CertainTeed

# Vinyl and Polymer Products

## Life Cycle Assessment Report

CertainTeed
SAINT-GOBAIN

## Table of Contents





## Introduction

The CertainTeed Siding Group manufactures vinyl and polymer siding products. CertainTeed is actively pursuing strategies to reduce their environmental impact and to increase the sustainability of the siding group operations and products. CertainTeed has developed a corporate sustainability strategy for reducing energy use, water use and waste, and has conducted Life Cycle Assessments (LCA's) of the siding products in order to better understand and to improve these products. Life Cycle Assessment (LCA) is a method for identifying the environmental impacts of a product, process or activity over its entire lifespan, including extraction and processing of raw materials, manufacturing, transportation and distribution, installation, use, maintenance, and end of life including recycling and final disposal. LCA is a primary tool of the CertainTeed Sustainable Product Design program and is integral to our product stewardship initiatives.

To provide full transparency and make this data available to the public, CertainTeed has decided to submit their data to the Building for Economic and Environmental Sustainability (BEES) program. BEES Online is a software program designed by the National Institute of Standards and Technology (NIST) that allows the comparison of building products on a life cycle basis. BEES fully reviews and investigates each product LCA to ensure that the data is correct and accurate. The graphs and tables showing the environmental impact of siding products were produced using BEES Online data, and all data submitted to BEES undergoes the thorough reviews required under ISO 14040 standards for the comparison of products using LCA. For more information or to utilize BEES Online directly, go to http://ws680.nist.gov/Bees/.

The information in this report is taken directly from the BEES program. All graphics were generated using the BEES program and are provided in this report to assist the reader with evaluating CertainTeed Siding Products using LCA.

## Life Cycle Assessment

The Life Cycle Assessment is an analytical tool used to quantify and interpret the flows to and from the environment (including emissions to air, water and land, as well as the consumption of energy and other material resources) over the entire life cycle of a product (or process or service). By including the impacts throughout the product life cycle, the LCA provides a comprehensive view of the environmental aspects of the product and an accurate picture of the environmental costs and benefits of product selection.

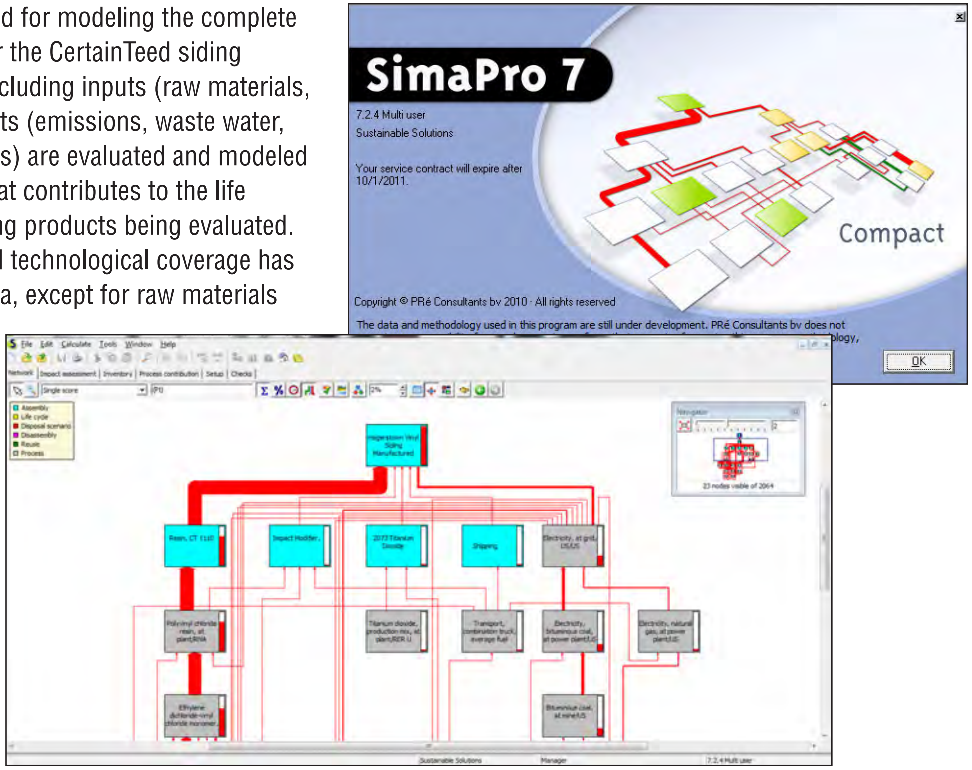
An LCA is generally conducted in four phases: (1) goal and scope definition, (2) life cycle inventory (LCI), (3) life cycle impact assessment, and (4) interpretation. An LCA starts with determining the scope of the study, functional unit, system boundaries, assumptions and limitations, allocation methods used, and impact categories. In the inventory analysis, a flow model of the technical system is constructed using data on inputs and outputs. The input and output data (such as resources, energy requirements, emissions to air and water, and waste generation for all activities within the system boundaries) needed for the construction of the model are collected. Then, the environmental impacts are calculated and analyzed in relation to the functional unit. Inventory analysis is followed by impact assessment, where the LCI data is characterized in terms of their potential environmental impacts (e.g., acidification, eutrophication, and global warming potential effects).

## Functional Unit

The functional unit is of great importance in an LCA. It provides a unit of analysis and comparison for all environmental impacts. The functional unit is based on the use and life of the product; for siding, this is typically expressed in terms of wall coverage for a given time period. BEES uses a functional unit for all siding products of 1 square foot of siding over a 50 year lifespan to establish the ability to compare multiple building products.

## Modeling Software

SimaPro software was utilized for modeling the complete cradle to cradle/grave LCI for the CertainTeed siding products. All process data including inputs (raw materials, energy and water) and outputs (emissions, waste water, solid waste and final products) are evaluated and modeled to represent each process that contributes to the life cycle of the CertainTeed siding products being evaluated. The study's geographical and technological coverage has been limited to North America, except for raw materials manufactured outside this region. SimaPro was used to generate life cycle impact assessment (LCIA) results utilizing the BEES impact assessment methodology.



# CertainTeed Vinyl Siding

## Product Description

CertainTeed's vinyl siding product in BEES is modeled as an average of its vinyl siding product lines manufactured at its Jackson, MI and Hagerstown, MD plants. Bills of materials and manufacturing data were collected from these two facilities and averaged on a weighted basis, based on vinyl siding output. This vinyl siding has a nominal thickness of 0.11 cm (0.044 in) and a mass ranging from 17.83 – 21.79 kg (39.4 – 48.2 lb) per 9.29 $m^2$ (100 $ft^2$). Consistent with the generic vinyl siding product in BEES, it is typically installed with galvanized nail fasteners placed 41 cm (16 in) on center.

## Raw Materials

The CertainTeed Vinyl Siding Constituents are listed in Table 1. "Other additives" include pigment, impact modifiers, stabilizers, and process aids. Data for all of the materials were provided in Material Safety Data Sheets (MSDS); their production data are included in the LCA model but are excluded from this documentation to protect company confidential data. Production data for materials is based on elements of the U.S. LCI database, the EcoInvent database, and the SimaPro database.

*Figure 1. Typical CertainTeed Vinyl Siding products*

*Table 1. CertainTeed Vinyl Siding Constituents*

| Constituent | % in the Siding[1] |
|---|---|
| PVC Resin | 73.9-90.3% |
| Calcium Carbonate | 8.6-10.5% |
| Acrylic-based additives | 2.8-3.4% |
| Titanium dioxide | 1.5-1.9% |
| Lubricant | 1.4-1.7% |
| Other additives | 1.8-2.2% |

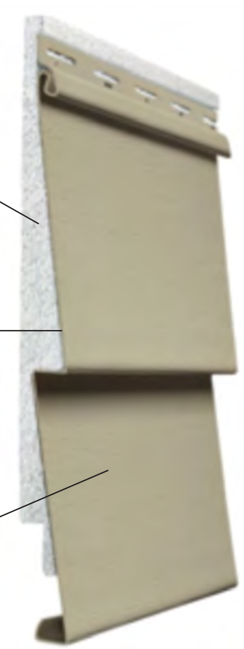
*[1]Table ranges based on proprietary information*

## CertainTeed Recycled Content CedarBoards™ D6 Insulated Siding

### Product Description

The CedarBoards Double 6" Clapboard product is a vinyl siding product with expanded polystyrene (EPS) foam backing for added insulation. The vinyl siding, containing both post-consumer and pre-consumer recycled content PVC resin, has the semblance of a rough cedar finish, and has a nominal thickness of 0.11 cm (0.044 in). CedarBoards D6 Vinyl Siding has a minimum recycled content of 60% with the total recycled content of the overall assembly at 54%. It is produced at CertainTeed's Jackson, MI plant, and is sent to another facility to be laminated onto the insulated foam. Its mass ranges from 18.61 – 22.75 kg (41.0 – 50.2 lb) per 9.29 $m^2$ (100 $ft^2$) and it is typically installed with galvanized nail fasteners placed 41 cm (16 in) on center. It has a thermal resistance value of 2.9 according to thermal testing results by an independent testing company.[2] Despite the added insulation, the building still requires base insulation. Thermal performance differences among exterior wall finish alternatives are not accounted for in BEES, but should be considered when interpreting BEES results. When insulated vinyl siding is installed on buildings it reduces energy consumption for the life of the product. Specifically, this energy savings reduces impacts during the use phase.

*Figure 2. Recycled Content CedarBoards D6 insulated Vinyl Siding*




### Raw Materials

Recycled Content CedarBoards are comprised of three main components: EPS foam, vinyl siding, and lamination glue, as shown in Figure 2. The foam backing is EPS foam board insulation produced by Progressive Foam Technologies, Inc.. The data for the raw materials and production of this foam can be found in the documentation for Progressive Foam's insulated siding. The recycled content vinyl siding is produced at the Jackson, MI plant. The table above on CertainTeed average vinyl siding provides the main bill of materials for the siding, with one exception: 74.6% of the PVC resin is recycled. According to CertainTeed's supplier, the recycled resin is both post-industrial (minimum 30%), from vinyl siding and window manufacturers, and post-consumer, (minimum of 30%) from scrap, end of life siding and construction tear-down. The recycler cleans and shreds the incoming material and produces recycled PVC flakes. General mass balance data were supplied by the recycler. Since primary data on recycling energy could not be obtained from the supplier, polyethylene terephthalate (PET) bottle recycling process energy was used as a proxy.[3] While the energy to shred and reclaim PET bottles may be very different from PVC reclamation processes, the Franklin data are primary data from four reclamation plants in the U.S., and these data are considered to be of very good quality. The table on the next page provides the recycling energy assumed for PVC recycling.

*[2]Architectural Testing, Inc. Computer Simulation Thermal Performance Test Report rendered to CertainTeed Corporation on CedarBoards Double 6 model, 2/16/09*
*[3]Franklin Associates, Life Cycle Inventory of 100% Post-Consumer HDPE and PET Recycled Resin from Post-Consumer Containers and Packaging (Prairie Village, KS: American Chemistry Council, Inc., et al., April 2010).*

## CertainTeed Recycled Content CedarBoards D6 Insulated Siding (continued)

***Table 2. Recycled Content CedarBoards D6 Siding Constituents***

| Constituent | % in the Siding |
|---|---|
| Foam Backing | 10.4-12.8% |
| CertainTeed Vinyl Siding with Recycled Content | 78.8-96.3% |
| Lamination Glue | 0.8-1.0% |

***Table 3. PVC Flake Recycling Energy[4]***

| Energy Source | Quantity per kg PVC flake |
|---|---|
| Electricity (MJ) | 1.66 |
| Natural Gas (MJ) | 2.88 |
| LPG& Propane (MJ) | 0.0076 |

Energy data comes from the U.S. LCI Database. The average distance the post-industrial and post-consumer vinyl feedstock is transported to the recycler is 1609 km (1000 mi); this is included in the model.

As part of CertainTeed's commitment to product stewardship, CertainTeed used the life cycle assessment (LCA) to evaluate the environmental benefits of a closed loop program for vinyl siding – a product that can be continuously recycled to make new vinyl siding. As a result, CertainTeed became the first company to develop a post-consumer collection and recycling program. CertainTeed has developed a partnership with a network of recyclers to collect end of life vinyl siding and installation scrap. The recyclers have recycling containers located at vinyl siding distributors and jobsites which allow installers to recycle end-of-life vinyl siding from remodeling as well as installation scrap.

With this recycling program, CertainTeed has become the first company to implement a closed loop process for recycling old vinyl siding.

***Figure 3. CertainTeed Closed Loop Recycling Process***

CedarBoards D6 insulated vinyl siding contains a minimum of 60% recycled material (54% for entire assembly) – the highest recycled content of any vinyl siding product currently on the market. This achievement is the result of CertainTeed's efforts to develop partnerships with a network of recyclers and a workable formula that meets the company's stringent quality guidelines. Recycled materials – including scrap from job sites, vinyl siding distributors and other post-consumer sources – are integrated into the manufacturing process and verified by a third-party auditor. The recycled content of CedarBoards has achieved GreenCircle™ Certification. Ultimately, CertainTeed plans to continue working with its customers to expand this true closed loop program, which would ensure that even more old vinyl siding torn off during building and remodeling projects would be collected and returned to CertainTeed for recycling.

**Lamination of Recycled Content CedarBoards**

After the CedarBoards vinyl siding has been manufactured, it is sent to Progressive Foam's Beach City, OH facility to be laminated. The vinyl siding sheets and EPS foam board are hand fed onto a table of rollers. Lines of glue are applied to the foam and then the foam and vinyl are run through a compression roller sealing the foam to the vinyl. The final product is boxed and shipped. The whole process relies primarily on human labor, with only a small amount of electricity being used for the roller machine. This electricity is included as part of the foam production process described in the Progressive Foam insulated siding Raw Materials section. Transportation by heavy-duty diesel truck from Jackson, MI to Beach City, OH (394 km, or 245 mi) is included in the model.

The lamination glue is made up of the following components, obtained from the MSDS.

***Table 4. Cedar Board Lamination Glue Constituents***

| Constituents | % by Mass |
|---|---|
| Tackifying Resins | 42.3%-51.7% |
| Mineral Oil | 18.0-22.0% |
| Polymer Solids | 24.3-29.7% |
| Carbonic Acid | 2.7-3.3% |
| Talc | 2.7-3.3% |

This glue emits no VOCs, according to the MSDS. The materials in the glue were modeled based on elements of the U.S. LCI database, the EcoInvent database, and the SimaPro database.

*[4]Franklin Associates (2010), Table 2-9 on PET bottle reclamation.*

# CertainTeed Cedar Impressions® Polypropylene Siding

### Product Description

CertainTeed Cedar Impressions siding is a polypropylene (PP) resin-based siding with the semblance and texture of cedar panels. With a mass ranging from 34.4 – 42.0 kg (75.6 – 92.4 lb) per 9.29 $m^2$ (100 $ft^2$) and a thickness of 1.25 cm (0.10 in), Cedar Impressions is manufactured at CertainTeed's McPherson, KS plant. It is typically installed with galvanized nail fasteners placed 26.7 cm (10.5 in) on center.

Two material mixes are blended together to form Cedar Impressions siding, as shown in Table 5. The PP resin compound is made up of PP resin, calcium carbonate filler, and other additives. The natural clay color concentrate is made up of approximately 50% inorganic, mineral-based compounds and 50% organic compounds. The full bills of materials for these compounds have been included in the model but are not provided in this documentation to protect company-confidential data. Production data for materials is based on elements of the U.S. LCI database, the EcoInvent database, and the SimaPro database.

*Figure 4. CertainTeed Cedar Impressions Polypropylene Siding*

*Table 5. CertainTeed Cedar Impressions Polypropylene Siding Constituents*

| Constituents | % in the siding |
|---|---|
| Polypropylene (PP) resin compound | 88.0-100% |
| Natural clay color concentrate | 0.0-2.4% |

## Manufacturing, Installation, Use Phase and End of Life for all three products

### Manufacturing

The manufacturing energy for each product is presented in the table below:

*Table 6. Energy Requirements for CertainTeed Products*

| Quantity per functional unit of product | | | |
|---|---|---|---|
| Energy Source | Average Vinyl Siding | Recycled Content CedarBoards | Cedar Impressions |
| Electricity (MJ) | 0.282-0.344 | 0.376-0.460 | 0.041-0.051 |
| Natural Gas (MJ) | 0.028-0.034 | 0.324-0.396 | 0.225-0.275 |
| Propane (MJ) | 0.009-0.011 | 0.077-0.094 | 0.020-0.024 |

Electricity is used to blend the ingredients in the products, propane is used for forklifts, and natural gas is used for plant heating. Electricity production fuels, natural gas, and propane production and combustion come from the U.S. LCI Database. The following table summarizes other manufacturing-related data:

*Table 7. Other Process Data for CertainTeed Products*

| Quantity per functional unit of product | | | |
|---|---|---|---|
| Process Input or Output | Average Vinyl Siding | Recycled Content CedarBoards D6 | Cedar Impressions |
| Input: Water Use (L) | 0.317-0.387 | 0.559-0.683 | 0.706-0.862 |
| Output: Wastewater (L) | 0.214-0.262 | 0.409-0.499 | 0.599-0.733 |
| Output: Waste (kg) | 0.010-0.012 | 0.005-0.007 | 0.002-0.002 |

The water is used for product cooling and to run the cooling towers. The wastewater, discharged to the sewer, comes directly from the cooling water use; the discrepancy between the reported water in and out is due to evaporation losses, and this water is assumed to be uncontaminated.

There are no manufacturing/product losses; the CertainTeed facilities have systems in place to recycle or recover and use all of the floor sweepings and product scrap. For example, the Cedar Impressions scrap is recycled into a part of packaging pallets used throughout CertainTeed plants. The solid waste is non-hazardous material composed of unrecyclable packaging, cafeteria trash, and other miscellaneous trash, and it is landfilled.

Combustion-related air emissions are accounted for in upstream energy use data sets (e.g., natural gas use in a boiler). According to CertainTeed, no other process-related air emissions are generated from these processes.

### CertainTeed's Commitment to Environmental and Operational Excellence

The CertainTeed Certavin resin plant is the only PVC manufacturing facility to use the bulk polymerization process. This patented process uses significantly less energy and water than the suspension process used by other PVC manufacturers. Additionally, the proximity to vendors and rail spurs allows transportation of raw materials and finished product by pipeline and rail, reducing the environmental impact and risks of transporting material by truck.

## Manufacturing, Installation, Use Phase, and End of Life for all three products (continued)

### Installation

Installation of the CertainTeed products is done primarily by manual labor. These products were modeled as being installed with nails to be consistent with other vinyl siding products in BEES. The CertainTeed products are also commonly installed with a hammer and nails. For the vinyl-based sidings, nails are installed 41 cm (16 in) on center. Similar to the generic vinyl siding product in BEES, the nails are modeled as galvanized steel, and for installation 41 cm (16 in) on center, 0.026 kg/$m^2$ (0.005 lb/$ft^2$) of siding is used. Cedar Impressions products are installed with galvanized steel nails 26.7 cm (10.5 in) on center. For installation 26.7 cm (10.5 in) on center, 0.04 kg/$m^2$ (0.008 lb/$ft^2$) of siding is used. The energy required to operate compressors to power air guns and circular saws for cutting is assumed to be very small and is not included in the analysis.

The model assumes an average installation waste of 5% by mass for each product, and this waste is assumed to go to a landfill. While sheathing, weather resistive barriers, and other ancillary materials may be required to complete the exterior wall system, these materials are not included in the system boundaries for BEES exterior wall finishes.

### Use Phase

CertainTeed offers homeowners a lifetime warranty for all siding products. However, in BEES all CertainTeed siding products are modeled as having useful lives of 50 years. Thus, one initial installation and use period is modeled for the BEES functional lifetime. No routine maintenance is required to prolong the lifetime of the product, although cleaning is recommended to maintain appearance. Cleaning would normally be done with water and household cleaners. Information on typical cleaning practices (e.g., frequency of cleaning, types and quantities of cleaning solutions used) was not available; maintenance was not included in the system boundaries.

### End of Life

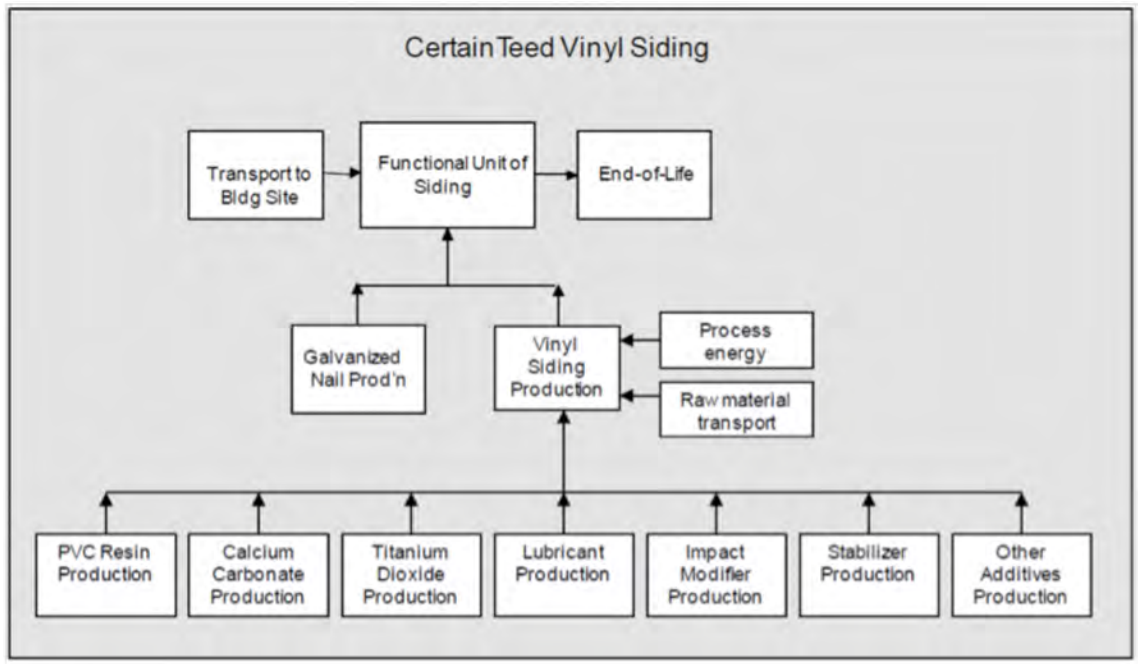
Each of these products were modeled as being disposed in a landfill at end of life. As described above, CertainTeed does have a Vinyl Siding take back program, it is recommended that vinyl siding be recycled at the end of life.

## System Boundary

This project considers the life cycle activities from resource extraction through product use, inclusive of maintenance and replacement and end-of-life effects.

The study system boundary includes the transportation of major inputs to (and within) each activity stage including the shipment of final products to the building site, based on logistics data provided by CertainTeed, by common modes as well as transportation to a landfill at the end of the service life. Any site-generated energy and purchased electricity is included in the system boundary. The extraction, processing and delivery of purchased primary fuels (e.g., natural gas and primary fuels used to generate purchased electricity) are also included within the boundaries of the system. Purchased electricity consumed at various site locations is modeled based on US grid averages, using the models published in the NREL US LCI database. Ancillary material use (e.g., nails for installation) is also included within the system boundary.

***Figure 5. CertainTeed Vinyl Siding System Boundaries***



## System Boundary (continued)

***Figure 6. CertainTeed CedarBoards D6 Boundary Diagram***

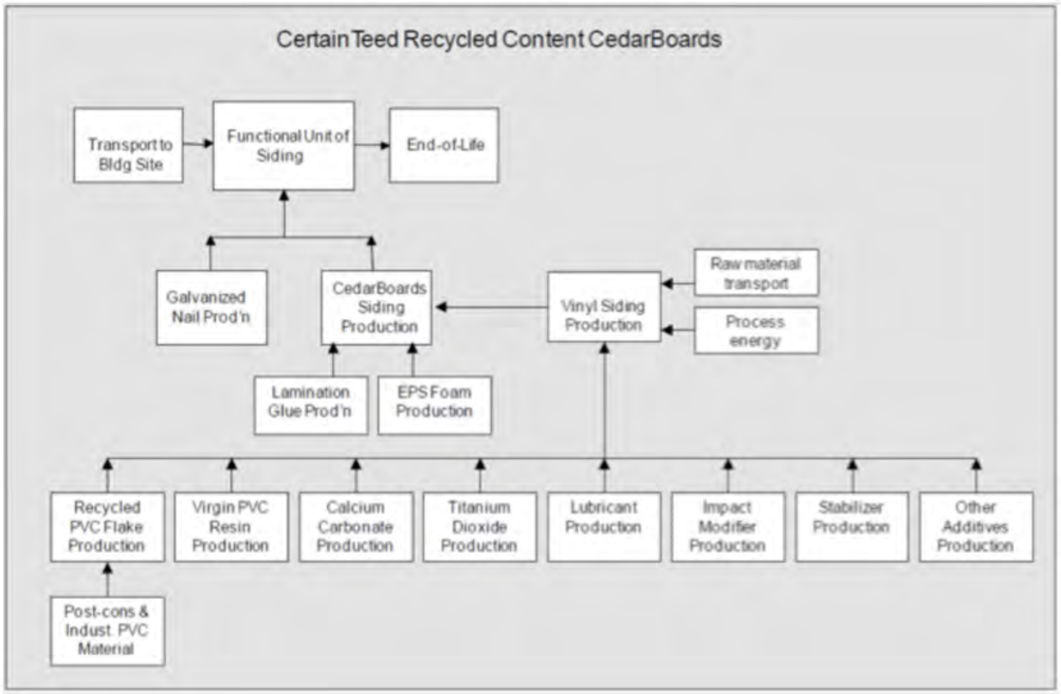
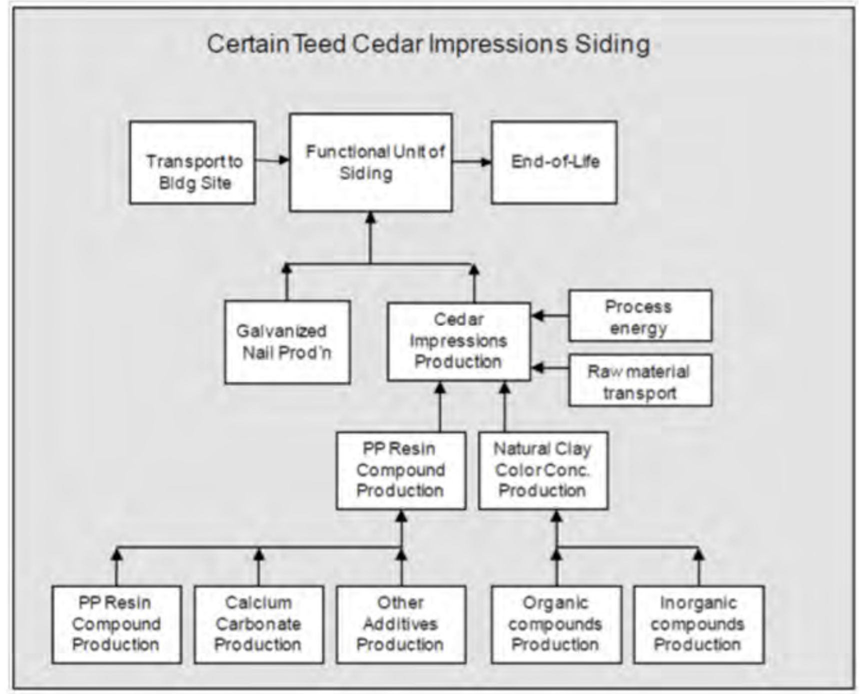



***Figure 7. CertainTeed Cedar Impressions Siding System Boundaries***




### Cut-off Criteria

The cut-off criteria for input flows to be considered within each system boundary were as follows:

a) Mass – if a flow is less than 1% of the cumulative mass of the model flows it may be excluded, providing its environmental relevance is minor.

b) Energy – if a flow is less than 1% of the cumulative energy of the system model it may be excluded, providing its environmental relevance is minor.

c) Environmental Relevance – if a flow meets the above two percent criteria, but is determined (via secondary data analysis) to contribute 2% or more to a product life cycle impact category, it is included within the system boundary.

## LCA Results

**BEES Impact Methodology**

The Building for Economic and Environmental Sustainability (BEES) impact methodology was used for all calculations of environmental impact. BEES was developed by the National Institute of Standards and Technology (NIST) as a tool for selecting cost-effective, environmentally-preferable building products. The specific impact categories included in BEES are described below:

**Global Warming Potential –** Carbon dioxide and other greenhouse gasses are emitted at every stage in the life cycle. These gasses can trap heat close to the Earth, contributing to global warming.

**Acidification –** Acidification is a more regional, rather than global, impact affecting fresh water and forests as well as human health when high concentrations of $SO_2$ are attained. Acidification is a result of processes that contribute to increased acidity of water and soil systems.

**Human Health: Cancer & Non-cancer –** This impact assesses the potential health impacts of more than 200 chemicals. These health impacts are general, based on emissions from the various life cycle stages, and do not take into account increased exposure that may take place in manufacturing facilities. For measuring the potential contribution to cancer, the Toxic Equivalency Potential for each chemical is determined and is displayed in terms of benzene equivalents. For measuring contribution to health impacts other than cancer, the Toxic Equivalency Potential for each chemical is determined and is displayed in terms of toluene equivalents.

**Criteria Air Pollutants –** This impact measures the amounts of criteria air pollutants: nitrogen oxides, sulfur oxides, and particulate matter.

**Eutrophication –** Eutrophication is the fertilization of surface waters by nutrients that were previously scarce. When a previously scarce or limiting nutrient is added to a water body, it leads to the proliferation of aquatic photosynthetic plant life. This may lead to the water body becoming hypoxic, eventually causing the death of fish and other aquatic life.

**Ecotoxicity –** The ecological toxicity impact measures the potential of a chemical released into the environment to harm terrestrial and aquatic ecosystems.

**Smog –** Under certain climatic conditions, air emissions from industry and transportation can be trapped at ground level where, in the presence of sunlight, they produce photochemical smog, a symptom of photochemical ozone creation potential (POCP). While ozone is not emitted directly, it is a product of interactions of volatile organic compounds (VOCs) and nitrogen oxides (NOx).

**Fossil Fuel Depletion –** This impact measures the extraction of fossil fuels (petroleum, coal, and natural gas).

**Indoor Air Quality –** It measures the effects of products on the air quality inside buildings, primarily through the measurement of volatile organic compound (VOC) emissions.

**Habitat Alteration –** This impact measures the potential for land use by humans to lead to damage of Threatened and Endangered Species. In BEES, habitat alteration is assessed based on the amount of waste sent to landfill through the life of the product and at the point of final disposal.

**Water Intake –** This impact measures water withdrawn from the groundwater or municipal system.

**Ozone Depletion –** Certain chemicals, when released into the atmosphere, can cause depletion of the ozone layer, which protects the Earth and its inhabitants from certain types of harmful radiation. This impact measures the releases of those chemicals.

In order to combine the environmental impacts categories above, a judgment was made about the relative importance of the environmental impact categories. The BEES impact assessment methodology weighting system is based on a volunteer stakeholder panel assembled by the National Institute of Standards and Technology (NIST) which included seven producers (i.e., building product manufacturers), seven users (i.e., green building designers), and five LCA experts. The relative weight of each impact category is shown in Table 8.

***Table 8. BEES Overall Assessment Methodology Impact Categories and Relative Weightings***

| Impact Category | Unit | Weighting |
|---|---|---|
| Global Warming | g $CO_2$ eq | 29% |
| Fossil Fuel Depletion | MJ surplus | 10% |
| Criteria Air Pollutants | microDALYs | 9% |
| Human Health Cancer | g $C_6H_6$ eq | 8% |
| Water Intake | liters | 8% |
| Ecological Toxicity | g 2,4-D eq | 7% |
| Eutrophication | g N eq | 6% |
| Habitat Alteration | T&E count | 6% |
| Human Health Non-cancer | g $C_7H_7$ eq | 5% |
| Smog | g NOx eq | 4% |
| Acidification | $H^+$ moles eq | 3% |
| Indoor Air Quality | kg TVOC eq | 3% |
| Ozone Depletion | g CFC-11 eq | 2% |

## Economic Performance

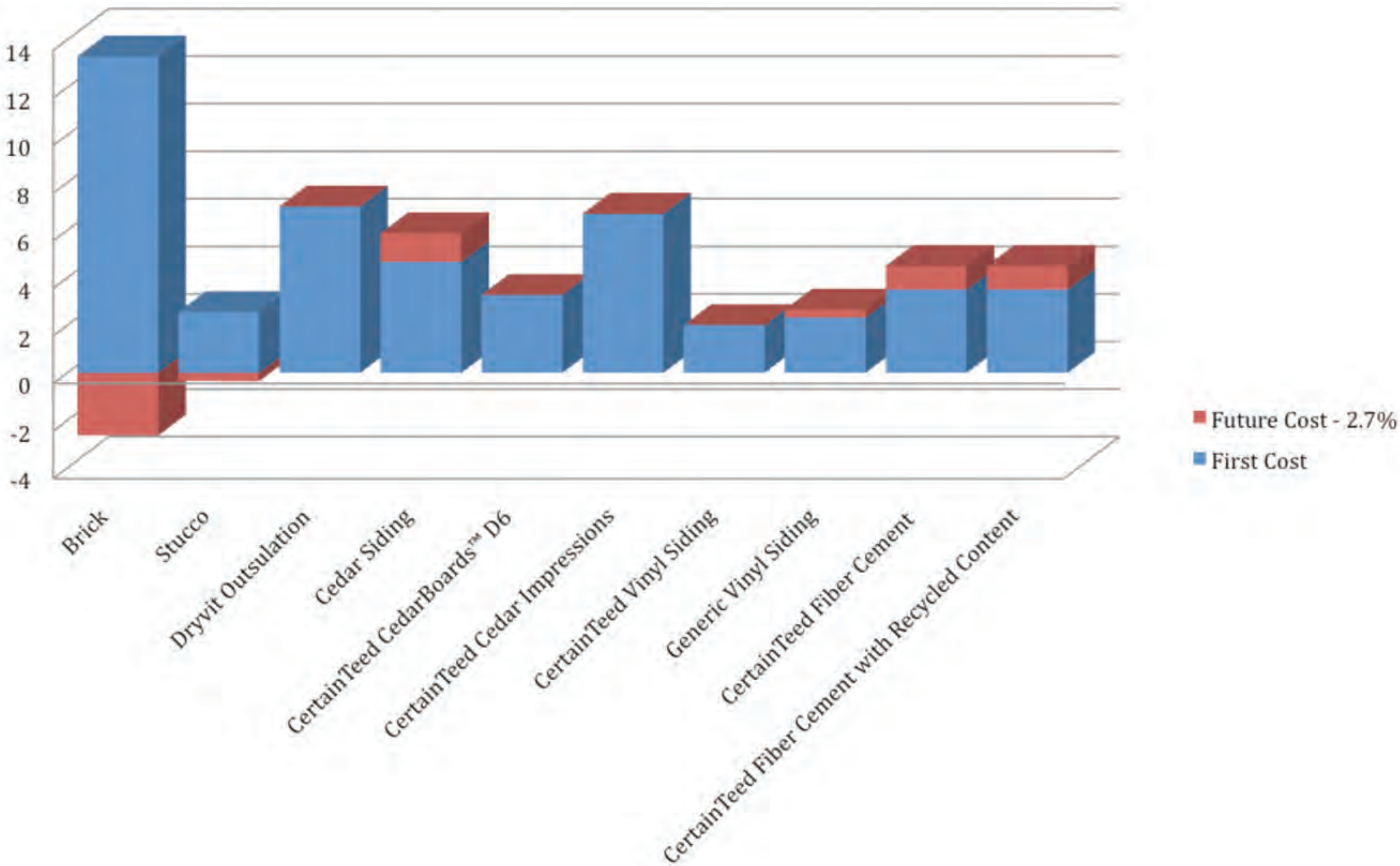
Economic performance is evaluated beginning at product purchase and installation because this is when out-of-pocket costs begin to be incurred, and investment decisions are made based upon out-of-pocket costs. In the BEES model, economic performance is measured over a 50-year study period. Life Cycle Costing (LCC) is the method used for the economic analysis. This method sums over the study period all relevant costs associated with a product. Categories of cost typically include costs for purchase, installation, operation, maintenance, repair, and replacement. A negative cost item is the residual value, which is the value of the product remaining at the end of the 50-year study period. Thus, negative future cost values represent the value left in the siding product after 50 years. Table 10 below shows that this situation only applies to brick, as all other claddings are expected to have a 50 year or lower life.

***Table 10. Economic Performance of Various Cladding Products***

| Category | Brick | Stucco | Dryvit Outsulation | Cedar Siding | CT CedarBoards D6 | CT Cedar Impressions | CT Vinyl Siding | Generic Vinyl Siding | CT Fiber Cement | CT Fiber Cement with Recycled Content |
|---|---|---|---|---|---|---|---|---|---|---|
| First Cost | 13.3 | 2.56 | 7 | 4.66 | 3.28 | 6.69 | 2.01 | 2.32 | 3.5 | 3.5 |
| Future Cost | -2.63 | -0.34 | 0 | 1.21 | 0 | 0 | 0 | 0.34 | 1 | 1 |
| Sum | 10.67 | 2.22 | 7 | 5.87 | 3.28 | 6.69 | 2.01 | 2.66 | 4.5 | 4.5 |

## Economic Performance (continued)

***Figure 9. Economic performance of various cladding products. With economic performance of various cladding products (large impact cladding removed)***



## Overall Environmental Impact

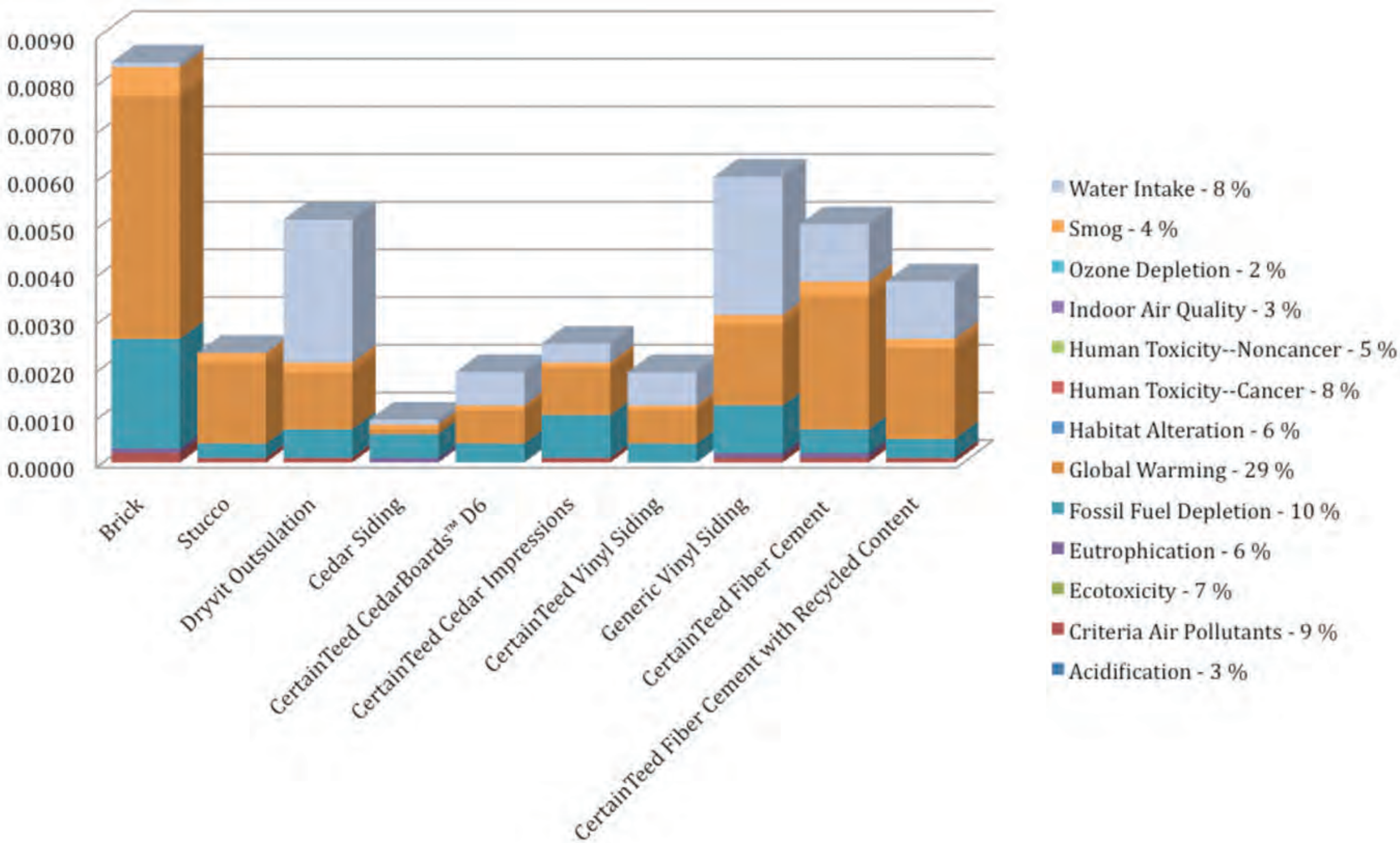
The tables and graphs below were generated using the BEES Online Software and display the overall environmental impact of siding products including CedarBoards D6, Cedar Impressions, and CertainTeed Vinyl Siding. The results are a composite score based on all of the impact categories combined and weighted according to the values in Table 9. The overall score is unit-less and is useful only for comparing products; however, many of the impact categories are illustrated in more detail in Appendix A. It is important to remember that the lower the score, the lower the environmental impact. As illustrated in Table 9 and Figure 8, in comparison to other siding options, all three CertainTeed products have very low impacts across all life cycle stages compared to other cladding options.

***Table 9. Overall Environmental Impact of Various Cladding Products***

| Category | Brick | Stucco | Dryvit Outsulation | Cedar Siding | CT CedarBoards D6 | CT Cedar Impressions | CT Vinyl Siding | Generic Vinyl Siding | CT Fiber Cement | CT Fiber Cement with Recycled Content |
|---|---|---|---|---|---|---|---|---|---|---|
| Acidification – 3% | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Criteria Air Pollutants – 9% | 0.0002 | 0.0001 | 0.0001 | 0.0000 | 0.0000 | 0.0001 | 0.0000 | 0.0001 | 0.0001 | 0.0001 |
| Ecotoxicity – 7% | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Eutrophication – 6% | 0.0001 | 0.0000 | 0.0000 | 0.0001 | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0001 | 0.0000 |
| Fossil Fuel Depletion – 10% | 0.0023 | 0.0003 | 0.0006 | 0.0005 | 0.0004 | 0.0009 | 0.0004 | 0.001 | 0.0005 | 0.0004 |
| Global Warming – 29% | 0.0051 | 0.0017 | 0.0012 | 0.0001 | 0.0007 | 0.001 | 0.0007 | 0.0017 | 0.0028 | 0.0019 |
| Habitat Alteration – 6% | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Human Toxicity: Cancer – 8% | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Human Toxicity: Noncancer – 5% | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Indoor Air Quality – 3% | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Ozone Depletion – 2% | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Smog – 4% | 0.0006 | 0.0002 | 0.0002 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0002 | 0.0003 | 0.0002 |
| Water Intake – 8% | 0.0001 | 0.0000 | 0.003 | 0.0001 | 0.0007 | 0.0004 | 0.0007 | 0.0029 | 0.0012 | 0.0012 |
| Sum | 0.0084 | 0.0023 | 0.0051 | 0.0009 | 0.0019 | 0.0025 | 0.0019 | 0.006 | 0.005 | 0.0038 |

## Overall Environmental Impact (continued)

***Figure 8. Overall environmental impact of various cladding products. With an overall environmental impact of CertainTeed vinyl siding products (with large impact cladding removed).***



## Global Warming Potential

The following provides more detail on the environmental impacts of insulated vinyl siding and the other cladding products examined in this report. All of these graphs and tables were produced using BEES Online and additional data can be obtained by going to http://ws680.nist.gov/Bees/.

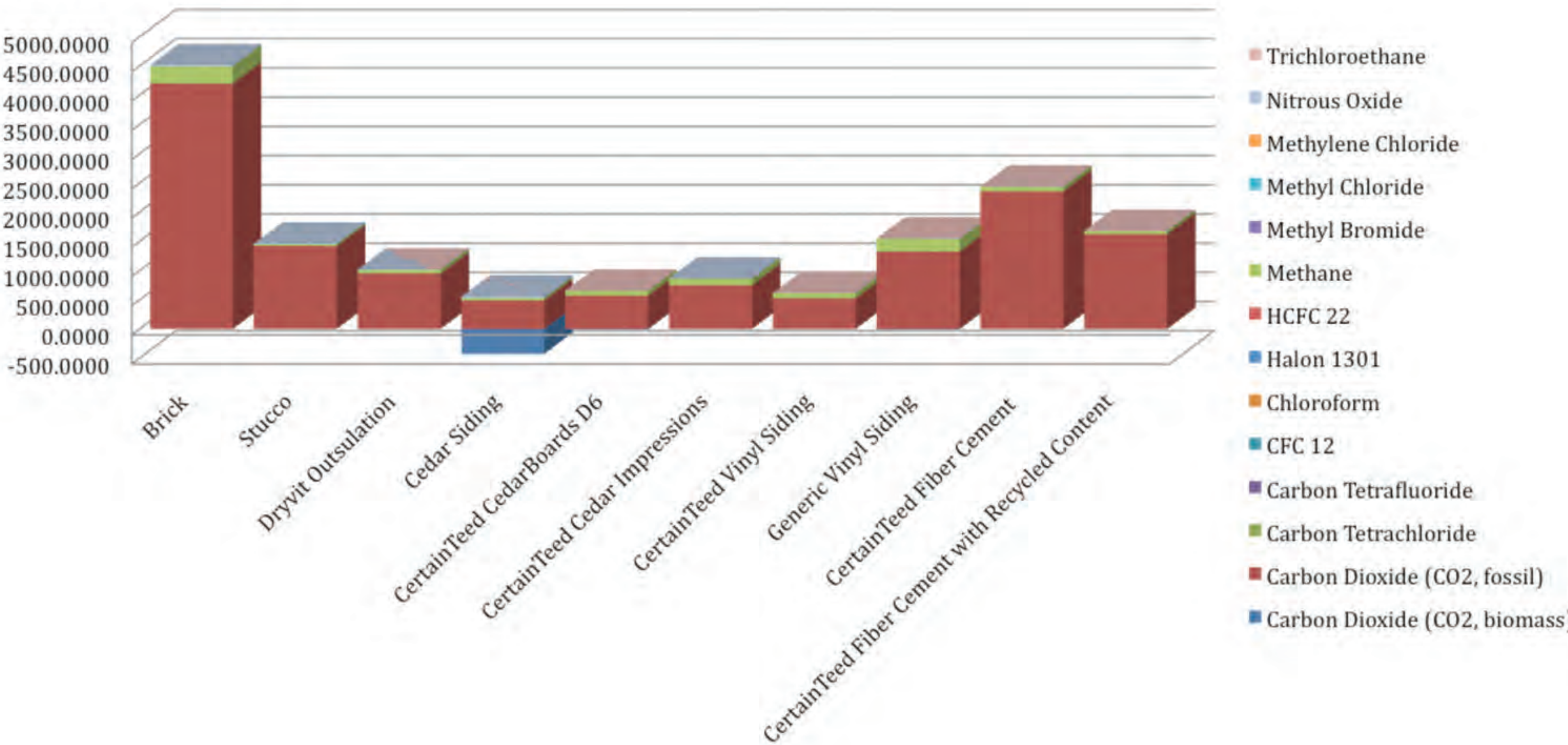
Carbon dioxide and other greenhouse gasses are emitted at every stage in the manufacturing process. These gasses can trap heat close to the Earth, contributing to global warming.

***Table 11. Global Warming Potential (g $CO_2$ eq)***

| Category | Brick | Stucco | Dryvit Outsulation | Cedar Siding | CT CedarBoards D6 | CT Cedar Impressions | CT Vinyl Siding | Generic Vinyl Siding | CT Fiber Cement | CT Fiber Cement with Recycled Content |
|---|---|---|---|---|---|---|---|---|---|---|
| Carbon Dioxide–biomass | 0.0000 | 0.0000 | -0.0020 | -425.7756 | -3.2061 | -0.0018 | 0.0063 | -3.8950 | 0.0007 | -0.0012 |
| Carbon Dioxide–fossil | 4200.9186 | 1417.4695 | 948.4352 | 486.1856 | 568.7947 | 748.6982 | 519.7618 | 1322.6183 | 2354.5497 | 1619.9052 |
| Carbon Tetrachloride | 0.0000 | 0.0000 | 0.0074 | 0.0725 | 0.0083 | 0.0008 | 0.0356 | 0.0903 | 0.0034 | 0.0033 |
| Carbon Tetrafluoride | 0.0000 | 0.0000 | 0.0116 | 0.0000 | 0.0028 | 0.0003 | 0.0012 | 0.0003 | 0.0267 | 0.0231 |
| CFC 12 | 0.0004 | 0.0002 | 0.0006 | 0.0001 | 0.0001 | 0.0004 | 0.0001 | 0.0001 | 0.0124 | 0.0103 |
| Chloroform | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0001 |
| Halon 1301 | 0.0000 | 0.0000 | 0.0015 | 0.0000 | 0.0009 | 0.0002 | 0.0004 | 0.0013 | 0.0013 | 0.0013 |
| HCFC 22 | 0.0000 | 0.0000 | 0.1038 | 0.0000 | 0.0546 | 0.0011 | 0.0014 | 0.0046 | 0.0023 | 0.0023 |
| Methane | 295.5823 | 35.0881 | 63.2584 | 41.0141 | 83.2852 | 111.2955 | 92.2947 | 219.4739 | 78.0566 | 56.8526 |
| Methyl Bromide | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Methyl Chloride | 0.0000 | 0.0002 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0003 | 0.0002 |
| Methylene Chloride | 0.0005 | 0.0002 | 0.0003 | 0.0026 | 0.0003 | 0.0001 | 0.0001 | 0.0004 | 0.0005 | 0.0003 |
| Nitrous Oxide | 16.6256 | 4.6380 | 2.8653 | 24.5607 | 1.3935 | 2.8604 | 1.8349 | 4.6226 | 3.2798 | 2.7151 |
| Trichloroethane | 0.0000 | 0.0001 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0001 |
| Sum | 4513.1274 | 1457.1963 | 1014.6821 | 126.0600 | 650.3343 | 862.8552 | 613.9365 | 1542.9169 | 2435.9339 | 1679.5127 |

## Global Warming Potential (continued)

***Figure 10. Global warming potential (g $CO_2$ eq). With global warming potential (g $CO_2$ eq) (large impact cladding removed)***



## Acidification

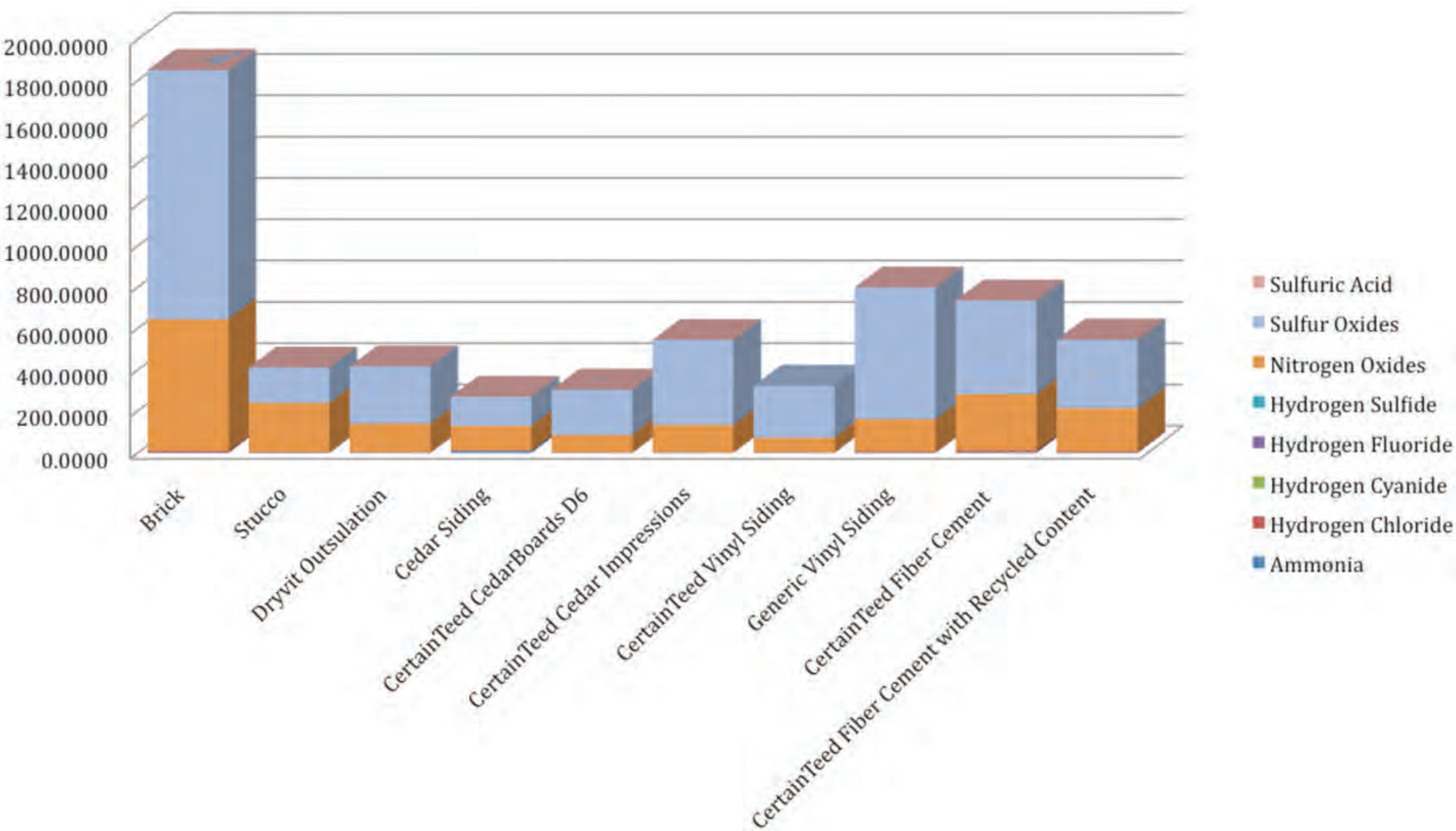
Acidification is a more regional, rather than global, impact affecting fresh water and forests as well as human health when high concentrations of $SO_2$ are attained. Acidification is a result of processes that contribute to increased acidity of water and soil systems. The acidification potential of an air emission is calculated on the basis of the number of $H^+$ ions that can be produced and, therefore, is expressed as potential $H^+$ equivalents on a mass basis.

***Table 12. Acidification ($H^+$ moles eq)***

| Category | Brick | Stucco | Dryvit Outsulation | Cedar Siding | CT CedarBoards D6 | CT Cedar Impressions | CT Vinyl Siding | Generic Vinyl Siding | CT Fiber Cement | CT Fiber Cement with Recycled Content |
|---|---|---|---|---|---|---|---|---|---|---|
| Ammonia | 0.9610 | 0.5016 | 0.4619 | 9.8150 | 0.2464 | 0.3666 | 0.2222 | 0.3237 | 0.6703 | 0.5367 |
| Hydrogen Chloride | 8.5969 | 3.3876 | 2.4601 | 1.9274 | 2.3439 | 1.1466 | 1.9530 | 5.5535 | 8.6925 | 6.1742 |
| Hydrogen Cyanide | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0015 | 0.0000 | 0.0018 | 0.0000 | 0.0000 | 0.0000 |
| Hydrogen Fluoride | 1.5616 | 0.3975 | 0.3540 | 0.2344 | 0.5053 | 0.2489 | 0.4366 | 1.2487 | 2.6098 | 1.5134 |
| Hydrogen Sulfide | 0.0000 | 0.2479 | 0.0610 | 0.0028 | 0.0214 | 0.0049 | 0.0107 | 0.0400 | 0.0271 | 0.0267 |
| Nitrogen Oxides | 633.8794 | 236.3306 | 135.8206 | 115.8552 | 83.2032 | 131.7683 | 70.8816 | 153.8736 | 270.0498 | 205.6361 |
| Sulfur Oxides | 1207.3494 | 170.0344 | 276.8264 | 141.7787 | 216.8831 | 411.5981 | 249.3843 | 637.7024 | 453.9697 | 331.7174 |
| Sulfuric Acid | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Sum | 1852.3483 | 410.8996 | 415.9840 | 269.6135 | 303.2048 | 545.1334 | 322.8902 | 798.7419 | 736.0192 | 545.6045 |

## Acidification (continued)

***Figure 11. Acidification (H+ moles eq). With Acidification (H+ moles eq) (large impact cladding removed).***



## Human Health: Cancer

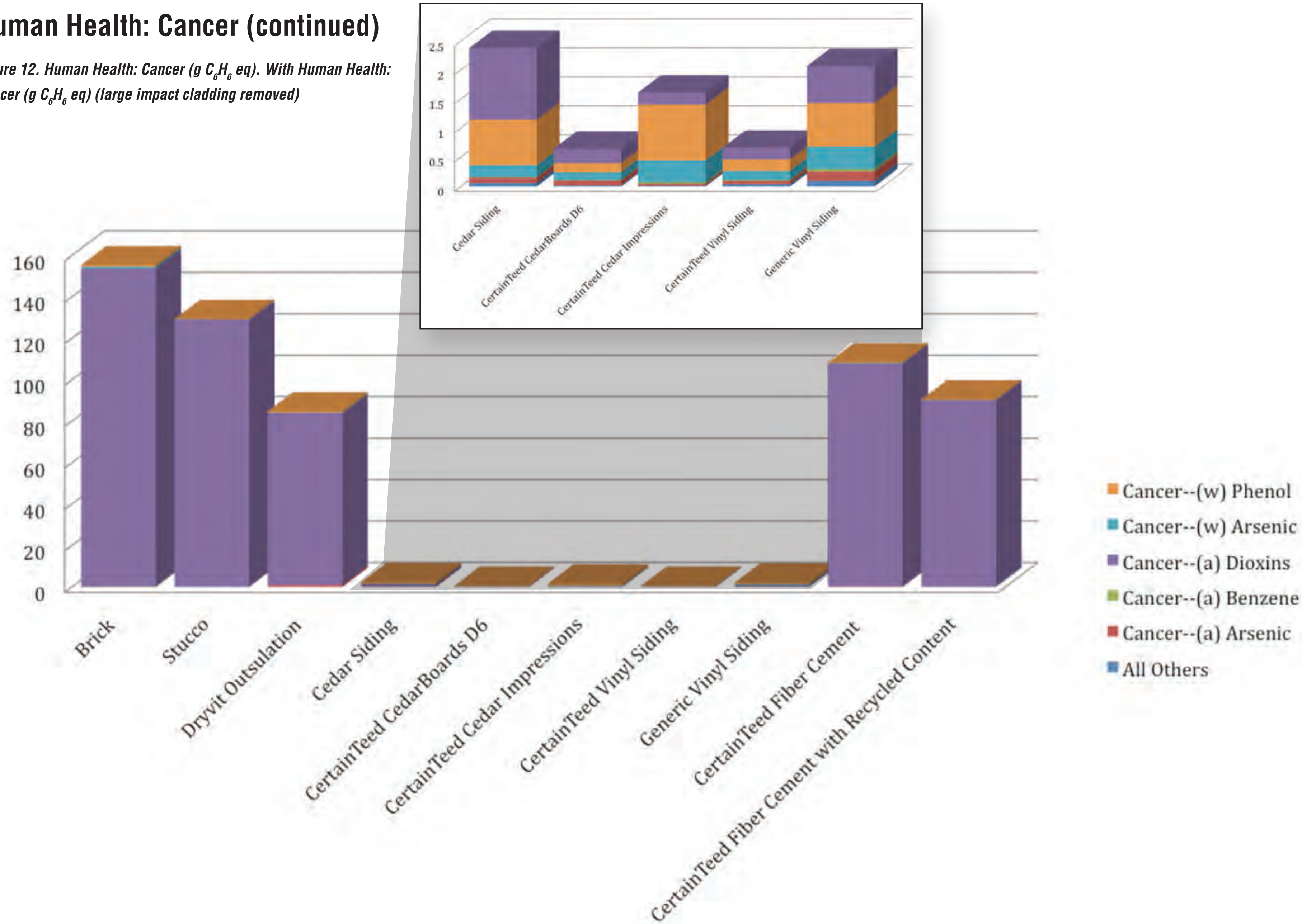
This impact assesses the potential health impacts of more than 200 chemicals. These health impacts are general, based on emissions from the various life cycle stages and do not take into account increased exposure that may take place in manufacturing facilities. For measuring the potential contribution to cancer, the Toxic Equivalency Potential for each chemical is determined and is displayed in terms of benzene equivalents.

***Table 13. Human Health: Cancer (g $C_6H_6$ eq)***

| Category | Brick | Stucco | Dryvit Outsulation | Cedar Siding | CT CedarBoards D6 | CT Cedar Impressions | CT Vinyl Siding | Generic Vinyl Siding | CT Fiber Cement | CT Fiber Cement with Recycled Content |
|---|---|---|---|---|---|---|---|---|---|---|
| All Others | 0.0258 | 0.1008 | 0.0281 | 0.0603 | 0.0189 | 0.0165 | 0.0379 | 0.0973 | 0.1641 | 0.1523 |
| Arsenic | 0.1987 | 0.0506 | 1.0338 | 0.0915 | 0.0831 | 0.0344 | 0.0603 | 0.1615 | 0.2279 | 0.1706 |
| Benzene | 0.0642 | 0.0035 | 0.0115 | 0.0097 | 0.0094 | 0.0262 | 0.0131 | 0.0337 | 0.0147 | 0.0109 |
| Dioxins | 153.4737 | 128.9051 | 82.9269 | 1.2364 | 0.2471 | 0.2094 | 0.1999 | 0.6355 | 107.5536 | 89.8616 |
| Arsenic | 0.8545 | 0.1302 | 0.2174 | 0.1964 | 0.1327 | 0.3645 | 0.1515 | 0.3875 | 0.2237 | 0.1639 |
| Phenol | 0.7984 | 0.1166 | 0.5864 | 0.7862 | 0.1528 | 0.9629 | 0.1966 | 0.7537 | 0.1952 | 0.1445 |
| Sum | 155.4153 | 129.3068 | 84.8041 | 2.3805 | 0.644 | 1.6139 | 0.6593 | 2.0692 | 108.3792 | 90.5038 |

## Human Health: Cancer (continued)

***Figure 12. Human Health: Cancer (g $C_6H_6$ eq). With Human Health: Cancer (g $C_6H_6$ eq) (large impact cladding removed)***



## Human Health: Non-Cancer

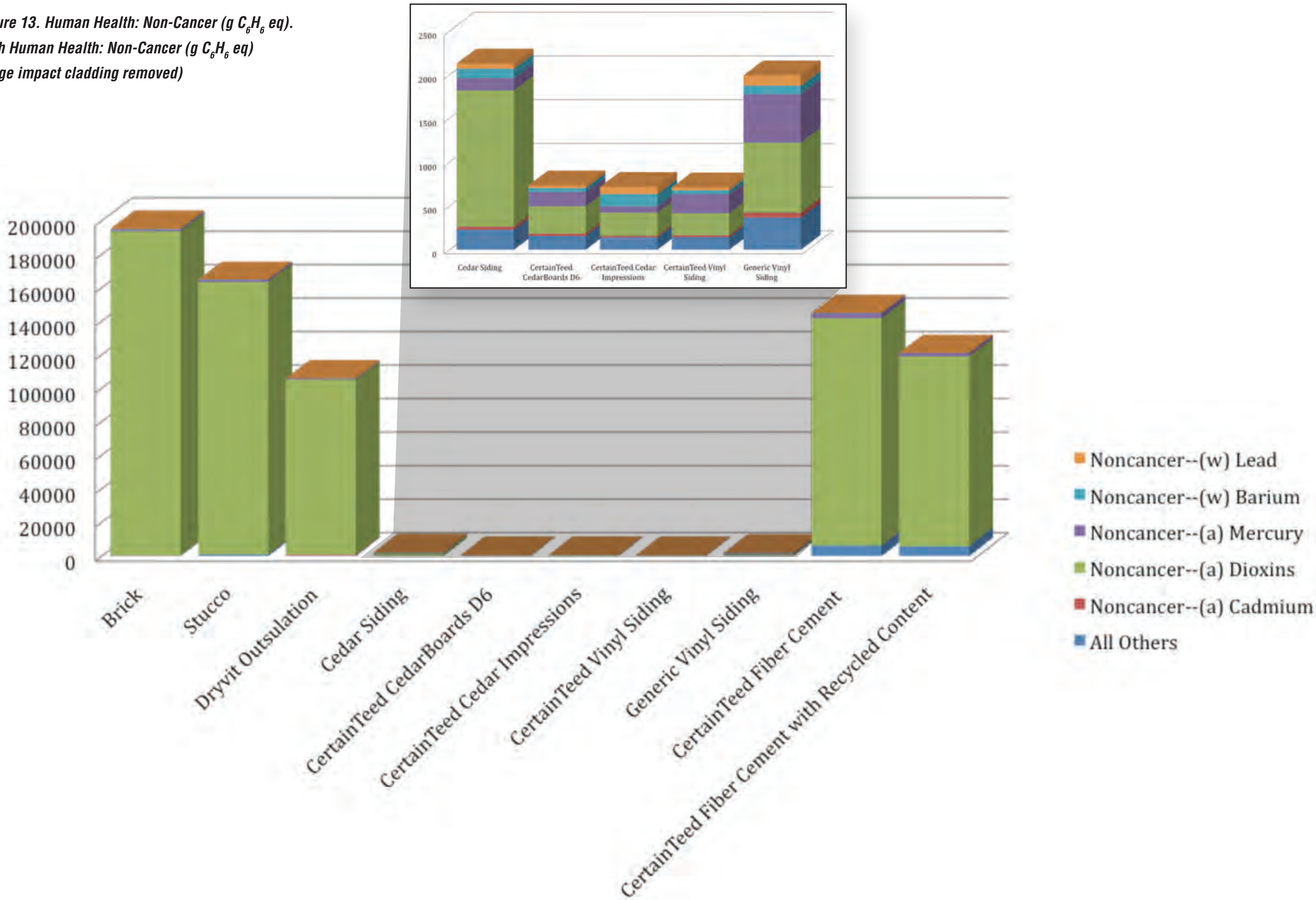
This impact assesses the potential health impacts of more than 200 chemicals. These health impacts are general, based on emissions from the various life cycle stages and do not take into account increased exposure that may take place in manufacturing facilities. For measuring contribution to health impacts other than cancer, the Toxic Equivalency Potential for each chemical is determined and is displayed in terms of toluene equivalents.

***Table 14. Human Health: Non-Cancer (g $C_7H_7$ eq)***

| Category | Brick | Stucco | Dryvit Outsulation | Cedar Siding | CT CedarBoards D6 | CT Cedar Impressions | CT Vinyl Siding | Generic Vinyl Siding | CT Fiber Cement | CT Fiber Cement with Recycled Content |
|---|---|---|---|---|---|---|---|---|---|---|
| All Others | 310.2273 | 979.8347 | 258.0612 | 228.7198 | 156.9974 | 141.3501 | 143.5133 | 365.7584 | 6179.8036 | 5796.7537 |
| Cadmium | 122.4779 | 56.7303 | 509.6966 | 35.46 | 28.071 | 16.9569 | 21.1635 | 58.3066 | 70.5912 | 52.4694 |
| Dioxins | 193353.669 | 162400.8943 | 104475.319 | 1557.6669 | 311.3637 | 263.8616 | 251.8877 | 800.696 | 135501.2462 | 113212.0327 |
| Mercury | 998.3203 | 1329.1067 | 573.2167 | 139.9944 | 162.5037 | 72.5667 | 218.5441 | 552.6058 | 3075.3736 | 1988.3074 |
| Barium | 308.7574 | 81.8529 | 74.9816 | 108.5443 | 45.8226 | 140.5123 | 43.433 | 98.9809 | 87.4298 | 62.6211 |
| Lead | 192.9806 | 40.4708 | 54.8453 | 58.376 | 30.3103 | 83.8754 | 32.4362 | 117.0465 | 57.2972 | 40.3559 |
| Sum | 195286.4325 | 164888.8897 | 105946.1204 | 2128.7614 | 735.0687 | 719.123 | 710.9778 | 1993.3942 | 144971.7416 | 121152.5402 |

## Human Health: Non-Cancer (continued)

*Figure 13. Human Health: Non-Cancer (g $C_6H_6$ eq).*
*With Human Health: Non-Cancer (g $C_6H_6$ eq)*
*(large impact cladding removed)*



## Criteria Air Pollutants

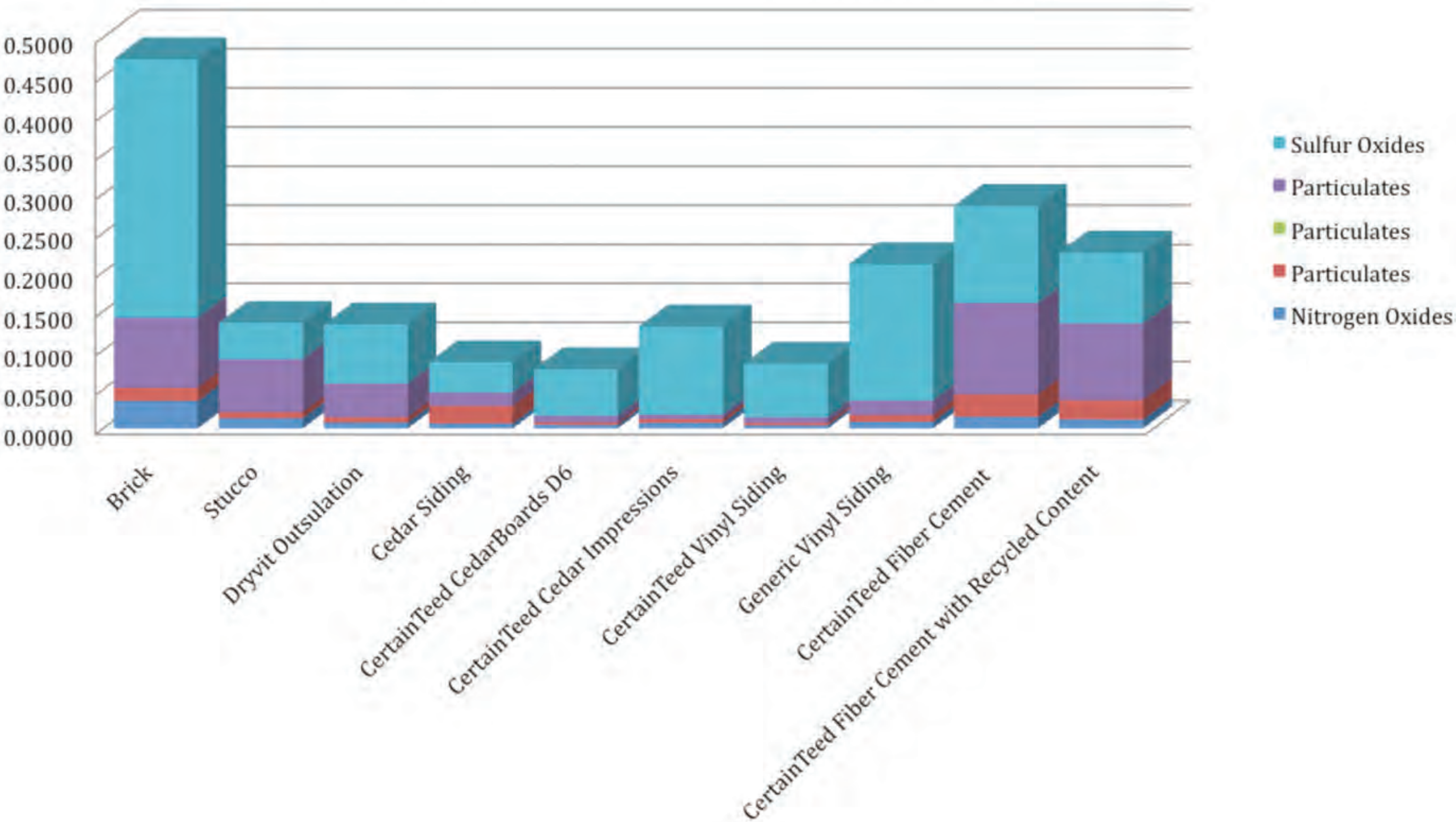
This impact measures the amounts of criteria air pollutants: nitrogen oxides, sulfur oxides, and particulate matter.

***Table 15. Criteria Air Pollutants (microDALYs)***

| Category | Brick | Stucco | Dryvit Outsulation | Cedar Siding | CT CedarBoards D6 | CT Cedar Impressions | CT Vinyl Siding | Generic Vinyl Siding | CT Fiber Cement | CT Fiber Cement with Recycled Content |
|---|---|---|---|---|---|---|---|---|---|---|
| Nitrogen Oxides | 0.0350 | 0.0131 | 0.0075 | 0.0064 | 0.0046 | 0.0073 | 0.0039 | 0.0085 | 0.0149 | 0.0114 |
| Particulates (greater than) | 0.0170 | 0.0076 | 0.0067 | 0.0223 | 0.0029 | 0.0047 | 0.0033 | 0.0086 | 0.0284 | 0.0246 |
| Particulates (PM 10) | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Particulates (unspecified) | 0.0896 | 0.0677 | 0.0431 | 0.0173 | 0.0087 | 0.0057 | 0.0073 | 0.0184 | 0.1171 | 0.0982 |
| Sulfur Oxides | 0.3306 | 0.0466 | 0.0758 | 0.0388 | 0.0594 | 0.1127 | 0.0683 | 0.1746 | 0.1243 | 0.0908 |
| Sum | 0.4722 | 0.1350 | 0.1331 | 0.0848 | 0.0756 | 0.1304 | 0.0828 | 0.2101 | 0.2847 | 0.2250 |

## Criteria Air Pollutants (continued)

*Figure 14. Criteria Air Pollutants (microDALYs). With Criteria Air Pollutants (microDALYs) (large impact cladding removed).*



## Eutrophication

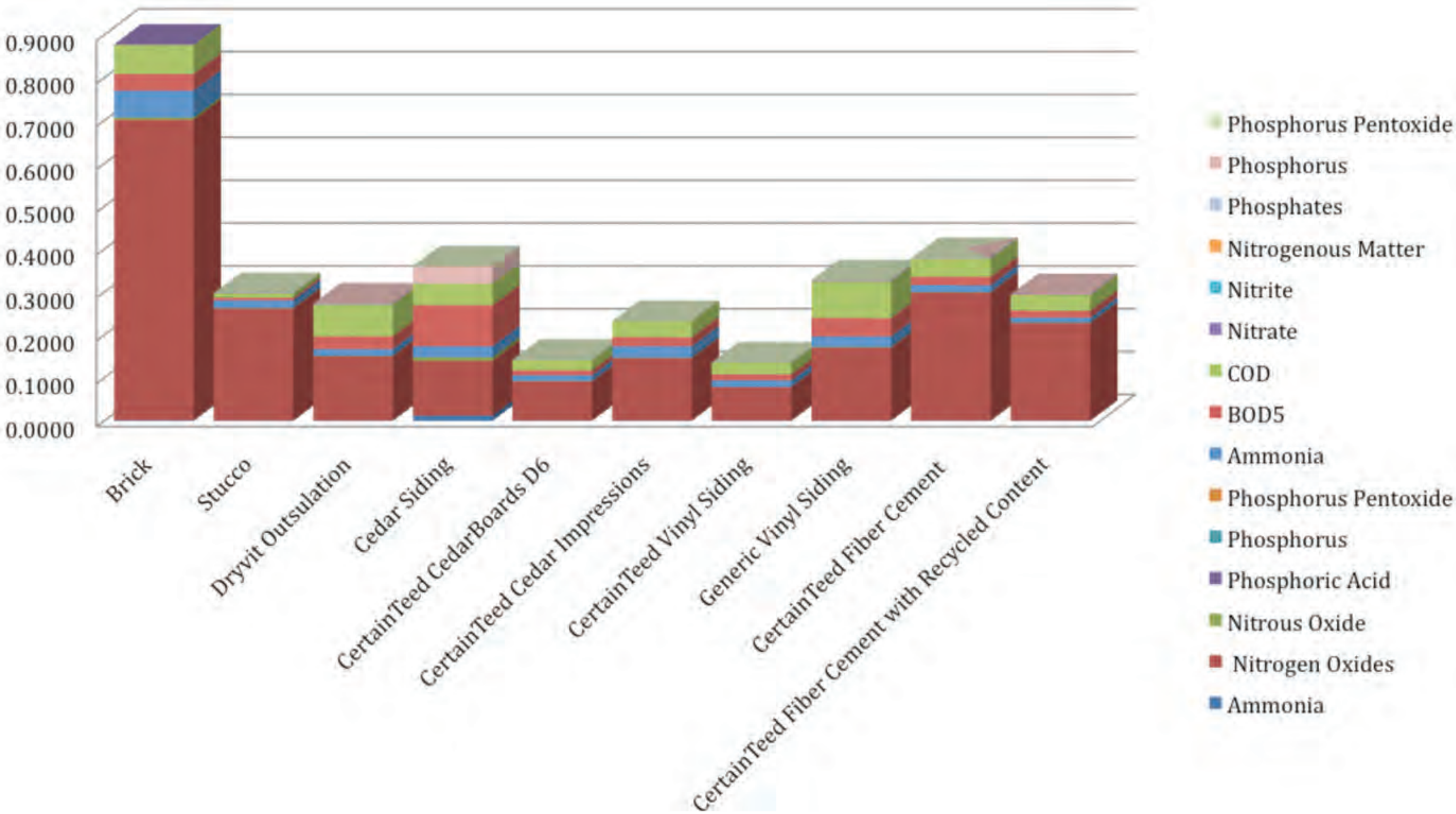
Eutrophication is the fertilization of surface waters by nutrients that were previously scarce. When a previously scarce or limiting nutrient is added to a water body, it leads to the proliferation of aquatic photosynthetic plant life. This may lead to the water body becoming hypoxic, eventually causing the death of fish and other aquatic life. This impact is expressed on an equivalent mass of nitrogen (N) basis.

***Table 16. Eutrophication (g N eq)***

| Category | Brick | Stucco | Dryvit Outsulation | Cedar Siding | CT CedarBoards D6 | CT Cedar Impressions | CT Vinyl Siding | Generic Vinyl Siding | CT Fiber Cement | CT Fiber Cement with Recycled Content |
|---|---|---|---|---|---|---|---|---|---|---|
| Ammonia | 0.0012 | 0.0006 | 0.0006 | 0.0122 | 0.0003 | 0.0005 | 0.0003 | 0.0004 | 0.0008 | 0.0007 |
| Nitrogen Oxides | 0.7012 | 0.2614 | 0.1502 | 0.1282 | 0.0920 | 0.1458 | 0.0784 | 0.1702 | 0.2987 | 0.2275 |
| Nitrous Oxide | 0.0052 | 0.0014 | 0.0009 | 0.0076 | 0.0004 | 0.0009 | 0.0006 | 0.0014 | 0.0010 | 0.0008 |
| Phosphoric Acid | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Phosphorus | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Phosphorus Pentoxide | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Ammonia | 0.0627 | 0.0179 | 0.0159 | 0.0262 | 0.0133 | 0.0267 | 0.0151 | 0.0251 | 0.0159 | 0.0116 |
| BOD5 | 0.0390 | 0.0054 | 0.0296 | 0.0956 | 0.0116 | 0.0211 | 0.0141 | 0.0425 | 0.0193 | 0.0163 |
| COD | 0.0675 | 0.0104 | 0.0745 | 0.0503 | 0.0242 | 0.0374 | 0.0273 | 0.0857 | 0.0419 | 0.0368 |
| Nitrate | 0.0010 | 0.0006 | 0.0015 | 0.0000 | 0.0002 | 0.0002 | 0.0002 | 0.0015 | 0.0015 | 0.0012 |
| Nitrite | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Nitrogenous Matter | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Phosphates | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Phosphorus | 0.0000 | 0.0000 | 0.0004 | 0.0406 | 0.0001 | 0.0000 | 0.0001 | 0.0009 | 0.0001 | 0.0001 |
| Phosphorus Pentoxid | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Sum | 0.8778 | 0.2977 | 0.2736 | 0.3607 | 0.1421 | 0.2326 | 0.1361 | 0.3277 | 0.3792 | 0.2950 |

## Eutrophication (continued)

***Figure 15. Eutrophication (g N eq). With Eutrophication (g N eq) (large impact cladding removed)***



## Ecological Toxicity

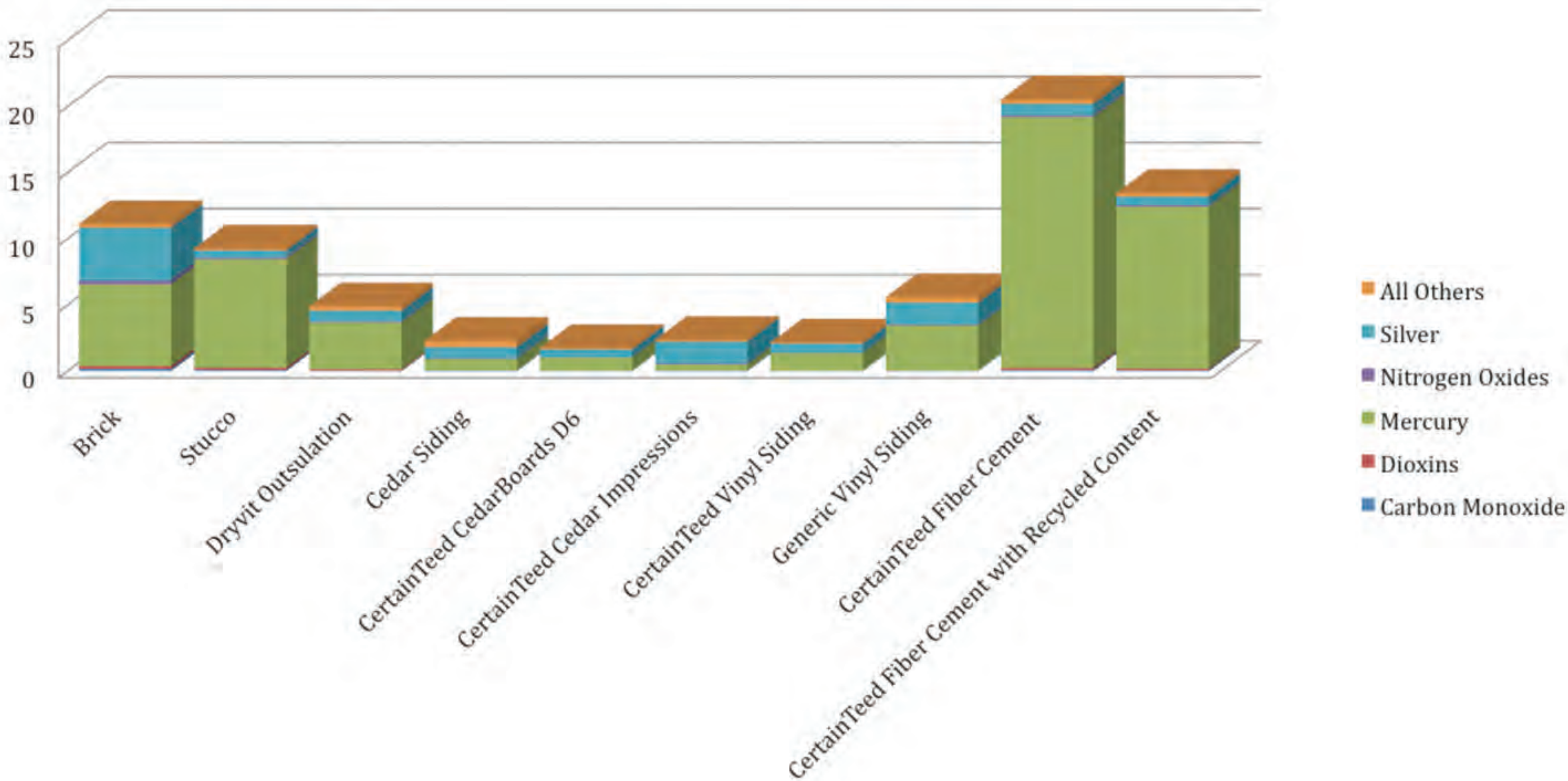
The ecological toxicity impact measures the potential of a chemical released into the environment to harm terrestrial and aquatic ecosystems.

***Table 17. Ecological Toxicity (g 2,4-D eq)***

| Category | Brick | Stucco | Dryvit Outsulation | Cedar Siding | CT CedarBoards D6 | CT Cedar Impressions | CT Vinyl Siding | Generic Vinyl Siding | CT Fiber Cement | CT Fiber Cement with Recycled Content |
|---|---|---|---|---|---|---|---|---|---|---|
| Carbon Monoxide | 0.1818 | 0.0988 | 0.0403 | 0.0471 | 0.0226 | 0.0632 | 0.0187 | 0.0422 | 0.0978 | 0.0648 |
| Dioxins | 0.2103 | 0.1766 | 0.1136 | 0.0017 | 0.0003 | 0.0003 | 0.0003 | 0.0009 | 0.1474 | 0.1231 |
| Mercury | 6.1572 | 8.1974 | 3.5354 | 0.8634 | 1.0023 | 0.4476 | 1.3479 | 3.4083 | 18.9677 | 12.2631 |
| Nitrogen Oxides | 0.3245 | 0.121 | 0.0695 | 0.0593 | 0.0426 | 0.0675 | 0.0363 | 0.0788 | 0.1383 | 0.1053 |
| Silver | 3.9779 | 0.5351 | 0.8103 | 0.836 | 0.5772 | 1.6643 | 0.687 | 1.6576 | 0.8754 | 0.6299 |
| All Others | 0.273 | 0.1443 | 0.3299 | 0.4918 | 0.108 | 0.1209 | 0.0799 | 0.4146 | 0.3294 | 0.2911 |
| Sum | 11.1247 | 9.2732 | 4.899 | 2.2993 | 1.753 | 2.3638 | 2.1701 | 5.6024 | 20.556 | 13.4773 |

## Ecological Toxicity (continued)

***Figure 16. Ecological Toxicity (g 2,4-D eq). With Ecological Toxicity (g 2,4-D eq) (large impact cladding removed).***



## Smog Potential

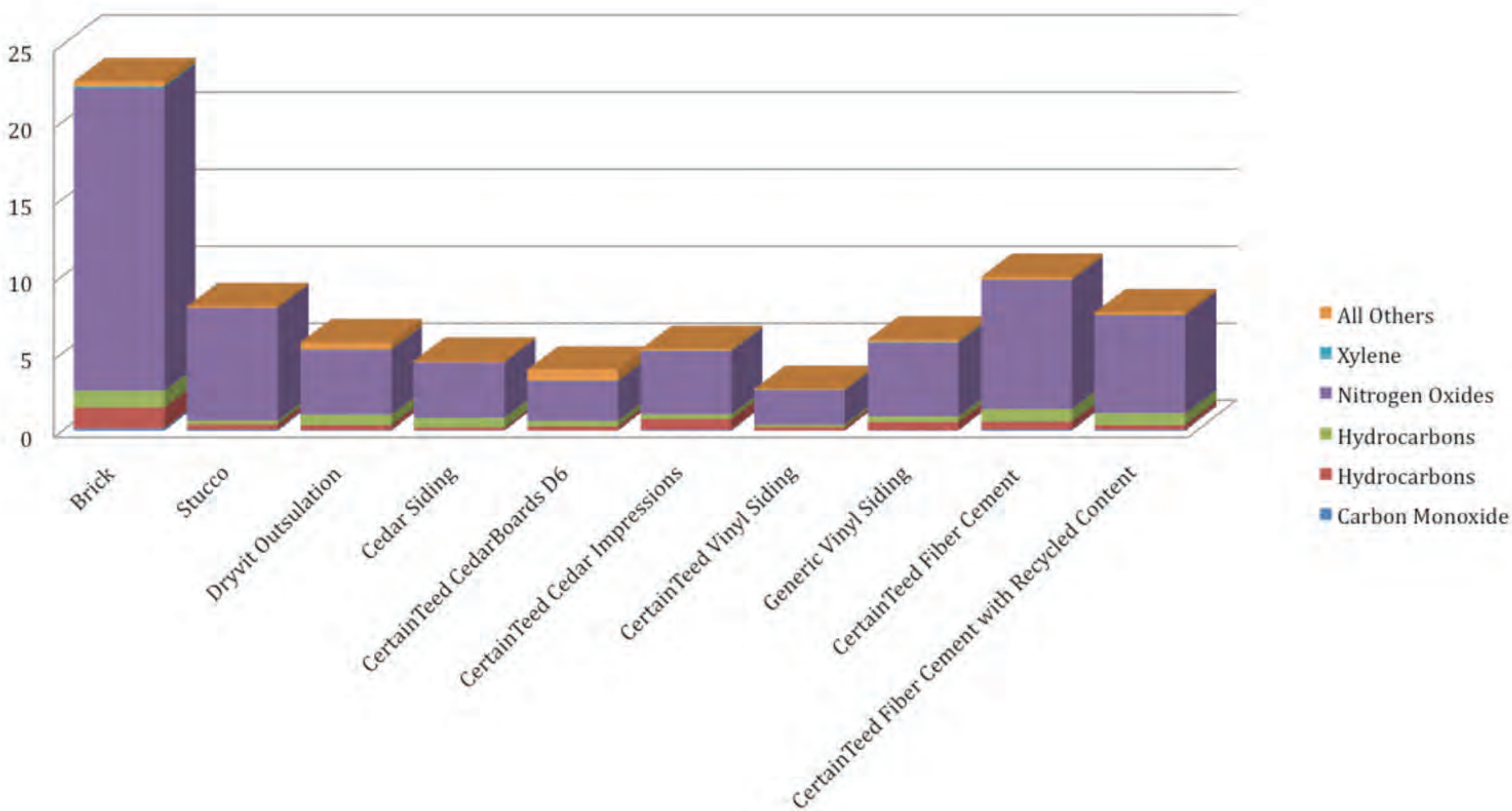
Under certain climatic conditions, air emissions from industry and transportation can be trapped at ground level where, in the presence of sunlight, they produce photochemical smog, a symptom of photochemical ozone creation potential (POCP). While ozone is not emitted directly, it is a product of interactions of volatile organic compounds (VOCs) and nitrogen oxides ($NO_x$). The Smog indicator is expressed as a mass of equivalent $NO_x$.

***Table 18. Smog Potential (g NOx eq)***

| Category | Brick | Stucco | Dryvit Outsulation | Cedar Siding | CT CedarBoards D6 | CT Cedar Impressions | CT Vinyl Siding | Generic Vinyl Siding | CT Fiber Cement | CT Fiber Cement with Recycled Content |
|---|---|---|---|---|---|---|---|---|---|---|
| Carbon Monoxide | 0.1472 | 0.0800 | 0.0326 | 0.0382 | 0.0183 | 0.0512 | 0.0152 | 0.0341 | 0.0792 | 0.0525 |
| Hydrocarbons | 1.3421 | 0.3335 | 0.3300 | 0.1750 | 0.2711 | 0.6827 | 0.2265 | 0.5166 | 0.4962 | 0.3277 |
| Hydrocarbons (unspecified) | 1.0736 | 0.2189 | 0.6477 | 0.6113 | 0.3251 | 0.3066 | 0.1532 | 0.3449 | 0.8008 | 0.7166 |
| Nitrogen Oxides | 19.6306 | 7.3189 | 4.2062 | 3.5879 | 2.5767 | 4.0807 | 2.1951 | 4.7653 | 8.3632 | 6.3684 |
| Xylene | 0.1222 | 0.0033 | 0.0213 | 0.0115 | 0.0175 | 0.0474 | 0.0244 | 0.061 | 0.0207 | 0.0151 |
| All Others | 0.3289 | 0.0976 | 0.4703 | 0.0884 | 0.7323 | 0.1037 | 0.0624 | 0.1576 | 0.1976 | 0.1612 |
| Sum | 22.6446 | 8.0522 | 5.7081 | 4.5123 | 3.941 | 5.2723 | 2.6768 | 5.8795 | 9.9577 | 7.6415 |

## Smog Potential (continued)

***Figure 17. Smog Potential (g $NO_x$ eq). With Smog Potential (g $NO_x$ eq) (large impact cladding removed)***



## Overall Environmental Performance by Life Cycle Stage

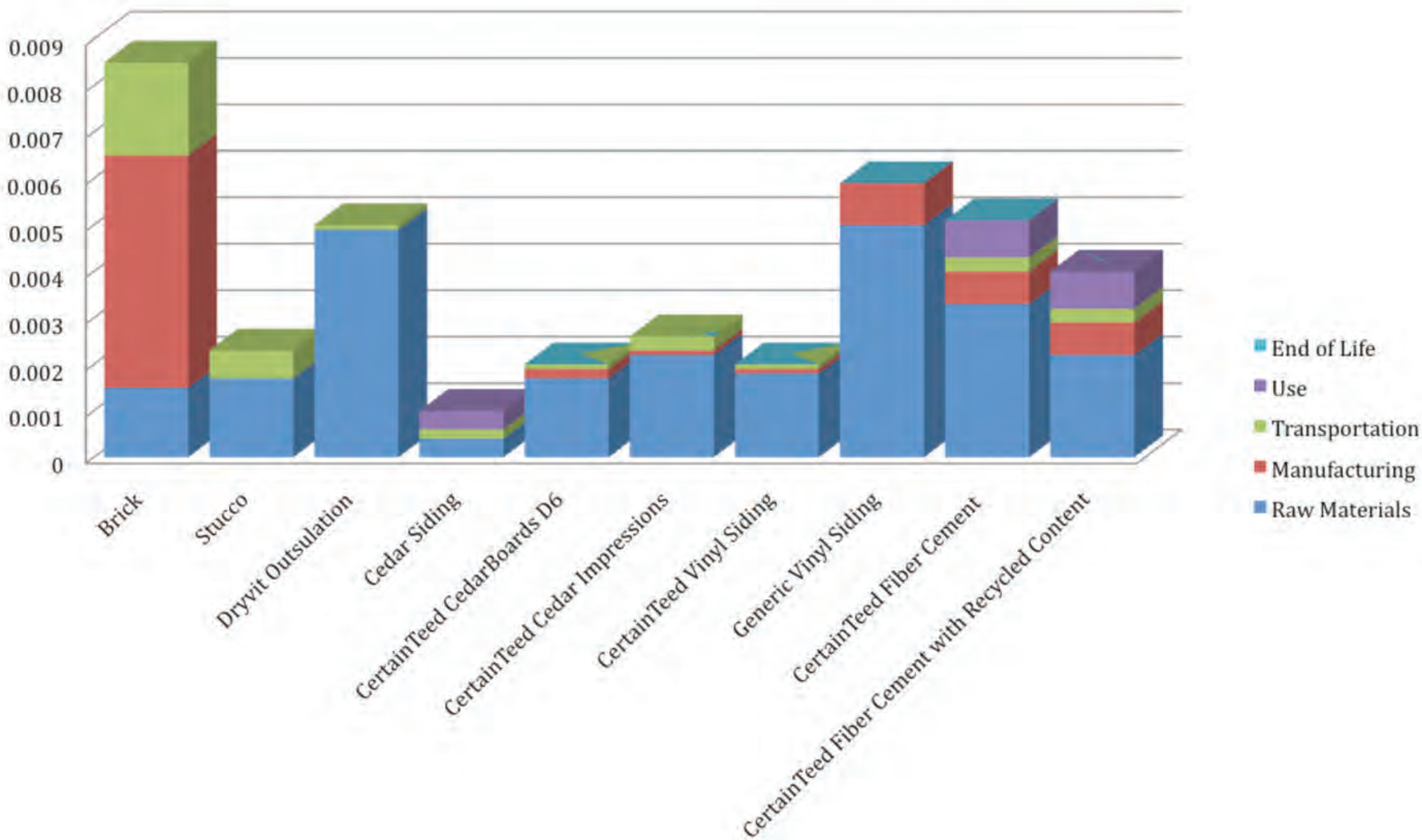
The following graphics evaluate the overall environmental impact by life cycle stage. The life cycle stages include raw materials, manufacturing, transportation, use and end-of-life. These graphics allow the user to understand where impacts are occurring during the life cycle. When considering various materials, it is important to look at the complete life cycle for example some products may have higher impacts during manufacturing or in transportation or require maintenance during the use phase which will have impacts during the life of the product. These graphics are helpful when evaluating products to compare the impacts for each life cycle stage.

***Table 19. Overall Environmental Performance by Life Cycle Stage***

| Category | Brick | Stucco | Dryvit Outsulation | Cedar Siding | CT CedarBoards D6 | CT Cedar Impressions | CT Vinyl Siding | Generic Vinyl Siding | CT Fiber Cement | CT Fiber Cement with Recycled Content |
|---|---|---|---|---|---|---|---|---|---|---|
| 1. Raw Materials | 0.0015 | 0.0017 | 0.0049 | 0.0004 | 0.0017 | 0.0022 | 0.0018 | 0.005 | 0.0033 | 0.0022 |
| 2. Manufacturing | 0.005 | 0 | 0 | 0 | 0.0002 | 0.0001 | 0.0001 | 0.0009 | 0.0007 | 0.0007 |
| 3. Transportation | 0.002 | 0.0006 | 0.0001 | 0.0002 | 0.0001 | 0.0003 | 0.0001 | 0 | 0.0003 | 0.0003 |
| 4. Use | 0 | 0 | 0 | 0.0004 | 0 | 0 | 0 | 0 | 0.0008 | 0.0008 |
| 5. End of Life | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sum | 0.0085 | 0.0023 | 0.005 | 0.001 | 0.002 | 0.0026 | 0.002 | 0.0059 | 0.0051 | 0.004 |

## Overall Environmental Performance by Life Cycle Stage (continued)

***Figure 18. Smog Potential (g $NO_x$ eq)***



## Global Warming by Life Cycle Stage

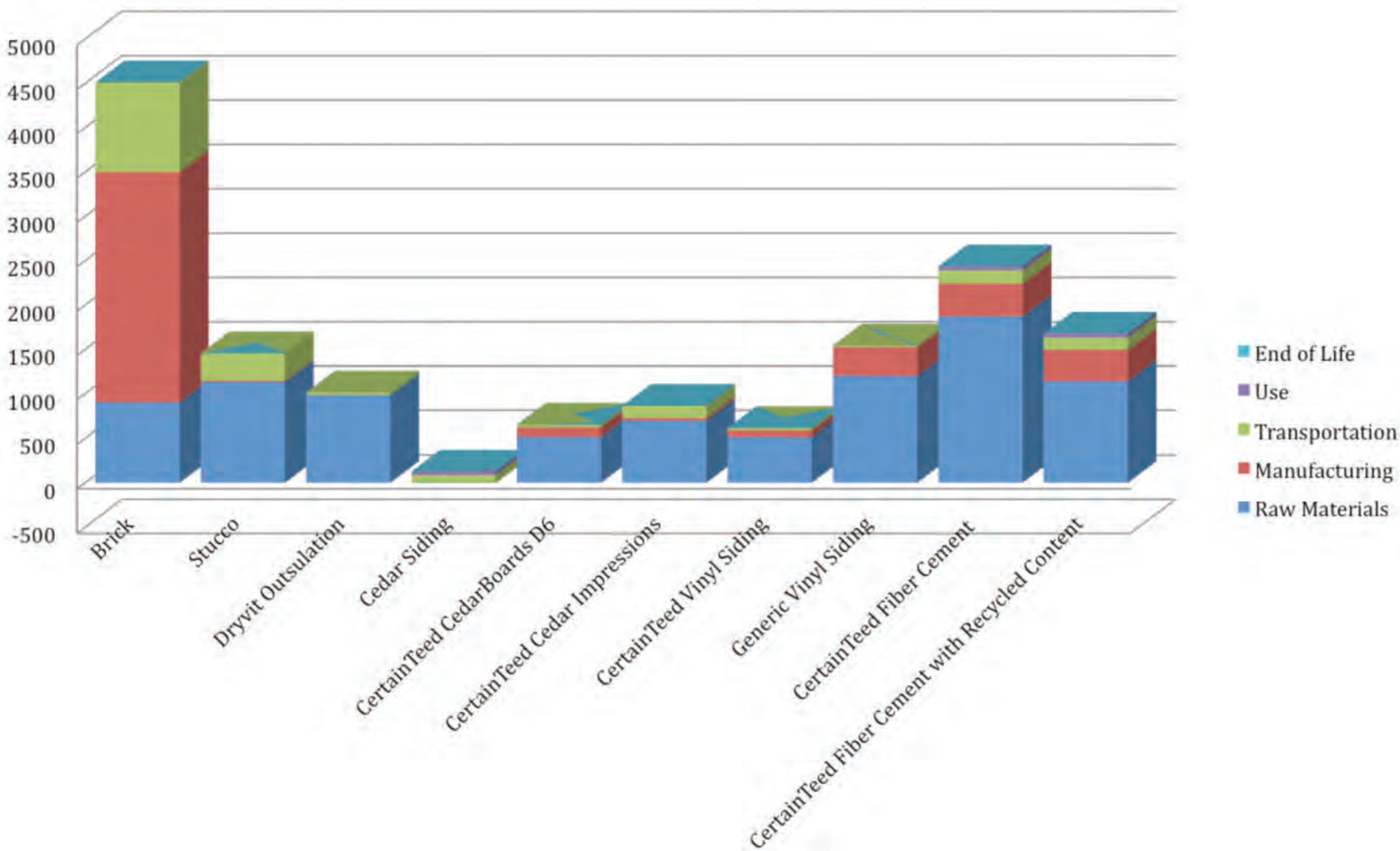
The following graphics evaluate the overall global warming impacts by life cycle stage. The life cycle stages include raw materials, manufacturing, transportation, use and end-of-life. These graphics allow the user to understand where impacts are occurring during the life cycle. When considering various materials, it is important to look at the complete life cycle, for example some products may have higher impacts during manufacturing or in transportation or require maintenance during the use phase which will have impacts during the life of the product. These graphics are helpful when evaluating products to compare the impacts for each life cycle stage.

***Table 20. Global Warming by Life Cycle Stage***

| Category | Brick | Stucco | Dryvit Outsulation | Cedar Siding | CT CedarBoards D6 | CT Cedar Impressions | CT Vinyl Siding | Generic Vinyl Siding | CT Fiber Cement | CT Fiber Cement with Recycled Content |
|---|---|---|---|---|---|---|---|---|---|---|
| 1. Raw Materials | 902.5505 | 1133.8012 | 984.733 | -2.2451 | 517.1955 | 695.2642 | 514.5131 | 1201.3399 | 1870.9038 | 1139.3018 |
| 2. Manufacturing | 2596.3812 | 12.8658 | 0.6046 | 0 | 104.0062 | 29.0915 | 71.5316 | 321.8902 | 371.2889 | 353.6596 |
| 3. Transportation | 1014.1958 | 310.5293 | 29.3447 | 86.8872 | 29.1325 | 138.4994 | 27.8918 | 19.6867 | 148.4733 | 141.2834 |
| 4. Use | 0 | 0 | 0 | 41.4179 | 0 | 0 | 0 | 0 | 45.268 | 45.268 |
| 5. End of Life | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sum | 4513.1275 | 1457.1963 | 1014.6823 | 126.06 | 650.3342 | 862.8551 | 613.9365 | 1542.9168 | 2435.934 | 1679.5128 |

## Global Warming by Life Cycle Stage

***Figure 19. Global Warming by Life Cycle Stage***



## Life Cycle Analysis Conclusions

**CedarBoards Double 6" Insulated Vinyl Siding:**

- Including recycled PVC in vinyl siding can significantly reduce its environmental impact. This relationship is especially strong because a majority of the environmental impact of vinyl siding comes from the impacts associated with manufacturing virgin PVC.
- Insulated siding significantly improves the environmental impact and argument for vinyl siding. The energy savings (and durability improvements) of insulated siding make it a superior product from a sustainability perspective.
- The energy savings associated with manufacturing and installing EPS-backed siding easily outweigh the environmental impacts associated with its manufacture.

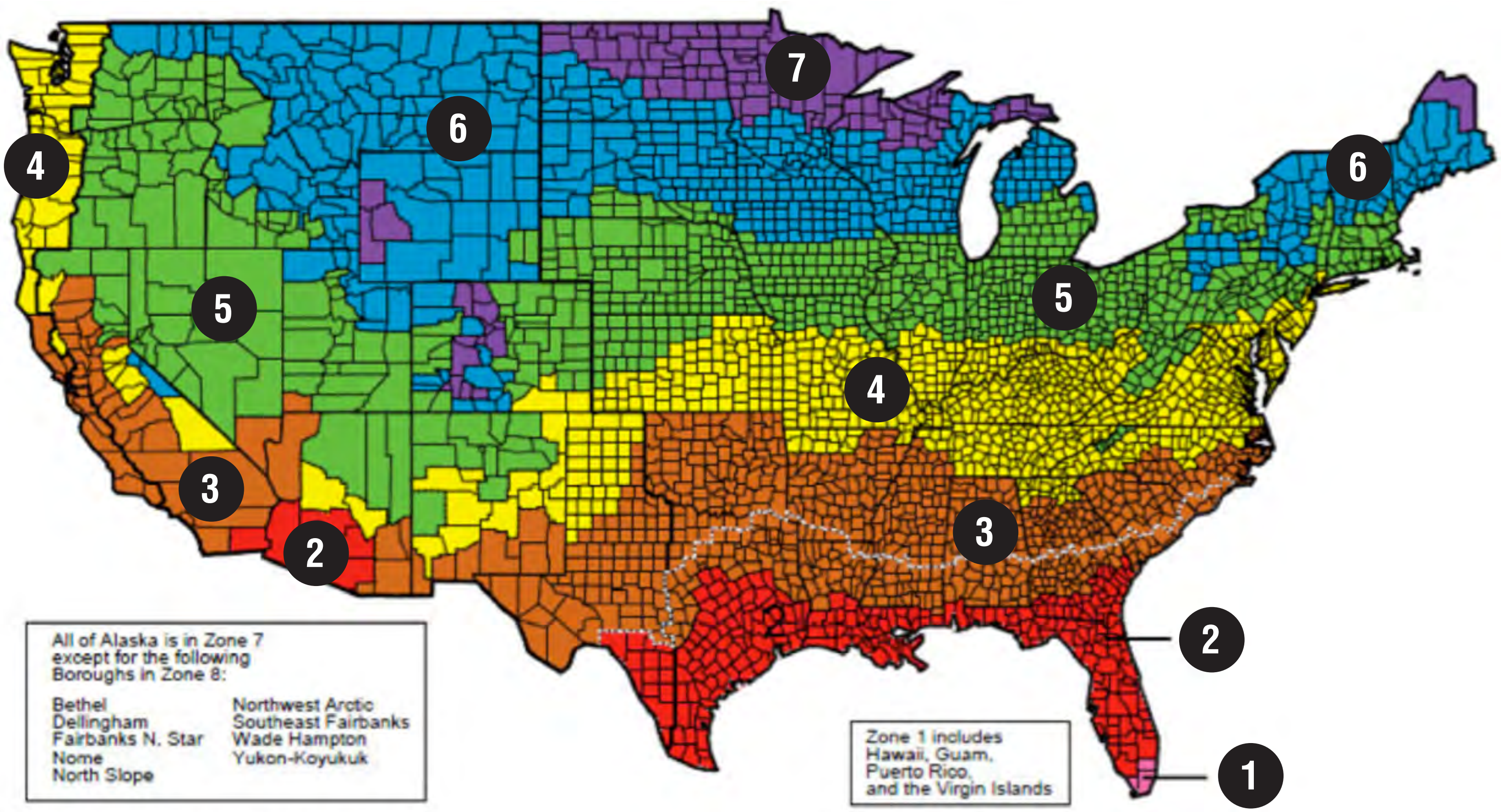
**Cedar Impressions:**

- The results of the Cedar Impressions LCA reinforces the need to use a LCA to choose green building products.
- Despite not having any recycled content, Cedar Impressions products have a lower environmental impact compared to other cladding options like brick and stucco.
- Polypropylene siding products have slightly higher environmental impact than vinyl plastic products; however, both are significantly lower than other cladding options.
- Based on recent scientific publications, plastic cladding options have significantly lower environmental impacts than previously thought.

## Energy Use

In addition to the life cycle impacts addressed above and measured in BEES, insulated vinyl siding can contribute to significant energy savings when installed on a home. BEES does not currently have the capability to model the energy savings during the use phase. The following information provides data on energy savings of insulated vinyl siding. To estimate the energy efficiency impact of insulated siding, energy models were created for typical homes in a variety of climate zones. Energy modeling involves the creation of a digital representation of the building including building envelope and construction, location and climate, heating and cooling set points, HVAC equipment, and schedules of use for lighting, appliances and other energy uses within the building. Climate has a significant impact on the energy use of a home, and to address this issue each of the energy models created was run in a variety of climate zones. Climate zones represent the variation in temperature and moisture that exist in different parts of the country. The map below, Figure 18, shows the various climate zones in the United States.

***Figure 20. Climate Zones of the United States***




Source: U.S. Department of Energy

## Energy Use (continued)

Two of the most popular energy efficiency programs for residential builders—EPA's ENERGY STAR Qualified Homes and DOE's Builder's Challenge—use a Home Energy Rating System (HERS) to develop a score, referred to as a HERS Index. The HERS Index serves as the metric for ranking and rating a home's energy performance and is developed by creating a building energy simulation model of the home. The model takes into account the thermal performance of the building envelope, among other factors. The HERS Index is a scoring system in which a home built to the specifications of the HERS Reference Home scores a HERS Index of 100, while a net zero energy home scores a HERS Index of 0. The lower a home's HERS Index, the more energy efficient it is in comparison to the HERS Reference Home. Each 1-point decrease in the HERS Index corresponds to a 1% reduction in energy consumption compared to the HERS Reference Home.[5] By specifying and installing insulated siding, designers and builders can improve a home's energy performance and lower its HERS Index. This, in turn, helps homes qualify for these programs and any incentives available for qualifying energy-efficient homes.

Energy modeling was also conducted to analyze the impact of installing insulated vinyl siding on both a home representing typical 1950's to 1970's construction with R-9 insulation in the walls and a modern home built to meet the minimum requirements of the 2009 International Energy Conservation Code. These home types were modeled in eight climate zones with an insulated vinyl siding value of approximately R-2.5.[6]

The homes modeled for this analysis consisted of two-story homes with 2,400 square feet of above-grade conditioned floor area, basement foundation in northern climates and slab-on grade in southern climates, etc. The prototypical home was modeled in each IECC climate zone, using one representative city for each zone. The HERS Index and projected heating, cooling and domestic water heating energy use were recorded. Based on the modeling data, the installation of insulated siding on an existing home can save anywhere from 2% to 8% and HERS index improvements of up to 6 points depending on where the home is constructed and the R-value of the insulated siding. Even on a home constructed to meet the strict requirements of IECC 2009, the installation of insulated vinyl siding can result in energy savings from 1% to 4% with a HERS index improvement of 1 to 3 points. To place that energy savings in context, consider the fact that replacing a refrigerator from 1993 or later with a new, ENERGY STAR qualified model will save approximately 1 million British Thermal Units (BTUs) of site energy per year, but re-siding a home with R-2.5 insulated siding is expected to save an average of four times this amount of energy, averaging across climate zones. Reducing energy consumption during the life of a building not only saves the building owner money, but also reduces the life cycle impacts of the building throughout its lifetime.

***[5] U.S. EPA. 2010. What is a HERS Rating? http://www.energystar.gov/index.cfm?c=bldrs_lenders_raters.nh_HERS***
***[6] Insulated Siding as Home Insulation: Guide for Users and Energy Raters. Vinyl Siding Institute. January 2011***

## Energy Use (continued)

***Table 21. Energy Savings and HERS Index Improvement by Climate Zone Compared to 1950's to 1970's Reference Home***

| Climate Zone | City | 1950's to 1970's Reference Home with R-2.5 Insulated Vinyl Siding | | 1950's to 1970's Reference Home with R-3.0 Insulated Vinyl Siding | |
|---|---|---|---|---|---|
| | | Percent Energy Savings | HERS Index Improvement v. Reference | Percent Energy Savings | HERS Index Improvement v. Reference |
| 1 | Miami | 3% | 1 | 3% | 2 |
| 2 | Phoenix | 2% | 4 | 3% | 5 |
| 3 | Dallas | 4% | 5 | 5% | 6 |
| 4 | Baltimore | 6% | 5 | 6% | 5 |
| 5 | Denver | 8% | 6 | 8% | 7 |
| 6 | Burlington | 6% | 6 | 7% | 6 |
| 7 | Duluth | 6% | 6 | 7% | 7 |
| 8 | Fairbanks | 3% | 5 | 3% | 6 |

***Table 22. Energy Savings and HERS Index Improvement by Climate Zone Compared to 2009 IECC Minimum Home***

| Climate Zone | City | 1950's to 1970's Reference Home with R-2.5 Insulated Vinyl Siding | | 1950's to 1970's Reference Home with R-3.0 Insulated Vinyl Siding | |
|---|---|---|---|---|---|
| | | Percent Energy Savings | HERS Index Improvement v. Reference | Percent Energy Savings | HERS Index Improvement v. Reference |
| 1 | Miami | 2% | 2 | 2% | 2 |
| 2 | Phoenix | 2% | 3 | 3% | 3 |
| 3 | Dallas | 3% | 2 | 3% | 2 |
| 4 | Baltimore | 4% | 2 | 6% | 3 |
| 5 | Denver | 3% | 1 | 4% | 2 |
| 6 | Burlington | 3% | 1 | 4% | 2 |
| 7 | Duluth | 3% | 2 | 3% | 2 |
| 8 | Fairbanks | 2% | 2 | 3% | 2 |

## Energy Use (continued)

Reducing energy consumption reduces fossil fuel use and greenhouse gas emissions as well as the impacts of extracting, processing and distributing the fossil fuels. The following graphics compare the amount of energy required to produce the CedarBoards D6 insulated siding to the expected energy savings for an existing and new home. When retrofitting an older home, insulated siding can pay for itself within five years in most climate zones. When using CedarBoards D6 on new homes, the energy savings within ten years can be more than double the energy used to produce the insulated siding.

***Figure 21. Energy Payback for an Existing Home (1950's to 1970's)***

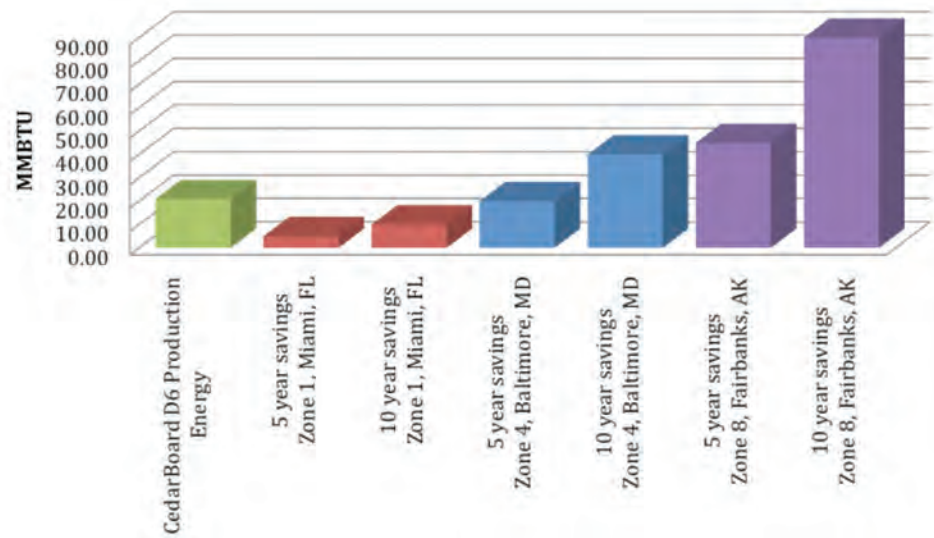
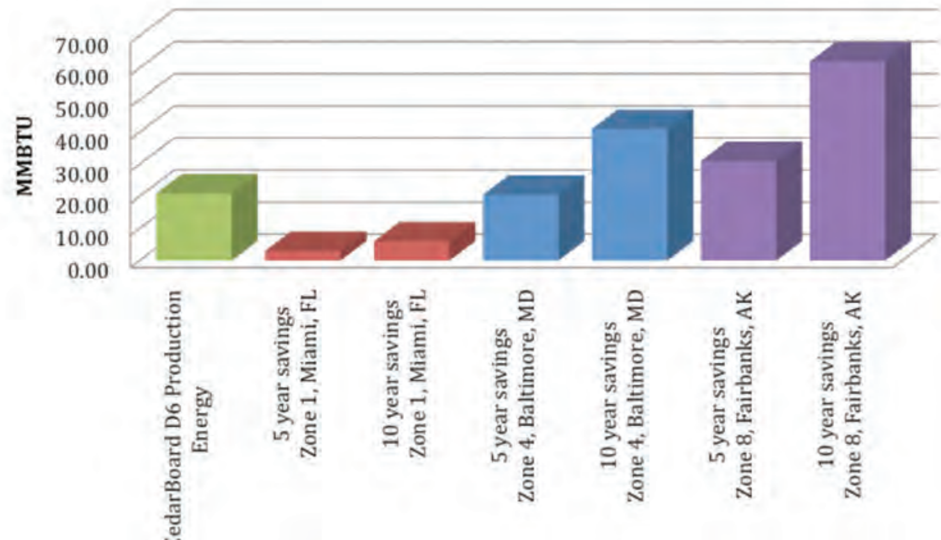



***Figure 22. Energy Payback for a New Home Built to IECC 2009***



buildingresponsibly™

**ASK ABOUT OUR OTHER CERTAINTEED PRODUCTS AND SYSTEMS:**

**EXTERIOR:** ROOFING • SIDING • TRIM • DECKING • RAILING • FENCE • FOUNDATIONS
**INTERIOR:** GYPSUM • CEILINGS • INSULATION • PIPE

CertainTeed Corporation
P.O. Box 860
Valley Forge, PA 19482

Professional: 800-233-8990
Consumer: 800-782-8777
**www.certainteed.com**

CertainTeed
SAINT-GOBAIN