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Progressive Foam Insulated Vinyl Siding

BEES LCA Update

LCA Report

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Commissioned by Progressive Foam Technologies, Inc.

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INTRODUCTION

Progressive Foam has been actively pursuing strategies to reduce their environmental impact and to increase the sustainability of their operations and products. They have developed a corporate sustainability strategy for reducing energy use, water use, and waste and have conducted this Life Cycle Assessment in order to better understand and improve their 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, and end of life including recycling and final disposal.

To provide full transparency and make this data available to the public, Progressive Foam 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 to ensure that the data is correct and accurate. The graphs and tables showing the environmental impact of siding products are drawn from BEES, and all data submitted to BEES undergoes the thorough reviews required under ISO 14040 standards for the comparison of products using LCA. In addition, Progressive Foam has conducted energy modeling to determine the effect of its product on energy savings. The data on energy savings is based on energy modeling conducted by the NAHB Research Center and Newport Ventures. For more information or to utilize BEES Online directly, go to http://ws680.nist.gov/Bees/.

PRODUCT DESCRIPTION

Progressive Foam's Insulated Vinyl Siding is vinyl siding that includes a rigid expanded polystyrene foam insulation, fused behind the exterior surface of the vinyl siding panel. The EPS foam manufacturing and some lamination occurs at the Progressive Foam facility in Beach City, Ohio. The insulation is contoured to fill the gap between the siding and the home, adding insulation value to the wall and improving durability. One square foot of insulated siding with an R-value of 2.5, according to ASTM International Standard 1363 test results, is estimated to weigh 0.195 kg and is comprised of 0.163kg of vinyl siding, 0.030 kg of foam, and 0.002 kg of glue. This is the model of insulated siding used throughout this analysis.

Figure 1. Insulated Vinyl Siding

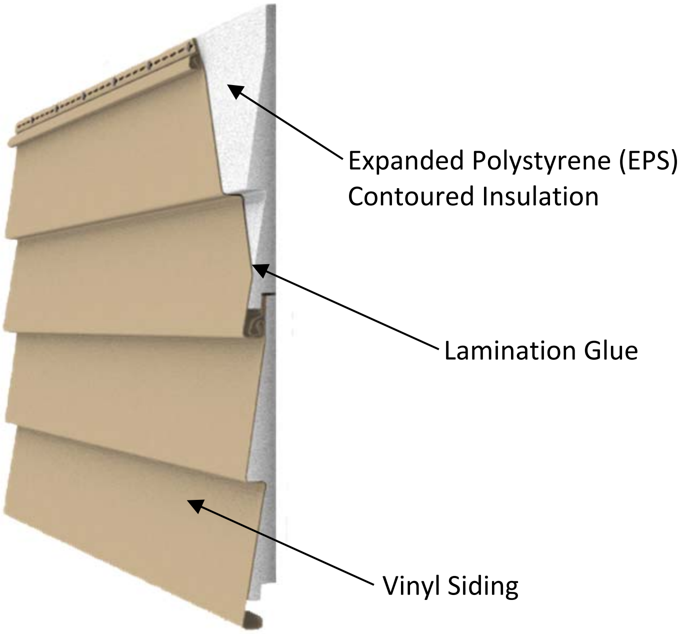

Table 1. Progressive Foam Insulated Siding Constituents

Constituent	kg/functional unit	% by Mass
Foam Backing	0.030	14.1%
Vinyl Siding	0.182	85.0%
Lamination Glue	0.002	0.9%
Total	**0.214**	**100%**

Production Process

EPS Foam Board Production

Progressive Foam expands polystyrene foam (EPS) and molds it into profiles that can be adhered to vinyl siding (Insulated Vinyl Siding) or can be installed separately (Fullback Siding Insulation). The addition of the expanded polystyrene to standard vinyl siding improves its impact resistance and R-value of the wall. Siding with polystyrene backing improves the energy efficiency of any home on which it is installed by improving the overall R-value of the wall assembly. This is achieved by reducing thermal bridging in the wall combined with an overall increase in the wall assembly R-value.

Progressive Foam acquires polystyrene resin beads that have been impregnated with a pentane expanding agent from a number of different suppliers. The beads are then expanded by direct exposure to steam (from a natural gas-fired steam generator) and allowed to rest before molding. During expansion, 0.0443 kg pentane/kg EPS foam is released. A small amount of the insecticide Preventol is used in the foam. No data was available to model the production of the Imidachloprid in this insecticide, but the quantity of Preventol, 1.3 .00013 kg/kg (1.3 .00013 lb/lb) of foam (0.01% of the final product) falls beyond the cut-off criteria.[1]

Progressive Foam uses two different molding processes: block molding and shape molding. Both molder types pressurize and apply steam to the resin beads causing them to fuse into the shape of the mold; however, the shape molder produces the profile directly, while the block molder produces a large rectangular block, which must be trimmed and then cut into the desired profiles using a hot wire cutting machine. After the foam profiles are complete, those that are to be used as backing for insulated siding are either shipped to the vinyl siding manufacturer or are laminated to the vinyl siding at the Progressive Foam facility and then the assembled vinyl siding is shipped back to the manufacturer. Electricity and natural gas are used in the expanding, forming and trimming processes. Propane is used to drive forklifts. The energy use for the EPS Board forming process is detailed in Table 2 below.

Table 2. Energy Requirements for Progressive Foam Manufacturing Operations

Energy Source	Quantity per kg Foam
Electricity	3.68 MJ (1.021 kWh)
Natural Gas	14 MJ (13,032 Btu)
Propane	.04 MJ (394 Btu)

Waste foam from the trimming of the foam profiles is densified and recycled off site. Plant personnel estimate that 99% of waste foam is collected and densified, while 1% is sent to landfill with the other plant trash that is not recycled.

Other Materials Production
Progressive Foam does not manufacture vinyl siding, but its foam and processes are used in the production of many insulated vinyl siding products. Since data on the production of this specific vinyl siding is not available, the BEES generic vinyl siding data is used. Refer to the Generic Vinyl Siding product summary for its description. The BEES generic vinyl siding has a mass of 0.182 kg/sq-ft.
The lamination glue used at Progressive Foam is made up of the constituents listed in Table 3 below.

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[1] A check for sensitivity using a biocide as a proxy was made, and the results did not change.

Table 3. Progressive Foam Lamination Glue Constituents

Constituent	% by Mass
Tackifying Resins	47.0%
Mineral Oil	20.0%
Polymer Solids	27.0%
Carbonic Acid	3.0%
Talc	3.0%

Shipping

Transport of the EPS foam beads from Progressive Foam's several suppliers of the vinyl siding and of the lamination glue are taken into account in this analysis. Ocean freighter, rail and truck are modeled for the foreign supplier of EPS beads, and these distances are approximately 4351 miles, 2362 miles, and 62 miles by ocean freighter, rail, and heavy-duty diesel truck, respectively. Heavy-duty diesel truck is the assumed transportation mode for the remaining beads, and distances range from 150 miles to 1160 miles. The vinyl siding travels an average of 300 mi, and the lamination glue is sourced from a location approximately 475 mi. from the Progressive Foam plant. All transportation modes are modeled based on the U.S. LCI Database. The insulated vinyl siding is transported an average of 275 miles by diesel truck to the building site. The nails necessary to install the product are assumed to be transported 150 miles by diesel truck to the building site.

Installation

Installation of siding is done primarily by manual labor. Nails and a nail gun are used to install the siding. Nails are installed 16 inches on center. The nails are modeled as galvanized steel, and for installation 16 inches on center, 0.0024 kg per square foot of siding is used. The energy required to operate compressors to power air guns is assumed to be very small and is not included in the analysis. Installation waste with a mass fraction of 5% is assumed, 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.

Use Phase

Consistent with the generic vinyl siding product in BEES, Progressive Foam's insulated siding is assumed to have a useful life of 50 years. 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) are not available; therefore, maintenance is not included in the system boundaries.

End of Life

For the disposal phase, Insulated Vinyl Siding was modeled as being disposed in a landfill. Although it is possible to recycle both polystyrene foam and vinyl at the end of its life, landfill disposal of construction waste is still the standard practice.

LIFE CYCLE ASSESSMENT

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, 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, (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 needed for the construction of the model are collected (such as resources, energy requirements, emissions to air and water, and waste generation for all activities within the system boundaries). 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 are characterized in terms of their potential environmental impacts (e.g., acidification, eutrophication, and global warming potential effects).

Functional Unit

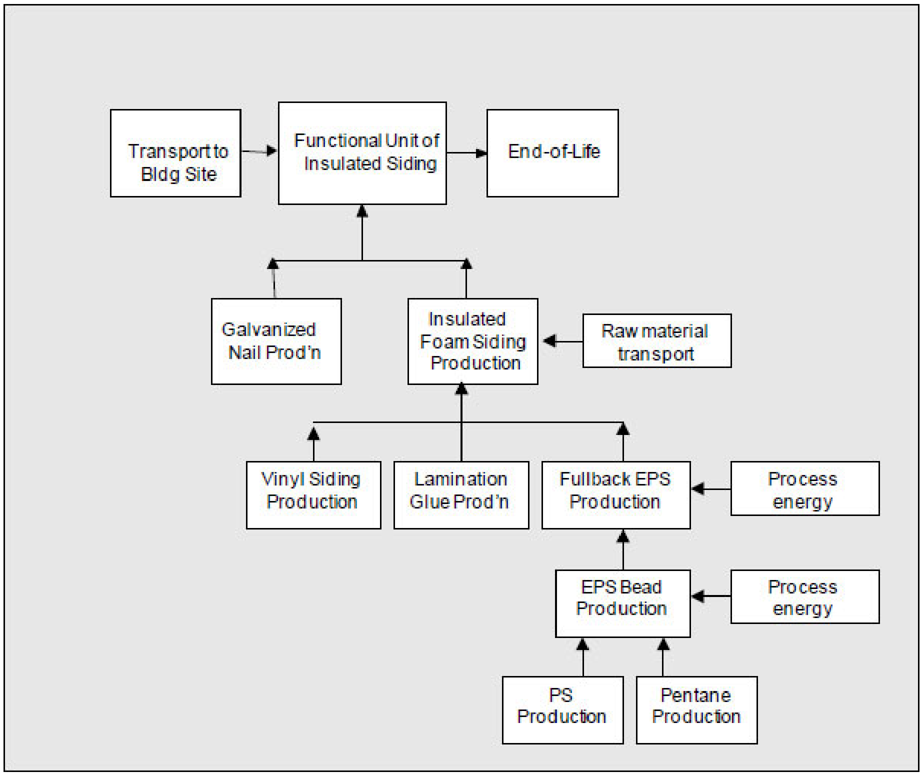
The functional unit is of great importance in an LCA. It provides a unit of analysis and comparison for all environmental impacts. The functional unit is based on the use and life of the product; for siding, this is typically expressed in terms of wall coverage for a given time period. BEES uses a functional unit for all siding products of 1 sq. ft. of siding over a 50 year lifespan to establish the ability to compare multiple building products. All calculations of environmental impact are in terms of 1 sq. ft. of siding for a 50 year lifespan. BEES assumes a 50 year lifespan for generic vinyl siding. One square foot of insulated siding is estimated to weigh 0.214 kg and is comprised of 0. 182 kg of vinyl siding, 0.030 kg of foam, and 0.002 kg of glue. This is the model of insulated siding used throughout this analysis.

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. Figure 2 defines the system boundary for the insulated vinyl siding analysis. Operational data for manufacturing as well as product recipes were collected directly from the Beach City, Ohio plant for the calendar year 2009.

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 Progressive Foam, 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) are also included within the system boundary.

Figure 2. Insulated Vinyl Siding System Boundary Diagram



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 criteria, but is determined (via secondary data analysis) to contribute 2% or more to a product life cycle impact category (see below), it is included within the system boundary.

Modeling Software

SimaPro software was utilized for modeling the complete cradle to cradle/grave LCI for the insulated vinyl siding product. 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 insulated vinyl 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.

Data Sources and Quality

Data on raw material production, transportation and other processes that occur outside of the Progressive Foam facility were obtained from other LCA data sources. The US LCI database (www.nrel.gov/lci) was a major source of data for this analysis, with the other data coming from published data and other LCA data sources. The expanding, molding, trimming, and lamination processes that occur at Progressive Foam facilities were modeled using information collected directly from facility personnel. Similarly, data about the distance and mode of shipment for all raw materials and final products was collected from Progressive Foam. Final decisions about modeling and data sources were made by the BEES program consultant.

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 4 below.

Table 4. BEES Impact 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 NO_x eq	4%
Acidification	H^+ moles eq	3%
Indoor Air Quality	kg TVOC eq	3%
Ozone Depletion	g CFC-11 eq	2%

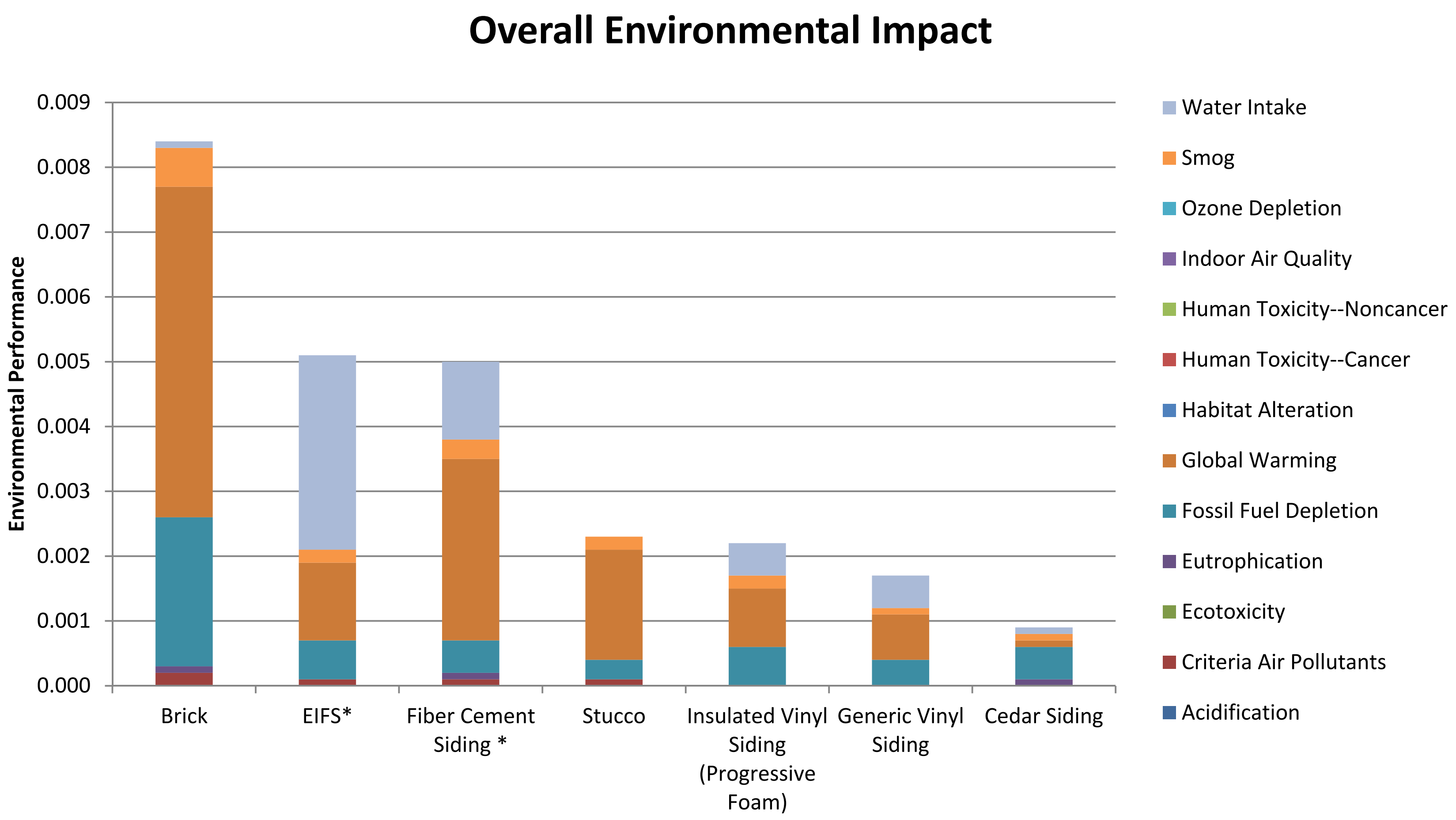
BEES Overall Environmental Impact

The tables and graphs below were generated using the BEES Online Software and display the overall environmental impact of siding products including Insulated Vinyl Siding. The results are a composite score based on all of the impact categories described above combined and weighted according to the values in Table 4 above. 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 5 and Figure 3 below, Progressive Foam has very low impacts across all life cycle stages compared to other cladding options.

Table 5. Overall Environmental Impact of Various Cladding Products

Category	Brick	EIFS	Fiber Cement Siding	Stucco	Insulated Vinyl Siding (Progressive Foam)	Generic Vinyl Siding	Cedar Siding
Acidification	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Criteria Air Pollutants	0.0002	0.0001	0.0001	0.0001	0.0000	0.0000	0.0000
Ecotoxicity	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Eutrophication	0.0001	0.0000	0.0001	0.0000	0.0000	0.0000	0.0001
Fossil Fuel Depletion	0.0023	0.0006	0.0005	0.0003	0.0006	0.0004	0.0005
Global Warming	0.0051	0.0012	0.0028	0.0017	0.0009	0.0007	0.0001
Habitat Alteration	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Human Health--Cancer	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Human Health--Noncancer	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Indoor Air Quality	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Ozone Depletion	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Smog	0.0006	0.0002	0.0003	0.0002	0.0002	0.0001	0.0001
Water Intake	0.0001	0.0030	0.0012	0.0000	0.0005	0.0005	0.0001
Sum	0.0084	0.0051	0.0050	0.0023	0.0022	0.0017	0.0009

Figure 3. Overall Environmental Impact of Various Cladding Products



Source: BEES Online database; National Institute of Standards and Technology; http://ws680.nist.gov/Bees; Accessed October 2012.
*EIFS and Fiber Cement Siding Without Recycled Content data submitted to BEES by individual companies.

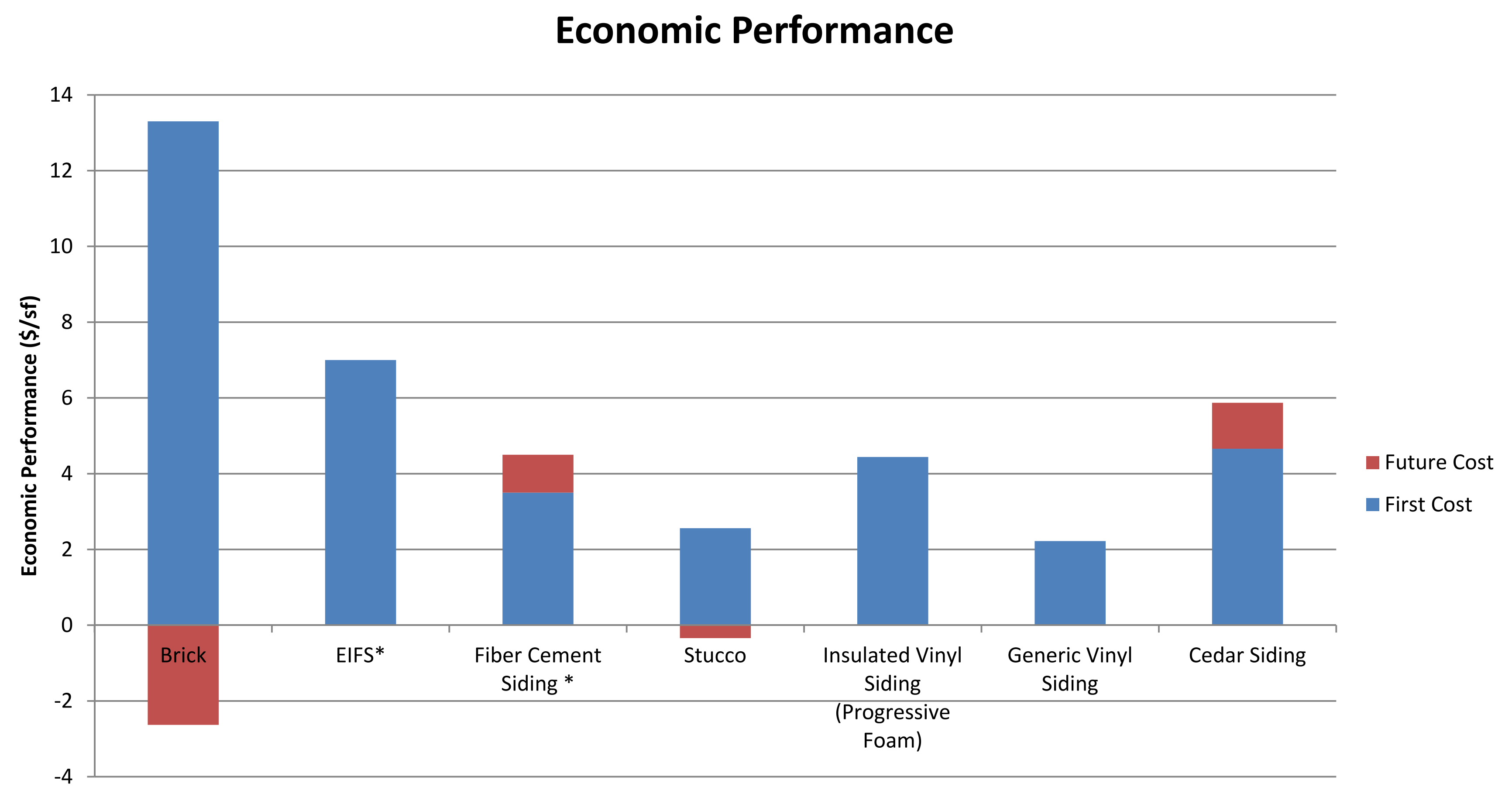
ECONOMIC PERFORMANCE

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. Figure 4 below shows that this situation only applies to brick, as all other claddings are expected to have a 50 year or lower life.

Table 6. Economic Performance of Various Cladding Products by Life Cycle Stage

Category	Brick	EIFS	Fiber Cement Siding	Stucco	Insulated Vinyl Siding (Progressive Foam)	Generic Vinyl Siding	Cedar Siding
First Cost	$13.30	$7	$3.50	$2.56	$4.44	$2.22	$4.66
Future Cost - 2.7%	-$2.63	$0	$1.00	-$0.34	$0	$0	$1.21
Sum	$10.67	$7	$4.50	$2.22	$4.44	$2.22	$5.87

Figure 4. Economic Performance of Various Cladding Products

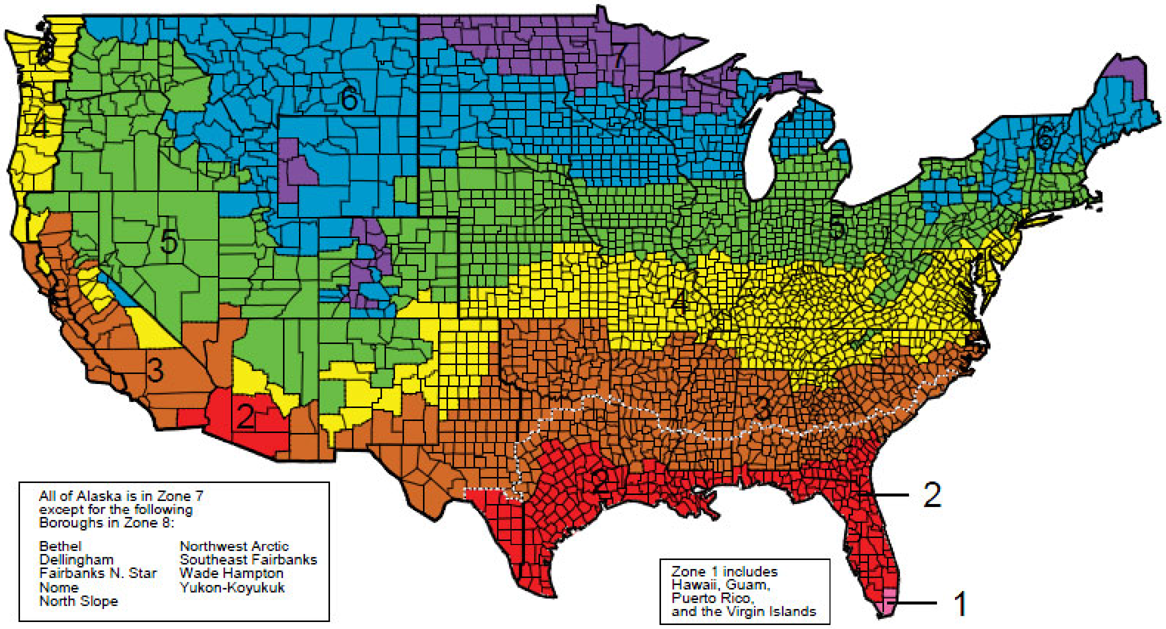


Source: BEES Online database; National Institute of Standards and Technology; http://ws680.nist.gov/Bees; Accessed October 2012.
*EIFS and Fiber Cement Siding Without Recycled Content data submitted to BEES by individual companies.

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. 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 5 shows the various climate zones in the United States.

Figure 5. Climate Zones of the United States



Source: U.S. Department of Energy

Energy modeling conducted by the NAHB Research Center shows the maximum energy savings that can be expected from the installation of insulated vinyl siding. These models represent older, two-story homes that would have been constructed without any wall insulation. The model includes the installation of insulated vinyl siding with an R-value of 3.5[2]. Table 7 below illustrates the energy savings that can be expected based on this model in many of the climate zones in the United States.

Table 7. Maximum Modeled Energy Savings from Insulated Siding

Climate Zone	Energy Savings (MMBTU)	Energy Savings (%)
Zone 2	10	15%
Zone 3	16	17%
Zone 4	18	15%
Zone 5	31	14%
Zone 6	46	16%

As illustrated in this case of a home with no installed wall insulation, the maximum estimated energy savings from using insulated vinyl siding will range from 10 to 46 MBTU/year, which will save between 14% to 17% of total energy consumed per year in each climate zone.

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 homes' 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.[3] 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 array of insulated vinyl siding values from R-2.0 to R 3.0.[4]

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

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[2] *Modeled Energy Performance of Insulated Siding Installed on New and Existing Houses in Five Climate Zones*. NAHB Research Center. August 2010

[3] U.S. EPA. 2010. What is a HERS Rating? http://www.energystar.gov/index.cfm?c=bldrs_lenders_raters.nh_HERS

[4] *Insulated Siding as Home Insulation: Guide for Users and Energy Raters*. Vinyl Siding Institute. January 2011

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 7% and HERS index improvements of up to 7 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 6% 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.

Table 8. Energy Savings and HERS Index Improvement by Climate Zone compared to 1950's to 1970's Reference Home

		1950's to 1970's Reference Home with R-2.0 Insulated Vinyl Siding		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	
Climate Zone	City	Percent Energy Savings	HERS Index Improvement v. Reference	Percent Energy Savings	HERS Index Improvement v. Reference	Percent Energy Savings	HERS Index Improvement v. Reference
1	Miami	2%	0	3%	1	3%	2
2	Phoenix	2%	3	2%	4	3%	5
3	Dallas	3%	4	4%	5	5%	6
4	Baltimore	5%	4	6%	5	6%	5
5	Denver	6%	5	8%	6	8%	7
6	Burlington	5%	4	6%	6	7%	6
7	Duluth	5%	5	6%	6	7%	7
8	Fairbanks	2%	4	3%	5	3%	6

Table 9. Energy Savings and HERS Index Improvement by Climate Zone compared to 2009 IECC Minimum Home

		2009 IECC Minimum Home with R-2.0 Insulated Vinyl Siding		2009 IECC Minimum Home with R-2.5 Insulated Vinyl Siding		2009 IECC Minimum Home with R-3.0 Insulated Vinyl Siding	
Climate Zone	City	Percent Energy Savings	HERS Index Improvement v. 2009 IECC	Percent Energy Savings	HERS Index Improvement v. 2009 IECC	Percent Energy Savings	HERS Index Improvement v. 2009 IECC
1	Miami	1%	2	2%	2	2%	2
2	Phoenix	2%	2	2%	3	3%	3
3	Dallas	2%	1	3%	2	3%	2
4	Baltimore	3%	2	4%	2	6%	3
5	Denver	2%	1	3%	1	4%	2
6	Burlington	2%	1	3%	1	4%	2
7	Duluth	2%	2	3%	2	3%	2
8	Fairbanks	2%	2	2%	2	3%	2

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 foam used in insulated siding to the expected energy savings for an existing and new home. When retrofitting an older home, insulated siding can save more than 6 times as much energy in the first year as was required to produce the foam. Even when installed on a new home, insulated siding can save more energy in the first year than was required to produce the foam.

Figure 6. Energy Payback for an Existing Home (1950’s to 1970’s)

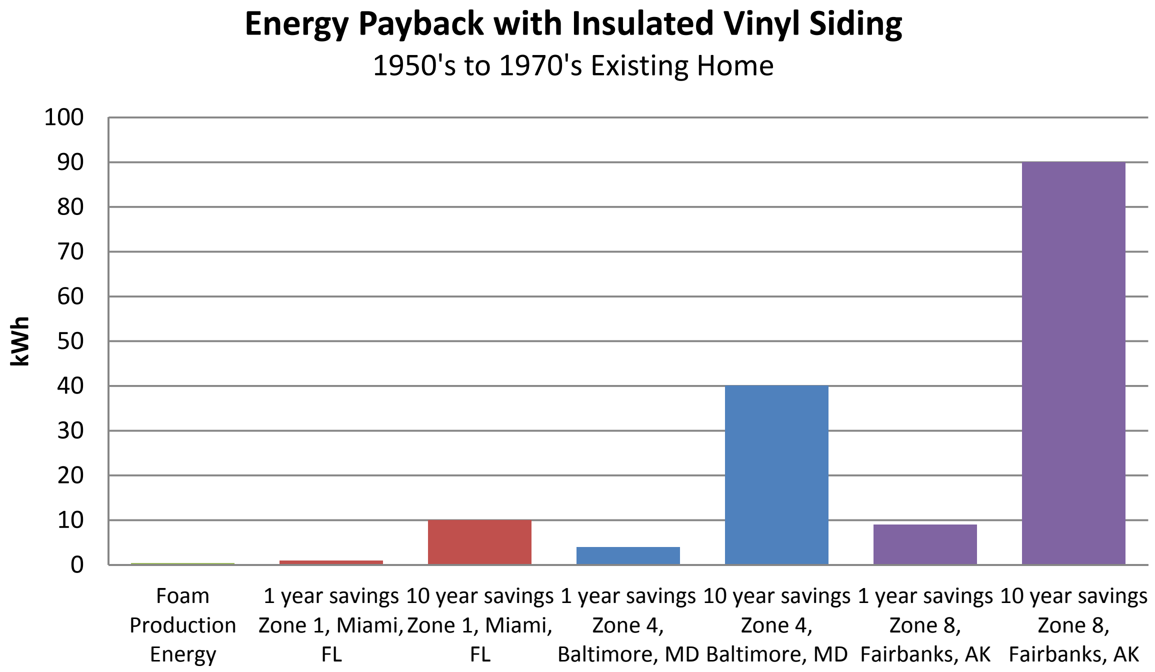
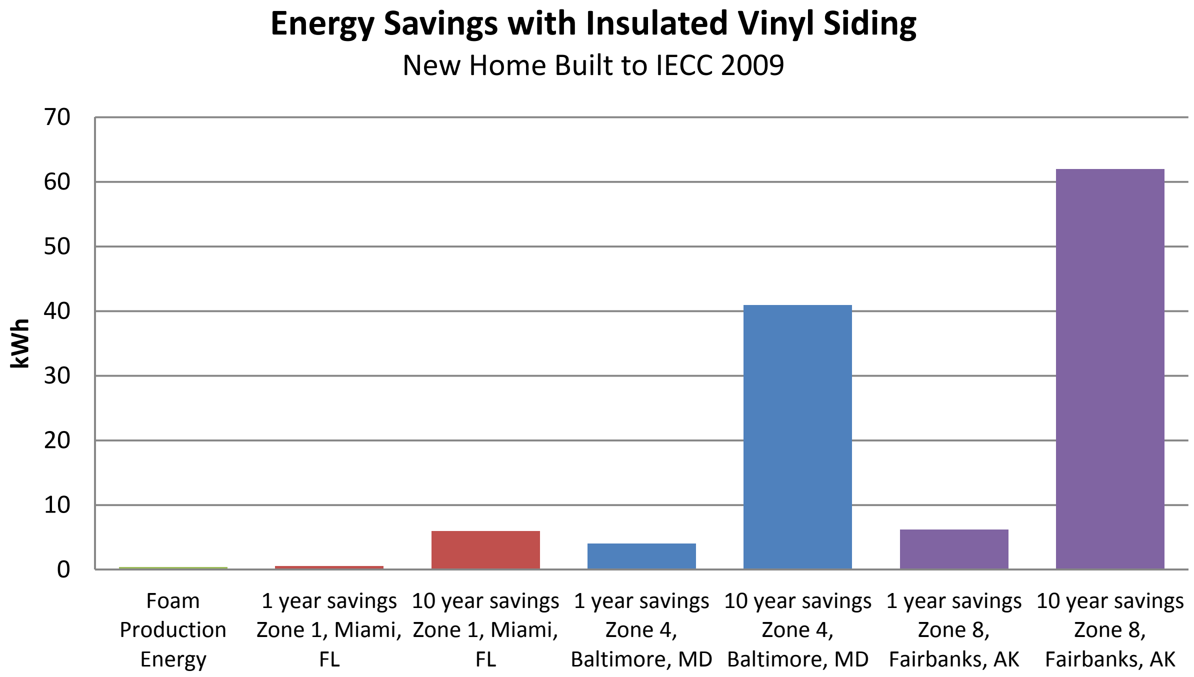


Figure 7. Energy Payback for a New Home Built to IECC 2009



APPENDIX A

The following appendix 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/.

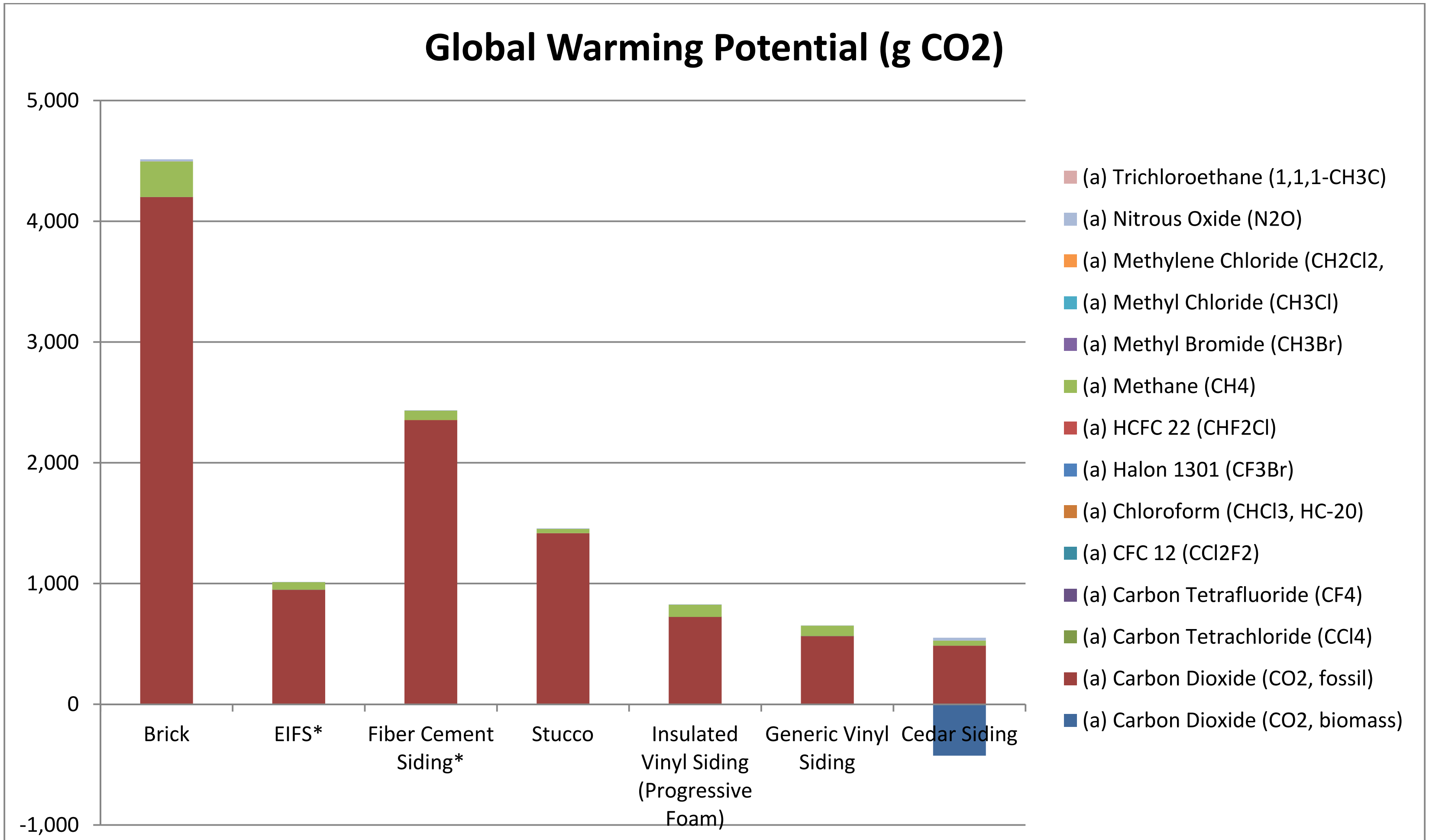
Global Warming Potential

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 A-1. Global Warming Potential (g CO_2 eq)

Global Warming Potential	Brick	EIFS	Fiber Cement Siding	Stucco	Insulated Vinyl Siding (Progressive Foam)	Generic Vinyl Siding	Cedar Siding
(a) Carbon Dioxide (CO2, biomass)	0.0000	-0.0020	0.0007	0.0000	-1.9331	0.1934	-425.7756
(a) Carbon Dioxide (CO2, fossil)	4,200.9186	948.4352	2,354.5497	1,417.4695	723.3370	565.1632	486.1856
(a) Carbon Tetrachloride (CCl4)	0.0000	0.0074	0.0034	0.0000	0.0285	0.0301	0.0725
(a) Carbon Tetrafluoride (CF4)	0.0000	0.0116	0.0267	0.0000	0.0060	0.0062	0.0000
(a) CFC 12 (CCl2F2)	0.0004	0.0006	0.0124	0.0002	0.0001	0.0001	0.0001
(a) Chloroform (CHCl3, HC-20)	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000
(a) Halon 1301 (CF3Br)	0.0000	0.0015	0.0013	0.0000	0.0004	0.0005	0.0000
(a) HCFC 22 (CHF2Cl)	0.0000	0.1038	0.0023	0.0000	0.0708	0.0010	0.0000
(a) Methane (CH4)	295.5823	63.2584	78.0566	35.0881	101.7809	86.2281	41.0141
(a) Methyl Bromide (CH3Br)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
(a) Methyl Chloride (CH3Cl)	0.0000	0.0000	0.0003	0.0002	0.0000	0.0000	0.0000
(a) Methylene Chloride (CH2Cl2,	0.0005	0.0003	0.0005	0.0002	0.0001	0.0001	0.0026
(a) Nitrous Oxide (N2O)	16.6256	2.8653	3.2798	4.6380	3.0026	2.5951	24.5607
(a) Trichloroethane (1,1,1-CH3C)	0.0000	0.0000	0.0001	0.0001	0.0000	0.0000	0.0000
Sum	4,513.1274	1,014.6821	2,435.9339	1,457.1963	826.2933	654.2178	126.0600

Figure A-1. Global Warming Potential (g CO_2 eq)



Source: BEES Online database; National Institute of Standards and Technology; http://ws680.nist.gov/Bees; Accessed October 2012.
*EIFS and Fiber Cement Siding Without Recycled Content data submitted to BEES by individual companies.

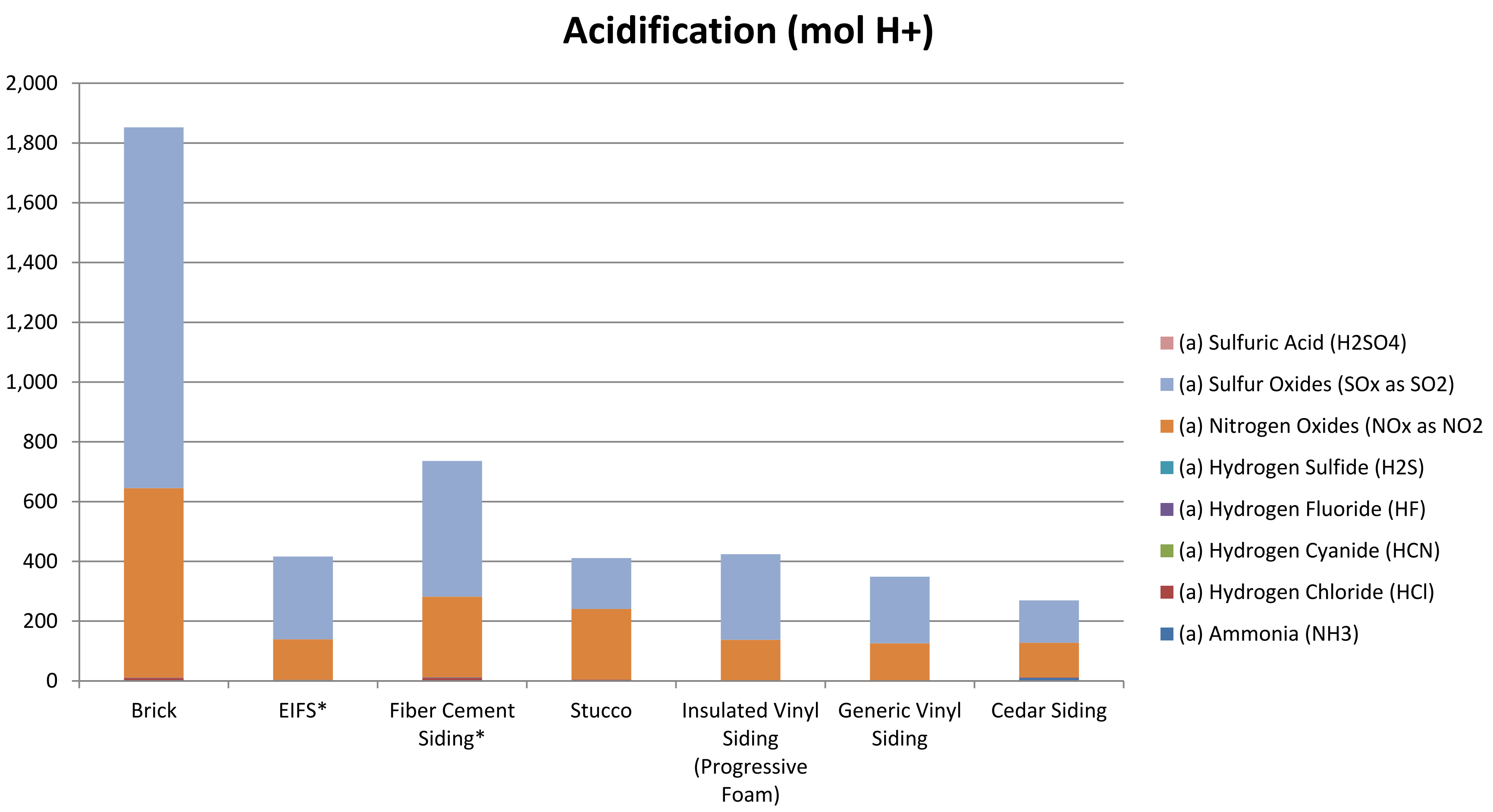
Acidification

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 A-2. Acidification (H^+ moles eq)

Category	Brick	EIFS	Fiber Cement Siding	Stucco	Insulated Vinyl Siding (Progressive Foam)	Generic Vinyl Siding	Cedar Siding
(a) Ammonia (NH3)	0.9610	0.4619	0.6703	0.5016	0.2115	0.2053	9.8150
(a) Hydrogen Chloride (HCl)	8.5969	2.4601	8.6925	3.3876	2.0309	1.6527	1.9274
(a) Hydrogen Cyanide (HCN)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
(a) Hydrogen Fluoride (HF)	1.5616	0.3540	2.6098	0.3975	0.4499	0.3675	0.2344
(a) Hydrogen Sulfide (H2S)	0.0000	0.0610	0.0271	0.2479	0.0072	0.0074	0.0028
(a) Nitrogen Oxides (NOx as NO2	633.8794	135.8206	270.0498	236.3306	134.8550	123.8390	115.8552
(a) Sulfur Oxides (SOx as SO2)	1,207.3494	276.8264	453.9697	170.0344	286.3310	222.5638	141.7787
(a) Sulfuric Acid (H2SO4)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Sum	1,852.3483	415.9840	736.0192	410.8996	423.8855	348.6357	269.6135

Figure A-2. Acidification (H^+ moles eq)



Source: BEES Online database; National Institute of Standards and Technology; http://ws680.nist.gov/Bees; Accessed October 2012.
EIFS and Fiber Cement Siding Without Recycled Content data submitted to BEES by individual companies.

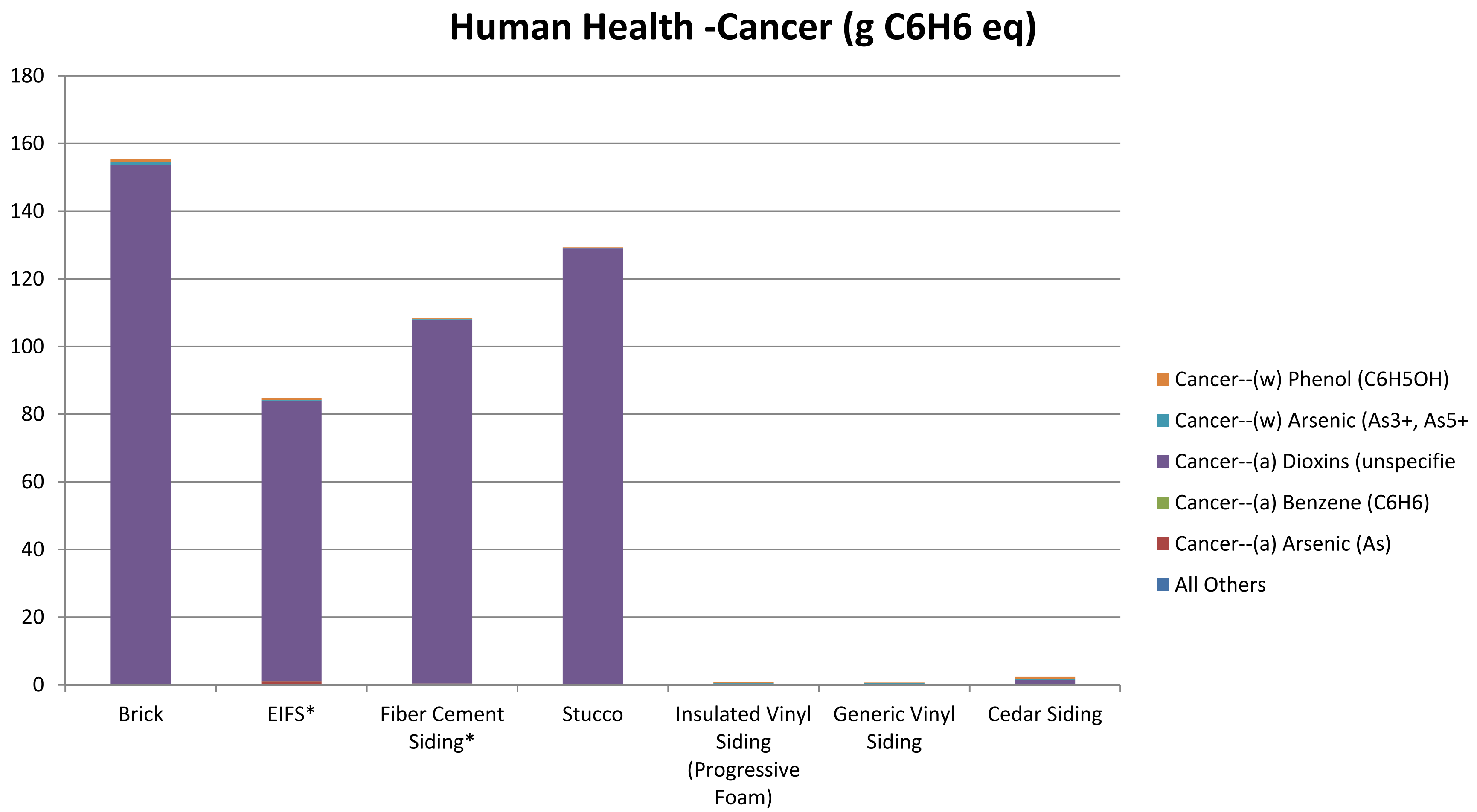
Human Health: Cancer

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 A-3. Human Health: Cancer (g C_6H_6 eq)

Category	Brick	EIFS	Fiber Cement Siding	Stucco	Insulated Vinyl Siding (Progressive Foam)	Generic Vinyl Siding	Cedar Siding
All Others	0.0258	0.0281	0.1641	0.1008	0.0536	0.0544	0.0603
Arsenic	0.1987	1.0338	0.2279	0.0506	0.0610	0.0502	0.0915
Benzene	0.0642	0.0115	0.0147	0.0035	0.0146	0.0116	0.0097
Dioxins	153.4737	82.9269	107.5536	128.9051	0.2120	0.1954	1.2364
Arsenic	0.8545	0.2174	0.2237	0.1302	0.2165	0.1767	0.1964
Phenol	0.7984	0.5864	0.1952	0.1166	0.2253	0.1848	0.7862
Sum	155.4153	84.8041	108.3792	129.3068	0.7830	0.6731	2.3805

Figure A-3. Human Health: Cancer (g C_6H_6 eq)



Source: BEES Online database; National Institute of Standards and Technology; http://ws680.nist.gov/Bees; Accessed October 2012.
*EIFS and Fiber Cement Siding Without Recycled Content data submitted to BEES by individual companies.

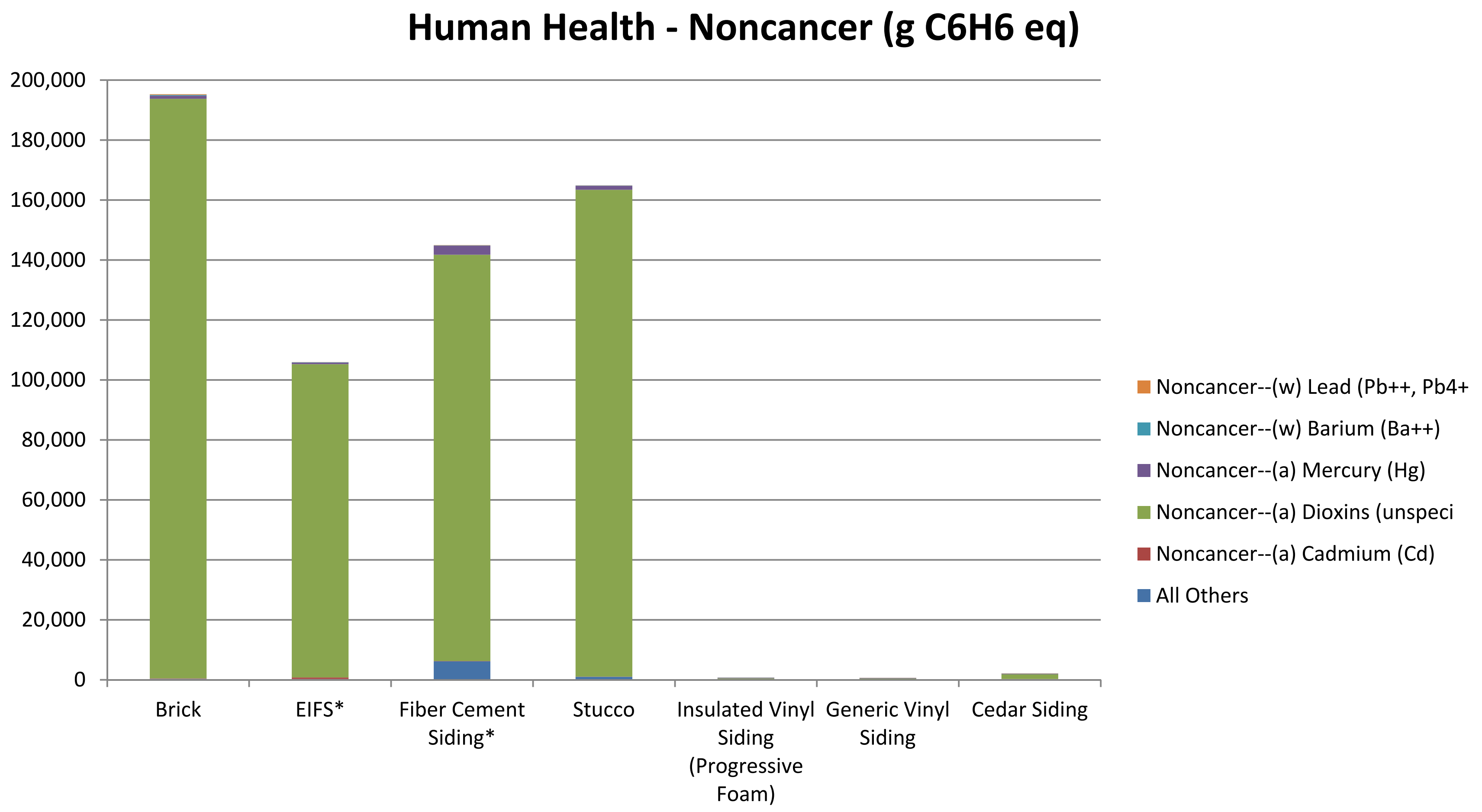
Human Health: Non-Cancer

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 A-4. Human Health: Non-Cancer (g C_6H_6 eq)

Category	Brick	EIFS	Fiber Cement Siding	Stucco	Insulated Vinyl Siding (Progressive Foam)	Generic Vinyl Siding	Cedar Siding
All Others	310.2273	258.0612	6,179.8036	979.8347	162.7540	133.3947	228.7198
Cadmium	122.4779	509.6966	70.5912	56.7303	25.2677	19.7357	35.4600
Dioxins	193,353.6690	104,475.3190	135,501.2462	162,400.8943	267.1129	246.1313	1,557.6669
Mercury	998.3203	573.2167	3,075.3736	1329.1067	178.9422	172.0031	139.9944
Barium	308.7574	74.9816	87.4298	81.8529	68.2437	61.5283	108.5443
Lead	192.9806	54.8453	57.2972	40.4708	61.8730	44.4633	58.3760
Sum	195,286.4325	105,946.1204	144,971.7416	164,888.8897	764.1935	677.2564	2,128.7614

Figure A-4. Human Health: Non-Cancer (g C_7H_7 eq)



Source: BEES Online database; National Institute of Standards and Technology; http://ws680.nist.gov/Bees; Accessed October 2012.
*EIFS and Fiber Cement Siding Without Recycled Content data submitted to BEES by individual companies.

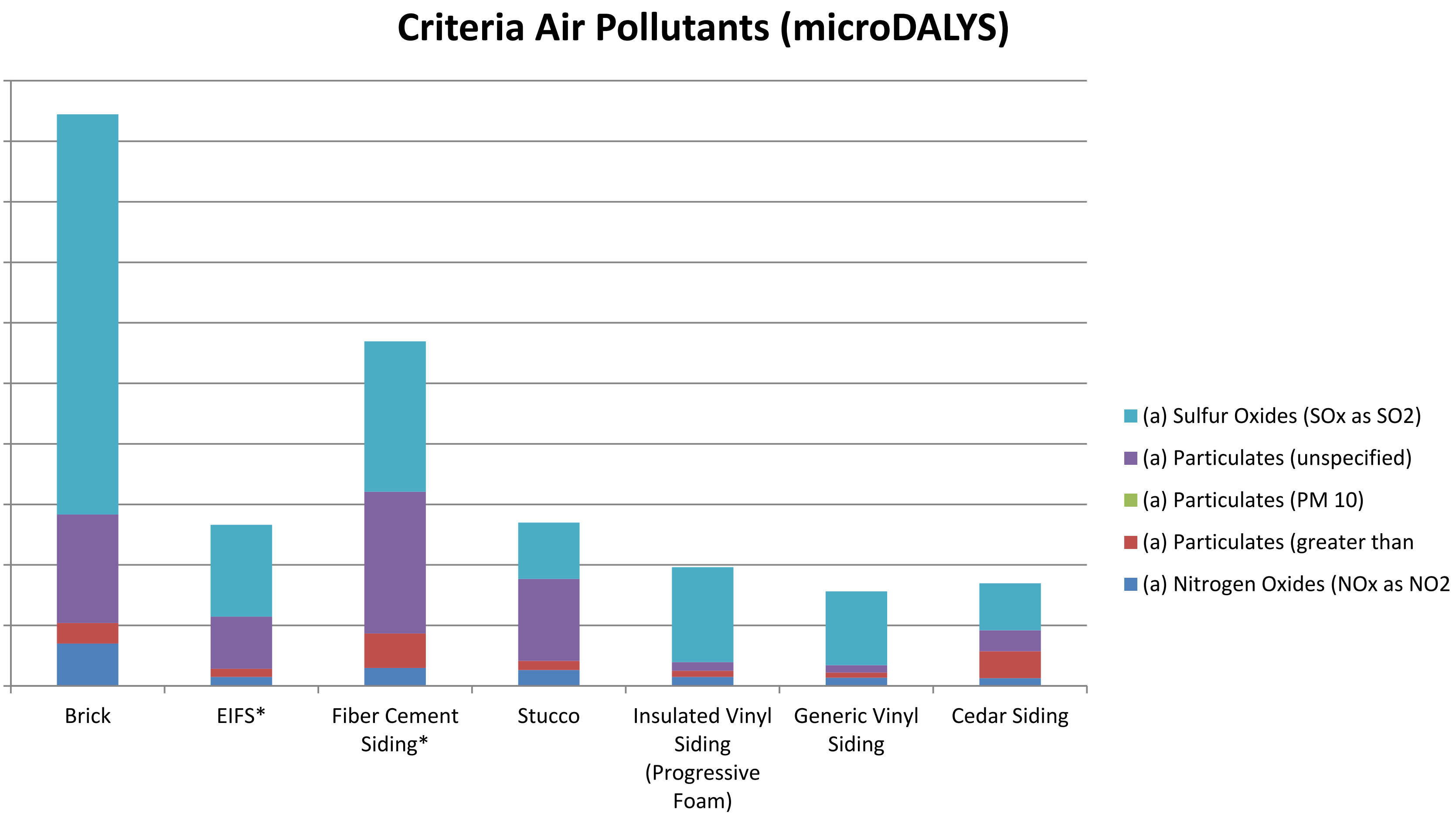
Criteria Air Pollutants

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

Table A-5. Criteria Air Pollutants (microDALYs)

Category	Brick	EIFS	Fiber Cement Siding	Stucco	Insulated Vinyl Siding (Progressive Foam)	Generic Vinyl Siding	Cedar Siding
(a) Nitrogen Oxides (NOx as NO2	0.0350	0.0075	0.0149	0.0131	0.0075	0.0068	0.0064
(a) Particulates (greater than	0.0170	0.0067	0.0284	0.0076	0.0050	0.0043	0.0223
(a) Particulates (PM 10)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
(a) Particulates (unspecified)	0.0896	0.0431	0.1171	0.0677	0.0072	0.0061	0.0173
(a) Sulfur Oxides (SOx as SO2)	0.3306	0.0758	0.1243	0.0466	0.0784	0.0609	0.0388
Sum	0.4722	0.1331	0.2847	0.1350	0.0981	0.0781	0.0848

Figure A-5. Criteria Air Pollutants (microDALYs)



Source: BEES Online database; National Institute of Standards and Technology; http://ws680.nist.gov/Bees; Accessed October 2012.
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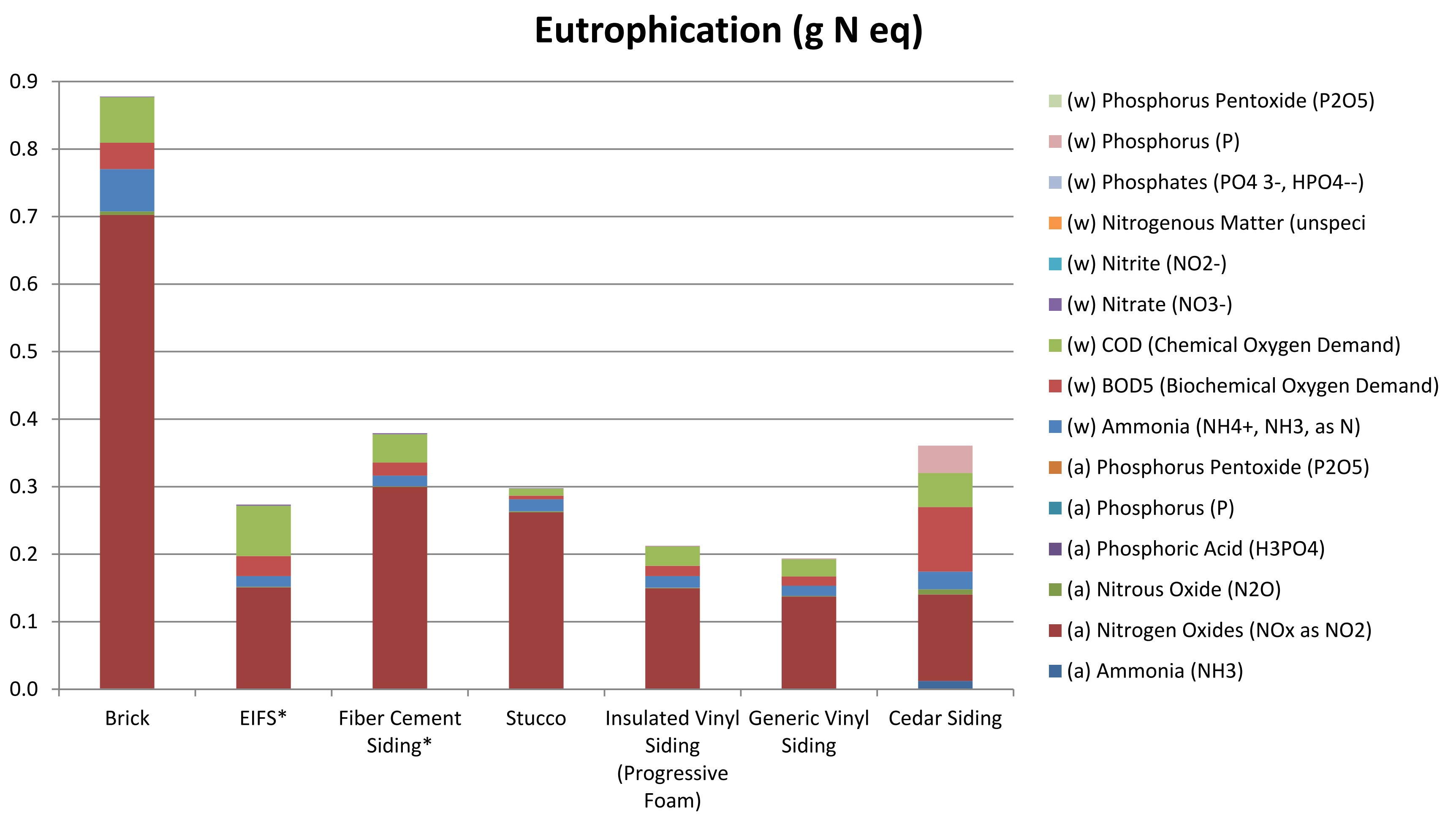
Eutrophication

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 A-6. Eutrophication (g N eq)

Category	Brick	EIFS	Fiber Cement Siding	Stucco	Insulated Vinyl Siding (Progressive Foam)	Generic Vinyl Siding	Cedar Siding
(a) Ammonia (NH3)	0.0012	0.0006	0.0008	0.0006	0.0003	0.0003	0.0122
(a) Nitrogen Oxides (NOx as NO2	0.7012	0.1502	0.2987	0.2614	0.1492	0.1370	0.1282
(a) Nitrous Oxide (N2O)	0.0052	0.0009	0.0010	0.0014	0.0009	0.0008	0.0076
(a) Phosphoric Acid (H3PO4)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
(a) Phosphorus (P)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
(a) Phosphorus Pentoxide (P2O5)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
(w) Ammonia (NH4+, NH3, as N)	0.0627	0.0159	0.0159	0.0179	0.0171	0.0151	0.0262
(w) BOD5 (Biochemical Oxygen De	0.0390	0.0296	0.0193	0.0054	0.0153	0.0138	0.0956
(w) COD (Chemical Oxygen Demand	0.0675	0.0745	0.0419	0.0104	0.0286	0.0254	0.0503
(w) Nitrate (NO3-)	0.0010	0.0015	0.0015	0.0006	0.0004	0.0004	0.0000
(w) Nitrite (NO2-)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
(w) Nitrogenous Matter (unspeci	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
(w) Phosphates (PO4 3-, HPO4--,	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
(w) Phosphorus (P)	0.0000	0.0004	0.0001	0.0000	0.0009	0.0010	0.0406
(w) Phosphorus Pentoxide (P2O5)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Sum	0.8778	0.2736	0.3792	0.2977	0.2127	0.1938	0.3607

Figure A-6. Eutrophication (g N eq)



Source: BEES Online database; National Institute of Standards and Technology; http://ws680.nist.gov/Bees; Accessed October 2012.
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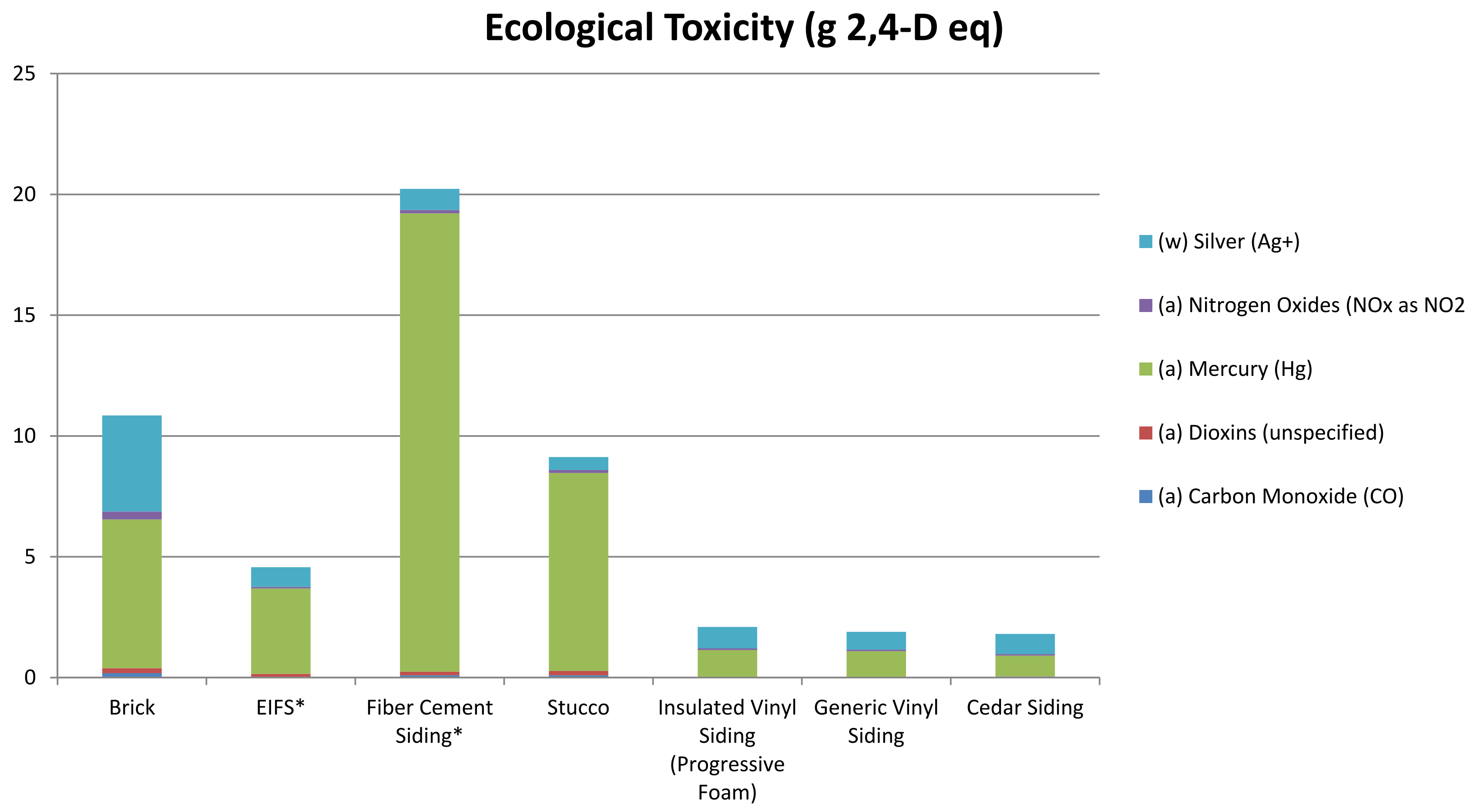
Ecological Toxicity

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

Table A-7. Ecological Toxicity (g 2,4-D eq)

Category	Brick	EIFS	Fiber Cement Siding	Stucco	Insulated Vinyl Siding (Progressive Foam)	Generic Vinyl Siding	Cedar Siding
Carbon Monoxide	0.1818	0.0403	0.0978	0.0988	0.0365	0.0340	0.0471
Dioxins	0.2103	0.1136	0.1474	0.1766	0.0003	0.0003	0.0017
Mercury	6.1572	3.5354	18.9677	8.1974	1.1036	1.0608	0.8634
Nitrogen Oxides	0.3245	0.0695	0.1383	0.1210	0.0690	0.0634	0.0593
Silver	3.9779	0.8103	0.8754	0.5351	0.8897	0.7392	0.8360
All Others	0.2730	0.3299	0.3294	0.1443	0.1087	0.0903	0.4918
Sum	11.1247	4.8990	20.5560	9.2732	2.2078	1.9880	2.2993

Figure A-7. Ecological Toxicity (g 2,4-D eq)



Source: BEES Online database; National Institute of Standards and Technology; http://ws680.nist.gov/Bees; Accessed October 2012.
*EIFS and Fiber Cement Siding Without Recycled Content data submitted to BEES by individual companies.

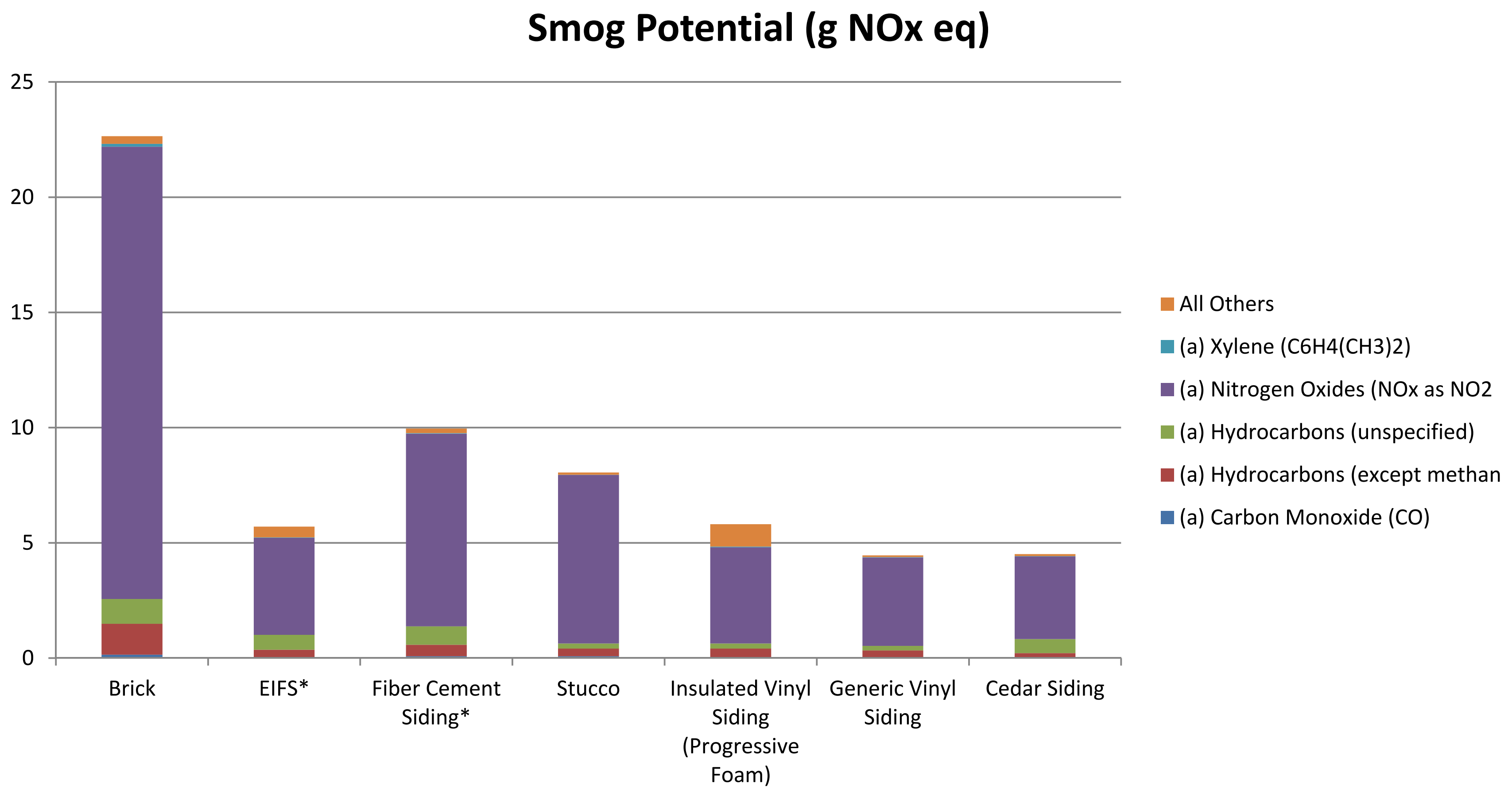
Smog Potential

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 (NOx). The Smog indicator is expressed as a mass of equivalent NOx.

Table A-8. Smog Potential (g NO_x eq)

Category	Brick	EIFS	Fiber Cement Siding	Stucco	Insulated Vinyl Siding (Progressive Foam)	Generic Vinyl Siding	Cedar Siding
(a) Carbon Monoxide (CO)	0.1472	0.0326	0.0792	0.0800	0.0296	0.0276	0.0382
(a) Hydrocarbons (except methane)	1.3421	0.3300	0.4962	0.3335	0.3853	0.3071	0.1750
(a) Hydrocarbons (unspecified)	1.0736	0.6477	0.8008	0.2189	0.2186	0.1948	0.6113
(a) Nitrogen Oxides	19.6306	4.2062	8.3632	7.3189	4.1763	3.8352	3.5879
(a) Xylene (C6H4(CH3)2)	0.1222	0.0213	0.0207	0.0033	0.0272	0.0214	0.0115
All Others	0.3289	0.4703	0.1976	0.0976	0.9719	0.0706	0.0884
Sum	22.6446	5.7081	9.9577	8.0522	5.8089	4.4567	4.5123

Figure A-8. Smog Potential (g NO_x eq)



Source: BEES Online database; National Institute of Standards and Technology; http://ws680.nist.gov/Bees; Accessed October 2012.
*EIFS and Fiber Cement Siding Without Recycled Content data submitted to BEES by individual companies.

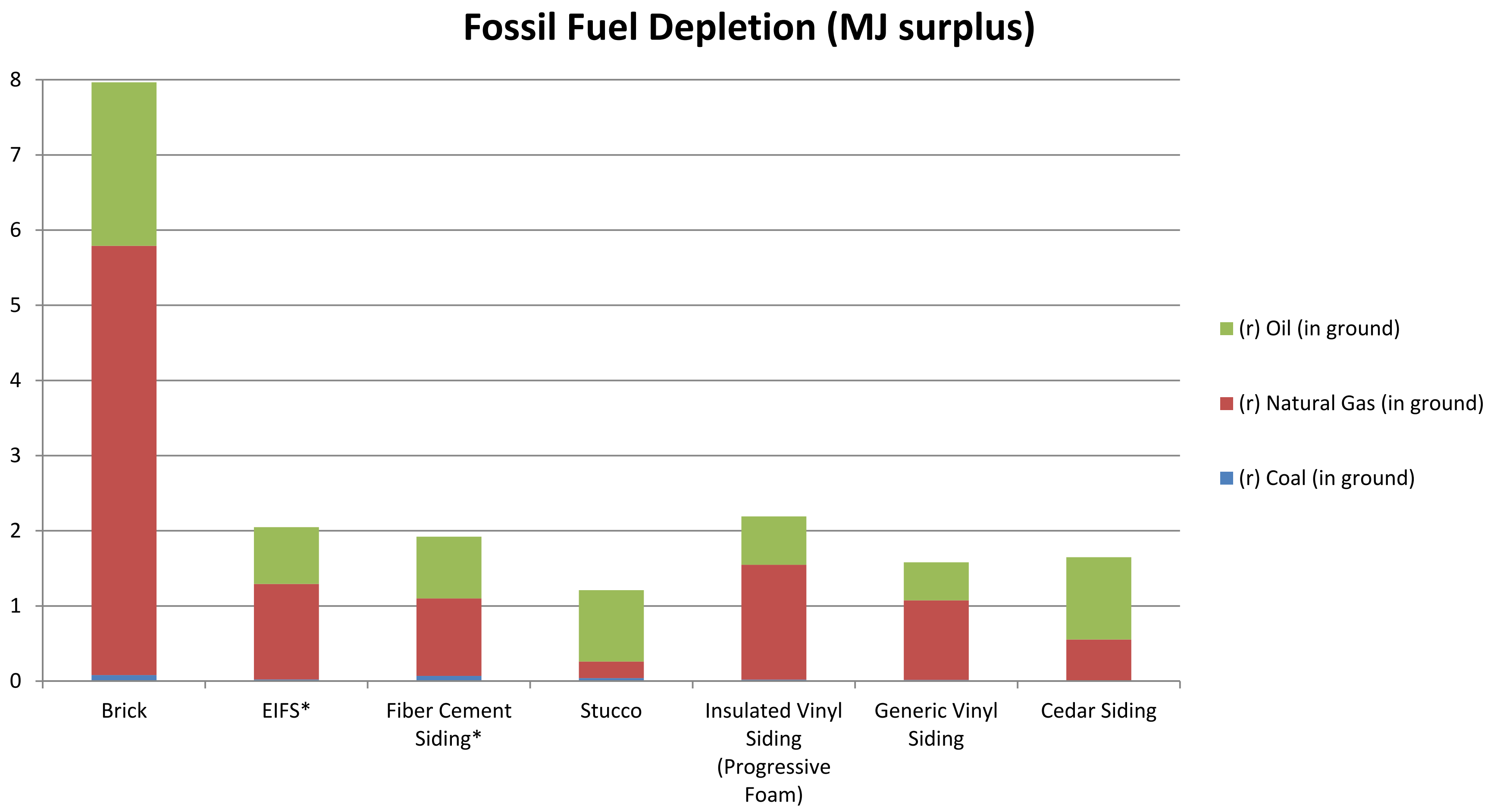
Fossil Fuel Depletion

This impact measures the extraction of fossil fuels (petroleum, coal and natural gas).

Table A-9. Fossil Fuel Depletion (MJ surplus)

Category	Brick	EIFS	Fiber Cement Siding	Stucco	Insulated Vinyl Siding (Progressive Foam)	Generic Vinyl Siding	Cedar Siding
(r) Coal (in ground)	0.0799	0.0218	0.0699	0.0402	0.0192	0.0158	0.0107
(r) Natural Gas (in ground)	5.7116	1.2705	1.0309	0.2196	1.5289	1.0592	0.5430
(r) Oil (in ground)	2.1749	0.7564	0.8203	0.9496	0.6430	0.5052	1.0948
Sum	7.9664	2.0487	1.9211	1.2094	2.1911	1.5802	1.6485

Figure A-9. Fossil Fuel Depletion (MJ surplus)



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