirrors national data, this does not negate the fact that communities in the fenceline zones are disproportionately people of color, low income, and linguistically isolated.

To illustrate how consideration of state-level data can highlight more localized disparities, we conducted a more detailed analysis for the six facilities whose fenceline zones are home to a percentage of people of color at least 1.5 times the percentage for the state as a whole. Our results are shown in Table A1 and discussed below.

In the fenceline area around the Owens Corning facility in Fairburn, Georgia, people of color make up 85 percent of the population, versus an estimated 47 percent for the state as a whole. This difference is accounted for primarily by a much greater percentage of Black or African American people living near the facility (73 percent) relative to the percentage in Georgia (31 percent)—which itself is more than 2.5 times the percentage in the nation overall (12 percent). The fact that the fenceline zone surrounding this facility has more than double the state percentage of Black population highlights the additional disparity.

In Kansas City, Kansas, the percentages of people of color living in the fenceline zones for both the Owens Corning facility (63 percent) and the CertainTeed plant (65 percent) are more than 2.5 times the percentage for Kansas (24 percent). Statewide, 12 percent of the population is Hispanic or Latino, 6 percent is Black or African American, and 3 percent is Asian. The fenceline population for the Owens Corning facility is 25 percent Hispanic or Latino, 29 percent Black or African American, and 5 percent Asian. The fenceline zone for the CertainTeed facility is 30 percent Hispanic or Latino, 27 percent Black or African American, and 5 percent Asian. The state of Kansas has a lower percentage of people of color than in the United States overall (24 percent compared to 39 percent), so the fenceline zones for these facilities have not only a higher percentage of people of color than in the nation overall, but an even greater disparity when compared with the population within the state.

The proportion of people of color living in the fenceline zone for the Knauf facility in Albion, Michigan, is 38 percent, versus 25 percent in Michigan as a whole. Statewide, 5 percent of the population is Hispanic or Latino, 14 percent is Black or African American, and 0.5 percent is American Indian or Alaska Native. The fenceline population has a disproportionately high population of all three of these groups (7 percent Hispanic or Latino, 26 percent Black or African American, and 1 percent American Indian or Alaska Native). While the proportion of people of color in the fenceline zone (38 percent) is similar to that in the nation overall (39 percent), it is greater than the percentage of people of color within the state (25 percent).

In the fenceline zone for the Knauf facility in Lanett, Alabama, 52 percent of the population is people of color, compared with 34 percent in Alabama. Statewide, 26 percent of the population is Black or African American and 1 percent is Asian, while in the fenceline zone, 44 percent of the population is Black or African American and 2 percent is Asian. Alabama has more than twice the national percentage of Black or African American residents, but even within the state, the community surrounding this facility is disproportionately Black or African American.

People of color make up 16 percent of the population in the fenceline zone for the Knauf facility in Inwood, West Virginia, compared with 8 percent in the state overall. Statewide, 4 percent of the population is Black or African American and 2 percent is Hispanic or Latino. The fenceline population is 8 percent Black or African American and 5 percent Hispanic or Latino. While the percentage of people of color in the fenceline zone (16 percent) is lower than in the United States overall (39 percent), it is twice as big as the percentage in West Virginia overall.

Table A1. Summary of demographic information for residents within three miles of selected glass fiber manufacturing facilities, compared with demographics for the states where the facilities are located

	Owens Corning Fairburn, GA	Georgia	Owens Corning Kansas City, KS	CertainTeed Kansas City, KS	Kansas	Knauf Albion, MI	Michigan	Knauf Lanett, AL	Alabama	Knauf Inwood, WV	West Virginia	U.S. Overall
Percentage of Population												
Hispanic or Latino	11%	9%	25%	30%	12%	7%	5%	4%	4%	5%	2%	18%
White Non-Hispanic	15%	53%	37%	35%	76%	62%	75%	48%	66%	84%	92%	61%
Black or African American	73%	31%	29%	27%	6%	26%	14%	44%	26%	8%	4%	12%
American Indian or Alaska Native	0.01%	0.2%	0.3%	0.2%	1%	1.0%	0.5%	0.2%	0.5%	0%	0.2%	0.7%
Asian	0.4%	4%	5%	5%	3%	1%	3%	2%	1%	1.0%	0.8%	5%
Native Hawaiian or Other Pacific Islander	0%	0.05%	0.02%	0.08%	0.06%	0%	0.02%	0%	0.03%	0%	0%	0.2%
Other Race	0.1%	0.3%	0.1%	0.1%	0.1%	0%	0.1%	0%	0.2%	0.4%	0.2%	0.2%
Two or More Races	1%	2%	3%	3%	3%	4%	2%	1%	2%	1%	2%	2%
People of Color	85%	47%	63%	65%	24%	38%	25%	52%	34%	16%	8%	39%

Orange highlights indicate where the percentage of historically marginalized populations is greater in the fenceline zones than in the state where the facility is located. The ACS reports both on race (white, Black, Asian, American Indian or Alaska Native, Native Hawaiian or other Pacific Islander, other race, or two or more races) and on ethnicity (Hispanic or Latino). Hispanic or Latino individuals will also fall into one or more of the race categories. To avoid double counting individuals, this table includes individuals reporting Hispanic or Latino in the row for Hispanic or Latino. Individuals reporting non-Hispanic or Latino are included in the subsequent rows.

See text box, "More on the EPA's EJScreen," for definitions of people of color, low income, and linguistically isolated populations. *Sources: EPA's EJScreen and U.S. Census Bureau American Community Survey five-year estimates for 2014–2018.*[124]

APPENDIX 3: SUPPLEMENTAL TABLES

Table A2. Air and water releases of glass fiber–related chemicals in 2019

		Air and Water Releases	
Manufacturer	**Location**	**Per Facility (lbs)**	**Per Manufacturer (lbs)**
CertainTeed	Athens, GA	0.4	15.7
	Kansas City, KS	11.6	
	Chowchilla, CA	3.8	
Johns Manville	Penbryn, NJ	1.5	81.5
	Winder, GA	40	
	Richmond, IN	16	
	McPherson, KS	10.9	
	Willows, CA	13.2	
Knauf	Inwood, WV	5.5	35.1
	Lanett, AL	9.8	
	Shelbyville, IN	3.9	
	Albion, MI	0	
	Shasta Lake, CA	16	
Owens Corning	Feura Bush, NY	22	763
	Fairburn, GA	141	
	Lakeland, FL	13	
	Mt. Vernon, OH	0	
	Newark, OH	157	
	Kansas City, KS	349	
	Waxahachie, TX	57	
	Nephi, UT	23	
	Santa Clara, CA	1	
		Total	**895**

Release amounts are not directly comparable between facilities on a per-glass-fiber production basis; see text for more explanation.
Source: EPA Toxics Release Inventory.

Table A3. Average annual waste of glass fiber–related chemicals and percentage released or disposed of on site, 2015–2019			
Manufacturer	**Location**	**Average annual waste reported (lbs)**	**Percentage of waste released or disposed of on site**
CertainTeed	Athens, GA	1	38%
	Kansas City, KS	182,689	<1%
	Chowchilla, CA	91	94%
Johns Manville	Penbryn, NJ	740	<1%
	Winder, GA	1,892	1%
	Richmond, IN	25,208	<1%
	McPherson, KS	31,070	<1%
	Willows, CA	61,946	<1%
Knauf	Inwood, WV	7,526	<1%
	Lanett, AL	30,376	<1%
	Shelbyville, IN	10,009	<1%
	Albion, MI	13,031	<1%
	Shasta Lake, CA	25	58%
Owens Corning	Feura Bush, NY	102,605	<1%
	Fairburn, GA	136,393	<1%
	Lakeland, FL	14,056	<1%
	Mt. Vernon, OH	3	13%
	Newark, OH	176,841	<1%
	Kansas City, KS	88,156	<1%
	Waxahachie, TX	273,975	<1%
	Nephi, UT	2,164	1%
	Santa Clara, CA	15,289	<1%

Amounts are not directly comparable among facilities on a per-glass-fiber production basis; see text for more explanation.
Source: EPA Toxics Release Inventory.

Table A4. Total air and water releases in 2019			
		Total TRI-Reported Air and Water Releases of all TRI Chemicals From the Facility	
Manufacturer	**Location**	**Per Facility (lbs)**	**Per Manufacturer (lbs)**
CertainTeed	Athens, GA	159,002	390,718
	Kansas City, KS	231,712	
	Chowchilla, CA	3.8	
Johns Manville	Penbryn, NJ	1.5	42,776
	Winder, GA	40	
	Richmond, IN	16	
	McPherson, KS	9,699	
	Willows, CA	33,019	
Knauf	Inwood, WV	280,551	1,424,860
	Lanett, AL	173,793	
	Shelbyville, IN	639,038	
	Albion, MI	136,094	
	Shasta Lake, CA	195,383	
Owens Corning	Feura Bush, NY	22	275,920
	Fairburn, GA	141	
	Lakeland, FL	13	
	Mt. Vernon, OH	0	
	Newark, OH	233,849	
	Kansas City, KS	349	
	Waxahachie, TX	41,522	
	Nephi, UT	23	
	Santa Clara, CA	1	
	Total		**2,134,274**

Source: EPA Toxics Release Inventory.

Table A5. Number of TRI facilities and total on-site releases in 2019 for the cities where glass fiber is manufactured for fiberglass insulation		
City	**# of TRI Facilities**	**Total On-Site Releases to Air, Water, and Land Reported to TRI (lbs)**
Athens, GA	10	197,996
Kansas City, KS	29	1,209,104
Chowchilla, CA	1	4
Penbryn, NJ	1	2
Winder, GA	4	20,635
Richmond, IN	16	134,573
McPherson, KS	5	185,181
Willows, CA	1	33,019
Inwood, WV	2	280,590
Lanett, AL	2	201,988
Shelbyville, IN	7	644,166
Albion, MI	3	143,468
Shasta Lake, CA	1	195,383
Feura Bush, NY	1	22
Fairburn, GA	4	142
Lakeland, FL	18	488,073
Mt. Vernon, OH	2	1
Newark, OH	5	242,352
Waxahachie, TX	13	48,886
Nephi, UT	1	23
Santa Clara, CA	11	5,771

Source: EPA Toxics Release Inventory.

Table A6. Summary of demographic information for residents within three miles of example facilities that are part of the glass fiber life cycle, compared with the United States overall					
	Dlubak Glass	**Ripple Glass**	**Clean Harbors Lone Mountain***	**IESI Turkey Creek Landfill**	**U.S. Overall**
Location	Upper Sandusky, OH	Kansas City, MO	Waynoka, OK	Alvarado, TX	
Function in Supply Chain	Glass Cullet Supplier	Glass Cullet Supplier	Landfill	Landfill	
Fenceline Communities					
Population	6,994	64,162	25	2,723	322,903,030
Percentage of Population					
Hispanic or Latino	5%	31%		14%	18%
White Non-Hispanic	94%	36%		81%	61%
Black or African American	0.1%	26%		0.4%	12%
American Indian or Alaska Native	0%	0.5%		2%	0.7%
Asian	0.1%	3%		0.1%	5%
Native Hawaiian or Other Pacific Islander	0%	0.1%		0%	0.2%
Other Race	0%	1%		0%	0.2%
Two or More Races	0.9%	2%		2%	2%
People of Color	6%	64%	12%	19%	39%
Low Income	39%	63%	21%	29%	33%
Linguistically Isolated	1%	9%	0%	2%	4%
Number of Schools	5	20	0	2	

*Demographic details for the fenceline zone for Clean Harbors Lone Mountain are not included because of the small population size.

Orange highlights indicate percentages of historically marginalized populations that exceed national figures. The ACS reports both on race (white, Black, Asian, American Indian or Alaska Native, Native Hawaiian or other Pacific Islander, other race, or two or more races) and on ethnicity (Hispanic or Latino). Hispanic or Latino individuals will also fall into one or more of the race categories. To avoid double-counting, this table includes individuals reporting Hispanic or Latino in the row for Hispanic or Latino. Those reporting non-Hispanic or Latino are included in the subsequent rows. See text box, "More on the EPA's EJScreen," for definitions of people of color, low income, and linguistically isolated populations. *Sources: EPA's EJScreen and U.S. Census Bureau American Community Survey five-year estimates for 2014–2018.*[125]

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